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

*HENRY SAFFER and MICHAEL GROSSMAN**

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. This trend began with the increase in the legal drinking age in Minnesota from eighteen to nineteen years of age in 1976, and an additional twenty-seven states had increased legal drinking ages by the time Congress passed the Federal Uniform Drinking Age Act of July 1984.[1] 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 was withheld if the minimum legal

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[1] Public Law 98-363.

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drinking age was below twenty-one years on October 1, 1986, and 10 percent will be withheld from each future fiscal year allocation in which its drinking age is below twenty-one. To date, nineteen states have passed laws complying with the act, and a total of forty-two states now have a minimum drinking age of twenty-one. A second major effect of the anti-drinking campaign is evidenced by more severe penalties for conviction of drunken driving, by the allocation of additional resources for apprehension of drunk drivers, and by the easing of standards required for conviction.

One policy that has been virtually ignored by federal and state governments in the antidrinking campaign is increased taxation of alcoholic beverages. By raising prices, this policy could, in effect, 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 $0.29 per gallon (approximately 4.5 percent alcohol by volume), and wine at the rate of $0.17 per gallon (11.6–21 percent alcohol by volume).[2]

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 [CPI]) 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. While twenty-nine states raised the legal drinking age during 1976–84, real alcoholic beverage prices continued to fall: 27 percent for liquor, 12 percent for beer, and 19 percent for wine.[3] Thus, if alcohol abuse is sensitive to price, a government policy of declining real excise tax levels actually may be exacerbating this problem.[4]

A primary purpose of this paper is to investigate the responsiveness of motor vehicle death rates of youths aged fifteen through twenty-four to variations in the cost of beer as reflected by differences in state excise tax rates on beer. We provide evidence for this important age group on the extent to which declining real beer excise taxes have contributed to in-

[2] 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.

[3] U.S. Dep't Labor, Bur. Labor Statistics, Monthly Labor Review (various issues).

[4] Philip J. Cook & George Tauchen, The Effect of Liquor Taxes on Heavy Drinking, 13 Bell J. Econ. 379 (1982).

creases 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 analysis of state cross sections for the period 1975–81. Logit motor vehicle death rate regressions are obtained for three age groups: youths aged fifteen through seventeen, youths aged eighteen through twenty, and youths aged twenty-one through twenty-four. During the period at issue, fifteen states raised their legal drinking age, and twenty-one states raised their nominal excise tax rate on beer. Moreover, there were substantial differences in both variables at each 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 thirty-five, and alcohol is involved in over half of these fatal accidents. In 1979, persons under the age of twenty-five accounted for 22 percent of all licensed drivers but 38 percent of all drivers involved in fatal accidents.[5] 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.[6] In 1980, the motor vehicle accident mortality rate of persons between the ages of fifteen and twenty-four was forty-five deaths per 100,000 population.[7] 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 the 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.[8] Moreover, although beer is the drink

[5] The above figures were taken from U.S. Dep't Transportation, Nat'l Highway Traffic Safety Administration, Fatal Accident Reporting System, 1981 (1983).

[6] Robert B. Voas & John Moulden, Historical Trends in Alcohol Use and Driving by Young Americans, in Minimum-Drinking-Age Laws: An Evaluation 59 (Henry Wechsler ed. 1980).

[7] U.S. Dep't Health and Human Services, Public Health Service, Nat'l Center for Health Statistics, Mortality, pt. A, vol. 2 in Vital Statistics of the United States, 1980 (1984).

[8] For example, Allan Luks, Will America Sober Up? (1983); Philip J. Cook, Increasing the Federal Alcohol Excise Tax, in Toward the Prevention of Alcohol Problems: Government, Business, and Community Action 24 (Dean R. Gerstein ed. 1984); Gary S. Becker, Don't Raise the Drinking Age, Raise Taxes, Business Week, November 25, 1985, at 21; and Michael Jacobson & Mark Albion, Raising Alcohol Taxes Is the Way to Cut Drinking and the Debt, Wash. Post, August 11, 1985, at L2. Under an ad valorem alcoholic beverage excise tax system, the tax rate would be set at a fixed proportion of wholesale price.

of choice among youths who drink alcoholic beverages,[9] 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.[10] Research on the sensitivity of youth alcohol use to legal drinking ages is also valuable given the adverse reaction to federal uniform drinking legislation.[11] This study will help explain the significance of the volatility of state minimum drinking age laws in the 1970s and 1980s and the effectiveness of these laws in reducing death rates in the affected populations.

One of the basic aims of our research is to compare the effect of a uniform minimum age of twenty-one for the purchase of beer in all states on the motor vehicle accident mortality rate of eighteen- through twenty-year-olds with that of one or more of the policies to raise the federal excise tax on beer described above. Before turning to a technical discussion of how these relations should be measured, we note that an effectively enforced prohibition of beer consumption in this age group clearly should have a larger influence on their motor vehicle accident mortality than an increase in the excise tax on beer. This issue is not clear-cut at the empirical level only because of the problem of evasion. Underage youths can obtain beer from their older siblings or friends. In addition, they can purchase fake identification cards or buy beer in stores that do not bother to demand proof of age. This type of evasion simply is not possible with an excise tax hike, so that the responsiveness of youths to the price of beer determines the change in its consumption and therefore the motor vehicle death rate. Given Coate and Grossman's evidence that youthful beer drinkers are very sensitive to price, the excise tax policy could well dominate the drinking age policy.[12]

[9] Douglas Coate & Michael Grossman, Effects of Alcoholic Beverage Prices and Legal Drinking Ages on Youth Alcohol Use (Working Paper No. 1852, Nat'l Bur. Economic Research, 1986).

[10] For example, Jeffrey E. Harris, More Data on Tax Policy, in Gerstein ed., *supra* note 8, at 33; and Jacobson & Albion, *supra* note 8. 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 $0.29 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 here also contain provisions to correct this distortion.

[11] Originally, the penalties imposed on states with a drinking age below twenty-one by the Federal Uniform Drinking Age Act of 1984 were scheduled to expire at the end of fiscal 1988. In response to this provision, Texas and Nebraska adopted laws that called for a revocation of the twenty-one drinking age as soon as the legislation expired. See Insurance Institute for Highway Safety, 20 Highway Loss Status Rep. 1 (1985). To counteract these laws, the federal legislation was made permanent in 1986.

[12] Coate & Grossman, *supra* note 9. They also present theoretical reasons why youthful drinkers are likely to be more sensitive to price than adults.

There have been no previous studies of the effects of beer taxes on youth motor vehicle fatalities. Cook, 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.[13] 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.[14] While this research is valuable, it is state specific and thus cannot be generalized to the population of all youths in the United States. More definitive estimates are contained in studies by McCornac and by Cook and Tauchen, both of which employ time-series analyses of state cross sections for the forty-eight contiguous states of the United States.[15] Cook and Tauchen use data for the period 1970–77, while McCornac uses data for the period 1970–75. Both studies conclude that a uniform minimum drinking age of twenty-one 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, twenty-nine states lowered their drinking age to conform with a federal shift in the voting age from twenty-one to eighteen in 1970. On the other hand, as noted previously, our study deals with a period in which fifteen states raised their drinking age. Second, we consider the effects of beer taxes on youth motor vehicle fatalities.

Our attempt to compare the excise tax and legal drinking age policies is particularly valuable because Males argues that an increase in the drinking age may simply redistribute fatal motor vehicle crashes from younger to older youths.[16] His hypothesis is that twenty-one-year-olds in a state

[13] Philip J. Cook, The Effect of Liquor Taxes on Drinking, Cirrhosis, and Auto Accidents, in Alcohol and Public Policy: Beyond the Shadow of Prohibition 255 (Mark H. Moore & Daniel R. Gerstein eds. 1981).

[14] For example, Allan F. Williams *et al.*, The Legal Minimum Drinking Age and Fatal Motor Vehicle Crashes, 4 J. Legal Stud. 219 (1975); Allan F. Williams *et al.*, The Effect of Raising the Legal Minimum Drinking Age on Involvement in Fatal Crashes, 12 J. Legal Stud. 169 (1983); and Alexander C. Wagenaar, Alcohol, Young Drivers, and Traffic Accidents (1983).

[15] Dennis C. McCornac, The Effects of Government Regulation on Teenage Motor Vehicle Mortality (Working Paper No. 1030, Nat'l Bur. Economic Research, 1982); and Philip J. Cook & George Tauchen, The Effect of Minimum Drinking Age Legislation on Youthful Auto Fatalities, 1970–1977, 13 J. Legal Stud. 169 (1984).

[16] Mike A. Males, The Minimum Purchase Age for Alcohol and Young-Driver Fatal Crashes: A Long-Term View, 15 J. Legal Stud. 181 (1986).

with a legal drinking age of eighteen, for example, may have more knowledge of the amount of alcohol they can safely consume shortly before driving than similar youths in a state with a legal drinking age of twenty-one (the "experience" effect). He presents evidence in support of this hypothesis based on univariate comparisons of states that did and did not raise their legal drinking age in the 1975–83 period. Since all youths must pay the higher alcoholic beverage prices associated with excise tax hikes, this factor is not relevant in evaluating the tax policy.

II. Analytical Framework

The 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) and which also depends on a vector of additional variables (z):

$$\pi = \pi(y, z). \tag{1}$$

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:

$$y = y(p, \boldsymbol{x}). \tag{2}$$

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

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

$$\pi = \pi(p, \boldsymbol{x}, z). \tag{3}$$

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 United States. This aim is facilitated by aggregating the equation over the n_j youths in the jth 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 twenty-one should be lower in states where the legal drinking age is eighteen as opposed to twenty-one. 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 study of state cross sections and consists of the forty-eight contiguous states of the United States for the years 1975–81. 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 forty-eight 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 an appendix to this paper (available on request). The appendix also includes a discussion of the theoretical roles of variables other than the real beer tax, the beer 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 fifteen through seventeen, youths aged eighteen through twenty, and youths aged twenty-one through twenty-four.[17] This is because the legal drinking age ranges from eighteen through twenty-one. Consequently, fifteen-, sixteen-, and seventeen-year-olds are illegal drinkers in all states, while twenty-one-, twenty-two-, twenty-three-, and twenty-four-year-olds are legal drinkers in all states. It follows that youths between the ages of eighteen and twenty should be most affected by differences in the drinking age. Formally, we rejected the hypothesis that slope coefficients are the same for the three age groups.

[17] The male death rate is approximately three times as large as the female death rate for the cohort of persons aged fifteen through twenty-four. 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 fifteen- through twenty-four-year-olds who are females across states, this variable is not included as a regressor.

TABLE 1

DEFINITIONS, MEANS, AND STANDARD DEVIATIONS OF VARIABLES

Variable	Definition, Mean, SD
Motor vehicle death rate	Deaths due to motor vehicle accidents per 100,000 population: ages fifteen to seventeen, mean = 31.581, SD = 8.794; ages eighteen to twenty, mean = 51.468, SD = 12.934; ages twenty-one to twenty-four, mean = 41.921, SD = 11.401.
Real beer tax	Sum of federal and state excise taxes on a case of twenty-four twelve-ounce cans of beer divided by CPI (1967 = 1), mean = .518, SD = .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, SD = 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, SD = .389.
Real income	Money per capita personal income divided by CPI (1967 = 1), expressed in thousands of dollars, mean = 3.830, SD = .447.
Vehicle miles traveled	Vehicle miles traveled in millions of miles per licensed driver, mean = .011, SD = .001.
Young drivers	Number of licensed drivers aged twenty-four or less as a fraction of the population aged fifteen to twenty-four, mean = .726, SD = .090.
Inspection of motor vehicles	Dichotomous variable that equals one if inspection of motor vehicles is required every year, mean = .548, SD = .498.
Mormon	Fraction of population who are Mormons, mean = .012, SD = .059.
Southern Baptist	Fraction of population who are Southern Baptists, mean = .074, SD = .098.
Catholic	Fraction of population who are Catholics, mean = .210, SD = .127.
Protestant	Fraction of population who are Protestants (excludes Southern Baptists and Mormons), mean = .199, SD = .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, SD = .084.

NOTE.—Data pertain to the forty-eight contiguous states of the United States for the years 1975–81. Means and standard deviations 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 fifteen through twenty-four by state and year.

Since the death rate differs among the three groups, this hypothesis was tested under the assumption that the intercepts are not the same.

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

A third reason for not limiting the analysis to youths aged eighteen through twenty 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,[18] the indirect cost of obtaining alcohol for persons younger than eighteen is lower in states where the legal drinking age is eighteen as opposed to nineteen, twenty, or twenty-one. To the extent that age at onset of alcohol consumption and current alcohol use are negatively related,[19] an increase in the legal drinking age can lower the motor vehicle death rate of twenty-one- to twenty-four-year-olds (the "consumption" effect). A factor that goes in the opposite direction is the "experience" effect discussed in Section I.

Studies of the effect of changes in legal drinking ages in individual states or in a small number of states by Williams et al., by Douglass, and by Wagenaar 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.[20] On the other hand, our outcome measure, like the one used by Cook and Tauchen, is more comprehensive. We adopt it for reasons given by Cook and Tauchen. They point out: "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

[18] Howard T. Blane & Linda E. Hewitt, Alcohol and Youth: An Analysis of the Literature (report prepared for the Nat'l Institute on Alcohol Abuse and Alcoholism 1977).

[19] J. Valley Rachal *et al.*, The Extent and Nature of Adolescent Alcohol Use: The 1974 and 1978 National Sample Survey (National Technical Information Service 1980).

[20] Williams *et al.*, supra note 14 (both studies); Richard L. Douglass, The Legal Drinking Age and Traffic Casualties: A Special Case of Changing Alcohol Availability in a Public Health Context, in Wechsler ed., *supra* note 6, at 93; and Wagenaar, *supra* note 14.

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.''[21] 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 multivehicle 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 fifteen or greater than age twenty-four 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. 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 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.[22] 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 Coate and Grossman find that youths substitute nonalcoholic beverages or other items such as leisure, rather than 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 the more youthful residents of the jth state are affected by it, the greater 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, as the fraction of the population of state j that live in counties that border on state k(f_j) increases. Hence we

[21] Cook & Tauchen, *supra* note 15, at 174–75.

[22] Coate & Grossman, *supra* note 9.

define the border age variable (b_j) as

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

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.[23]

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 occurrence. 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 in Section IV how the results are affected when the border variable is omitted from the regressions.[24]

The cost of beer is given by the sum of the federal and state excise tax rates on a case of twenty-four twelve-ounce cans of beer divided by the annual consumer price index (CPI) (1967 = 1) for the United States 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 last condition is satisfied 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

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

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

[24] 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.

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.[25]

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 those religious groups that oppose the use of alcohol, such as Mormons and Southern Baptists, are prevalent. Antidrinking sentiment should also 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

[25] Cook & Tauchen, *supra* note 4, 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 Stanley I. Ornstein & Dominique M. Hanssens, Alcohol Control Laws and the Consumption of Distilled Spirits and Beer, 12 J. Consumer Research 200 (1985); and Coate & Grossman, *supra* note 9. 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 forty-seven of the forty-eight 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.

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.[26]

The role of drinking sentiment is considered in detail by Coate and Grossman in the context of a formal econometric model.[27] 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 then to construct a second set of regressions that includes these variables.[28]

An alternative estimation strategy to control for hard-to-measure variables, such as drinking sentiment, is to employ dichotomous variables for forty-seven of the forty-eight states. Each dichotomous variable identifies a specific state. This is the strategy adopted by Cook and Tauchen 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 seven of the eight 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 we present one regression for each of the three age groups that includes dichotomous variables for forty-seven of the forty-

[26] 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 that 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.

[27] Coate & Grossman, *supra* note 9.

[28] An alternative approach to the problem discussed above is to estimate a simultaneous-equations model of the joint determination of the legal drinking age, the beer tax, and the motor vehicle accident mortality rate. This approach is pursued by Henry Saffer & Michael Grossman, Endogenous Drinking Age Laws and Highway Mortality Rates of Young Drivers (Working Paper No. 1982, Nat'l Bur. Economic Research 1986). Although our results are quite sensitive to alternative specifications, they suggest that the tax and legal drinking age effects presented here are conservative lower-bound estimates. Moreover, the relative ranking of the two estimates is not affected by biases associated with endogeneity.

eight 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 ith age group in the jth state in year t—ranges between zero and one. Therefore, a logistic functional form for the death rate is selected because it imposes this constraint. The equation is specified as

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

where x_{jtk} is the value of the kth independent variable in the jth 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:

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

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 $\mathbf{x}_{jtk}$.

Maddala shows that a regression estimate of equation (6) should employ weighted least squares.[29] The weights are given by $[n_{ijt}\pi_{ijt}(1 - \pi_{ijt})]^{1/2}$, where n_{ijt} is the number of youths in the ith age group in the jth 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 fifteen through seventeen, eighteen through twenty, and twenty-one through twenty-four 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 forty-seven of the forty-eight states. The logit coefficients of the state variables

[29] G. S. Maddala, Limited-Dependent and Qualitative Variables in Econometrics (1983).

TABLE 2

WEIGHTED LEAST SQUARES ESTIMATES OF LOGIT MOTOR VEHICLE ACCIDENT MORTALITY EQUATIONS

	PANEL A—AGES 15–17 (Regression Number)			PANEL B—AGES 18–20 (Regression Number)			PANEL C—AGES 21–24 (Regression Number)		
INDEPENDENT VARIABLE	(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

NOTE.—Logit coefficients and t-ratios are shown in parentheses. 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 intercept and dichotomous variables for the years 1975–80. Regressions 2-A3, 2-B3, and 2-C3 include dichotomous variables for forty-seven of the forty-eight states.

are not presented. Each of the three regressions contains an intercept and dichotomous variables for the years 1975–80. 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.[30] 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.[31] Data contained in Coate and Grossman 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 1975–81.[32] 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 -0.7 for fifteen- through seventeen-year-olds and -1.3 for eighteen- through twenty-year-olds and twenty-one- through twenty-four-year-olds.

How reasonable are elasticities that range from -0.7 to -1.3? Cook estimates an elasticity of the motor vehicle death rate of persons of all ages with respect to the price of liquor of -0.7.[33] Thus our elasticities appear to be quite reasonable. This is particularly true because Coate and Grossman 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.[34]

Based on the first two regressions in panels A–C, the only negative and statistically significant legal drinking age coefficients pertain to youths aged eighteen through twenty. These are extremely plausible results because eighteen- through twenty-year-olds should be most affected by differences in the drinking age, which ranges from eighteen to twenty-one.

[30] 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.

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

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

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.

[32] Coate & Grossman, *supra* note 9.

[33] Cook, *supra* note 13.

[34] Coate & Grossman, *supra* note 9.

The border age coefficients have the appropriate positive signs for the middle age group in regressions 2-B1 and 2-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 eighteen through twenty. But the coefficients are not significant for the two other groups.[35] 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–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 relation 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 elasticities: -1.0 for the youngest age group, -0.8 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 fifteen through twenty-four 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 fifteen through twenty-four 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.[36] States that require compulsory inspec-

[35] The negative legal drinking age coefficient for the twenty-one- through twenty-four-year-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, *supra* note 15, do not support the experience hypothesis proposed by Males, *supra* note 16.

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

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

TABLE 3

LOGIT COEFFICIENTS OF BEER LEGAL DRINKING AGE, BORDER AGE OMITTED

	REGRESSION NUMBER		
	(3-1)	(3-2)	(3-3)
Ages fifteen through seventeen	.007	.006	−.044
	(.99)	(.92)	(−2.49)
Ages eighteen through twenty	−.033	−.033	−.055
	(−4.91)	(−4.75)	(−3.41)
Ages twenty-one through twenty-four	.004	.005	−.048
	(.57)	(.62)	(−2.95)

NOTE.—*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 forty-seven of the forty-eight states.

tion 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 increases in the beer tax and the legal drinking age play the dominant role in reducing consumption of beer and, through it, road deaths. The cultural factors are

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Here d_{ij} is the number of deaths in the ith age group in the jth 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 subscripts 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 ith 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 jth state, w_{1524j} is the fraction of licensed drivers ages fifteen through twenty-four, and the factors of proportionality (s_i and v_i) do not vary among states.

therefore less important than the financial and legal variables. 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 clear-cut. Death rates are lower in states where Mormons and Southern Baptists are prevalent, although the effect with Southern Baptists 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 find that the frequency of beer consumption by youths is positively related to the prevalence of Protestants and Catholics in their area of residence.[37] 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–C of Table 2 includes dichotomous variables for forty-seven of the forty-eight states. 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, indicating that the state excise tax rate on beer has an independent effect on the motor vehicle accident mortality rate of youths.

The specification with the state dummies 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 effect for eighteen- through twenty-year-olds, which was negative and significant in the second regression model, rises by slightly more than 50 percent in absolute value. The drinking age coefficient for fifteen- through seventeen-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. These results suggest that a model with state dummies is overdetermined and plagued by multicollinearity. The

[37] Coate & Grossman, *supra* note 9.

implausible nature of the estimates that emerge from this specification provides a justification for not emphasizing it.

To evaluate the potential effects 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 jth 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 eq. (5)). Then we obtain the actual death rate as a weighted average of the 336 computed probabilities (forty-eight states times seven years) multiplied by 100,000. The weight is the fraction of the total population of all youths in the ith age group in the period 1975–81 who reside in the jth state in year t.[38] 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 eighteen- through twenty-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 are also presented for comparative purposes.

The legal drinking age policy pertains to a uniform minimum age of twenty-one for the purchase of beer in all states. This policy is simulated by setting the legal drinking age equal to twenty-one 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 twenty-one in all states throughout the period 1975–81.

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 $0.64 in

[38] 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

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

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 one death per 100,000 population.

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 jth state in year $t(q_{jt})$ becomes

$$q_{jt} = [r_{jt} + (\$0.64)(c_{t,51})]/(c_{t,67}), \tag{7}$$

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 \$0.64 to \$2.09 to equalize the rates at which the alcohol in beer and liquor are taxed (see note 4). It is termed the alcohol tax equalization policy. In this simulation the real beer tax is given by

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

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

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

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 1975–81 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 midyear of the sample period) that is 2.5 times larger than the actual tax. Equalization of the tax on the alcohol in 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 eightfold increase in the federal beer tax in 1978, which would have raised the nominal price of beer by roughly 60 percent in that year.[39]

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 regression model with the state dummy variables.

Based on panel A, a uniform legal drinking age of twenty-one throughout the period would have reduced the death rate of youths ages eighteen through twenty (fifty-two deaths per 100,000 population based on the

[39] Since the excise tax and legal drinking age increases are nonmarginal 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.

TABLE 4

PREDICTED EFFECTS OF IMPOSITION OF UNIFORM LEGAL DRINKING AGE OF TWENTY-ONE OR INCREASE IN FEDERAL EXCISE TAX ON BEER ON MOTOR VEHICLE ACCIDENT MORTALITY RATE OF EIGHTEEN- TO TWENTY-YEAR-OLDS

	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

NOTE.—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.

actual values of all independent variables) by four 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 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 eleven 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 twenty-eight 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 that accompanies the inflation tax policy appears to have a larger effect than a uniform drinking age of twenty-one, 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 twenty-one in one

or more years of the period. Therefore, we have simulated the death rates of eighteen- through twenty-year-olds under the assumption of a uniform drinking age of eighteen. Based on the regression model with the anti-drinking sentiment measures, the mortality rate in the latter simulation exceeds the one in the simulation with a drinking age of twenty-one by seven deaths per 100,000 population. The corresponding differential in the regression with the state dummies is ten deaths per 100,000 population. The former differential but not the latter is smaller than the eight-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 twenty-one in all states during the period 1975–81. On the other hand, Cook and Tauchen's results suggest that the drinking age policy would have lowered the death rate by approximately 4 percent during the period 1970–77.[40] 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 fifteen through seventeen, eighteen through twenty, and twenty-one through twenty-four. Negative and statistically significant legal drinking age effects are obtained for youths aged eighteen through twenty. These results cannot be attributed to the omission of drinking sentiment from the estimating equation because we control for this phenomenon by including as regressors religion measures and the fraction of the population who reside in counties that permit the sale of alcohol.

Quantitatively, the enactment of a uniform drinking age of twenty-one in all states would have reduced the number of eighteen- through twenty-year-olds killed in motor vehicle crashes by 8 percent in the period 1975–81. 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.

[40] We computed the 4 percent figure based on Cook & Tauchen, *supra* note 15, table 5, at 186.

The preceding figures suggest that, if reductions in youth motor vehicle accident deaths are desired, both a uniform drinking age of twenty-one and an increase in the federal excise tax rate on beer are effective policies to accomplish this goal. 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 eighteen through twenty would have been saved by the inflation excise tax policy in a typical year during the period 1975–81, 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 eightfold (thirteenfold 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 twenty-one 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 fifteen and seventeen and between the ages of twenty-one and twenty-four. These benefits do not accompany a rise in the drinking age. In addition, the tax policy may reduce fatal crashes involving adults. Of course, a substantial tax hike may greatly stimulate the demand for illegally produced beer suggesting that we have overestimated the impact of an eightfold increase in the federal excise tax on beer.

Finally, Becker has shown that the optimal way for a society to deter offenses is via a system of severe and fairly certain punishments.[41] In the case of drunk driving, these might take the form of loss of driving privileges for long periods of time, mandatory community service, enrollment in alcohol rehabilitation programs, and prison sentences for repeat offenders. Of course, youthful drunk drivers may respond to an increase in the penalty 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 severe penalties. 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.

[41] Gary G. Becker, Crime and Punishment: An Economic Approach, 76 J. Pol. Econ. 169 (1968). In Becker's model, a system of monetary fines is optimal in most situations. Since teenagers involved in serious automobile accidents presumably would not have enough resources to pay an adequate fine, other punishments for drunk driving are required.