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BEER TAXES, THE LEGAL DRINKING AGE, AND YOUTH MOTOR VEHICLE FATALITIES

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ABSTRACT

Based on a time series of state cross sections for the period from 1975 through 1981, we find that motor vehicle accident mortality rates of youths ages 15 through 17, 18 through 20, and 21 through 24 are negatively related to the real beer excise tax. We also find that the death rate of 18 through 20 year olds is inversely related to the minimum legal age for the purchase of beer. Simulations suggest that the lives of 1,022 youths between the ages of 18 and 20 would have been saved in a typical year during the sample period if the Federal excise tax rate on beer, which has been fixed in nominal terms since 1951, had been indexed to the rate of inflation since 1951. This represents a 15 percent decline in the number of lives lost in fatal crashes. The simulations also suggest that the lives of 555 youths per year would have been saved if the drinking age had been 21 in all states of the U.S. These figures indicate that, if reductions in youth motor vehicle accident deaths are desired, both a uniform drinking age of 21 and an increase in the Federal excise tax rate on beer are effective policies to accomplish this goal. They also indicate that the tax policy may be more potent than the drinking age policy.

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I. Introduction and Background

Since the mid 1970s, the Federal government of the United States and various state and local governments have been involved in a campaign to reduce deaths from motor vehicle accidents by discouraging alcohol abuse. One major element of this campaign has been the upward trend in state minimum legal ages for the purchase and consumption of alcoholic beverages that began with the increase in the legal drinking age in Minnesota from 18 to 19 years of age in 1976. An additional 27 states had increased legal drinking ages by the time of the Federal Uniform Drinking Act of July 1984. This legislation allows the Federal government, through its control of Federal highway funds, to intercede in a legislative area traditionally reserved for states. Five percent of a state's Federal highway construction fund allocation for the fiscal year 1987 will be withheld if the minimum legal drinking age is below 21 years on October 1, 1986, and 10 percent will be withheld from the 1988 fiscal year allocation if its drinking age is below 21 on October 1, 1987. To date, 14 states have passed laws complying with the act, and a total of 37 states now have a minimum drinking age of 21. A second major element of the antidrinking campaign is reflected by more severe penalties for conviction of drunken driving, the allocation of additional resources to apprehend drunk drivers, and an easing in the standards required for conviction.

One policy that has been virtually ignored by the Federal and state governments in the antidrinking campaign is increased taxation of alcoholic beverages which, by raising prices, would lower alcoholic beverage consumption and motor vehicle mortality. Instead, the Federal excise tax rates on liquor (distilled spirits), beer, and wine remained constant in nominal terms between November 1, 1951 and the end of fiscal 1985. During this period the Federal government taxed liquor at the rate of $10.50 per proof gallon (one gallon of 100 proof liquor, which is the equivalent of 50 percent alcohol by volume), beer at the rate of $.29 per gallon (approximately 4.5 percent alcohol by volume), and wine at the rate of $.17 per gallon (between 11.6 percent and 21 percent alcohol by volume).[1]

Partly as a result of the stability of the Federal excise taxes and the modest increases in state and local excise taxes, the real price of alcoholic beverages (the nominal price divided by the Consumer Price Index) has declined substantially over time. Between 1960 and 1980, the real price of liquor fell by 48 percent; the real price of beer fell by 27 percent; and the real price of wine fell by 20 percent (Cook 1981). While 29 states raised the legal drinking age from 1976 through 1984, real alcoholic beverage prices continued to fall: 27 percent for liquor, 12 percent for beer, and 19 percent for wine (Bureau of Labor Statistics various years). Thus, as argued by Cook and Tauchen (1982), if alcohol abuse is sensitive to price, a government policy of declining real excise tax levels actually may be exacerbating this problem.

A primary purpose of this paper is to investigate the responsiveness of motor vehicle death rates of youths aged 15 through 24 to variations in the cost of beer as reflected by differences in state excise tax rates on beer.

Thus, we provide evidence for this important age group on the extent to which declining real beer excise taxes have contributed to increases in fatal motor vehicle crashes and on the extent to which increases in real beer taxes can serve as a potent instrument in the antidrinking campaign. We also examine the effect of an increase in the legal drinking age on youth motor vehicle deaths. Our empirical research is based on a time series of state cross sections for the period from 1975 through 1981. Logit motor vehicle death rate regressions are obtained for three age groups: youths aged 15-17, youths aged 18-20, and youths aged 21-24. During the period at issue, 15 states raised their legal drinking age, and 21 states raised their nominal excise tax rate on beer. Moreover there were substantial differences in both variables at a moment in time among states.

We focus on teenagers and young adults in the context of the antidrinking campaign because motor vehicle accident mortality is the leading cause of death of persons under the age of 35, and the National Highway Traffic Safety Administration (1983) estimates that alcohol is involved in over half of these fatal accidents. In 1979 persons under the age of 25 accounted for 22 percent of all licensed drivers but 38 percent of all drivers involved in fatal accidents (National Highway Traffic Safety Administration 1983). These figures are even more dramatic than they appear because members of the young driver group do not drive nearly as much as older drivers (Voas and Moulden 1980). In 1980 the motor vehicle accident mortality rate of persons between the ages of 15 and 24 was 45 deaths per 100,000 population (National Center for Health Statistics

1984). This figure was approximately twice as large as either the crude motor vehicle death rate or any other age-specific motor vehicle death rate.

Research on the responsiveness of youth motor vehicle deaths to the cost of beer is particularly timely in light of proposals to correct the erosion in the real value of the Federal excise tax rates on all forms of alcoholic beverages since 1951 and to prevent future erosion by indexing tax rates to the rate of inflation or by converting to an ad valorem alcoholic beverage excise tax system (for example, Moore and Gerstein 1981; Luks 1983; Cook 1984; Harris 1984; Becker 1985; Jacobson and Albion 1985).[2] Moreover, although beer is the drink of choice among youths who drink alcoholic beverages (for example, Coate and Grossman 1986; Grossman, Coate, and Arluck forthcoming), the alcohol in liquor is taxed three times as heavily as the alcohol in beer. This has led to suggestions to equalize the tax rates on the alcohol in all forms of alcoholic beverages by raising the tax on beer (for example, Harris 1984; Jacobson and Albion 1985).[3] Research on the sensitivity of youth alcohol use to legal drinking ages is also valuable given the adverse reaction to Federal uniform drinking legislation,[4] its scheduled expiration at the end of fiscal 1988, and volatility in state minimum drinking ages in the 1970s and 1980s.

There have been no previous studies of the effects of beer taxes on youth motor vehicle fatalities. Cook (1981), however, finds that states that raised their excise tax rates on liquor between 1960 and 1974 experienced below-average increases or above-average reductions in motor vehicle deaths of persons of all ages relative to states that did not increase their tax rates. Given the popularity of beer among young people and their poor driving records, it is crucial to obtain estimates of the impacts of beer excise taxes on youth motor vehicle death rates.

Statistically significant short-run increases in youth motor vehicle deaths have been reported in selected states that lowered their legal drinking age in the early 1970s, and significant short-run reductions in fatalities have been reported in selected states that raised their legal drinking age in the late 1970s or early 1980s (for example, Williams et al. 1975, 1983; Douglass 1980; Wagenaar 1983; Lillis, Williams and Williford forthcoming). While this research is valuable, it is state-specific and thus cannot be generalized to the population of all youths in the U.S. More definitive estimates are contained in studies by McCornac (1982) and Cook and Tauchen (1984), both of which employ time series of state cross sections for the 48 contiguous states of the U.S. Cook and Tauchen use data for the period from 1970 through 1977, while McCornac uses data for the period from 1970 through 1975. Both studies conclude that a uniform minimum drinking age of 21 in the mid 1970s would have saved a substantial number of lives.

The research reported here differs from that by Cook and Tauchen and by McCornac in two important respects. First, McCornac and Cook and Tauchen deal with a period during which there was a downward trend in the legal drinking age. In particular, between 1970 and 1975, 29 states lowered their drinking age to conform with a Federal shift in the voting age from 21 to 18 in 1970. On the other hand, as noted previously we deal with a period in which 15 states raised their drinking age. Second, we consider the effects of beer taxes on youth motor vehicle fatalities.

II. Analytical Framework

The basic model employed in this paper consists of two equations. One is a technical relationship or a production function in which the probability that a youth will experience a fatal motor vehicle accident (π) is positively related to his consumption of alcohol (y)[5] and also depends on a vector of additional variables (z):

$$\pi = \pi(y,z). \qquad (1)$$

Examples of members of the z vector include highway density in the state in which the youth resides and the general quality and state of repair of the motor vehicle that he drives. The second equation is a behavioral relationship or a demand function for alcohol:[6]

$$y = y(p,x). \qquad (2)$$

In this equation p is the price of alcohol, and x is a vector whose members include the youth's command of real resources, the prices of substitute goods, and tastes or preferences.

Substitution of equations (2) into equation (1) yields a reduced form probability of death equation:

$$\pi = \pi(p,x,z). \qquad (3)$$

Equation (3) is termed a reduced form equation because alcohol consumption, an endogenous right-hand side variable in equation (1), has been replaced by its exogenous determinants. Of course, the demand function for alcohol also is a reduced form equation.

Our empirical aim in this paper is to estimate equation (3) using data for states of the U.S. This aim is facilitated by aggregating the equation over the n_j youths in the j^{th} state and by interpreting the resulting probability of death as the observed motor vehicle mortality rate. The principal hypothesis tested is that youth alcohol consumption is negatively related to its price, and therefore the youth motor vehicle accident mortality rate is negatively related to the price of alcohol. In testing this hypothesis, we define price broadly as the sum of the direct cost of alcohol and the indirect cost that must be incurred to obtain it. In particular, the indirect cost of obtaining alcohol for a person under the age of 21 should be lower in states where the legal drinking age is 18 as opposed to 21. Thus, subject to certain modifications in Section III, the money price of alcohol and the legal drinking age play symmetrical roles in the reduced form motor vehicle mortality equation.

III. Empirical Implementation

The data set employed here is a time series of state cross sections and consists of the 48 contiguous states of the U.S. for the years 1975 through 1981. Hence there are 336 observations in each regression estimated in Section IV. Alaska and Hawaii were omitted from the data set because several important variables were missing for these two states. The District of Columbia was omitted because it is a much smaller physical area than any of the 48 states, and it is likely that many of its motor vehicle accidents involve nonresidents. Table 1 contains definitions, means, and standard deviations of the variables in the data set. A detailed description of the variables and their sources appears in the Appendix to this paper (available upon request). The Appendix also includes a discussion of the theoretical roles of variables other than the real beer tax, the beer

Table 1

Definitions, Means, and Standard Deviations of Variables[a]

Variable	Definition, Mean, and Standard Deviation
Motor vehicle death rate	Deaths due to motor vehicle accidents per 100,000 population for the following three age groups: Ages 15-17, mean=31.581, s.d.=8.794 Ages 18-20, mean=51.468, s.d.=12.934 Ages 21-24, mean=41.921, s.d.=11.401
Real beer tax	Sum of Federal and state excise taxes on a case of 24-twelve ounce cans of beer divided by Consumer Price Index, 1967=1, mean=.518, s.d.=.240
Beer legal drinking age	Minimum legal age in years for the purchase and consumption of beer, alcoholic content more than 3.2 percent, mean=19.404, s.d.=1.391
Border age	Sums of differences between own-state legal drinking age and bordering states' legal drinking ages (if positive) multiplied by fractions of population living in border counties. mean=.208, s.d.=.389
Real income	Money per capita personal income divided by Consumer Price Index, 1967=1, expressed in thousands of dollars, mean=3.830, s.d.=.447
Vehicle miles traveled	Vehicle miles traveled in millions of miles per licensed driver, mean=.011, s.d.=.001
Young drivers	Number of licensed drivers aged 24 or less as a fraction of the population aged 15-24, mean=.726, s.d.=.090
Inspection of motor vehicles	Dichotomous variable that equals one if inspection of motor vehicles is required every year, mean=.548, s.d.=.498
Mormon	Fraction of population who are Mormons, mean=.012, s.d.=.059
Southern Baptist	Fraction of population who are Southern Baptists, mean=.074, s.d.=.098
Catholic	Fraction of population who are Catholics, mean=.210, s.d.=.127
Protestant	Fraction of population who are Protestants (excludes Southern Baptists and Mormons), mean=.199, s.d.=.080
Residents of "wet" counties	Fraction of the population who reside in fully or partially "wet" counties (counties that permit the sale of alcoholic beverages), mean = .967, s.d. = .084

[a]Data pertain to the 48 contiguous states of the U.S. for the years 1975 through 1981. Means and standard deviations, denoted s.d., of the death rates are weighted by the age-specific number of persons in the category at issue by state and year. Means and standard deviations of all other variables are weighted by the number of persons aged 15-24 by state and year.

legal drinking age, and the "drinking sentiment" measures in the estimated mortality equations. In addition it includes comments on preliminary results obtained with several variables that are not listed in Table 1.

Separate motor vehicle accident mortality regressions are obtained for three age groups: youths aged 15-17, youths aged 18-20, and youths aged 21-24.[7] This is because the legal drinking age ranges from 18 through 21. Consequently, 15, 16, and 17 year olds are illegal drinkers in all states, while 21, 22, 23, and 24 year olds are legal drinkers in all states. It follows that youths between the ages of 18 and 20 should be most affected by differences in the drinking age. Formally, we rejected the hypothesis that slope coefficients but not intercepts are the same for the three age groups.

Youths between the ages of 15 and 17 and between the ages of 21 and 24 are not excluded entirely from the analysis because they have higher motor death rates than any other age group except for 18 to 20 year olds. Thus, it is of interest to assess the impacts on these death rates of differences in the cost of alcohol. A second consideration is that persons aged 21 through 24 or aged 15 through 17 may be passengers in cars driven by youths aged 18 through 20 and may die in crashes caused by these drivers.

A third reason for not limiting the analysis to youths aged 18 through 20 is that differences in the legal drinking age can affect motor vehicle fatalities of young teenagers and older youths. Since peers are a common source of alcohol (for example, Blane and Hewitt 1977), the indirect cost of obtaining alcohol for persons younger than 18 is lower in states where the legal drinking age is 18 as opposed to 19, 20, or 21. To the extent that age at onset of alcohol consumption and current alcohol use are negatively related [see Rachal et al. (1975) for evidence that this is in fact the case], an increase in the legal drinking age can lower the motor vehicle death rate of 21-24 year olds (the "consumption" effect). As pointed out by Males (1986), a factor that goes in the opposite direction is that persons beyond the age of 20 in states with low legal drinking ages may have more knowledge of the amount of alcohol they can safely consume shortly before driving (the "experience" effect).[8]

Studies of the impact of changes in legal drinking ages in individual states or in a small number of states by Williams et al. (1975, 1983), Douglass (1980), and Wagenaar (1983) employ one or more of the following outcome measures: (1) nighttime fatal accidents involving youthful drivers; (2) nighttime single-vehicle fatal accidents involving youthful drivers; and (3) nighttime single-vehicle fatal accidents involving youthful male drivers. On the other hand, our outcome measure, like the one used by Cook and Tauchen (1984), is more comprehensive. We adopt it for reasons given by Cook and Tauchen. They point out (1984, pp. 174-175): "In evaluating alternative minimum drinking age legislation, it is desirable to have as comprehensive a measure of the associated social costs as possible. For example, from the evaluation viewpoint, it is more useful to know the effect of MLDA [minimum legal drinking age] change on total fatalities than nighttime fatal crashes....The Douglass-Wagenaar 'three factor surrogate'--nighttime single vehicle crashes involving male drivers--is only remotely related to any natural indicator of social costs." Thus, we have chosen not to employ single-vehicle nighttime fatal accidents as an outcome measure because the policy variables at issue may affect single-vehicle daytime fatal crashes and multi-vehicle fatal crashes at all times of the day or night.

Our outcome measure, like Cook and Tauchen's, is incomplete in that it omits auto fatalities of persons under age 15 or greater than age 24 caused by youthful drivers. Cook and Tauchen summarize data that indicate, however, that most of the victims of fatal crashes involving youthful drivers are the drivers themselves or youthful passengers in their vehicles. Motor vehicle deaths by age were provided to us by the National Highway Traffic Safety Administration (NHTSA) and come from unpublished data in NHTSA's Fatal Accident Reporting System.[9] Deaths pertain to state of occurrence rather than to state of residence.

The key independent variables in the model are the legal drinking age and the price of alcohol. Both pertain to beer because of its popularity among youths. Moreover, Coate and Grossman (1986) and Grossman, Coate and Arluck (forthcoming) report that the consumption of beer by youths is inversely related to the price of beer and to the minimum legal age for its purchase and consumption. They also report that the magnitudes of these effects are substantial. On the other hand, the consumption of liquor or wine by youths is much less sensitive to the relevant beverage-specific price or legal drinking age, and there is no evidence that youths substitute liquor or wine for beer when the price of beer rises.

Youths who reside in a state with a high legal drinking age may be able to purchase and consume alcohol in a border state with a lower legal drinking age. In turn they may be killed in motor vehicle accidents that occur when they are returning from the border state. To deal with the border phenomenon (out-of-state purchases), we note that more youthful residents of the j^{th} state are affected by it the greater is the difference between the legal drinking age in that state (a_j) and the legal drinking age in the border state (a_k, $k \neq j$), provided this difference is positive. In addition, the border effect is larger the larger is the fraction of the population of state j that live in counties that border on state k (f_j). Hence we define the border age variable (b_j) as

$$b_j = f_j(a_j - a_k), \text{ if } a_j > a_k$$
$$b_j = 0 \text{ if } a_j < a_k \tag{4}$$

and include it as a regressor. With the resident-state legal drinking age held constant, an increase in the border variable reflects a reduction in a_k or an increase in f_j, both of which should cause the motor vehicle fatality rate to rise.[10]

If motor vehicle deaths pertain to the state of residence, the measure of b_j given above captures all elements of the border phenomenon. In our data, however, deaths are tabulated by state of occurence. Nevertheless, b_j still is a perfect indicator of the border phenomenon provided youths who travel from state j to state k to drink are killed in accidents that occur within the boundary of state j. To the extent that some residents of state j die in state k, certain modifications of the border variable may be desirable. We do not pursue such modifications in this paper, but we indicate how the results are affected when the border variable is omitted from the regressions in Section IV.[11]

The cost of beer is given by the sum of the Federal and state excise tax rates on a case of 24-twelve ounce cans of beer divided by the annual Consumer Price Index (CPI, 1967=1) for the U.S. as a whole. Deflation by the CPI is required to take account of trends in the prices of other goods between 1975 and 1981. All regressions include dichotomous variables for each year except 1981. Therefore, the measure of the real or relative price of beer just defined is an accurate indicator of the true relative price provided the relative price of beer exclusive of tax does not vary from state to state. This follows because the time variables account for any trend in the real price of beer exclusive of tax.

It should be stressed that the state excise tax is a preferable regressor to the price of beer if the price exclusive of tax varies among states because the supply curve of beer slopes upward. The reason is that an outward shift in the demand function for beer simultaneously raises the price of beer, the quantity of beer consumed, and the motor vehicle mortality rate. Consequently, the coefficient of the price of beer in the mortality equation is understated in absolute value if the equation is estimated by ordinary least squares because price is positively correlated with the disturbance term. In our context, the tax also is superior to the price because the policy simulations performed in Section IV require reduced form as opposed to structural parameter estimates.[12]

To take account of the potential role of "drinking sentiment" in the endogenous determination of beer excise tax rates, legal drinking ages, and alcohol consumption, the fractions of the population who are Mormons, Southern Baptists, Catholics, and Protestants (excluding Southern Baptists and Mormons); and the fraction of the population who reside in "wet" counties (counties that permit the sale of alcoholic beverages) are included in one specification of the motor fatality equations. Drinking sentiment refers to cultural and taste variables that may either encourage or discourage alcohol consumption. For example, antidrinking sentiment should be relatively widespread in states in which religious groups that oppose the use of alcohol, such as Mormons and Southern Baptists, are prevalent. Antidrinking sentiment also should be an important force in states in which a higher-than-average fraction of the population reside in "dry" counties (counties that prohibit the sale of alcoholic beverages). These states may enact high alcoholic beverage excise tax rates as part of the political process. In this situation, the tax coefficients that emerge from regressions that omit drinking sentiment overstate in absolute value the true parameters. On the other hand, states in which prodrinking sentiment is prevalent (antidrinking sentiment is weak) and alcohol consumption is large may enact high excise tax rates because the taxation of alcoholic beverages is an attractive source of revenue. In this case, the tax effects are understated if drinking sentiment is excluded from the regressions. Similar comments can be made with respect to drinking age effects that do not control for drinking sentiment.[13]

The role of drinking sentiment is considered in detail by Coate and Grossman (1986) in the context of a formal econometric model. They emphasize the point made above: namely, tax and legal drinking age effects are not necessarily overstated in absolute value when drinking sentiment is omitted from the regression model. This is particularly true if omitted proxies for drinking sentiment are correlated with those included. Our strategy here is to fit a set of regressions that excludes the religion variables and the fraction of the population who reside in wet counties and a second set of regressions that includes these variables.

An alternative estimation strategy to control for hard-to-measure variables, such as drinking sentiment, is to employ dichotomous variables for 47 of the 48 states. This is the strategy adopted by Cook and Tauchen (1984) in their study of youth motor vehicle fatalities described in Section I. In fact, the only other independent variables in their model are the legal drinking age and dichotomous variables for 7 of the 8 years of their time series. Our approach, on the other hand, is to work with a more fully specified model of the determinants of youth motor vehicle accident mortality rates. This is because a model with state dummies has the potential of creating severe problems of multicollinearity. Nevertheless, we view a model with state dummy variables as a reasonable alternative to the one that we stress and present one regression for each of the three age groups that includes dichotomous variables for 47 of the 48 states. Since this specification is viewed as an alternative way to control for drinking sentiment, the religion variables and the fraction of the population residing in wet counties are omitted from it.

The actual motor vehicle mortality rate (π_{ijt}) -- defined as deaths per person rather than per 100,000 persons in the i^{th} age group in the j^{th} state in year t -- ranges between zero and one. Therefore, a logistic equation for the death rate is specified:

$$\pi_{ijt} = \{1 + \exp[-\alpha_i + \sum_{k=1}^{m} (-\beta_{ik})(x_{jtk}) - u_{ijt}]\}^{-1}, \qquad (5)$$

where x_{jtk} is the value of the k^{th} independent variable in the j^{th} state in year t and u_{ijt} is the disturbance term. By solving for the logarithm of the odds of death from a motor vehicle accident relative to survival or death from other causes $[\pi_{ijt}/(1-\pi_{ijt})]$, one transforms the logistic function into a linear equation:

$$\ln [\pi_{ijt}/(1-\pi_{ijt})] = \alpha_i + \sum_{k=1}^{m} \beta_{ik} x_{jtk} + u_{ijt}, \qquad (6)$$

which is called the logit function. The logit coefficient β_{ik} is the percentage change in the odds of motor vehicle mortality for a one unit change in x_{jtk}.

Maddala (1983) shows that a regression estimate of equation (6) should employ weighted least squares. The weights are given by $[n_{ijt}\pi_{ijt}(1-\pi_{ijt})]^{1/2}$, where n_{ijt} is the number of youths in the i^{th} age group in the j^{th} state in year t. This weighted least squares regression method is employed in Section IV.

IV. Results

Weighted least squares regression estimates of logit motor vehicle mortality equations for youths aged 15 through 17, 18 through 20, and 21 through 24 are contained in Panels A, B, and C, respectively, of Table 2. Three regressions are shown in each panel. The first omits the religion variables and the fraction of the population who reside in wet counties, while the second includes these measures of drinking sentiment. The third regression excludes the five drinking sentiment variables but includes dichotomous variables for 47 of the 48 states. The logit coefficients of

Table 2

Weighted Least Squares Estimates of Logit Motor Vehicle Accident Mortality Equations[a]

Independent Variable	Panel A: Ages 15-17			Panel B: Ages 18-20			Panel C: Ages 21-24		
	Regression Number			Regression Number			Regression Number		
	(2-A1)	(2-A2)	(2-A3)	(2-B1)	(2-B2)	(2-B3)	(2-C1)	(2-C2)	(2-C3)
Real beer tax	-.144	-.177	-.261	-.296	-.327	-.319	-.246	-.326	-.470
	(-3.05)	(-3.49)	(-1.54)	(-5.94)	(-6.16)	(-2.09)	(-4.41)	(-5.89)	(-3.07)
Beer legal drinking age	.009	.003	-.046	-.037	-.045	-.069	-.001	-.016	-.064
	(1.13)	(.33)	(-2.39)	(-4.56)	(-5.12)	(-3.96)	(-.09)	(-1.82)	(-3.72)
Border age	-.015	.019	.016	.025	.069	.118	.033	.120	.142
	(-.55)	(.65)	(.25)	(.88)	(2.22)	(2.08)	(1.06)	(3.87)	(2.51)
Real income	-.198	-.268	.081	-.121	-.204	.372	-.135	-.264	.232
	(-7.43)	(-7.82)	(.67)	(-4.47)	(-5.95)	(3.56)	(-4.52)	(-7.47)	(2.20)
Vehicle miles traveled	84.807	91.234	47.613	82.159	89.988	34.196	83.522	89.745	54.497
	(12.52)	(11.54)	(2.78)	(12.04)	(11.26)	(2.26)	(10.95)	(10.78)	(3.64)
Young drivers	1.436	1.302	.542	1.330	1.226	.683	1.418	1.317	.775
	(14.01)	(11.65)	(1.72)	(12.75)	(10.83)	(2.43)	(12.19)	(11.22)	(2.71)
Inspection of motor vehicles	-.022	-.050	.079	-.034	-.066	.036	-.032	-.085	.072
	(-1.09)	(-2.32)	(1.18)	(-1.65)	(-3.00)	(.58)	(-1.37)	(-3.78)	(1.16)
Mormon	------	-.377	------	------	-.444	------	------	-.767	------
	------	(-2.19)	------	------	(-2.48)	------	------	(-4.26)	------
Southern Baptist	------	-.068	------	------	-.120	------	------	-.050	------
	------	(-.33)	------	------	(-.57)	------	------	(-.23)	------
Protestant	------	-.300	------	------	-.449	------	------	-.951	------
	------	(-2.28)	------	------	(-3.37)	------	------	(-6.87)	------
Catholic	------	-.226	------	------	-.224	------	------	-.431	------
	------	(-1.84)	------	------	(-1.80)	------	------	(-3.36)	------
Residents of wet counties	------	.572	------	------	.577	------	------	.901	------
	------	(4.14)	------	------	(3.91)	------	------	(5.86)	------
R^2	.690	.711	.838	.605	.634	.845	.584	.665	.865
F	55.21	43.38	23.68	37.93	30.54	24.93	34.78	34.93	29.49

[a]Logit coefficients and t-ratios in parentheses are shown. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two tailed test. The F-ratio associated with each equation is significant at the 1 percent level. Each equation includes an intercept and dichotomous variables for the years 1975 through 1980. Regressions (2-A3), (2-B3), and (2-C3) include dichotomous variables for 47 of the 48 states.

the state variables are not presented. Each of the three regressions contains an intercept and dichotomous variables for the years 1975 through 1980. The intercepts and the coefficients of the time variables are omitted from the tables.

Focusing on the first two regressions in each panel, one sees that all logit coefficients of the real beer tax are negative and statistically significant at the 5 percent level of significance or better.[14] At the point of means, the elasticity of the death rate with respect to the real beer tax is -.09 for the youngest age group and -.17 for the other two age groups.[15] Data contained in Coate and Grossman (1986) indicate that the sum of the Federal and state excise tax on a case of beer accounted for 13 percent of the retail price of beer inclusive of tax on average in the period from 1975 through 1981. Suppose that the beer industry is competitive and has an infinitely elastic supply curve, so that a tax increase is fully passed on to consumers. Then the elasticity of the motor vehicle death rate with respect to the real price of beer would equal -.7 for 15 through 17 year olds and -1.3 for 18 through 20 year olds and 21 through 24 year olds.

How reasonable are elasticities that range from -.7 to -1.3? Cook (1981) estimates an elasticity of the motor vehicle death rate of persons of all ages with respect to the price of liquor of -.7. Thus our elasticities appear to be quite reasonable. This is particularly true because Coate and Grossman (1986) present arguments that suggest that youth price elasticities of demand for alcoholic beverages may be larger in absolute value than the corresponding adult price elasticities.

Based on the first two regressions in Panels A through C, the only negative and statistically significant legal drinking age coefficients pertain to youths aged 18 through 20. These are extremely plausible results because 18 through 20 year olds should be most affected by differences in the drinking age, which ranges from 18 to 21. The border age coefficients have the appropriate positive signs for the middle age group in regressions (2-B1) and (3-B2). In the latter model the coefficient is significant.

The above conclusions are not altered when the border age is omitted from the regressions. As shown by the first two regression specifications in Table 3, the legal drinking age coefficients remain significant for youths aged 18 through 20. But the coefficients are not significant for the two other groups.[16] The drinking age coefficient in regression (3-2) is almost 30 percent smaller in absolute value than the corresponding coefficient in regression (2-B2), indicating that the magnitude of the estimated effect is somewhat sensitive to the inclusion or exclusion of the border age. The parameter estimates of the other regressors (not shown in Table 3) are very similar to the corresponding estimates in Panels A through C of Table 2.

The income and highway variables prove to be important determinants of youth motor vehicle death rates. The income effect is negative, suggesting that higher-income persons or their offspring are safer drivers and operate motor vehicles that are in better physical condition than lower-income persons. These factors dominate the presumed positive relationship between income and the demand for alcohol. Based on the second regression in each panel, the income elasticities are similar in magnitude to the price

Table 3

Logit Coefficients of Beer Legal Drinking Age, Border Age Omitted[a]

	Regression Number		
	(3-1)	(3-2)	(3-3)
Ages 15-17	.007 (.99)	.006 (.92)	-.044 (-2.49)
Ages 18-20	-.033 (-4.91)	-.033 (-4.75)	-.055 (-3.41)
Ages 21-14	.004 (.57)	.005 (.62)	-.048 (-2.95)

[a]t-ratios in parentheses. First equation excludes religion and residents of wet counties. Second equation includes these variables. Third equation omits religion and residents of wet counties, but includes dichotomous variables for 47 of the 48 states.

elasticities: -1.0 for the youngest age group, -.8 for the middle age group, and -1.0 for the oldest age group.

An increase in the number of vehicle miles traveled per licensed driver or in the fraction of youths aged 15 through 24 who are licensed drivers raises each of the three age-specific death rates. The elasticity of the death rate with respect to the number of vehicle miles traveled per licensed driver is unity for each age group. A similar comment applies to the magnitude of the elasticity of the death rate with respect to the fraction of youths aged 15 through 24 who are licensed drivers. These results underscore the plausibility of our empirical specification because they imply that deaths per miles traveled by licensed drivers do not depend on miles traveled per licensed driver or on the fraction of licensed drivers.[17] States that require compulsory inspection of motor vehicles every year have lower death rates than other states. Except for the middle age group, this effect is significant only when the drinking sentiment measures are held constant.

Comparing the first and second regressions in each panel of Table 2, one sees that the signs, significance levels, and magnitudes of the tax and legal drinking age effects are not in general affected by the inclusion of the drinking sentiment proxies. If anything, the significant coefficients become larger in absolute value when the religion variables and the fraction of the population residing in wet counties are added to the set of regressors. This is an important finding because it means that the tax and drinking age effects emphasized here are not artifacts of the endogeneity of state laws and decisionmaking. The estimated income and highway coefficients also are not sensitive to the inclusion of the sentiment variables, with the exception of the inspection coefficient noted above.

With regard to the drinking sentiment measures themselves, the coefficient of the fraction of persons who reside in wet counties always is positive and significant. The results for the religion variables are less clearcut. Death rates are lower in states where Mormons and Southern Baptists are prevalent, although the latter effect never is significant. But death rates also fall as the fraction of the population who are Protestants or Catholics rises. This result is puzzling because Coate and Grossman (1986) find that the frequency of beer consumption by youths is positively related to the prevalence of Protestants and Catholics in their area of residence. We offer no explanation of the finding. We note, however, that our conclusions with respect to the tax and legal drinking age effects are not altered when the religion variables or the fraction of the population who reside in wet counties are omitted from the drinking sentiment vector.

The third regression in Panels A through C of Table 2 includes dichotomous variables for 47 of the 48 states. This specification exhibits a number of peculiarities. All three income effects become positive, and two of the positive coefficients are significant. The coefficients pertaining to vehicle miles traveled per driver and to the fraction of youths who have drivers' licenses are greatly reduced. The sign of the inspection coefficient switches from negative to positive. The drinking age effects for 18 through 20 year olds, which were negative and significant in the second regression model, rises by slightly more than 50 percent in absolute value.

The drinking age coefficients for 15 through 17 year olds switches signs from positive to negative and becomes significant. For the oldest age group, the negative drinking age coefficient rises by a factor of four and becomes significant.

The above results suggest that a model with state dummies is overdetermined and plagued by multicollinearity. The implausible nature of the estimates that emerge from this specification provides a justification for not emphasizing it. The tax effects rise in absolute value when the state dummies are held constant, except for the middle age group where the coefficient is virtually unchanged. Thus, the negative tax effects that we report are quite robust. In particular, they cannot be attributed to unmeasured state-specific variables.

To evaluate the potential impacts of the Federal excise tax and legal drinking age policy initiatives discussed in Section I, we simulate their effects on youth motor vehicle accident mortality rates. Specifically, first we compute the "actual" mortality rate for a given age group by predicting the mortality probability for the j^{th} state in year $t(\hat{\pi}_{ijt})$ based on the logit coefficients and the actual values of the independent variables (x_{jtk}) for that observation [see equation (5)]. Then we obtain the actual death rate as a weighted average of the 336 computed probabilities (48 states times 7 years) multiplied by 100,000. The weight is the fraction of the total population of all youths in the i^{th} age group in the period from 1975 through 1981 who reside in the j^{th} state in year t.[18] Next we vary one or more of the independent variables by a certain amount, recompute each $\hat{\pi}_{ijt}$, and average to obtain to the "new" mortality rate.

The simulations are restricted to 18 through 20 year olds because public policy with respect to the legal drinking age focuses on this age group. Simulations based on the second regression model in Table 2 are emphasized, but simulations based on the third regression model also are presented for comparative purposes.

The legal drinking age policy pertains to a uniform minimum age of 21 for the purchase of beer in all states. This policy is simulated by setting the legal drinking age equal to 21 for each of the 336 observations in the regression and by setting the border age variable equal to zero. The resulting mortality rate is the one that would have been observed if the legal drinking age had been 21 in all states throughout the period from 1975 through 1981.

Three Federal excise tax policies are considered. The first indexes the Federal excise tax rate on a case of beer, which has been fixed at \$.64 in nominal terms since 1951, to the rate of inflation since 1951. It is termed the inflation tax policy. Under it, the real beer tax in the j^{th} state in year t (q_{jt}) becomes

$$q_{jt} = [r_{jt} + (\$.64)(c_{t,51})]/(c_{t,67}), \tag{7}$$

where r_{jt} is the state excise tax rate in nominal terms, $c_{t,51}$ is the CPI in year t relative to 1951, and $c_{t,67}$ is the CPI in year t relative to 1967. The second tax policy raises the excise tax on a case of beer from \$.64 to \$2.09 to equalize the rates at which the alcohol in beer and liquor are taxed (see note 3). It is termed the alcohol tax equalization policy. In this simulation the real beer tax is given by

$$q^*_{jt} = (r_{jt} + \$2.09)/(c_{t,67}). \qquad (8)$$

The third tax policy combines the first two and is termed the combined tax policy. The real beer tax becomes

$$q'_{jt} = [r_{jt} + (\$2.09)(c_{t,51})]/(c_{t,67}). \qquad (9)$$

The resulting simulation shows the mortality rate that would have prevailed if the excise tax rate on beer had been fixed in real as opposed to nominal terms during the 1975-1981 period and if the alcohol in beer had been taxed as heavily as the alcohol in liquor.

Note that substantial tax hikes are involved in the last three simulations. Indexation of the nominal Federal excise tax on beer to the rate of inflation produces a tax on a case of beer in 1978 (the mid year of the sample period) that is 2.5 times larger than the actual tax. Equalization of the tax on the alcohol on beer with that on the alcohol in liquor produces a beer tax that is 3.3 times as large as the actual tax. Both policies combined amount to an approximately eight fold increase in the Federal beer tax in 1978, which would have raised the nominal price of beer by roughly 60 percent in that year.[19] Note also that the inflation tax policy would have caused the nominal price of beer to rise by approximately 12 percent in 1978. This percentage increase in price is almost the same as the percentage increase in the legal drinking age that results when it is raised from its sample mean of 19 to 21.

Table 4 contains the results of the simulations. The figures in Panel A are obtained from the regression model with the religion variables and the residents of wet counties. Those in Panel B are obtained from the

Table 4

Predicted Effects of Imposition of Uniform Legal Drinking Age of 21 or Increase in Federal Excise Tax on Beer on Motor Vehicle Accident Mortality Rate of 18-20 Year Olds[a]

	Actual	Drinking Age Policy	Inflation Tax Policy	Alcohol Tax Equalization Policy	Combined Tax Policy
	Panel A: Model with Religion Variables and Residents of Wet Counties [Regression (2-B2)]				
Death rate	52.04	47.76	44.16	41.16	24.06
Absolute change	--	4.28	7.88	10.88	27.98
Percentage change	--	8.22	15.14	20.91	53.77
	Panel B: Model with State Dummies [Regression (2-B3)]				
Death rate	51.72	45.32	44.06	41.12	24.34
Absolute change	--	6.40	7.66	10.60	27.38
Percentage change	--	12.37	14.81	20.49	52.94

[a]Death rate and absolute change are expressed in terms of deaths per 100,000 population. Absolute change equals the actual death rate minus the death rate predicted by one of the four policies at issue. Percentage change equals the absolute change divided by the actual death rate and multiplied by 100.

regression model with the state dummy variables.

Based on Panel A, a uniform legal drinking age of 21 throughout the period would have reduced the death rate of youths ages 18 though 20 (52 deaths per 100,000 population based on the actual values of all independent variables) by 4 deaths per 100,000 population. This represents an 8 percent decline in the number of youths who would have died in motor vehicle crashes. The corresponding reduction in Panel B is 12 percent.

More dramatic declines are produced by the excise tax tax policies. Since these results are not sensitive to the regression model used, we focus on the results in Panel A. The number of deaths falls by 9 per 100,000 population if the Federal excise tax rises at the rate of inflation, which represents a 15 percent decline in the number of lives lost in fatal crashes. The policy that taxes the alcohol in beer and liquor at the same rates has a slightly bigger effect. It saves 11 lives per 100,000 population, which represents a 21 percent reduction in the number of lives lost. The combination of both tax policies causes the mortality rate to fall by 28 deaths per 100,000 population, which represents a whopping 54 percent reduction.

It is notable that a 12 percent increase in the price of beer which accompanies the inflation tax policy appears to have a larger impact than a 10 percent increase in the legal drinking age even when the 12 percent drinking age effect from Panel B is used in the comparison. In part this conclusion is reached because many states had legal drinking ages of 21 in one or more years of the period. Therefore, we have simulated the death rates of 18 through 20 year olds under the assumption of a uniform legal drinking age of 18. Based on the regression model with the antidrinking sentiment measures, the mortality rate in the latter simulation exceeds the one in the simulation with a drinking age of 21 by 7 deaths per 100,000 population. The corresponding differential in the regression with the state dummies is 10 deaths per 100,000 population. The former differential but not the latter is smaller than the 8-deaths-per-100,000-population reduction produced by the policy to adjust the beer tax for inflation.

Our preferred regression model indicates that 8 percent fewer youths would have died in motor vehicle crashes if the drinking age had been 21 in all states during the period from 1975 through 1981. On the other hand, Cook and Tauchen's (1984) results suggest that the drinking age policy would have lowered the death rate by approximately 4 percent during the period from 1970 through 1977.[20] In part our estimate is larger than their estimate because they do not control for the border age. Indeed, we predict a reduction of 5 percent when the border age is omitted from the regression. Our figure also may exceed Cook and Tauchen's because the mean drinking age may have been higher in their sample period than in ours.

To summarize the qualitative results of the logit equations, negative and statistically significant real beer tax effects are obtained for youths aged 15 through 17, 18 through 20, and 21 through 24. Negative and statistically significant legal drinking age effects are obtained for youths aged 18 through 20. These results cannot be attributed to the omission of drinking sentiment from the estimating equation because we control for this phenomenon by including religion measures and the fraction of the population who reside in counties that permit the sale of alcohol as regressors.

Quantitatively, the enactment of a uniform drinking age of 21 in all states would have reduced the number of 18 through 20 year olds killed in motor vehicle crashes by 8 percent in the period from 1975 through 1981. A policy that fixed the Federal beer tax in real terms since 1951 would have reduced the number of lives lost in fatal crashes by 15 percent, while a policy that taxed the alcohol in beer at the same rate as the alcohol in liquor would have lowered the number of lives lost by 21 percent. A combination of the two tax policies would have caused a 54 percent decline in the number of youths killed.

The preceding figures suggest that, if reductions in youth motor vehicle accident deaths are desired, both a uniform drinking age of 21 and an increase in the Federal excise tax rate on beer are effective policies to accomplish this goal.[21] They also suggest that the tax policy may be more potent than the drinking age policy. Indeed, according to our computations, the lives of 1,022 youths aged 18 through 20 would have been saved by the inflation excise tax policy in a typical year during the period from 1975 through 1981, while the lives of 555 youths would have been saved by the drinking age policy.

It does not follow that we have provided enough evidence to justify the approximately eight fold (thirteen fold based on the 1984 CPI) increase in the Federal excise tax on beer that is implicit in the most comprehensive tax policy. Excise tax hikes impose welfare costs on all segments of the population, while a drinking age policy is targeted at the group in the population that accounts for a disproportionate share of motor vehicle accidents and deaths. On the other hand, the enforcement and administrative costs associated with a uniform minimum drinking age of 21 may exceed those associated with the tax policy. Moreover, our results indicate that an excise tax increase lowers death rates of youths between the ages of 15 and 17 and between the ages of 21 and 24. These benefits do not accompany a rise in the drinking age. In addition, the tax policy may reduce fatal crashes involving adults.

Finally, Becker (1968) has shown that the optimal way for a society to deter offenses is via a system of monetary fines. Of course, youthful drunken drivers may respond to an increase in the fine for this offense only if the probabilities of apprehension and conviction are nontrivial. If substantial resources must be allocated to raising these probabilities, the excise tax policy may be preferable to or complementary with a system of large fines. In conclusion more research is required to formulate the best mix of policies to deal with youth motor vehicle accident mortality. Our study represents a useful step in this process.

FOOTNOTES

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[1]The Federal excise tax rate on distilled spirits was raised from $10.50 per proof gallon to $12.50 effective October 1, 1985, as part of the Deficit Reduction Act of 1984.

[2]Under an ad valorem alcoholic beverage excise tax system, the tax rate would be set at a fixed proportion of wholesale price.

[3]Under the Federal excise tax on liquor of $10.50 per gallon of liquor (50 percent alcohol by volume) in effect prior to October 1, 1985, one gallon of alcohol in liquor was taxed at a rate of $21. Since the Federal excise tax on beer is $.29 per gallon and since one gallon of beer contains 4.5 percent alcohol by volume, the tax rate on one gallon of alcohol in beer is $6.44. The alcohol in liquor is taxed fifteen times as heavily as the alcohol in wine, and the proposals mentioned above also contain provi-

sions to correct this distortion.

[4]At least two states -- Texas and Kansas -- have adopted laws that will revoke the 21 drinking age as soon as the legislation expires (Insurance Institute for Highway Safety 1985).

[5]If a youth never drives while under the influence of alcohol, an increase in alcohol consumption would not increase his probability of dying in a motor vehicle crash. We believe, however, that it is reasonable to suppose that the number of times that a youth drives while under the influence of alcohol or is driven by a friend in this state is positively related to his consumption of alcohol, at least for the average youth.

[6]The demand function for alcohol results from the maximization of the youth's utility function subject to his income constraint and his probability of death equation.

[7]The male death rate is approximately three times as large as the female death rate for the cohort of persons aged 15 through 24. Sex-specific regressions are not presented because we tested and accepted the hypothesis that slope coefficients but not intercepts are the same for males and females. Since there is almost no variation in the fraction of 15 through 24 year olds who are females across states, this variable is not included as a regressor.

[8]The existence of an experience effect suggests that the legal drinking age could have a positive regression coefficient in the motor vehicle accident mortality equation for the older youths. This is not the case for the younger youths because they are both inexperienced drinkers and because an increase in the drinking age raises their indirect cost of obtaining

alcohol.

[9]The Fatal Accident Reporting System is described in detail in NHTSA (1983). Motor vehicle deaths were not taken from the National Center for Health Statistics (NCHS) because NHTSA data are available on a much more timely fashion. In particular, NCHS figures for the years 1979, 1980, and 1981 were not available when this project was begun. Note that NCHS reports motor vehicle deaths by state of residence. Note also that NHTSA tabulates alcohol-related motor vehicle fatalities. We did not use these data because the identification of alcohol-related crashes is made by the police based on methods that may vary from state to state.

[10]Suppose that there are m border states, each of which has a lower drinking age than state j. Then b_j becomes

$$b_j = \sum_{k=1}^{m} f_{jk}(a_j - a_k).$$

[11]If residents of state j who drink in state k are as likely to die in that state as in state j, b_k could be set equal to b_j rather than to zero. Given more than one border state and little information about the precise location of accidents involving youths who leave their state of residence to drink, the construction of an appropriate border variable becomes somewhat arbitrary.

[12]Cook and Tauchen (1982) present a similar argument in the context of the estimation of demand functions for liquor. The transactions price of a single leading brand of medium priced, nationally sold beer is available for two unidentified major markets in each state for the years 1976, 1977, and 1978 (see Ornstein and Hanssens 1985 and Coate and Grossman 1986). In

addition to the reasons given above, this price is not used here because it would have to be predicted for the years 1975, 1979, 1980, and 1981 from a regression that includes dichotomous variables for 47 of the 48 contiguous states. This would create severe problems of multicollinearity in the motor vehicle mortality regression model specified below that includes dichotomous variables for the states. Note that state excise tax rates on wine and liquor are poor proxies for the prices of wine and liquor in control (monopoly) states because such states derive most of their revenue from the sale of wine and liquor from the price markups rather than from the excise taxes. This comment does not apply to state excise tax rates on beer because beer is sold privately in monopoly states.

[13]Although it might appear as if the drinking age effect is overstated, this need not be the case. For example, adult voters in a state with a vocal minority who opposes alcohol consumption may enact a high legal drinking age to prevent the minority from campaigning to raise alcohol excise tax rates. To cite another illustration, the high mortality rate in a state where prodrinking sentiment is widespread may result in the enactment of a high legal drinking age.

[14]Statements concerning statistical significance in the text are based on one-tailed tests except when the direction of the effect is unclear on a priori grounds or when the estimated effect has the "wrong sign." In the latter cases two-tailed tests are used. When no significance level is indicated, it is assumed to be 5 percent.

[15]These elasticities are based on the second regression in each panel. The formula for the elasticity (ε_i) is

$$\varepsilon_i = \beta_{ik}(1-\pi_{ijt})x_{jtk},$$

where x_{jtk} is the real beer tax and β_{ik} is its logit coefficient. We evaluate ε_i at the weighted sample means of π_{ijt} and x_{jtk} (see Table 1). Note that the mean death rates in Table 1 must be divided by 100,000 before the elasticities are computed.

[16]The negative legal drinking age coefficient for the 21 through 24 years olds in regression (2-C2) is not significant at the 5 percent level for a two-tailed test. This is the appropriate test because the experience factor suggests a positive effect, while the consumption factor suggests a negative effect (see Section III). Since the age coefficient is negative, our results, like those of Cook and Tauchen (1984), do not support the experience hypothesis proposed by Males (1986).

[17]Strictly speaking, the above proposition holds for the following logarithmic regression model:

$$\ln(d_{ij}/m_{ij}) = \alpha_i + \beta_i x_j.$$

Here d_{ij} is the number of deaths in the i^{th} age group in the j^{th} state, m_{ij} is the number of miles traveled by licensed drivers in this age group, x_j is the vector of exogenous variables, and time supscripts are suppressed. As an identity,

$$m_{ij} \equiv n_{ij} w_{ij} \bar{m}_{ij},$$

where n_{ij} is the number of persons in the i^{th} age group, w_{ij} is the fraction who are licensed drivers, and $\bar{m}_{ij}$ is the number of miles driven per licensed driver. Therefore,

$$\ln \pi_{ij} \equiv \ln(d_{ij}/n_{ij}) = \alpha_i + \beta_i x_j + \ln w_{ij} + \ln \bar{m}_{ij}.$$

The last steps in the derivation are to assume that

$$\bar{m}_{ij} = s_i \bar{m}_j$$

$$w_{ij} = v_i w_{1524j},$$

where $\bar{m}_j$ denotes the number of miles driven by licensed drivers of all ages divided by the number of licensed drivers of all ages in the j^{th} state, w_{1524j} is the fraction of licensed drivers ages 15 through 24, and the factors of proportionality (s_i and v_i) do not vary among states.

[18]That is, the actual death rate ($\bar{\pi}_i$) is given by

$$\bar{\pi}_i = 100{,}000 \sum_{t=1}^{7} \sum_{j=1}^{48} f_{ijt} \hat{\pi}_{ijt},$$

where

$$f_{ijt} = n_{ijt} / \left(\sum_{t=1}^{7} \sum_{j=1}^{48} n_{ijt} \right) .$$

As shown by Table 4, $\bar{\pi}_i$ differs from the corresponding mean in Table 1. This is because the logit regression does not necessarily pass through the point of weighted arithmetic means. But the difference is very small; in a given regression model it is always less than 1 death per 100,000 population.

[19]Since the excise tax and legal drinking age increases are non marginal and the logit functions are nonlinear, the simulations are employed to evaluate their effects. This is preferable to computing marginal price or legal drinking age effects at the point of means or for each observation and then multiplying by the change in the policy variable at issue.

[20]We computed the 4 percent figure based on Table 5 (p. 186) in Cook and Tauchen (1984).

[21]Some caution should be exercised in applying the results of the

drinking age simulation to the Federal Uniform Drinking Age Act of 1984 because the mean legal drinking age in that year was somewhat higher than in the period of our sample. On the other hand, as pointed out in Section I, a long-term prohibition of purchases of alcoholic beverages by persons below the age of 21 is not a fait accompli because the penalties imposed on states that do not raise their drinking age to 21 by the Federal Uniform Drinking Age Act expire at the end of fiscal 1988. Therefore, the figure given above probably is reasonable to use in a long-term evaluation of the drinking age policy.

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APPENDIX

Motor Vehicle deaths by age were provided to us by the National Highway Traffic Safety Administration (NHTSA) and come from unpublished data in NHTSA's Fatal Accident Reporting System. Deaths pertain to state of occurrence rather than to state of residence. Population deflators by single years of age for 1980 were taken from the 1980 Census of Population (Bureau of the Census 1983). Population figures for the age groups 15 through 19 and 20 through 24 for 1975 were obtained from the Area Resource File (Applied Management Sciences 1980) and pertain to estimates prepared for the National Cancer Institute. Figures for years other than 1975 and 1980 were derived by logarithmic interpolation and extrapolation. Population estimates for years other than 1980 were adjusted so that the age-specific sum for any year coincided with the U.S. figure reported by the Bureau of the Census (1982). Population data by single years of age for years other than 1980 were computed by assuming, for example, that the state-specific ratio of youths aged 18 to youths aged 15 through 19 in 1975 was the same as in 1980.

The minimum legal age for the purchase of beer (alcoholic content more than 3.2 percent by weight) was taken from Wagenaar's (1981/82) painstaking and definitive compilation of this age for every state for the years 1970 through 1981. A few states have two legal drinking ages for beer. One age is for beer that contains 3.2 percent or less alcohol by weight, and the second and higher age is for beer that contains more than 3.2 percent alcohol by weight. We use the latter variable, but it is very highly correlated with the former variable and with the legal drinking ages for liquor and wine.

If a state raised its legal drinking age during the year rather than on January 1, the legal drinking age is given as a weighted average of the two ages, where the weights are the fraction of months each age was in effect. For example, suppose a state raised its legal age for the purchase of beer from 18 to 21 on April 1, 1980. Its legal drinking age for that year is

$$(3/12)(18.00) + (9/12)(21.00) = 20.25.$$

This is the procedure employed by Cook and Tauchen (1984).

The cost of beer is given by the sum of the Federal and state excise tax rates on a case of 24-twelve ounce cans of beer divided by the annual Consumer Price Index (CPI, 1967=1) for the U.S. as a whole. The Federal excise tax on a case of beer was fixed in nominal terms at $.64 throughout the period. State excise tax rates were obtained from the U.S. Brewers Association (1984). If a state raised its tax during the year rather than on January 1, its tax for that year is given as a weighted average of the two rates, where the weights are the fraction of months each rate was in effect. As long as the time variables are held constant, it makes no difference whether the real Federal excise tax is included in or excluded from the tax measure. Inclusion of the Federal tax facilitates the simulations in Section IV.

Real per capita personal income should be positively related to the demand for alcohol, positively related to the quality and condition of motor vehicle, and positively related to safe-driving practices. The last relationship emerges because income and schooling levels are positively related. In turn, more educated persons and their offspring are likely to be safer drivers. Attempts to test this proposition were not possible because of a high correlation between income and median years of formal schooling completed. It follows that the predicted effect of income on the death rate is ambiguous. The income variable was taken from the Bureau of Economic Analysis (various years).

Three highway measures are included in the regressions: the number of vehicle miles traveled in millions of miles per licensed driver, the number of licensed drivers aged 24 years or less as a fraction of the population aged 15 through 24, and a dichotomous variable that identifies states that require compulsory inspection of motor vehicles every year. Similar variables have been used in interstate studies of the determinants of motor vehicle death rates of all age groups by Fuchs and Leveson (1967) and Peltzman (1975). The number of vehicle miles traveled per driver obviously reflects motor vehicle use and is expected to have a positive regression coefficient. In addition highway driving density probably rises as the number of miles traveled per driver rises. Highway driving density (the ratio of vehicle miles traveled to highway miles) has an ambiguous impact on mortality on a priori grounds. On the one hand, increased density is expected to increase the probability of an accident at a given speed and therefore the risk of death. On the other hand, increased density may force the average speed limit to be lower and can result in fewer deaths. In preliminary regressions a density measure was not statistically significant, and its inclusion had almost no effect on the coefficients of the other variables.

In general young drivers are more accident prone than older drivers, possibly because the former group has a higher demand for risky driving (Peltzman 1975). Thus, an increase in the per capita number of young drivers should cause the death rate to expand. Nonwhite youths have much lower motor vehicle death rates than white youths (National Center for Health Statistics 1984). In preliminary regressions the fraction of the population aged 15 through 24 who are nonwhite was not a significant predictor of the death rate because of a large negative correlation between it and the fraction of the population aged 15 through 24 with drivers' licenses. Note that death rates by race are not available from NHTSA. States with compulsory motor vehicle inspection programs are expected to have lower death rates than other states because these programs should result in safer vehicles being operated by the driving public. The number of licensed drivers of all ages, the number of licensed drivers aged 24 or less, and the number of vehicle miles traveled were taken from the Federal Highway Administration (various years). The number of licensed drivers for the years 1976, 1978, and 1980 was obtained by linear interpolation. That is, the number of drivers in 1976 in a given state was computed as a simple average of the number in 1975 and the number in 1977. The Federal Highway Administration estimates vehicle miles of travel from data on gasoline consumption and motor vehicle registration by state. The compulsory inspection variable was obtained from the Council of State Governments (various years).

The measure of residents of wet counties was obtained from the Distilled Spirits Council of the United States (various years). Religion variables for the years 1971 and 1980 were taken from surveys conducted by the National Council of the Churches of Christ and the Glenmary Research Center (see Johnson, Picard, and Quin 1974; Quinn et al. 1982). Estimates for other years were computed by logarithmis interpolation and extrapolation. Jews are included with non-church members in the omitted category because the size of the Jewish population was not reported in the 1971 survey and was significantly underestimated in the 1980 survey.

In preliminary research we experimented with variables pertaining to the availability and regulation of alcohol including the per capita number of establishments that are licensed to sell alcoholic beverages, a dichotomous variable that indicates whether off-premise alcoholic beverage stores are state owned and operated, a dichotomous variable that indicates whether drug and grocery stores can sell alcoholic beverages, and a dichotomous variable that indicates whether billboard advertising of alcoholic beverages is allowed. These variables contributed little to an understanding of the determinants of motor vehicle fatalities, and their inclusion had little impact on the coefficients of the basic regressors. These results are consistent with Arluck's (in progress) findings that youth alcohol use is not sensitive to the measures just defined. We also experimented with variables pertaining to the probability of apprehension and conviction for drunken driving and to the penalties for this offense. Our conclusions with respect to these variables were similar to those with respect to the availability and regulatory variables. In part this may reflect reverse causality. In particular, states with high death rates may allocate a substantial amount of resources to the apprehension and punishment of drunk drivers.

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