Effects of Alcoholic Beverage Prices and Legal Drinking Ages on Youth Alcohol Use

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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 effect 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. 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 has been withheld if that state's minimum legal drinking age was below twenty-one on October 1, 1986, and 10 percent will be withheld from each future fiscal year allocation if that state's

[1] Federal Uniform Drinking Age Act Pub. L. No. 98-363 (1984).

drinking age remains below twenty-one. To date, twenty-seven states have passed laws complying with the act, and only Wyoming has failed to raise its minimum drinking age to twenty-one.[2] A second major element of the antidrinking campaign is reflected by more severe penalties for conviction of drunk driving, the allocation of additional resources to apprehend drunk drivers, and the 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).[3]

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. While twenty-nine 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.[4] Thus, if alcohol abuse is sensitive to price, a government policy of declining real excise tax levels actually may be exacerbating this problem.[5]

A primary purpose of this article is to investigate the sensitivity of alcoholic beverage consumption, particularly excessive consumption, to price among sixteen- through twenty-one-year-olds in the United States.

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[2] The increases in the legal drinking age documented above represent a dramatic reversal of the downward trend between 1970 and 1975. In that period, twenty-nine states lowered their drinking age to conform with a federal shift in the voting age from twenty-one to eighteen in 1970.

[3] 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.

[4] U.S. Dep't of Labor, Bureau of Labor Statistics, Monthly Labor Review (various issues).

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

We provide evidence for this important age group on the extent to which declining real alcoholic beverage excise taxes have contributed to increases in youth drinking and on the extent to which increases in real alcoholic beverage excise 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 alcohol use. Our empirical research is based on the second National Health and Nutrition Examination Survey (NHANES II), which was conducted by the National Center for Health Statistics (NCHS) between February 1976 and February 1980. It capitalizes on substantial differences in legal drinking ages among states in the period of NHANES II and on substantial differences in the prices of alcoholic beverages among states that were due primarily to differences in state excise tax rates on these beverages.

We focus on teenagers and young adults in the context of the antidrinking campaign because motor vehicle accidents are 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 1984, persons under the age of twenty-five accounted for 20 percent of all licensed drivers but constituted 35 percent of all drivers involved in fatal accidents.[6] 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.[7] We also focus on youths because alcohol abuse in adolescence appears to be associated with alcohol abuse in adult life.[8] Thus, policies to prevent the onset of this behavior in adolescents might be the most effective means to reduce it in all segments of the population.

Research on the responsiveness of youth alcohol use to alcoholic beverage prices is particularly timely in light of proposals to correct the erosion since 1951 in the real value of the federal excise rates on all forms of alcoholic beverages and in light of proposals 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.[9] Moreover, although beer

[6] The above figures were taken from U.S. Dep't of Transportation, Nat'l Highway Traffic Safety Administration, Fatal Accident Reporting System, 1984 (1986).

[7] 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).

[8] Howard T. Blane & Linda E. Hewitt, Alcohol and Youth: An Analysis of the Literature (report prepared for the Nat'l Inst. on Alcohol Abuse and Alcoholism, 1977); J. Valley Rachal et al., The Extent and Nature of Adolescent Alcohol Use: The 1974 and 1978 National Sample Survey, Nat'l Technical Information Service (1980).

[9] For example, Allan Luks, Will America Sober Up? (1983); Philip J. Cook, Increasing the Federal 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

is the drink of choice among youths who drink alcoholic beverages (see Section II), 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] In addition, this study complements the one by Saffer and Grossman,[11] which reports dramatic reductions in youth motor vehicle accident mortality rates in response to increases in real state excise tax rates on beer. Research on the sensitivity of youth alcohol use to legal drinking ages is also valuable given the adverse reaction to federal uniform drinking legislation[12] and the volatility of state minimum drinking ages in the 1970s and 1980s.

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 alcohol in all states on youth alcohol use with that of one or more of the policies to raise the federal excise tax rates on alcohol beverages described above. Before turning to a technical discussion of how these relations should be measured, we note that an effectively enforced prohibition of alcohol consumption in this age group clearly should have a larger effect on their consumption than an increase in excise tax rates. This issue is not clearcut at the empirical level only because of the problem of evasion. Underage youths can obtain alcohol from their older siblings or friends. In addition, they can purchase fake identification cards or buy alcohol in

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Raise the Drinking Age, Raise Taxes, Bus. Week, November 25, 1985, at 21; 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.

[10] For example, Jeffrey E. Harris, More Data on Tax Policy, in Gerstein, *supra* note 9, at 33; Jacobson & Albion, *supra* note 9. 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 $21.00. 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 here also contain provisions to correct this distortion.

[11] Henry Saffer & Michael Grossman, Beer Taxes, the Legal Drinking Age, and Youth Motor Vehicle Fatalities, 16 J. Legal Stud. 351 (1987).

[12] 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 Inst. for Highway Safety, 20 The Highway Loss Status Report 1 (1985). To counteract these laws, the federal legislation was made permanent in 1986. South Dakota challenged the constitutionality of the 1984 Federal Uniform Drinking Age Act in a suit before the Supreme Court, South Dakota v. Dole, No. 86-260 (December 1986), which was supported by eight additional states. In June 1987, the Court ruled against South Dakota.

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 alcohol determines the change in its consumption.

Aside from our study with Arluck[13] described below, there has been no research on the price sensitivity of youth alcohol use and no investigation of the long-run effects of differences in legal drinking ages in recent nationally representative samples. Statistically significant short-run increases in alcohol consumption by youths have been reported in selected states or provinces of Canada that lowered their legal drinking age in the early 1970s, and significant short-run reductions in consumption have been reported in selected states that raised their legal drinking age in the late 1970s or early 1980s.[14] Grossman, Coate, and Arluck[15] found that the incidence of heavy drinking and frequent drinking by youths falls as alcoholic beverage prices or legal drinking ages rise. These results are based on the first National Health and Nutrition Examination Survey (NHANES I), conducted by NCHS between May 1971 and June 1974, and pertain to youths of ages sixteen through twenty-one who reside in large metropolitan areas.

Studies that use time series or state cross sections to estimate price elasticities of alcoholic beverages[16] employ per-capita consumption by all age groups as the dependent variable. Therefore, the estimated price elasticities primarily reflect adult drinking behavior and cannot be used to predict how youths would respond to excise tax and price changes. As pointed out above, however, it is especially important to focus on youths in the context of the antidrinking campaign.

It should be noted that, even if adult price elasticities are relatively

[13] Michael Grossman, Douglas Coate & Gregory M. Arluck, Price Sensitivity of Alcoholic Beverages in the United States, in Control Issues in Alcohol Abuse Prevention: Strategies for Communities 169 (Harold D. Holder ed. 1987).

[14] For example, Reginald G. Smart & Michael S. Goodstadt, Effects of Reducing the Legal Alcohol-Purchasing Age on Drinking and Drinking Problems, 38 J. Stud. Alcohol 1313 (1977); Alexander C. Wagenaar, Alcohol, Young Drivers, and Traffic Accidents (1983). Stephen A. Maistro & J. Valley Rachal, Indications of the Relationship among Adolescent Drinking Practices, Related Behaviors, and Drinking-Age Laws, in Wechsler, supra note 7, at 155, have studied the effects of differences in legal drinking ages among states on teenage alcohol use in a 1978 national drinking survey. Their research is limited to youths who are almost all below the lowest legal drinking age of eighteen and is conducted in a univariate context.

[15] Grossman, Coate & Arluck, supra note 13.

[16] For example, Stanley I. Ornstein, Control of Alcohol Consumption through Price Increases, 41 J. Stud. Alcohol 807 (1980); Stanley I. Ornstein & Dominique M. Hanssens, Alcohol Control Laws and the Consumption of Distilled Spirits and Beer, 12 J. Consumer Res. 200 (1985).

small (inelastic) in absolute value, this need not be the case for youth price elasticities. Given the habitual nature of alcohol abuse, adult users, who almost always will have been users for longer periods of time than youths, may be much less sensitive to price than youths. In addition, the fraction of disposable income that a youthful drinker spends on alcohol probably exceeds the corresponding fraction of an adult drinker. It is well known that the uncompensated (income-constant) price elasticity of a good rises as the fraction of income spent on that good rises. Finally, bandwagon or peer effects are much more important in the case of youth drinking than in the case of adult drinking. That is, youths are more likely to drink if their peers also drink.[17] As shown by Leibenstein and by Lewit, Coate, and Grossman,[18] the presence of bandwagon or peer effects increases the price elasticity of demand.[19]

II. METHODOLOGY

A. Data and Subsample Selection

To examine the effects of alcohol prices and legal drinking ages on youth alcohol use, we have used NHANES II to estimate demand functions for alcohol consumption by youths. The NHANES II is a national probability sample of the civilian, noninstitutionalized population of the United States with some oversampling of low-income persons, preschool children, and the elderly. The survey was conducted by NCHS between February 1976 and February 1980 and contains approximately 21,000 persons between the ages of six months and seventy-four years. These persons were selected from sixty-four primary sampling units, which consist of one or more counties. Each person in the survey was given a detailed physical examination. A variety of information on medical and health histories, family socioeconomic characteristics, and diet patterns also was obtained. Data on alcohol use for the past three months were col-

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[17] For example, Blane & Hewitt, *supra* note 8 and Rachal *et al.*, *supra* note 8.

[18] Harvey Liebenstein, Bandwagon, Snob, and Veblen Effects in the Theory of Consumer Behavior, 64 Q. J. Econ. 183 (1950); Eugene M. Lewit, Douglas Coate & Michael Grossman, The Effects of Government Regulation on Teenage Smoking, 24 J. Law & Econ. 545 (1981).

[19] In a penetrating economic analysis of rational addiction over the life cycle, Gary S. Becker and Kevin M. Murphy, A Theory of Rational Addiction (Working Paper No. 41, Univ. Chicago, Dep't Economics 1986), show that the effect of habit formation or peer pressure on price responsiveness depends on whether the price variation is permanent or temporary, whether the magnitude of the effect is measured by the slope or the elasticity, and whether the outcome pertains to the probability of consuming the addictive good or to consumption given participation. In certain cases, adults can be more responsive to price than youths in their model, while in other cases the reverse holds.

lected for persons from ages twelve through seventy-four. These data were acquired on the date on which the physical examination was given as one component of a food frequency interview.[20]

We have limited our demand function estimates to sixteen- through twenty-one-year-olds because of our interest in the sensitivity of alcohol consumption of older youths to price and to legal drinking age. Youths below the age of sixteen are excluded from the demand functions because they cannot legally drive in most states. Youths aged sixteen and seventeen are illegal drinkers in all states, but they are included in the demand functions because it is likely to be easier (less costly) for them to obtain alcoholic beverages in a state with a legal drinking age of eighteen than in one with a higher legal drinking age.[21] Twenty-one-year-olds are legal drinkers in all states, but they are not excluded from the demand functions because twenty-one-year-olds in states with a legal drinking age of eighteen will have been legal drinkers for a longer period of time than youths in states with a legal drinking age of nineteen, twenty, or twenty-one. This may have an effect on their consumption of alcoholic beverages. Although the sixteen through twenty-one age range is somewhat arbitrary, demand functions estimated with youths of slightly different ages (fifteen through twenty or sixteen through twenty) yield results that are very similar to those presented in Section III.

Alcoholic beverage prices and legal drinking ages have been added to the NHANES II survey based on a given youth's place of residence (primary sampling unit) from sources indicated in Section IIC. Since beer prices for the state of Hawaii were not available and since beer is the drink of choice among youths who consume alcoholic beverages (see Section IIB), youths residing in Honolulu, Hawaii, were excluded. After deleting observations with missing data, we obtained a final sample of 1,761 youths aged sixteen through twenty-one living in sixty-three of the sixty-four NHANES II primary sampling units.[22]

B. Measurement of Alcohol Use

The NHANES II alcohol use measures for the final sample of 1,761 youths are summarized by the percentage distributions of beverage-

[20] The NHANES II is described in detail in U.S. Dep't of Health and Human Services, Nat'l Center for Health Statistics, Plan and Operation of the Second Health and Nutrition Examination Survey, 1976–80 (1981).

[21] Philip J. Cook & George Tauchen, The Effects of Minimum Drinking Age Legislation on Youthful Auto Fatalities, 1970–77, 13 J. Legal Stud. 169 (1984).

[22] Of the variables employed in the demand functions, the only ones with missing values are alcohol use and family income. In each case the number of observations with missing values is very small.

specific drinking frequencies in the past three months in panel A of Table 1. These measures pertain to the number of drinking occasions per week in the past three months. Information about the number of drinks consumed in total or on a typical drinking occasion was not obtained. The figures in Table 1 highlight the popularity of beer among teenagers and young adults. Approximately 57 percent of all youths drank beer in the past three months, while only 39 percent drank liquor and only 32 percent drank wine. Moreover, 11 percent of youths drank beer four to seven times a week, while fewer than 1 percent drank liquor or wine that often.

The beverage-specific number of drinking occasions in the past three months is a categorical variable in NHANES II, and the four categories shown in Table 1 (four to seven times a week, one to three times a week, less than once a week, and never) are employed as outcome measures in demand functions estimated by multivariate techniques described in Section IID.[23] Here it is important to note that the use of a categorical variable allows us to examine the determinants of beverage-specific drinking participation and infrequent, fairly frequent, and frequent participation simultaneously. It also permits the effect of prices and legal drinking ages on these outcomes to differ. In addition, if more alcohol is consumed per drinking occasion as the number of occasions rises, true consumption would not be linearly related to a continuous drinking-frequency measure. To take account of this nonlinearity, a categorical variable would be preferable to a continuous one even if the latter were available.

The number of drinking occasions per week is closely related to, and in a majority of cases probably coincides with, the number of drinking days per week. Under this interpretation, the most frequent drinking category identifies youths who consumed alcohol at least every other day in the past three months. Given the age cohort studied here, this is a very reasonable indicator of frequent consumption.

Information on alcohol consumption was obtained directly from youths in NHANES II. Parents were not present during the interviews with the youths and were not informed about the alcohol responses of their chil-

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[23] The actual beverage-specific frequency measure in NHANES II has more categories than those given in Table 1. The complete set of outcomes is never, less than once a week, 1–6 times a week (each of the 6 outcomes can be reported), and 1–24 times a day (each of the 24 outcomes can be reported). We collapse these 32 outcomes into 4 because, as indicated in the text, the number of drinks consumed per drinking occasion is likely to rise as the number of occasions rises and because very frequent consumers are likely to underreport. In addition, it is possible that respondents in the 1–24 times a day categories drink every day and are indicating the number of drinks consumed per day or on a typical drinking day. For these reasons, we do not form a separate category of 7 or more times a week. We have experimented with several alternative categorical variables and have found that the demand function estimates are similar to those presented in Section III.

TABLE 1

VARIABLES EMPLOYED IN EMPIRICAL ANALYSIS
A. PERCENTAGE DISTRIBUTIONS OF BEVERAGE-SPECIFIC DRINKING FREQUENCIES IN PAST THREE MONTHS[a]

		OUTCOME CATEGORY		
BEVERAGE	4–7 Times a Week	1–3 Times a Week	Less Than Once a Week	Never
Beer	11.07	27.43	18.57	42.93
Liquor	.85	13.57	24.48	61.10
Wine	.85	9.20	22.37	67.58

B. DEFINITIONS, MEANS, AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES[b]

Variable Name	Definition
Real price of beer (1967 dollars)	Price of a package of six 12-ounce cans of a leading brand of beer divided by CPI, 1967 = 1 (mean = 1.027, s.d. = .116)
Real price of liquor (1967 dollars)	Price of Seagram's 7-Crown, 80 proof (40% alcohol), fifth-size bottle (four-fifths of a quart), divided by CPI, 1967 = 1 (mean = 2.941, s.d. = .309)
Beer legal drinking age (months)	Minimum legal age for purchase and consumption of beer, alcoholic content 3.2% or less (mean = 228.572, s.d. = 16.092)
Liquor legal drinking age (months)	Minimum legal age for purchase and consumption of liquor (mean = 234.835, s.d. = 17.651)
Border age	Dichotomous variable that equals 1 if youth lives within 20 miles of a state with a lower legal drinking age than his state of residence, computed separately for beer and liquor but assumed the same value for each beverage (mean = .197, s.d. = .398)
Mormon	Percentage of population who are Mormons in youth's primary sampling unit (mean = 1.585, s.d. = 8.323)
Southern Baptist	Percentage of population who are Southern Baptists in youth's primary sampling unit (mean = 7.955, s.d. = 13.179)
Catholic	Percentage of population who are Catholics in youth's primary sampling unit (mean = 19.161, s.d. = 15.708)
Protestant	Percentage of population who are Protestants in youth's primary sampling unit, excludes Southern Baptists and Mormons (mean = 20.465, s.d. = 8.389)

[a] Sample size is 1,761. For each beverage, the four cell entries give the percentage of all youths in each outcome category.
[b] s.d. denotes standard deviation.

dren. Nevertheless, there is a possibility that youths may report their alcohol use with error.[24] If any such response error is uncorrelated with the independent variables in the demand function for alcohol, coefficients will be unbiased, although their standard errors will be inflated. In this case, the existence of response error essentially presents no problem for the statistical analysis. Response error becomes a problem only if it is systematic or correlated with some or all of the variables in the demand functions.

The validity of the NHANES II alcohol measures is underscored by referring to the related problem of the measurement of cigarette smoking by adolescents. Williams and Gillies have reviewed the literature on self-reported smoking behavior of adolescents and have concluded "that teenagers probably do report 'truthfully' about their smoking behavior when anonymous questionnaires are used."[25] An additional consideration is that the drinking questions were included as a small part of a much larger survey that was focused on very different issues. Gordon and Kannel argue that this improves the quality of reports of alcohol consumption.[26]

To be sure, it is possible that heavy consumers of alcoholic beverages are more likely to underreport their consumption than are other persons.[27] If heavy users are more likely to be found in areas with low prices or low legal drinking ages, estimates of the demand parameters of these variables are biased toward zero. This is another reason for the use of a categorical rather than a continuous drinking measure. In particular, the former does not assume a linear relation between true and reported consumption. Moreover, youths are unlikely to be found in one of the four outcome categories used here rather than in another as a result of reporting error.

C. Measurement of Independent Variables

Panel B of Table 1 contains definitions, means, and standard deviations of the key independent variables in the demand functions. In addition to

[24] Past surveys of alcohol use by all segments of the population have been criticized because of apparent underreporting. If national alcoholic beverage sales data are compared to national consumption estimates that are based on survey data, underreporting by survey respondents appears to range between 20 percent and 50 percent. For discussions of underreporting, see Lorraine Midanik, The Validity of Self-reported Alcohol Consumption and Alcohol Problems: A Literature Review, 77 Brit. J. Addiction 357 (1982); and J. Michael Polich, The Validity of Self-Reports in Alcoholism Research, 7 Addictive Behaviors 123 (1982). For reasons indicated below, underreporting is not likely to be a problem in our research.

[25] Ruth Williams & Pam Gillies, Do We Need Objective Measures to Validate Self-Reported Smoking? 98 Pub. Health London 297 (1984).

[26] Tavia Gordon & William B. Kannel, Drinking and Its Relation to Smoking, BP, Blood Lipids and Uric Acid, 143 Archives Internal Medicine 1366 (1983).

[27] Midanik, supra note 24; Polich, supra note 24.

the variables listed in panel B, all demand functions include as regressors the youth's age in months on the date of his or her NHANES II examination, a dichotomous variable that identifies blacks, a dichotomous variable that identifies females, and real family income (family monetary income divided by the Consumer Price Index). We do not present or discuss the effects of these variables on alcohol use in Section III. But it should be realized that all estimated price and legal drinking age effects control for (hold constant) the effects of these variables.[28] We have used a relatively sparse set of independent variables because Arluck found that the coefficients of interest in NHANES I demand functions are not sensitive to the inclusion of additional family background and youth characteristics. They also do not change much when state-specific measures of the availability and regulation of alcohol are added to the set of independent variables.[29]

The minimum legal ages in months for the purchase of beer (alcoholic content 3.2 percent or less by weight) and liquor were taken from Wagenaar's (1981/82) extremely painstaking and definitive compilation for every state for the years 1970 through 1981.[30] Each NHANES II youth was assigned beverage-specific legal drinking ages in his state of residence as of the midmonth of the three-month period culminating on the date of his examination. In principle, this algorithm takes account of the upward

[28] Briefly, the results indicate that the frequency of alcohol use rises sharply with age. Males drink more frequently than females, and whites drink more frequently than blacks. Real family income is not a significant determinant of youth alcohol use.

[29] Gregory M. Arluck, Economic and Other Factors in Youth Alcohol Use (unpublished Ph.D. dissertation, City Univ. New York Graduate School 1987). The availability and regulatory measures considered by Arluck include 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. All of them pertain to the state in which a given youth resides. Arluck's results are based on ordinary least squares regressions. It is beneficial for us to limit the set of independent variables because the estimation techniques that we employ (see Section IIID) are computer intensive.

[30] Alexander C. Wagenaar, Legal Minimum Drinking Age Changes in the United States: 1970–1981, 6 Alcohol Health and Res. World 21 (1981/82). In the case of beer, a few states have two legal drinking ages. 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 former variable, but it is very highly correlated with the latter. The beer and liquor legal drinking ages also are highly correlated (the latter is always greater than or equal to the former) and cannot be included in the same demand equation. If beer and liquor were substitutes, an increase in the liquor legal drinking age should increase the demand for beer. Studies summarized by Ornstein, *supra* note 16, however, find almost no substitution among alcoholic beverages. Additional evidence on this lack of substitution is reported in Section III.

trend in state legal drinking ages during the period of the NHANES II examinations. In fact, only two NHANES II primary sampling units—Dakota, Minnesota, and Hennepin, Minnesota—are in a state that raised its legal drinking age during a three-month period culminating on the date of the examination or before that period. All other states that raised their legal drinking age did so after the NHANES II examinations in those states were completed.[31]

Youths who reside in a state with a high legal drinking age may be able to purchase alcohol in a border state with a lower legal drinking age. To deal with this phenomenon, we created a dichotomous variable that equals one for youths who live within twenty miles of a state with a lower legal drinking age than the one in their state of residence. With the own-state legal drinking age held constant, the coefficient of the border age variable in the demand functions should be positive.

An alternative model of drinking age effects results when the two variables just defined are replaced by dichotomous variables that identify youths who are illegal drinkers in their own state but legal drinkers in the border state. This model is less flexible than the one that we used because it does not recognize that evasion of drinking age laws by an illegal drinker is easier (less costly) the closer the person is to the legal drinking age in his state of residence or in the border state. Consider two eighteen-year-olds who are identical in all respects except that one resides in a state with a legal drinking age of nineteen, while the other resides in a state with a drinking age of twenty-one. Since peers are a common source of alcohol,[32] the indirect cost of obtaining alcohol is likely to be lower for the first youth than for the second. Moreover, it should be easier for an eighteen-year-old to pass for nineteen than for twenty-one.

Our specification also is preferable to the alternative model because it allows for the negative relation that frequently has been reported between age at onset of alcohol consumption and current use.[33] Put differently, current use is expected to be positively related to the number of years that a youth has been a legal drinker. Thus, a twenty-year-old in a state with a legal drinking age of eighteen should not be constrained by the specification to consume the same quantity of alcohol as an otherwise identical youth in a state with a drinking age of twenty.

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[31] This statement also pertains to the border legal drinking age variable described below. Minnesota raised its legal drinking age from eighteen to nineteen effective September 1, 1976. The legislation contained a grandfather clause that exempted youths who were eighteen years of age as of August 31, 1976, from the new act. This clause is taken into account in our legal drinking age variables for Minnesota youths.

[32] Blane & Hewitt, *supra* note 8.

[33] For example, Rachal *et al., supra* note 8.

Since the youth's age is included as an independent variable, the specification employed here is equivalent to one in which alcohol use (y) depends on the youth's age (a), the difference between the legal drinking age and age $(x_1 = d - a)$, and a vector of additional variables (x_2):

$$y = \alpha_0 + \alpha_1 a + \alpha_2 x_1 + \alpha_3 x_2. \tag{1}$$

Substitute the definition of x_1 into this equation to obtain

$$y = \alpha_0 + (\alpha_1 - \alpha_2)a + \alpha_2 d + \alpha_3 x_2. \tag{2}$$

The coefficient of x_1 in the first equation is identical to the coefficient of d in the second equation. A dichotomous variable identifying illegal drinkers cannot be added to equation (2) because of multicollinearity. Consequently, for the reasons given above, our specification has more desirable properties than the one in which the drinking age is replaced by the illegal drinker identifier.

The beer price variable pertains to the transactions price of a single leading brand of medium-priced, nationally sold beer. The specific brand is confidential. Prices are reported in two unidentified major markets in each state (one in the cases of Rhode Island and the District of Columbia) in January and July of 1976, 1977, and 1978 and in January of 1979. The data were obtained by Stanley Ornstein[34] and kindly made available to us.

Monthly prices for each state from January 1976 through January 1979 were obtained by linear interpolation of state-specific price series, computed by averaging the two prices for each state at a moment in time. Monthly prices for the period February 1979 through January 1980 were predicted from a regression of the state price on the state excise tax rate, time (a continuous variable), and dichotomous variables for all contiguous states except one.[35] The beer price of the midmonth in the three month period for which alcoholic beverage consumption was reported was then assigned to each subject.[36] To take account of trends in the prices of other

[34] See Ornstein & Hanssens, *supra* note 16.

[35] Specifically, let t be a time counter that starts at zero in January 1979 and ends at twelve in January 1980, and let p_{jt} be the price of beer in the jth state in month t. Then $p_{jt} = p_{j0} + bt$, where b is the monthly time trend from the regression. The regression employs annual price data, with the price in 1976, for example, defined as an average of the prices in January 1976, July 1976, and January 1977. Annual data are used because state excise tax rates on beer are very stable over time. Moreover, when a state raises its tax rate, beer prices may rise gradually rather than instantaneously. Indeed, the increase may begin before the actual date on which the tax rate is scheduled to rise. The regression is estimated for a cross section of the contiguous states of the United States for the years 1976, 1977, and 1978. Each observation is weighted by the square root of the population of the state in a given year. The annual trend obtained from the regression is converted to a monthly trend by dividing it by 12.

[36] The earliest NHANES II examination was conducted on February 20, 1976, and the latest was conducted on February 27, 1980. Therefore the midmonth dates are January 1976 through January 1980.

goods during the four-year period of NHANES II, the monthly beer price is divided by the annual Consumer Price Index (CPI, 1967 = 1) to obtain the real or relative price of beer.[37]

The real price of liquor is given by the price of Seagram's 7-Crown (a blended whiskey) divided by the CPI. This price is selected because Seagram's 7-Crown was the leading brand of liquor in the United States during the period of NHANES II, and its price commonly is used as a standard in the liquor industry. It was obtained from the annual survey of the retail prices of eight leading brands of distilled spirits in each state conducted by the Distilled Spirits Council of the United States and kindly made available to us by Gary Marshall.[38]

There were no data available on wine prices by state for the period of NHANES II. As a result, wine demand functions are not presented in the following section.

To take account of the potential role of "drinking sentiment" in the endogenous determination of alcoholic beverage prices, legal drinking ages, and alcohol consumption, the percentages of the population in a youth's primary sampling unit who are Mormons, Southern Baptists, Catholics, and Protestants (excluding Southern Baptists and Mormons) are included in some specifications of the demand functions. Drinking sentiment refers to cultural and taste variables that may either encourage or discourage alcohol consumption. For example, antidrinking sentiment

[37] Although we have specified real income–real price demand functions, we interpret the estimated price effects as uncompensated (money income-constant) rather than compensated (utility-constant) substitution effects. One consideration is that family income may be a very imperfect measure of a youth's command of real resources. A second consideration is that the CPI measures the cost of living of a four-person family. Expenditure patterns and thus the cost-of-living index of that unit are likely to be very different from those of a youth between the ages of sixteen and twenty-one. For the same reason, seasonal patterns in a youth's cost-of-living index may be very different from seasonal patterns in the CPI. Consequently, we do not deflate the monthly beer price by the monthly CPI. In preliminary research we estimated demand functions with money family income, the money price of beer, and a monthly time trend (a proxy for the youth's CPI) as regressors. The price effects in this specification were very similar to those reported in Section III.

[38] Distilled Spirits Council of the United States, Price per Fifth for Selected Types and Brands of Liquor in Control and License States (various years). The seven additional brands are Old Crow (bourbon), Old Grand-Dad (bonded whiskey), Dewar's (scotch), Smirnoff (vodka), Bacardi (rum), Canadian Club (whiskey), and Beefeater (gin). The prices of the eight brands all are highly correlated in a positive direction. In a time series of state cross sections for the period of NHANES II, the lowest pairwise correlation coefficient is .73. The correlation coefficient between the price of Seagram's 7-Crown and an unweighted average of the prices of the eight brands is .94. Recently, sales of Bacardi and Smirnoff have overtaken sales of Seagram's 7-Crown. In this context, note that the correlation coefficients between the price of Seagram's 7-Crown and the prices of Bacardi and Smirnoff are .92 and .93, respectively.

should be relatively widespread in states where religious groups that op-
pose the use of alcohol, such as Mormons and Southern Baptists, are
prevalent. These states may enact high alcoholic beverage excise tax
rates as part of the political process. In this situation, the price
coefficients that emerge from demand functions that omit drinking senti-
ment 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 high may enact high excise tax rates
because the taxation of alcoholic beverages is an attractive source of
revenue. In this case, the price effects are understated if drinking senti-
ment is excluded from the demand functions.[39]

The preceding issue is illuminated with reference to an econometric
model of the determinants of beer consumption, both at the aggregate
(state or county) level and at the individual level (available on request).
The price of beer, the legal drinking age, drinking sentiment, and beer
consumption are treated as endogenous. The model is recursive rather
than simultaneous, but the disturbance terms in the price and demand
equations, for example, are correlated. This is because drinking sentiment
is not observed. Instead, it must be replaced by a vector of observable
variables whose elements in the state model include the state-specific
equivalents of the religion measures in Table 2 and a disturbance term.

Biases arise if the demand function is estimated by ordinary least
squares because the disturbance terms in that equation and the price
equation share a common element: the unobserved component of drink-
ing sentiment. It is shown, however, that the importance of omitted vari-
ables bias is greatly reduced when individual demand functions are esti-
mated with drinking sentiment omitted. This is because an individual
consumer's beer consumption depends on his drinking sentiment, while
the tax on beer or its price depends on the average value of drinking
sentiment in the relevant market area. Therefore, the correlation between
price (a state or county variable) and drinking sentiment is much weaker
in micro data than in aggregate data.

The above conclusion is important because no measures of an individ-
ual's religious preference are available in NHANES II, and two-stage
least squares estimation of demand functions with price treated as endog-
enous is not feasible. Some demand functions are obtained with the four

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[39] Similar comments can be made with respect to drinking age effects that do not control
for drinking sentiment. Although it might appear as if the drinking age effect is overstated,
this need not be the case. For example, the high youth motor vehicle accident mortality rate
in a state where prodrinking sentiment is widespread may result in the enactment of a high
legal drinking age.

TABLE 2

Maximum Likelihood Estimates of Multinomial Logit Beer Frequency Equations[a]

INDEPENDENT VARIABLE	OUTCOME CATEGORY		
	4–7 Times a Week	1–3 Times a Week	Less than Once a Week
A. Religion variables excluded:			
Real price of beer	−1.790	−1.209	−.587
	(−2.12)	(−2.19)	(−1.01)
Beer legal drinking age	−.024	−.015	−.008
	(−3.69)	(−3.24)	(−1.62)
Border age	.196	.366	.279
	(.74)	(2.01)	(1.43)
χ^2	383.77		
B. Religion variables included:			
Real price of beer	−1.028	−.987	−.714
	(−1.12)	(−1.57)	(−1.07)
Beer legal drinking age	−.019	−.008	−.001
	(−2.63)	(−1.68)	(−.28)
Border age	−.079	.994	.008
	(−.27)	(.51)	(.04)
Mormon	−.026	−.010	−.019
	(−1.38)	(−1.16)	(−1.58)
Southern Baptist	−.031	−.021	−.014
	(−3.09)	(−3.23)	(−1.98)
Catholic	.013	.015	.012
	(1.48)	(2.47)	(1.79)
Protestant	.028	.035	.039
	(1.91)	(3.44)	(3.62)
χ^2	464.18		

[a] Logit coefficients and asymptotic t-ratios in parentheses are shown. The critical asymptotic t-ratios at the 5% level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The χ^2 associated with each equation is significant at the 1% level. Each equation includes three intercepts and the following additional independent variables: age of youth in months, race of youth, sex of youth, and real family income.

primary sample-specific religion variables listed in Table 2. These results should, however, be interpreted with caution because the price of beer or liquor is specific to the state rather than to the primary sampling unit. Given errors of measurement in price and correlations between true price and the religion variables, price coefficients are biased toward zero and religion coefficients are biased away from zero. Therefore, we wish to reemphasize that price effects are not necessarily overstated in absolute value when drinking sentiment is excluded from the demand functions. We also wish to reemphasize that the most relevant religion measure is the youth's own religious preference. In theory, this variable is more closely related to the youth's consumption of alcohol but less closely

related to price than the community religion variables that are actually employed as regressors.

The religion variables pertain to 1980, and were taken from a survey conducted by the National Council of Churches of Christ and the Glenmary Research Center.[40] Jews are included with nonchurch members in the omitted category because the size of the Jewish population was significantly underestimated in the survey. The religion measures pertain to the youth's primary sampling unit of residence rather than to his state of residence because the former are better predictors of the youth's actual religion.

An alternate specification of drinking sentiment results when the religion measures are replaced by average alcohol use by persons over the age of twenty-one in the youth's primary sampling unit of residence. Adult drinking practices should be influenced by the same underlying sentiments that influence youthful drinking practices, all other things being equal. This is an indirect effect that is associated with the ecology of the social drinking environment.

We have rejected the above specification of drinking sentiment on theoretical, econometric, and empirical grounds. Theoretically, an increase in price will reduce adult consumption. Thus, a rise in price will curtail youth consumption directly and indirectly via its effect on adult consumption. We are concerned with the total price effect, whereas the youth price coefficient from a model that includes adult drinking gives the difference between the youth and adult price effects.[41] To be sure, we could obtain one set of results with adult consumption as a regressor and a

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[40] Bernard Quinn et al., Churches and Church Membership in the United States, 1980 (1982).

[41] Suppose that the youth and adult demand functions are, respectively,

$$y = \alpha_0 + \alpha_1 p + \alpha_2 s + u,$$
$$z = \beta_0 + \beta_1 p + \beta_2 s + w.$$

Here, p is price, s is drinking sentiment, and u and w are disturbance terms that are not correlated with p and s. Note that adult drinking (z) may have a direct effect on youth drinking (y), with drinking sentiment held constant, for the same reason that youth consumption responds to the behavior of peers (see, for example, Blane & Hewitt, supra note 8, and Rachal et al., supra note 8). In that case, the first equation should be interpreted as a reduced form. Solve the second equation for s, substitute the result into the first equation, and assume that α_2 equals β_2 to obtain

$$y = \alpha_0 - \beta_0 + (\alpha_1 - \beta_1)p + z + u - w.$$

If e denotes the composite disturbance term in the last equation ($e = u - w$) and σ_w^2 denotes the variance of w, the covariance between e and z is

$$\text{cov}(e,z) = -\sigma_w^2.$$

More generally, if $\alpha_2 \neq \beta_2$, $e = u - (\beta_2/\alpha_2)w$, and

$$\text{cov}(e,z) = -(\beta_2/\alpha_2)\sigma_w^2.$$

second set that excludes that control. The first set of results could be used to isolate the other effect of interest in our research, the legal drinking age. The econometric problem here, however, is that the disturbance term in the youth demand function is correlated with adult alcohol use (see note 41). Empirically, NHANES II is representative of the population of the United States, but it is not representative of the population of each primary sampling unit. Thus, it is inappropriate to estimate mean alcohol consumption by adults in a given community from the sample.

Although youths are more likely to drink if their peers also drink, it is inappropriate to include peers' consumption of alcohol in the demand functions. This is because peer behavior is an endogenous rather than an exogenous variable in a more broadly defined model of drinking. That is, peer behavior is determined by such a model rather than by factors not specified by the model. For instance, suppose that one is evaluating a policy to curtail youth drinking by raising the federal excise tax rate on beer. An increase in the tax would raise the price of beer paid by youths and their peers, which would discourage consumption by both groups. Therefore, in evaluating the effect of such a policy, peers' beer consumption should not be held constant (included in the demand equation).

D. Estimation Techniques

The beverage-specific frequency of drinking in the past three months consists of four outcome categories (see Table 1). Therefore, multinomial logit equations are fitted by the method of maximum likelihood. In the case of beer, let π_{i1}, π_{i2}, π_{i3}, and π_{i4} be the probabilities that the ith youth consumes beer four to seven times a week, one to three times a week, less than once a week, and never, respectively. The probability of the kth outcome (π_{ik}, $k = 1, 2, 3$) is

$$\pi_{ik} = \pi_{i4} \exp\left(\alpha_k + \sum_{t=1}^{n} \beta_{kt} x_{it}\right), \tag{3}$$

where x_{it} is the value of the tth independent variable for the ith youth. The logarithm of the odds of category k relative to category 4 is

$$\ln(\pi_{ik}/\pi_{i4}) = \alpha_k + \sum_{t} \beta_{kt} x_{it}. \tag{4}$$

The logit coefficient β_{kt} shows the percentage change in the odds of category i relative to no beer participation for a one unit change in x_{it}. The marginal effect of x_{it} on π_{ik} is

$$(\partial \pi_{ik}/\partial x_{kt}) = \pi_{ik}\beta_{kt} - \pi_{ik} \sum_{k=1}^{3} \pi_{ik}\beta_{kt}. \tag{5}$$

Multinomial logit estimation methods are discussed in detail by Maddala.[42] Here it is important to emphasize several features of our estimates. The measures of drinking frequency are ordered categorical variables, but we do not use the ordered logit model. This is because that model does not allow for nonlinear and possibly nonmonotonic effects of the independent variables on the outcomes at issue.

Since the beer frequency equation, for example, contains non–beer drinkers (the omitted category), it gives an estimate of the effect of each independent variable on the probability of no beer participation.[43] We do not model beer consumption as a two-stage process in which youths first determine whether they will drink beer and then determine the frequency of beer consumption, given participation. In the two-stage model, non-beer participants would be excluded from the equation for frequency. We do not use this model because it is appropriate only when the determinants of participation differ from those of frequency. This condition is not satisfied in our research.[44]

III.   RESULTS

Table 2 contains maximum likelihood estimates of multinomial logit beer frequency equations. Logit coefficients and their asymptotic t-ratios

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

[43] Since

$$\sum_{k=1}^{4} \pi_{ik} = 1,$$

$$\pi_{i4} = \left[1 + \sum_{k=1}^{3} \exp\left(\alpha_k + \sum_{t=1}^{n} \beta_{kt} x_{it} \right) \right]^{-1},$$

and

$$(\partial \pi_{i4} / \partial x_{it}) = - \sum_{k=1}^{3} (\partial \pi_{ik} / \partial x_{it}).$$

[44] For a discussion of the two-stage model, see Daniel McFadden, Conditional Logit Analysis of Qualitative Choice Behavior, in Frontiers of Econometrics 105 (Paul Zarembka ed. 1973). An estimation issue in addition to those discussed above arises because NHANES II is a stratified cluster sample rather than a simple random sample. Consider an ordinary least squares regression in this context. If the regression is fit under the assumption of simple random sampling, regression coefficients are unbiased, but their t-ratios are overstated. A computer program called SURREG estimates unbiased t-ratios for ordinary least squares regressions—t-ratios that account for sample design effects. See Michael M. Holt, SURREG: Standard Errors of Regression Coefficients from Sample Survey Data, Research Triangle Inst. (1977). There is, however, no SURREG equivalent of a logit model. This suggests that the asymptotic t-ratios (the ratios of logit coefficients to their standard errors) shown in Section III may be biased upward. There is, however, a factor that goes in the opposite direction. We employ a relatively sparse set of regressors; standard errors would fall if this set were expanded. Recall that Arluck, *supra* note 29, finds that the coefficients of interest in the demand functions are not sensitive to the inclusion of additional independent variables.

are shown.[45] An equation that excludes the four religion measures is presented in panel A of the table, while an equation that includes them is presented in panel B. In the discussion of these results, youths who drink beer four to seven times a week are termed frequent drinkers; those who drink one to three times a week are termed fairly frequent drinkers; and those who drink less than once a week are termed infrequent drinkers.

In the beer frequency equation in panel A, the logit coefficients of the real price of beer and the legal drinking age all are negative and are statistically significant at the 5 percent level of significance or better, except in the infrequent drinking category.[46] The border legal age coefficients have the appropriate positive signs, but only the coefficient pertaining to fairly frequent drinking is significant.

There is a perfect rank correlation between the absolute values of the price and legal drinking age coefficients and the number of drinking occasions represented by each outcome category. That is, the logit coefficient of price in the frequent drinking category exceeds the corresponding coefficient in the fairly frequent category. In turn, the latter exceeds the logit coefficient of price in the infrequent category. In general, this guarantees that an increase in price lowers the probabilities of frequent and fairly frequent drinking. Indeed, the price elasticities of the probabilities of frequent and fairly frequent beer consumption are substantial: -1.18 and -0.59, respectively. The price elasticity of the probability of infrequent drinking is positive and very small (0.05), which indicates that the probability of infrequent drinking rises (but by a smaller percentage than that of nonparticipation) as the real price of beer rises. The positive price elasticity of the probability of nonparticipation of 0.65 is relatively large.[47]

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[45] The ratios of logit coefficients to their standard errors do not have Student's t-distribution. These ratios do, however, have an asymptotic normal distribution. Therefore, the t-test is an asymptotic one.

[46] 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. In particular, the own price and legal drinking effects are expected to be negative, and the border legal age effects are expected to be positive. When no significance level is indicated, it is assumed to be 5 percent for a one-tailed test.

[47] On the basis of eq. (5), the elasticity of π_{ik} with respect to x_{it} is

$$\epsilon_{ikt} = \left(\beta_{kt} - \sum_{k=1}^{3} \pi_{ik}\beta_{kt} \right) x_{it}.$$

This elasticity is computed for each youth in the sample by first predicting π_{ik} from eq. (3) and the second equation in note 43. The resulting figures are averaged over all youths to obtain the elasticity reported in the text. Note that, since each of the three logit coefficients

The price and legal drinking age effects retain their negative signs and relative rankings when the religion variables are included as regressors (see panel B, Table 2), but the significant coefficients in the equation in panel A are reduced in absolute value. In percentage terms these reductions range from 47 percent for the legal drinking age coefficient associated with the fairly frequent outcome category to 18 percent for the price coefficient in the same category. The two significant legal drinking age coefficients in panel A retain their significance in panel B. The price coefficients, however, lose their significance at the 5 percent level, although the *t*-ratio associated with each coefficient exceeds one in absolute value. The price elasticities are still relatively large: -0.53 for the probability of frequent drinking, -0.48 for the probability of fairly frequent drinking, -0.20 for the probability of infrequent drinking, and 0.53 for the probability of no drinking. For all practical purposes, there are no border age effects when the religion variables are held constant. The frequency of beer consumption is negatively related to the percentage of Mormons or Southern Baptists in the primary sampling unit, while it is positively related to the percentage of Catholics or Protestants.

Recall from Section III*C* that the price and legal drinking age coefficients are likely to be conservative lower-bound estimates of the true parameters with the religion variables included in the demand equations. Also, the corresponding coefficients obtained without controlling for religion are not necessarily upper-bound estimates of the true parameters. In light of these considerations, the findings that the real beer price coefficients retain their signs and relative rankings, and that the beer legal drinking age coefficients retain their signs, rankings, and statistical significance, are impressive and important.

Fewer negative and significant price and legal drinking age effects emerge from the demand functions for liquor (not shown) than from the demand functions for beer. Moreover, the negative liquor price elasticities are smaller in absolute value than the corresponding beer price elasticities. For these reasons, and because beer is the most popular alcoholic beverage among youths, we focus on the frequency of beer consumption in the remainder of this article.

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of price is negative, the marginal price effect (see eq. [5]) and the elasticity will be negative if

$$| \beta_{kt} | > \left| \sum_{k=1}^{3} \pi_{ik}\beta_{kt} \right|.$$

Clearly, the above inequality must hold with respect to the largest β_{kt}. Given the range of the estimated π_{ik} and the values of β_{kt} in our sample, the inequality also is satisfied with respect to the second-largest logit coefficient of price in a majority of cases.

In logit equations not shown, the real price of liquor was included in the demand functions for beer. No evidence of substitution between beer and liquor was revealed by these equations. In most cases, the cross price effect was negative (suggesting complementarity) but not significant. This finding is probably not an artifact of multicollinearity; the simple correlation coefficient between the price of beer and liquor is positive but not substantial ($r = .19$).

To evaluate the potential effect of the federal excise tax and legal drinking age policy initiatives discussed in Section I, we simulate their effects on the frequency of beer consumption by youths. Specifically, we first compute the "actual" percentage distribution of the frequency of beer consumption (four to seven times a week, one to three times a week, less than once a week, and never) by predicting the four outcome probabilities (π_{ik}) for each youth based on the logit coefficients and the actual value of each independent variable (x_{it}) for that youth (see eq. [3] and the second equation in note 43 *supra*). Next, we average each of the four outcome probabilities over all youths. Then we vary one or more of the independent variables by a certain amount, recompute each π_{ik}, and average a given probability over all youths. This gives a "new" percentage distribution.

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 beer legal drinking age equal to twenty-one for each youth in our NHANES II sample and by setting the border age variable equal to zero. The resulting distribution shows the percentage distribution of the frequency of beer consumption that would have been observed if the legal drinking age had been twenty-one throughout the period of the NHANES II survey (February 1976–February 1980).

Three federal excise tax policies are considered. The first indexes the federal excise tax on a six-pack of beer, which has been fixed at $.16 in nominal terms since 1951, to the rate of inflation since 1951. It is termed the inflation tax policy. Under it, the real price of beer in 1967 dollars faced by an NHANES II youth examined in year t becomes

$$p_t^* = [p_t - \$.16 + (\$.16) (c_{t,51})]/(c_{t,67}),\qquad(6)$$

where p_t is the actual money price faced by the youth, $c_{t,51}$ 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 six-pack of beer from $.16 to $.52 to equalize the rates at which the alcohol in beer and liquor are taxed (see note 10 *supra*). It is termed the alcohol tax equalization policy. In this simulation the real beer price is given by

$$p_t' = (p_t - \$.16 + \$.52)/(c_{t,67}).\qquad(7)$$

   The third tax policy combines the first two and is termed the combined tax policy. The real beer price is given by

$$\hat{p}_t = [p_t - \$.16 + (\$.52) \, (c_{t,51})]/(c_{t,67}). \tag{8}$$

The resulting simulation contains the percentage distribution of beer consumption that would have prevailed if the excise tax had been indexed to the rate of inflation since 1951 during the period of NHANES II and if the alcohol in beer had been taxed as heavily as the alcohol in liquor.

   Each tax policy simulation assumes that a tax increase is fully passed on to consumers or that the beer industry is competitive and has an infinitely elastic supply curve. The inflation excise tax policy causes the price of beer to rise by approximately 12 percent in the sample period. The alcohol tax equalization policy involves an 18 percent increase in price. Both policies combined amount to a substantial rise of 57 percent in the price of beer.[48] Although the price of beer rises relative to the price of liquor, our demand function estimates suggest that youths would not substitute liquor for beer. Thus, cross price effects are assumed to be zero in the simulations.

   Table 3 contains the results of the simulations. Two simulations of each policy are presented. The first is based on the beer demand function that excludes the religion variables, while the second is based on the beer demand function that includes the religion variables.

   According to panels A and B of Table 3, the number of youths who drink beer frequently (11 percent of all youths on the basis of actual values of all independent variables) or fairly frequently (28 percent of all youths, which is an average of the actual percentages in panels A and B) falls substantially in response to the enactment of a uniform legal drinking age of twenty-one in all states. To be precise, the number of frequent beer drinkers falls by 29 percent in panel A and by 27 percent in panel B. At the

   [48] The percentage increases in price pertain to the actual mean price of beer in the NHANES II sample ($1.03 per six-pack in 1967 dollars) compared to the new mean price under each of the three tax policies. 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 individual and then multiplying by the change in the policy variable at issue. Note that the actual percentage distribution of the frequency beer consumption in Table 3 differs from the corresponding "observed" distribution in Table 1. The latter contains, for example, the mean of a dichotomous variable that equals one if a youth is a frequent beer drinker. These differences emerge because a multinomial logit equation, unlike a multiple regression, does not necessarily pass through the point of means of the sample. But they are very small. In particular, the difference between an outcome probability in Table 1 and the corresponding probability in Table 3 is always less than 1 percentage point in absolute value.

TABLE 3

PREDICTED EFFECTS OF IMPOSITION OF A UNIFORM LEGAL DRINKING AGE OF TWENTY-ONE OR
INCREASE IN FEDERAL EXCISE TAX ON BEER ON FREQUENCY OF BEER CONSUMPTION

Outcome Category	Actual Percentage Distribution	New Percentage Distribution	Percentage Change in Number of Youths in Each Category[a]
A. Uniform Legal Drinking Age of 21, Religion Variables Excluded			
4–7 times a week	10.99	7.84	−28.66
1–3 times a week	27.74	23.48	−15.36
Less than once a week	18.78	18.21	−3.04
Never	42.49	50.47	+18.78
B. Uniform Legal Drinking Age of 21, Religion Variables Included			
4–7 times a week	11.43	8.40	−26.51
1–3 times a week	27.27	25.24	−7.44
Less than once a week	18.51	19.96	+7.83
Never	42.78	46.40	+8.46
C. Inflation Tax Policy, Religion Variables Excluded			
4–7 times a week	10.99	9.83	−10.56
1–3 times a week	27.74	26.15	−5.73
Less than once a week	18.78	18.81	+.16
Never	42.49	45.21	+6.40
D. Inflation Tax Policy, Religion Variables Included			
4–7 times a week	11.43	10.97	−4.02
1–3 times a week	27.27	26.00	−4.66
Less than once a week	18.51	18.06	−2.43
Never	42.78	44.97	+5.12
E. Alcohol Tax Equalization Policy, Religion Variables Excluded			
4–7 times a week	10.99	9.21	−16.20
1–3 times a week	27.74	25.27	−8.90
Less than once a week	18.78	18.80	+.11
Never	42.49	46.72	+9.96
F. Alcohol Tax Equalization Policy, Religion Variables Included			
4–7 times a week	11.43	10.70	−6.39
1–3 times a week	27.27	25.29	−7.26
Less than once a week	18.51	17.80	−3.84
Never	42.78	46.21	+8.02

TABLE 3 (*Continued*)

Outcome Category	Actual Percentage Distribution	New Percentage Distribution	Percentage Change in Number of Youths in Each Category[a]
	G. Combined Tax Policy, Religion Variables Excluded		
4–7 times a week	10.99	6.15	−44.04
1–3 times a week	27.74	20.13	−27.43
Less than once a week	18.78	18.29	−2.61
Never	42.49	55.43	+30.45
	H. Combined Tax Policy, Religion Variables Included		
4–7 times a week	11.43	9.19	−19.60
1–3 times a week	27.27	21.25	−22.08
Less than once a week	18.51	16.11	−12.97
Never	42.78	53.45	+24.94

[a] Col. 1 minus col. 2 divided by col. 1 and multiplied by 100.

same time, the number of fairly frequent beer drinkers falls by 15 percent in the former panel and by 7 percent in the latter panel. These declines imply increases in the number of youths who do not drink beer (43 percent of all youths) that range from 8 percent to 19 percent. If averages of the figures in the last columns of panels A and B are taken as "best estimates," then the drinking-age policy causes the number of youths who drink beer four to seven times a week to fall by 28 percent and the number who drink beer one to three times a week to fall by 11 percent. Simultaneously, the number of infrequent beer drinkers rises by 2 percent and the number of nonparticipants rises by 14 percent.

Either of the two excise tax policies taken alone produces smaller declines in the number of frequent or fairly frequent beer drinkers than the drinking age policy. On the basis of the best estimates (averages of the figures in the last columns of panels C and D), the inflation tax policy causes the number of youths in the former category to decline by 8 percent and the number of youths in the latter category to fall by 6 percent. The corresponding reductions under the alcohol tax equalization policy are 11 percent and 8 percent (see panels E and F).

Under the combined tax policy, the incidence of excessive drinking falls dramatically (see panels G and H). To be specific, the numbers of youths who drink beer four to seven times a week, one to three times a week, and less than once a week fall by 32 percent, 24 percent, and 8

percent, respectively.[49] Simultaneously, the number of youths who do not drink beer rises by 28 percent.

Although the combined tax policy has somewhat larger effects on the rates of frequent and fairly frequent beer consumption than the drinking age policy, it probably is more notable that both policies have sizable negative effects on these measures of beer consumption. Put differently, the negative responses are not limited to the probability of infrequent drinking. Indeed, that probability rises under the drinking age policy. It falls under the tax policy but by a smaller percentage amount than the other two probabilities. Even the absolute reduction in the infrequent drinking rate (1 percentage point on average) is smaller than the absolute reductions in the fairly frequent and frequent rates (seven percentage points and four percentage points, respectively).

IV. SUMMARY

To summarize, our results suggest that the frequency of the consumption of beer, the most popular alcoholic beverage among youths, is inversely related to the real price of beer and to the minimum legal age for its purchase and consumption. The negative price and legal drinking age effects are by no means limited to reductions in the fraction of youths who consume beer infrequently (less than once a week). Instead, the fractions of youths who consume beer fairly frequently (one to three times a week) and frequently (four to seven times a week) fall more in absolute or percentage terms than the fraction of infrequent drinkers when price or the drinking age rises. These are striking findings because frequent and fairly frequent drinkers are likely to be responsible for a large percentage of youth motor vehicle accidents and deaths.

With regard to the magnitude of the effects at issue, a federal policy that simultaneously taxes the alcohol in beer and liquor at the same rates and offsets the erosion in the real beer tax since 1951 would have reduced the number of youths who drink beer frequently (approximately 11 percent of all youths) by 32 percent during the period of NHANES II and would have reduced the number of fairly frequent beer drinkers (approximately 28 percent of all youths) by 24 percent. The enactment of a minimum uniform drinking age of twenty-one in all states would have reduced the number of frequent drinkers by 28 percent and the number of fairly frequent drinkers by 11 percent. These figures suggest that, if reductions in

[49] Although the elasticity of the probability of infrequent beer consumption with respect to the real price of beer is positive, the probability of infrequent beer drinking falls as the excise tax rises. This is because the probability of infrequent drinking is not a monotonically increasing function of price (see eq. [5]).

youth alcohol use and abuse 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.[50] They also suggest that the tax policy may be more potent than the drinking age policy.

It does not follow that we have provided enough evidence to justify the approximately eightfold (thirteenfold on the basis of the 1984 CPI) increase in the federal excise tax on beer that serves as the basis of the above computations. 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, an excise tax increase may reduce excessive alcohol consumption by adults as well as by youths. Of course, a substantial tax hike may stimulate the demand for illegally produced beer, suggesting that we have overestimated the effect of an eightfold increase in the federal excise tax on beer unless the legal and illegal prices are the same.

Finally, Becker has shown that the optimal way for a society to deter offenses is via a system of severe and fairly certain punishments.[51] 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 of 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. Moreover, severe and certain punishments for drunk driving do not address the problems caused by the link between youth alcohol abuse and adult alcohol abuse. In conclusion, more research is required to formulate the best mix of policies to deal with youth alcohol abuse. Our study represents a useful first step in this process.

[50] Some caution should be exercised in applying the results of the drinking age simulation to the Federal Uniform Drinking Age Act because the mean legal drinking age was closer to twenty in July 1984 than to the NHANES II mean of nineteen. 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 twenty-one is not a fait accompli given the adverse reaction to the Federal Uniform Drinking Age Act. Therefore, the figures given above probably are reasonable to use in a long-term evaluation of the drinking age policy.

[51] Gary S. 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.