COUNTY-LEVEL ALCOHOL AVAILABILITY AND CIRRHOSIS MORTALITY

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INTRODUCTION

Alcohol abuse has been linked to 18,000 suicides and homicides, approximately 50,000 deaths from liver cirrhosis and other alcohol-related diseases, and about 20,000 fatal motor vehicle accidents in the U.S. annually.[1] Standard policies designed to reduce alcohol abuse include alcohol taxation and availability restrictions, such as minimum drinking-age laws, prohibition of alcohol sales, and limitations on the number or type of alcohol vendors. All of these policies aim to reduce alcohol consumption and the social problems associated with heavy drinking by raising the full price of alcohol, comprised of the dollar price plus a travel-cost component.

There is strong evidence that alcohol consumption is sensitive to tax-induced price increases. Using state-level data, Cook and Tauchen [1982] find that excise taxes on distilled spirits significantly reduce alcohol consumption and heavy drinking, measured by liver cirrhosis mortality. Using survey data, Kenkel [1993], Laixuthai and Chaloupka [1993], and Coate and Grossman [1988] verify that alcohol consumption and heavy drinking are responsive to increases in alcohol taxes. Saffer and Chaloupka [1989] and Saffer and Grossman [1987a; 1987b] report that both alcohol taxes and minimum drinking-age laws reduce state-level motor vehicle fatalities, a mortality measure strongly correlated with drinking and driving. However, Asch and Levy [1987] suggest that the effect of minimum drinking-age laws on vehicle fatalities is insignificant for most categories of drivers.[2]

The effects of local alcohol vendor restrictions on alcohol consumption and alcohol-related behavior are examined less frequently in the literature. Theoretical predictions concerning the impact of alcohol availability center on the sensitivity of consumption to availability-induced variations in the full price of alcohol. For instance, restricting the number of licensed vendors in a geographical area raises the travel cost associated with acquiring alcohol. If consumption is sufficiently responsive to price increases, then alcohol consumption and alcohol-related behavior should decrease. Alternatively, if consumption is insensitive to price changes, then availability restrictions will be ineffective in reducing alcohol abuses.

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Winn and Giacopassi [1993] examine the effect of alcohol prohibition on drinking and driving using county-level data for Kentucky. Counties that are "dry," i.e., those which prohibit the sale of alcoholic beverages, have significantly lower rates of alcohol-related motor vehicle fatalities, motor vehicle injuries, and property damage than "wet" counties. Saffer and Grossman [1987a; 1987b] and Chaloupka et al. [1993] control for the proportion of a state's population residing in dry counties and find a negative impact on state-level motor vehicle fatality rates. Ornstein and Hanssens [1985] report that the number of on-premise licenses per capita in a state, as well as other state regulatory laws, positively impact the consumption of alcoholic beverages. Wilkinson [1987] also shows a positive relationship between the number of outlets in a state and alcohol consumption. Scribner et al. [1995] utilize city-level data from California to examine the link between local alcohol availability and assaultive violence.

All of this literature treats the observed policy instrument—such as the tax rate on alcohol or the level of alcohol availability—as exogenous in the estimation. However, these policies are ultimately established through either a public-choice mechanism or the market forces of supply and demand for alcohol; therefore, overlooking the endogeneity of the observed policy instrument potentially biases the empirical results and the policy evaluation. Brown et al. [1996] address this issue within a public-choice framework in examining county-level alcohol prohibitions and drunk driving. The authors find that counties in which alcohol is prohibited tend to have lower rates of drunk driving fatalities.

This paper estimates the impact of local alcohol availability on heavy drinking utilizing data on the 254 counties in Texas. Alcohol availability is measured using data on the number of licensed alcohol vendors in each county. This paper differs from past literature in two ways. First, the empirical methodology accounts for the endogeneity of the observed level of alcohol availability. Second, these unique county-level data allow for assessing the direct impact of locally-established availability restrictions on heavy drinking. Following Cook [1981] and Cook and Tauchen [1982], we use cirrhosis mortality as the indicator for heavy drinking. Since cirrhosis results from excessive drinking over a period of 10 to 20 years, cirrhosis mortality rates may not reflect current heavy drinking among younger individuals. However, the cirrhotic process is responsive to average consumption rates of older individuals who are chronic drinkers; therefore, any availability-induced changes in average consumption rates should be observed in cirrhosis mortality rates [Terris, 1967].

DATA AND ESTIMATION METHOD

Individuals are assumed to derive utility from alcohol consumption, so that the county-level demand for alcohol depends on the price of alcohol and consumer preferences, as well as such standard socioeconomic factors as population, income, education, and age. County-level data on the dollar price of alcohol is unavailable and, in any case, would be unobservable in the 15 counties without licensed alcohol vendors. If we assume that the dollar price is constant across counties with equivalent alcohol availability, then variations in the travel-cost component of price across counties effectively capture price variations. In this sense, alcohol availability can be viewed as the observable component of price variation across counties.[3] However, the absence of dollar price data is potentially problematic. For instance, greater alcohol availability may lead to more competition, reducing the dollar price of alcohol as well as the travel-cost component of price. Furthermore, counties with fewer licenses may have larger vendors that can offer lower dollar prices. To the extent that the dollar price is correlated with travel cost, the Texas data will produce biased estimates of the relationship between alcohol availability and heavy drinking.

The Texas Department of Health provides data on cirrhosis deaths by county of residence. Data from the Texas Alcohol Beverage Commission measure the number of licensed alcohol vendors in each county, including the number of wholesale and retail alcohol beverage outlets. The data on cirrhosis mortality rates and licensed alcohol vendors are averaged over five years (1988-92) to minimize any random yearly fluctuations. Two alcohol availability measures are computed for each county. The first is the number of licensed vendors per 1,000 county residents, providing a measure of availability-density per population. The second is the number of licensed alcohol vendors per lane mile of road in a county; this measure provides additional information about the travel-cost component of price, since travel cost is related to actual road distances traveled.

Data on county-level population density per square mile, income and poverty levels, education level, and age are collected from the U.S. Bureau of the Census [1992] and Skrabanek et al. [1985]. Religious affiliation characterizes important preferences toward alcohol consumption. In particular, conservative Protestant denominations strongly disapprove of alcohol consumption, so that counties with a higher proportion of these denominations would presumably consume less alcohol and have lower rates of cirrhosis mortality. The percent of Catholics and Baptists in a county, the two largest religious groups in Texas, are included in the estimation to control for the nature and degree of religious affiliation.[4] Religious affiliation data are found in Bradley et al. [1990].

The demand for heavy drinking is a function of the full price of alcohol, which is endogenously determined through the interaction of the demand and supply for alcohol. Therefore, we apply a two-stage estimation method to account for endogeneity of the alcohol availability measure. The first-stage regression estimates the county-level availability of alcohol, the observable component of price variation, as a function of the county-level determinants of the full price of alcohol. The second-stage regression estimates the demand for heavy drinking using the predicted values from the first-stage regression as instruments for the observed availability of alcohol.

Since availability is partially determined by the demand for alcohol, the first-stage regression includes conventional demand variables. In addition, county-level alcohol availability may reflect the sentiment of citizens toward having alcohol available, independent of their preferences for consuming alcohol. Voters in Texas have the opportunity to make incremental decisions on the type of alcohol sales in their county through local option elections; prospective vendors must then apply for

TABLE 1
County-Level Summary Statistics
(n = 254)

	Mean	Standard Deviation
Cirrhosis Deaths Per 1,000 Residents	0.062	0.236
Licenses Per 1,000 Residents	3.580	3.270
Licenses Per Lane Mile	0.179	0.338
Population Density	68.897	203.570
Median Income	13,861	3146.4
Percent Poverty	14.115	6.281
Percent Catholic	15.620	18.165
Percent Baptist	27.380	13.272
Median Education	11.720	0.983
Percent College	11.156	4.294
Median Age	32.076	5.545
Border Availability	237.71	509.09
Percent Tourism	0.082	0.074
Percent Democrat	31.465	12.244

licenses subject to these alcohol sales restrictions.[5] Accordingly, alcohol availability in a county should reflect the characteristics and preferences of its citizens, such as political ideology, economic interests associated with alcohol availability, alcohol restrictions in surrounding counties, and demographic factors.

Political ideology may influence county-level restrictions on alcohol sales, perhaps reflecting the electorate's willingness to impose government restrictions on individual behavior. The percent of county voters identifying with the Democratic Party is included to capture differences in political sentiment toward alcohol availability not captured in other control variables.[6] In addition, political pressure for alcohol sales can be exerted by individuals associated with industries that are economically dependent on alcohol sales; the percentage of a county's population employed in the tourism industry proxies the degree to which local industries depend on alcohol sales. Finally, the relative availability of alcohol in surrounding counties impacts the relative travel cost of acquiring alcohol in any given county; the average number of licensed vendors in adjacent counties, the variable *Border Availability*, is included to capture this effect. Summary statistics are presented in Table 1.

To uniquely estimate the second-stage regression, the cirrhosis equation must be differentiated (i.e., identified) from the first-stage alcohol-availability equation. The common method is to exclude from the cirrhosis equation at least one independent variable that is included in the alcohol availability equation [Judge et al., 1988; Greene, 1993]. The measures of percent employed in the tourism industry and percent identifying with the Democratic Party serve as exclusion restrictions for identifying the second-stage estimation. Furthermore, the cirrhosis mortality data are grouped by

TABLE 2
County-Level Heavy Drinking:
Dependent Variable is Alcohol Availability
(t-statistics in parentheses)

	(I) Licenses Per 1,000 Residents	(II) Licenses Per Lane Mile
Constant	3.957	-1.086
	(0.632)	(-2.910)[a]
Population Density	-0.0001	0.0012
	(-0.789)	(21.134)[a]
Median Income	-0.0002	0.000003
	(-1.494)	(0.520)
Percent Poverty	-0.124	0.002
	(-1.946)[b]	(0.461)
Percent Catholic	0.052	0.003
	(3.269)[a]	(3.274)[a]
Percent Baptist	-0.104	-0.004
	(-6.433)[a]	(-3.970)[a]
Median Education	0.388	0.079
	(0.982)	(3.377)[a]
Percent College	-0.157	0.004
	(-3.088)[a]	(1.231)
Median Age	0.039	0.001
	(0.864)	(0.481)
Border Availability	0.0002	0.00003
	(0.534)	(1.489)
Percent Tourism	13.116	-3.244
	(5.116)[a]	(-0.212)
Percent Democrat	0.019	0.478
	(1.047)	(4.395)[a]
Adjusted R^2	0.36	0.78

a. Significant at the 0.01 level.
b. Significant at the 0.05 level.
c. Significant at the 0.10 level.

county. Maddala [1983] suggests estimating grouped data with the minimum chi-square estimation method, a weighted least squares estimation applied to a linear probability function. The minimum chi-square method fits easily into the two-stage least squares method. A log-linear functional form is chosen in which the dependent variable is the natural log of the cirrhosis mortality rate and the independent variables enter linearly. The weights are $(n_i p_i/(1-p_i))^{1/2}$, where p_i is the county's cirrhosis mortality rate and n_i is the county's population. A similar functional form, the minimum logit chi-square, has been applied in motor vehicle fatality studies. Two-stage estimates using the minimum logit chi-square functional form were not significantly different than the log-linear model; therefore, we report only the log-linear results.[7]

TABLE 3
County-Level Heavy Drinking:
Dependent Variable is Log of Cirrhosis Deaths Per 1,000 Residents
(t-statistics in parentheses)

	(I) Endogenous Licenses Per 1,000 Residents	(II) Endogenous Licenses Per Lane Mile
Constant	-3.724	-1.579
	(-3.657)[a]	(-1.171)
Alcohol Availability	0.077	0.787
	(2.033)[b]	(2.063)[b]
Population Density	0.0001	-0.0007
	(1.984)[b]	(-1.744)[c]
Median Income	-0.00000	-0.00004
	(-0.195)	(-1.943)[b]
Percent Poverty	0.011	-0.015
	(0.843)	(-1.007)
Percent Catholic	0.006	0.007
	(1.820)[c]	(2.343)[b]
Percent Baptist	0.004	0.005
	(1.052)	(1.070)
Median Education	0.038	-0.043
	(0.672)	(-0.592)
Percent College	-0.011	-0.022
	(-1.494)	(-2.408)[b]
Median Age	0.016	0.013
	(1.869)[c]	(1.486)
Border Availability	0.00001	0.00006
	(0.258)	(1.201)
adjusted R^2	0.18	0.56

a. Significant at the 0.01 level.
b. Significant at the 0.05 level.
c. Significant at the 0.10 level.

RESULTS

Table 2 presents the results from the first-stage regressions, where alcohol availability in a county is regressed on standard economic and demographic factors, as well as variables capturing citizen sentiment toward alcohol availability. In column (I), the dependent variable is the number of vendor licenses per 1,000 residents. *Percent Poverty* is significantly negative, which may reflect a declining ability to pay for alcohol as poverty increases. *Percent Catholic* is significantly positive, indicating that Catholics either have a greater demand for alcohol or are less opposed to availability restrictions; *Percent Baptist* is significantly negative. These results confirm previous research suggesting that religious affiliation affects sentiment toward alcohol availability. *Percent Tourism* is positive and statistically significant, indicating that economic dependence on alcohol sales leads to greater availability. *Percent Democrat* is positive but insignificant.

In column (II), alcohol availability is measured by the number of licenses per lane mile, or the actual travel-cost component of price. In comparison to column (I), the coefficients on *Population Density*, *Percent Democrat*, and *Median Education* are positive and statistically significant, while *Percent Poverty* and *Percent Tourism* are insignificant. The insignificance of *Percent Tourism* in column (II) could result from larger counties having more tourism as well as more lane miles of road, causing the tourism measure to be negatively related to licenses per lane mile.

Table 3 presents the two-stage results of the demand for heavy drinking, where the predicted values from Table 2 are used as instruments for the observed level of alcohol availability. The standard errors are corrected for endogeneity using the two-stage least squares method described by Greene [1993]. The estimates suggest that the demand for heavy drinking is responsive to availability-induced changes in the full price of alcohol: greater availability lowers the travel-cost component of price, leading to an increase in heavy drinking. Of primary concern in Table 3 are the interpretations for the coefficient estimates on county-level alcohol availability. In column (I), adding another vendor per 1,000 residents in a county will increase cirrhosis mortality rates by 7.7 percent. In column (II), an additional vendor per lane mile raises the cirrhosis mortality rate by 78.7 percent. The Appendix presents the single-stage (ordinary least squares) estimates, where alcohol availability is treated exogenously. The coefficients on alcohol availability are much smaller when assuming exogeneity, biasing downward the effect of alcohol availability on cirrhosis mortality.

Consider the marginal effects of an additional licensed vendor in a county. Take, for instance, the average county where there are 65,705 residents, 227 licensed vendors, and 715 lane miles. From specification (I), an additional alcohol vendor raises the cirrhosis mortality rate by 0.117 percent; from specification (II), an additional vendor increases the cirrhosis mortality rate by 0.110 percent. Furthermore, an additional vendor in the average county amounts to a 0.441 percent increase in vendors; thus, the price elasticity of cirrhosis mortality computed at the sample means is approximately -0.26. Heavy drinking appears to respond to availability-induced changes in the full price of alcohol, although it is relatively price inelastic.

Percent Poverty performs poorly in each specification of Table 3, while *Median Income* is consistently negative but only significant in specification (II). If alcohol is a normal good, then higher income per capita should increase consumption and the rate of cirrhosis mortality; however, as income increases, consumers may substitute toward a higher quality and a lower quantity of alcohol. *Population Density* is positive and significant in specification (I), but negative and marginally significant in specification (II). Less populated areas tend to be more rural, and rural areas typically have lower overall rates of alcohol consumption and lower cirrhosis mortality

rates. *Median Age* is positive and marginally significant in specification (I), as expected since cirrhosis usually results from heavy drinking over at least 10 years.

The positive coefficient on *Border Availability* suggests that availability in adjacent counties lowers the relative travel costs of obtaining alcohol, although the coefficient is insignificant. The estimates on the religious variables are interpreted as conditional on a given level of alcohol availability. That is, for any given level of availability, Catholics are more likely to have cirrhosis while Baptists show no significant pattern. *Median Education* and *Percent College* are included as indicators of knowledge about the detrimental effects of heavy drinking. *Median Education* has a mean of 11.72, essentially a high school education. Both measures are included to capture any differences attributable to a college education. *Median Education* is insignificant in both specifications, *Percent College* is negative in both specifications and significant in (II).

CONCLUSION

Alcohol taxation and restricting alcohol sales are commonly practiced policies aimed at reducing alcohol abuse. Each policy induces an effective price increase for alcohol to discourage alcohol consumption and alcohol-related behavior. An empirical literature shows evidence that alcohol consumption, heavy drinking, and drunk driving are sensitive to tax-induced increases in the price of alcohol. This paper takes a different approach by examining the relationship between heavy drinking and local alcohol availability restrictions. We estimate the sensitivity of the demand for heavy drinking to availability-induced changes in the full price of alcohol using data at the county level, where availability restrictions are generally established. In addition, our methodology accounts for the endogeneity of the observed policy instrument—the county-level availability of alcohol—an issue commonly overlooked in the literature. Our estimates report that restricting alcohol sales, thereby raising the travel cost of acquiring alcohol, significantly reduces cirrhosis mortality rates in Texas counties. Furthermore, we find that failing to account for the endogeneity of alcohol availability introduces a bias in the estimates.

Finally, we can compare the effectiveness of vendor restrictions relative to taxes on alcohol as a means to reduce heavy drinking. For example, estimates from this paper show that revoking a licensed alcohol vendor in the average Texas county, thereby raising the full price of alcohol, will reduce cirrhosis mortality by approximately 0.11 percent. Cook and Tauchen [1982] show that a $1.00 increase in the alcohol tax per proof gallon, in 1967 dollars, reduces state-level cirrhosis mortality rates by 5.4 percent. In Texas, the average county has approximately four cirrhosis deaths per year. A 5.4 percent reduction in the cirrhosis mortality rate (0.22 fewer cirrhosis deaths per year for the average county) requires a decrease of approximately 49 licensed vendors. Since an average county has 227 vendors, such an increase in price would necessitate a 21.6 percent decrease in the number of vendors.

APPENDIX
County-Level Heavy Drinking:
Dependent Variable is Log of Cirrhosis Deaths Per 1,000 Residents
(t-statistics in parentheses)

	(i) Exogenous Licenses Per 1,000 Residents	(ii) Exogenous Licenses Per Lane Mile
Constant	-3.551	-2.690
	(-3.506)[a]	(-2.644)[a]
Alcohol Availability	0.047	0.273
	(3.070)[a]	(3.516)[a]
Population Density	0.0001	-0.0002
	(1.913)[c]	(-1.634)[c]
Median Income	-0.00000	-0.00002
	(-0.466)	(-1.478)
Percent Poverty	0.007	-0.040
	(0.596)	(-0.334)
Percent Catholic	0.007	0.009
	(2.775)[a]	(3.494)[a]
Percent Baptist	0.002	0.0006
	(0.638)	(0.201)
Median Education	0.037	0.008
	(0.639)	(0.139)
Percent College	-0.011	-0.015
	(-1.536)	(-2.103)[b]
Median Age	0.019	0.020
	(2.380)[b]	(2.588)[a]
Border Availability	0.00002	0.00004
	(0.490)	(1.010)
Adjusted R^2	0.19	0.20

a. Significant at the 0.01 level.
b. Significant at the 0.05 level.
c. Significant at the 0.10 level.

NOTES

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1. These estimates are reported for 1987 by the U.S. Centers for Disease Control.
2. Cook [1981] also discusses the effect of taxes on motor vehicle accidents and cirrhosis mortality rates. See Ross [1992] for a review of the literature on drinking and driving.
3. Deyak and Smith [1976] use an analogous method in estimating the travel cost associated with legal restrictions on state abortion statutes. Other studies have included the alcohol excise tax as a measure of the tax-induced price change to account for price variations in alcohol. For example, see alcohol-related studies such as Saffer and Grossman [1987a; 1987b] and Saffer and Chaloupka [1989]. Coate and Grossman [1988] and Ornstein and Hanssens [1985] include a dollar price variable averaged at the state level, but exclude data on states where the dollar price is unavailable.
4. Meier [1994] discusses the correlation between religious affiliation and alcohol preference measures. Meier finds that areas with more conservative Protestants have higher federal and state taxes on alcohol, and areas with more Catholics have lower taxes.
5. Brown et al. [1996] examine the relationship between voter preferences and alcohol-prohibition legislation.
6. Direct measures of political affiliation are unavailable in Texas since voters do not register with a party and can vote in any primary. The measure chosen is the percentage of each county's voters who voted for the Democratic candidate, Robert Krueger, in the 1993 U.S. Senate race against Republican Kay Bailey Hutchison. Both the Texas Democratic Party and the Texas Republican Party suggest that this variable captures the effect of politically liberal versus conservative voters due to the perceived ideologies of each candidate. *Percent Tourism* and *Percent Democrat* are collected from *The Texas Almanac and State Industrial Guide: 1994-1995,* Dallas Morning News, 1994.
7. An alternative estimation method for grouped data is maximum likelihood, which is asymptotically equivalent to minimum chi-square. Both methods break down when a county has a cirrhosis mortality rate of zero. During the sample period, 25 counties reported zero cirrhosis deaths. We remedy this problem with a frequently used solution of assigning a value of 0.00000001 to occurrence rates observed as zero [Greene, 1993]. Cook and Tauchen [1982] also use a log-linear model to analyze cirrhosis mortality data. For examples of the minimum logit chi-square method, see Chaloupka et al. [1993] and Saffer and Chaloupka [1989]. Maddala [1983] discusses this variation of the minimum chi-square method. Minimum logit chi-square estimates of the reported regressions are available from the authors.

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