Alcohol Consumption, Beverage Prices and Measurement Error*

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ABSTRACT. *Objective*: Alcohol price data collected by the American Chamber of Commerce Researchers Association (ACCRA) have been widely used in studies of alcohol consumption and related behaviors. A number of problems with these data suggest that they contain substantial measurement error, which biases conventional statistical estimators toward a finding of little or no effect of prices on behavior. We test for measurement error, assess the magnitude of the bias and provide an alternative estimator that is likely to be superior. *Method*: The study utilizes data on per capita alcohol consumption across U.S. states and the years 1982-1997. State and federal alcohol taxes are used as instrumental variables for prices. *Results*: Formal tests strongly confirm the hypothesis of measurement error. Instrumental variable estimates of the price elasticity of demand range from -0.53 to -1.24. These estimates are substantially larger in absolute value than ordinary least squares estimates, which sometimes are not significantly different from zero or even positive. *Conclusions*: The ACCRA price data are substantially contaminated with measurement error, but using state and federal taxes as instrumental variables mitigates the problem. (*J. Stud. Alcohol* **64:** 235-238, 2003)

ALCOHOL CONSUMPTION is an important public policy issue because of its associations with drunk driving, violence and diseases such as cirrhosis of the liver. How these behaviors respond to changes in the price of alcohol is important for a variety of policy purposes. A key problem in obtaining reliable estimates of price responses is the quality of the available data, which may contain substantial measurement error (Leung and Phelps, 1993; Ornstein and Levy, 1983; Young, 1993). One frequently used set of price data is from ACCRA, formerly known as the American Chamber of Commerce Researchers Association (1982-1997). These data report retail prices for beer, wine and distilled spirits. They have been used by Beard et al., 1997; Grossman et al., 1998; Gruenewald et al., 1993; Kenkel, 1993; Manning et al., 1995; Markowitz, 2000; Nelson, 2003; Sloan et al., 1994; and Young and Likens, 2000, among others.

However, a number of problems with the conceptual and practical aspects of the ACCRA survey suggest that the data may contain substantial measurement errors. The specific beverages for which prices are recorded—currently a six pack of Heinekin's beer, a 750 ml bottle of J&B Scotch and a 1.5 liter bottle of Gallo or Livingston Cellars Chablis—may not be representative of all alcohol prices, or of the prices which are most related to alcohol abuse. These

beverage definitions have changed over time, requiring adjustments to create a consistent time series. Errors may also be inadvertently introduced by local economic development agencies, which are responsible for data collection and reporting. Although ACCRA provides detailed instructions, personnel are not specifically trained as data gatherers (ACCRA, 2002). ACCRA instructs the data gatherers not to sample prices from discount stores, even if they are a majority of the overall market. The ACCRA survey covers only urban areas. The sample of stores may vary from quarter to quarter in each city, and the sample of cities that report has grown dramatically over time as well as varying from quarter to quarter. Finally, although the data are reviewed for accuracy by a panel of "volunteers," the alcohol components are a small part of the overall index (about 1.7%), and thus they may not be fully scrutinized.

Measurement error in the price data implies that the ordinary least squares (OLS) estimator commonly used in regression analysis is biased and inconsistent (Greene, 2003, Section 5.6.1). In addition, beverage prices may be endogenous in the sense that higher demand may result in higher market prices (Manning et al., 1995, p. 126). In simple models, both measurement error and endogeneity cause the estimated price response to be biased away from negative values. That is, the conventional OLS estimator may substantially underestimate how much consumers decrease consumption in response to an increase in price.

An alternative to the ACCRA data is to use excise taxes as measures of the price of alcohol. However, taxes do not accurately measure prices either. One reason is that combined state and federal excise taxes typically amount to

only about 10-15% of retail beverage prices (Young and Bielinska-Kwapisz, 2002). In addition, distilled spirits and wine taxes are themselves difficult to measure accurately. In 18 "control" states spirits are sold through state stores and are subject to ad valorem markups and/or excise taxes. In these states, the markup is in part a tax, because the government receives the "profits" from the markup, but it is difficult to separate the implicit tax rate from the normal costs of wholesaling and retailing spirits. Tax rates for all types of beverages also vary according to alcohol content, place or volume of production, size of container, place purchased (on- or off-premises), and there may be case- or bottle-handling fees.

These problems with price data, in general, and distilled spirits and wine taxes, in particular, have led some researchers to conclude that beer taxes are the best available indicator of the cost of alcohol (Chaloupka et al., 1993, pp. 169-170; Freeman, 2000, p. 329). However, Young and Bielinska-Kwapisz (2002) show that beer taxes alone are not highly correlated with either the ACCRA price data or national trends in the detailed Consumer Price Index for alcohol. But a broader set of tax variables, including not just beer taxes but also distilled spirits and wine per unit excise taxes, percentage excise taxes and state markups, provides a set of instrumental variables which, in principle, can resolve the problems with the price data.

In brief, the instrumental variable technique involves two estimation steps. First, the alcohol price data are regressed on the tax and other variables, and the predicted prices are retained. In the second step, the response of alcohol consumption to beverage prices and other variables is estimated, using the predicted prices from the first step as right-hand side variables. The important result is that these predicted prices are "cleansed" of measurement error and demand effects, so that the resulting estimator is unbiased in large samples (Greene, 2003, Section 5.6.2).

Method

The analysis uses annual data for 49 states (excluding Hawaii, because price data are not available) plus the District of Columbia over the time period 1982-1997. Consumer demand for beverage alcohol is modeled as a function of price, income and other socioeconomic variables. Consumption of beer, wine and distilled spirits are shipments data from the Beer Institute (1997), divided by total population. Quantities of beer, wine and distilled spirits are multiplied by their average alcohol content (respectively, 4.5%, 11% and 40%) and expressed as gallons of pure ethanol per capita. The dependent variable is (the logarithm of) total alcohol consumption. A detailed description of the price and tax variables is provided in Young and Bielinska-Kwapisz (2002). The estimated equations always include dummy variables for each year, which control for unmea-

sured changes that are common across states, such as beverage definitions or changes in attitudes. In addition, state-specific dummy variables are also sometimes included, in order to control for unmeasured differences across states that are constant over time.

Hausman (1978) established a test for correlation between a right-hand side variable and the disturbance term, which would result from either measurement error or endogeneity of prices. We employ a version due to Davidson and MacKinnon (1989, 1993). Thus, we first test for measurement error and/or endogeneity using a Hausman test. The null hypothesis of no measurement error is strongly rejected, and we proceed to estimate alcohol demand using instrumental variable methods.

For these techniques to be effective, the tax variables must satisfy two properties: They are significantly correlated with true alcohol prices, and uncorrelated with the disturbances in the consumption equation. Young and Bielinska-Kwapisz (2002) show that state and federal excise taxes and markups explain about 30% of the variation in alcohol prices in pooled cross-section time series data similar to that employed in this study, and thus satisfy the first property. However, it is possible that state taxes and other alcohol policies reflect unmeasured attitudes toward alcohol, which are captured in the disturbance term of the consumption equation. In particular, taxes may be higher in states in which there is stronger anti-alcohol sentiment, or taxes may change over time in response to changes in attitudes toward alcohol. If this is the case, taxes are correlated with the disturbance and not proper instrumental variables (Manning et al., 1995, footnote 4).

Results

Estimates of the demand for alcohol are presented in Table 1. The first column presents OLS estimates with state dummy variables excluded. The estimated price elasticity of demand is -0.345 and significantly different from zero. However, a Hausman test strongly rejects exogeneity in favor of endogeneity and/or measurement error ($F = 13.5$, $p = .0003$).

Column 2 presents two-stage least squares (2SLS) estimates of alcohol demand using the tax variables as instruments for the price variable. As expected, the estimated price elasticity of demand is larger than in column 1: A 1% increase in alcohol prices is estimated to reduce consumption by 1.24%, a response that is 3.5 times larger than the OLS estimate.

Most of the other coefficient estimates also conform to theoretical expectations. The estimated income elasticity is positive, although only about 0.1. A 1% increase in the share of the population aged 18-29 is estimated to increase per capita alcohol consumption by about 3%. A 1% increase in the population share over age 65 is estimated to

TABLE 1. Composite demand for alcohol (dependent variable: Ln alcohol consumption per capita, t statistics below parameter estimates)

Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS
State dummies included:	No	No	Yes	Yes	Yes	Yes
Ln (alcohol price)	-.345	-1.24	-.055	-.750	.027	-.530
	4.1	4.4	1.4	5.5	0.6	4.8
Ln (income per capita)	.103	.138	.497	.764	.524	.663
	1.9	2.3	11.3	10.6	11.3	11.5
Pop. age 18-29 (%)	.049	.031	.022	.014		
	8.7	3.9	7.0	3.5		
Pop. age >65 (%)	-.004	-.005	.018	.034		
	1.2	1.5	3.4	4.8		
Legal drinking age	-.010	-.010	.003	.004		
	1.2	1.1	1.1	1.2		
Pop. in dry counties (%)	-.003	-.002	.001	-.001		
	4.6	3.5	0.9	0.5		
Catholic (%)	-.000	-.001	.002	.011		
	0.8	2.0	1.4	4.4		
Mormon (%)	-.012	-.010	-.016	-.004		
	17.5	10.5	3.2	0.7		
Southern Baptist (%)	-.006	-.004	.036	.044		
	7.1	3.9	12.2	11.5		
Other religion (%)	-.006	-.004	-.005	-.008		
	7.8	4.5	5.8	6.9		
Tourism (%)	.047	.045	-.020	-.014		
	16.9	15.0	3.1	1.7		
Constant	1.68	6.49	-2.58	.066	-1.45	1.11
	3.3	4.3	11.6	0.1	6.0	2.1
Adjusted R^2	.67	.62	.98	.97	.97	.96

Notes: Year dummies for 1982-96 are included in every equation; the base year is 1997. When state dummies are included, the base state is Alabama. Instruments for the 2SLS estimates include the combined state and federal excise taxes on beer, spirits and wine, and, for control states, the percentage excise taxes and/or markups on spirits and wine, as applicable. Price is treated as endogenous. $N = 761$. Mean of the dependent variable = 0.601.

reduce consumption by about 0.5%, and increasing the legal drinking age by 1 year is estimated to reduce consumption by 1%, although neither of these estimates is statistically significant. The population residing in dry counties and the religion variables are each negatively and significantly related to consumption (Bradley et al., 1992; Quinn et al., 1982). Finally, tourism has a statistically significant and large, positive relationship with consumption. (The two "states" with the highest alcohol consumption are Washington, DC and Nevada, both of which have large tourism industries.)

What happens when state-specific dummy variables are included (see column 3)? The overall explanatory value of the equation (R^2) increases markedly, reflecting two important features of the data: Most of the variation in consumption is cross-sectional, and much of it is not accounted for by price, income and the other control variables. The price elasticity is small in magnitude and not statistically different from zero when the estimation method is OLS. We again perform the Hausman test for measurement error, this time including the state dummies among the instruments. The null hypothesis of exogeneity is even more strongly rejected ($F = 46.7$, $p = .0000$).

The fourth column presents two-stage least squares estimates with the state dummies included. The estimated price

elasticity is statistically significant and again much larger in absolute value than when using OLS: A 1% increase in the price of alcohol is estimated to reduce consumption by about three fourths of 1%.

The estimated coefficients of some of the control variables, however, display unexpected signs when state dummies are included and others become statistically insignificant. Apparently, there is insufficient within-state variation in the control variables to provide reliable estimates when state dummies are included.

The last two columns therefore display estimates of alcohol demand with only price, income and the state and time dummies included. The OLS estimate of the price elasticity is small, positive and insignificant (column 5), but a Hausman test again strongly confirms measurement error and/or endogeneity ($F = 25.4$, $p = .0000$). Using two-stage least squares, the estimated price elasticity continues to be statistically significant and has a magnitude of about -0.50.

Discussion

The main point of this article is that in any application using the ACCRA data, the problem of measurement error must and apparently can be confronted using comprehensive measures of state and federal alcohol taxes as instru-

ments. For example, Manning et al.'s (1995) finding that heavy consumers of alcohol are essentially unresponsive to prices may be, in part, an artifact of measurement error. Since measurement error is likely to bias the estimated response for both heavy and light consumers, the responses of both groups are probably underestimated. It may remain true, however, that heavy drinkers are less responsive to prices than are light drinkers. Using instrumental variable methods, our estimates indicate somewhat more price responsiveness than do previous studies using aggregate data (Leung and Phelps, 1993). However, we are somewhat less confident that taxes are completely satisfactory instruments to deal with endogeneity bias, because taxes may be correlated with unmeasured attitudes or other alcohol policies.

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