

# DO YOUTHS SUBSTITUTE ALCOHOL AND MARIJUANA? SOME ECONOMETRIC EVIDENCE

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## INTRODUCTION

Youth alcohol use and abuse have been a focus of government policy since the mid 1970s. When the voting age was lowered to 18 years, several states subsequently lowered minimum legal drinking ages. The consequent increase in youth alcohol abuse, particularly in drinking and driving, led states to rethink this policy. In 1984, the federal government became involved by enacting the Federal Uniform Drinking Age Act. This act required states to raise all legal drinking ages to 21 years or lose part of their federal highway funding. All states complied by 1988. The higher drinking ages succeeded in reducing youth alcohol use [Coate and Grossman, 1988; Saffer and Grossman, 1987]. However, drinking, heavy drinking, drunken driving, and other measures of youth alcohol abuse remain stubbornly high.

Three recent studies suggest that part of the reason for the persistently high level of youth drinking may be the success of the "War on Drugs." DiNardo and Lemieux [1992] use annual state level measures of marijuana and alcohol use from the 1980 through 1989 Monitoring the Future (MTF) surveys of high school seniors to examine the impact of higher legal drinking ages. They find that the higher drinking ages reduced youth alcohol consumption, as expected. However, they find that lower alcohol consumption was accompanied by an almost one-for-one increase in marijuana consumption. They conclude that this unintended consequence is attributable to standard substitution effects. In two studies, Model looks at the effects of marijuana decriminalization on drug related hospital emergency room episodes, [1993] and violent crime [1991]. Based on the hospital data, she concludes that marijuana decriminalization induces substitution away from alcohol and illegal drugs towards marijuana. She finds that emergency episodes related to marijuana use are higher in states which have decriminalized, while those related to alcohol and other illegal drug use are lower. Similarly, she finds that lower violent crime rates, particularly homicide rates, are associated with marijuana decriminalization. Since many of these are alcohol related, she attributes the lower crime rates in decriminalized states to substitution away from alcohol toward marijuana.

Others, however, have found that marijuana decriminalization has little impact on youth marijuana, and in some cases alcohol, use. Johnston, O'Malley, and Bachman [1981], using the 1975 through 1980 MTF surveys and their followups, find that marijuana use and attitudes towards marijuana among youths and young adults are little changed after decriminalization in the seven states which decriminalized marijuana during their sample. Similarly, Thies and Register [1993] and Pacula [1994], using data from the National Longitudinal Survey of Youth generally find no significant impact of decriminalization on marijuana use by young adults. Moreover, both papers look at the impact of marijuana decriminalization and various other drug and alcohol control measures on alcohol use by young adults (Thies and Register also examine cocaine use). Thies and Register find weak support for substitution between alcohol and marijuana, while Pacula finds evidence of complementarity.

This paper adds to the limited economic literature addressing the question of substitution between marijuana and alcohol. Youth drinking and heavy drinking, taken from the 1982 and 1989 MTF surveys, are estimated as functions of the price of alcohol, legal drinking ages, and the price of marijuana. In addition, the probability of a non-fatal youth traffic accident, an outcome related to both alcohol and drug abuse, is estimated. Finally, state level youth motor vehicle accident rates are examined using data from the Fatal Accident Reporting System (FARS).

## YOUTH ALCOHOL CONSUMPTION

### *Analytical Framework*

An individual's utility at any time is assumed to be a function of that person's level of "intoxication" ( $I$ ), as well as a composite of other consumption goods ( $X$ ), based on Siegel's [1989] hypothesis that individuals consume drugs and alcohol in an attempt at mood alteration:

$$(1) \quad U = u(I, X), \quad \text{where } u_i > 0 \text{ and } u_{ii} < 0, \quad I = I, X.$$

Intoxication is produced by consuming alcohol ( $A$ ), marijuana ( $M$ ), and/or other drugs ( $D$ ) each of which have positive but diminishing marginal productivity:

$$(2) \quad I = I(A, M, D).$$

Maximizing utility, subject to the intoxication production function and an appropriate budget constraint yields the demands for alcohol, marijuana, and other drugs:

$$(3) \quad A = A(P_A, P_M, P_D, P_X, Y, Z),$$

$$(4) \quad M = M(P_M, P_A, P_D, P_X, Y, Z), \text{ and:}$$

$$(5) \quad D = D(P_D, P_A, P_M, P_X, Y, Z),$$

where  $P_A$ ,  $P_M$ ,  $P_D$ , and  $P_X$  are the prices of alcohol, marijuana, other drugs, and other goods, respectively,  $Y$  represents the youth's income, and  $Z$  is a vector which captures the youth's tastes and productive efficiency.

### *Data*

Alternative versions of equation (3) are estimated below using data from the 1982 and 1989 MTF surveys of high school seniors. These surveys, described in detail by Johnston, O'Malley and Bachman [1987], focus on the use of illegal drugs, alcohol, and cigarettes, and are conducted in the spring of the youth's senior year. Parents were not present during the interviews and were not informed about the responses of their children. By special agreement, variables measuring youth alcohol consumption were made available as part of a restricted data set which includes identifiers for each youth's county of residence.<sup>1</sup> In addition, a variety of socioeconomic and demographic information was provided.

Three measures of youth alcohol consumption were constructed from the categorical data contained in the surveys. The first measures the frequency of alcohol consumption in the previous year and is defined as follows: zero for abstainers (no drinking occasions in the past year); one for infrequent drinkers (1-9 drinking occasions); two for fairly frequent drinkers (10-39 drinking occasions); and three for frequent drinkers (40 or more drinking occasions). The second captures drinking in the past 30 days, and is defined comparably for abstainers (no drinking occasions), infrequent drinkers (1 to 5 drinking occasions), fairly frequent drinkers (6 to 9 drinking occasions), and frequent drinkers (10 or more drinking occasions). The final drinking variable is an indicator of heavy drinking and is defined as one if the youth had at least one drinking occasion in the two weeks prior to the survey in which he/she consumed five or more drinks, and is zero otherwise.

The alcoholic beverage prices are taken from the quarterly reports of the American Chamber of Commerce Researchers Association (ACCRA). The ACCRA surveys between 200 and 300 cities quarterly, collecting information on the prices of a number of consumer goods, including beer, wine, and distilled spirits.<sup>2</sup> In addition, the ACCRA constructs a city-specific cost-of-living index for each of the cities in its quarterly reports. The results presented below use the price of beer as the measure of alcoholic beverage prices. The beer price is chosen since beer is the most heavily consumed alcoholic beverage and because beer is the beverage of choice among youths.<sup>3</sup> The ACCRA beer price and city-specific cost-of-living index are matched to the surveys by county in each of the first two quarters of 1982 and 1989.<sup>4</sup> Similarly, the quarterly national Consumer Price Index for the first two quarters of 1982 and 1989 is added to the survey data. Real prices are obtained by deflating alcoholic beverage prices by both the national CPI and the ACCRA cost-of-living index and then taking the simple average of the real prices for the first and second quarters.

The minimum legal drinking age for low alcohol beer is added as an additional measure of the full price of alcohol.<sup>5</sup> While almost all respondents are below 18, and thus unable to legally purchase alcoholic beverages in any state, youths in states with

higher minimum ages will face greater difficulty in obtaining alcoholic beverages than those in states where the legal age is lower. In addition, an indicator equal to one for youths residing within 25 miles of a state with a lower legal age is added. This variable captures potential border crossing by youths from high age states to nearby lower age states to obtain alcohol.<sup>6</sup>

Two variables are added to capture the full price of marijuana. The first is a dichotomous indicator equal to one for youths residing in a state where marijuana possession is decriminalized and equal to zero otherwise. While possession and use of marijuana are not legal in decriminalized states, expected penalties are generally below those in states where marijuana remains criminalized. Thus, marijuana consumption is expected to be higher in states which have decriminalized. If marijuana and alcohol are substitutes for one another, then youths residing in decriminalized states are expected to drink less than youths in states where penalties for marijuana possession remains criminalized.

The second variable is a measure of the money price of marijuana. These data come from the Drug Enforcement Agency's System to Retrieve Information from Drug Evidence (STRIDE) database. Prices for both commercial grade marijuana (which dominates U.S. markets) and sinsemilla (a more potent strain) are reported at both the wholesale and retail levels. The wholesale prices are reported in dollars per pound, while the retail prices are reported in dollars per ounce.

There are several obstacles to using the marijuana price data in this research. First, prices are reported for at most 19 major metropolitan areas. To match the price data to the survey data, the following strategy was employed: if the youth resides in a county containing a city in the STRIDE database, then the price in that city is used (this is considered a "perfect" match); if there is no "perfect" match, then the price in the nearest STRIDE city to the youth's county of residence is used. Three levels of quality are defined: a "border" match is one where the STRIDE city is in a county which borders on the youth's county of residence and is in the same state; a "state" match is one where the price is for a city within the same state but is not a "perfect" or "border" match; and a "poor" match is one where the price comes from a city in another state (where quality is defined at two levels — a "nearby" match if the STRIDE city is within 50 miles of the youth's county of residence and the "poorest" match is for STRIDE cities more than 50 miles from the youth's county of residence).

A second problem with the price data is that they are available only for the fourth quarters of 1988 and 1989. Price data for 1982 were not available in the data graciously provided by Paul Taubman for this research. Thus, all equations estimated which include marijuana prices use only the 1989 cross-section (or a subsample). A simple average of the 1988 and 1989 fourth quarter prices is used as the price of marijuana for the 1989 sample (surveyed in the spring of 1989).<sup>7</sup>

A third problem is that the price data are reported as a range of values rather than as a single value. For example, the 1988 fourth quarter national average price of commercial grade marijuana at the wholesale level is reported as \$350-\$1,800. While the ranges reported for the city-specific prices are somewhat narrower, there is still a large range of prices reported for each city. The results presented in this paper use the midpoint of the range reported in the STRIDE data as the price of marijuana.<sup>8</sup>

There is clearly measurement error in the marijuana money price data. For example, the four price measures should be highly correlated, since each is likely to be related to drug enforcement efforts and other factors which would be expected to influence price. It is reassuring to note that the correlation between the wholesale prices for commercial grade and sinsemilla marijuana is 0.45, while the correlation between the wholesale and retail prices of commercial grade marijuana is also 0.45. However, the correlation between the two retail marijuana prices is only 0.15, while the correlation between the wholesale and retail prices of sinsemilla is -0.002.<sup>9</sup> This suggests that the retail sinsemilla price may be measured with the most error, since it is neither correlated with its own wholesale price nor with the retail price of commercial grade marijuana.

Several variables were constructed from the socioeconomic and demographic information collected in the surveys, including: indicators of gender, race (black and other), religious participation (infrequent and frequent attendance), and work status (part-time and full-time); continuous measures of age and real weekly income (nominal weekly income data deflated by the local cost-of-living index and the national CPI) and, finally, in all equations using the pooled 1982 and 1989 sample, a dichotomous indicator for those surveyed in 1982 is included.

### **Results**

Ordered probit estimates for the frequency of alcohol consumption in the past year and in the past thirty days are presented in columns 1 and 2, respectively, of Tables 1 and 2. Dichotomous probit estimates for the probability of at least one heavy drinking incident in the past two weeks are shown in column 3. Panel A of Table 1 presents estimates using the combined 1982 and 1989 sample for equations which exclude the money price of marijuana. Table 2 presents estimates using the 1989 sample only of equations which include each of the four alternative marijuana money prices in Panels A through D.<sup>10</sup> Panel B of Table 1, for comparison purposes, contains estimates of equations excluding the money price of marijuana for the 1989 sample. Each table presents the coefficient estimates for beer prices, the minimum legal drinking age, the border age indicator (pooled sample only), the indicator of marijuana decriminalization, and, where included, the money price of marijuana.<sup>11</sup>

The beer price coefficient is negative and significant at the ten percent significance level or better in nearly every estimated equation. The only exceptions are some of the equations for the 1989 sample which include the wholesale sinsemilla price. In general, these results are consistent with the literature describing the negative relationship between youth alcohol consumption and alcohol prices [Grossman, et al., 1994]. Furthermore, these estimates indicate that the effects of price are not limited to infrequent drinkers. This is clearly shown by the negative significant coefficients estimated for the beer price in the probability of heavy drinking equations. The negative and significant estimates obtained for price in the frequency of drinking equations indicate that an increase in the beer price reduces the number of youths in the most frequent drinking categories (40 or more occasions in the past year or ten or more occasions in the past month). Similarly, these estimates imply that the number

**TABLE 1**  
**Ordered and Dichotomous Probit Estimates of Drinking Frequency**  
**Beer Prices, Drinking Ages, and Marijuana Decriminalization<sup>a</sup>**

Variable	Drinking in the Past Year	Drinking in the Past Month	Heavy Drinking in the Past Two Weeks
Panel A: Pooled Sample			
Beer Price	-11.085 (-5.24)	-8.832 (-4.06)	-4.783 (-1.84)
Minimum Legal Drinking Age	-0.009 (-1.10)	-0.018 (-2.24)	-0.011 (-1.10)
Lower Border Age	0.159 (6.86)	0.133 (5.68)	0.108 (3.90)
Marijuana Decriminalization	-0.071 (-4.59)	-0.096 (-6.06)	-0.111 (-5.82)
Panel B: 1989 Sample			
Beer Price	-10.507 (-3.78)	-8.737 (-3.04)	-8.444 (-2.45)
Minimum Legal Drinking Age	-0.202 (-3.05)	-0.197 (-2.89)	-0.174 (-2.16)
Marijuana Decriminalization	-0.073 (-3.22)	-0.084 (-3.60)	-0.088 (-3.16)

a. Asymptotic t-ratios are in parentheses. The critical values for the t-ratios are 2.58 (2.33), 1.96 (1.64), and 1.64 (1.28) at the one, five, and ten percent significance levels respectively, based on a two-tailed (one-tailed) test. All equations, based on a Chi-square test of  $-2 \times \log$ -likelihood ratio are significant at the one percent significance level. The sample sizes are 25,340 for the pooled sample and 12,597 for the 1989 sample. All equations include variables reflecting gender, race, religious participation, work status, age, real weekly income, and intercepts. In addition, the pooled sample includes a dichotomous indicator for those surveyed in 1982.

of youths who do not drink rises in response to an increase in beer prices. However, no clear conclusions for the number of infrequent or fairly frequent drinkers can be drawn directly from the estimates (for example, while some fairly frequent drinkers will reduce consumption in response to the price increase, some formerly frequent drinkers may end up as fairly frequent drinkers, leaving the net effect unclear). The results from the policy simulations presented in the next section shed some light on the impact of prices on these groups.

Similarly, the impact of a higher minimum legal drinking age on both the frequency of alcohol consumption and the probability of heavy drinking is negative and significant while the indicator for youths near a state with a lower legal age is positive and highly significant as expected. These estimates imply that higher minimum legal drinking ages raise the "cost" to youths of obtaining alcohol and, consequently, reduce both the frequency of youth drinking and the probability of heavy drinking among youths. However, states which raise their own drinking ages above those in nearby states (as happened throughout the late 1970s and early 1980s) can expect at least some young residents to leave the state to obtain alcohol. Thus, while overall

**TABLE 2**  
**Ordered and Dichotomous Probit Estimates of Drinking Frequency,  
 Beer and Marijuana Prices, Drinking Ages, and Marijuana Decriminaliza-  
 tion, 1989 Sample<sup>a</sup>**

Variable	Drinking in the Past Year	Drinking in the Past Month	Heavy Drinking in the Past Two Weeks
Panel A: Wholesale Commercial Grade Marijuana Price			
Beer Price	-8.281 (-2.95)	-6.622 (-2.28)	-5.635 (-1.62)
Minimum Legal	-0.152	-0.152	-0.117
Drinking Age	(-2.28)	(-2.20)	(-1.43)
Marijuana	-0.052	-0.065	-0.064
Decriminalization	(-2.29)	(-2.74)	(-2.27)
Marijuana Price	0.0003 (5.83)	0.0002 (5.25)	0.0003 (5.59)
Panel B: Wholesale Sinsemilla Marijuana Price			
Beer Price	-5.022 (-1.61)	-1.578 (-0.49)	1.360 (0.35)
Minimum Legal	-0.203	-0.201	-0.180
Drinking Age	(-3.07)	(-2.94)	(-2.22)
Marijuana	-0.095	-0.113	-0.129
Decriminalization	(-4.07)	(-4.70)	(-4.47)
Marijuana Price	0.0001 (3.91)	0.0001 (4.92)	0.0002 (5.55)
Panel C: Retail Commercial Grade Marijuana Price			
Beer Price	-10.355 (-3.70)	-9.063 (-3.13)	-9.221 (-2.67)
Minimum Legal	-0.087	-0.074	-0.013
Drinking Age	(-1.24)	(-1.02)	(-0.16)
Marijuana	0.015	0.014	0.034
Decriminalization	(0.54)	(0.47)	(0.97)
Marijuana Price	0.0001 (0.22)	0.001 (2.08)	0.002 (3.13)
Panel D Retail Sinsemilla Marijuana Price			
Beer Price	-9.544 (-3.35)	-8.196 (-2.79)	-8.121 (-2.32)
Minimum Legal	-0.150	-0.150	-0.134
Drinking Age	(-2.24)	(-2.16)	(-1.62)
Marijuana	-0.042	-0.053	-0.065
Decriminalization	(-1.67)	(-2.05)	(-2.09)
Marijuana Price	-0.001 (-3.93)	-0.001 (-3.69)	-0.001 (-2.54)

a. Asymptotic t-ratios are in parentheses. The critical values for the t-ratios are 2.58 (2.33), 1.96 (1.64), and 1.64 (1.28) at the one, five, and ten percent significance levels respectively, based on a two-tailed (one-tailed) test. All equations, based on a Chi-square test of  $-2 \times \log$ -likelihood ratio are significant at the one percent significance level. The sample size is 12,597. All equations include variables reflecting gender, race, religious participation, work status, age, real weekly income, and intercepts.

youth alcohol consumption falls as the result of higher drinking ages, drinking and driving by youths may actually rise when differences between own and nearby state drinking ages increase. This potential consequence was eliminated when all states raised their legal ages to 21 years to comply with the Uniform Drinking Age Act.

The indicator for marijuana decriminalization is negative and significant at the one percent significance level in all equations using this variable as the only measure of the full price of marijuana. Similarly, in the equations for the 1989 sample which also include a measure of the money price of marijuana, the decriminalization indicator is negative, albeit somewhat less significant in some equations, with the exception of those equations which use the retail price of commercial grade marijuana, where it is positive but insignificant. These estimates imply that youths residing in states where marijuana is decriminalized consume alcohol less frequently and are less likely to engage in heavy drinking than those in states where marijuana possession is criminalized. This suggests that, at least for high school seniors, alcohol and marijuana are substitutes for one another. This is consistent with DiNardo and Lemieux's [1992] finding that increases in the price of alcohol (as captured by higher legal drinking ages) led to higher marijuana consumption among high school seniors. This does not, however, discredit the hypothesis that alcohol is a gateway drug, and that frequent and/or heavy drinking increases the likelihood of marijuana use (intertemporal complementarity). Indeed, a large psychosocial literature finds that drug use progresses from tobacco and alcohol to marijuana and, in some cases, more dangerous illegal drugs [Kandel, Kessler, and Margulies, 1978; O'Donnell and Clayton, 1982; and Yamaguchi and Kandel, 1984]. Instead, this finding implies that high school seniors, most of whom initiated their alcohol and drug use several years earlier, treat alcohol and marijuana as substitutes for one another.

This conclusion is generally supported by the coefficients obtained for the marijuana prices. Positive and highly significant coefficients are obtained for the wholesale price of marijuana (both commercial grade and sinsemilla). The findings for retail marijuana prices are mixed. The coefficients for the retail price of commercial grade marijuana are always positive and generally significant, except in the frequency of drinking in the past year equations where they are positive but insignificant. Retail sinsemilla prices, however, are estimated to have a negative and generally significant impact on alcohol consumption. The findings for both wholesale prices and for the retail price of commercial grade marijuana can be viewed as more reliable for two reasons: first, the retail price of sinsemilla appears to be subject to the most measurement error, as discussed above; and, second, sinsemilla is a much higher priced strain of marijuana which constitutes a small part of the market making it less likely to be used by youths.<sup>12</sup>

### *Policy Simulations*

As mentioned above, it is difficult to use the ordered probit coefficients to interpret the effects of changes in the policy variables on the frequency of drinking. While the coefficients provide some information, particularly for the top (frequent drinkers) and bottom (abstainers) categories, the marginal effect of the variable on each cat-

egory is more useful. Table 3 presents simulation results using the marginal effects to evaluate the impact of changes in policies on the frequency of drinking and the probability of heavy drinking by youths. Each of the cells in Table 3 indicates the percentage change in the number of respondents predicted to fall into each of the categories as a result of the simulated change in policy. Panel A of Table 3 contains simulation results for the pooled sample, while Panel B contains those for the 1989 sample. Panels B.1, B.2, B.3, B.4, and B.5 present the results for no marijuana price, the wholesale commercial grade price, the wholesale sinsemilla price, the retail commercial grade price, and the retail sinsemilla price, respectively. These simulation results are based on the coefficients presented in Tables 1 and 2.

Four alternative policy changes are simulated. The first increases the federal excise tax on beer to offset the effects of inflation since 1951 (a 17.1 percent increase in price in the pooled sample and about an 18 percent increase in the 1989 sample, assuming the tax increase is fully passed on to consumers). The second simulates the impact of marijuana criminalization in every state while the third considers marijuana decriminalization in all states. Finally, the fourth examines the impact of a reduction in the price of marijuana comparable to the increase in the price of beer associated with the tax increase described above (that is, the price of marijuana is assumed to fall by 18 percent). This provides some comparison between the relative responsiveness of young drinkers to changes in beer prices and marijuana prices.

An increase in the beer tax significantly increases the number of youths who abstain while the number of frequent drinkers or heavy drinkers falls sharply. For example, in the pooled sample, increasing the federal tax with inflation since 1951 raises the numbers of abstainers in the past year and past month by 8.42 percent and 4.35 percent, respectively, while reducing the comparable numbers of frequent drinkers by 7.49 percent and 6.57 percent. The numbers of fairly frequent drinkers in either the past year or past month also fall as a result of this policy. However, the number of infrequent drinkers in the past year rises by 2.15 percent while the number of infrequent drinkers in the past month falls slightly. Finally, the probability of a heavy drinking episode falls by 2.28 percent in response to the large price increase induced by the tax change. This confirms the findings of other studies [Grossman, Coate and Arluck, 1987; Coate and Grossman, 1988] which find that the impact of increases in alcoholic beverage excise taxes are not limited to infrequent drinkers, but that frequent drinkers are responsive to price changes as well.

As discussed above, these estimates generally imply that, at least for high school seniors, marijuana and alcohol are substitutes. The simulation results provide some evidence on the strength of this relationship. Based on the results from the pooled sample, for example, moving from a policy where marijuana is criminalized everywhere to one where marijuana is decriminalized everywhere would increase the number of abstainers in the past year by nearly 12 percent, while reducing the number of frequent drinkers in the past year by almost 11 percent. The number of infrequent drinkers would rise by about three percent, while the number of fairly frequent drinkers would fall by almost four percent. Likewise, the probability of a heavy drinking episode would fall sharply, by approximately 11.55 percent.

**TABLE 3**  
**Policy Simulations: Drinking Frequency and**  
**the Probability of Heavy Drinking<sup>a</sup>**

Policy Simulation	Drinking in the Past Year	Drinking in the Past Month	Heavy Drinking in the Past Two Weeks
Panel A: Pooled Sample			
Inflation Tax Policy			
Abstainers	+8.42%	+4.35%	
Infrequent Drinkers	+2.15%	-0.65%	+1.25%
Fairly Frequent Drinkers	-2.71%	-3.78%	
Frequent (Heavy) Drinkers	-7.49%	-6.57%	-2.28%
Nationwide Criminalization			
Abstainers	-3.44%	-3.11%	
Infrequent Drinkers	-0.97%	+0.38%	-1.93%
Fairly Frequent Drinkers	+1.10%	+2.74%	
Frequent (Heavy) Drinkers	+3.35%	+4.45%	+3.53%
Nationwide Decriminalization			
Abstainers	+8.31%	+7.36%	
Infrequent Drinkers	+2.13%	-1.17%	+4.38%
Fairly Frequent Drinkers	-2.67%	-6.37%	
Frequent (Heavy) Drinkers	-7.39%	-10.85%	-8.02%
Panel B1: 1989 Sample, No Marijuana Price			
Inflation Tax Policy			
Abstainers	+7.68%	+3.97%	
Infrequent Drinkers	+1.54%	-1.14%	+2.01%
Fairly Frequent Drinkers	-3.20%	-4.27%	
Frequent (Heavy) Drinkers	-7.69%	-6.94%	-4.35%
Nationwide Criminalization			
Abstainers	-3.29%	-2.42%	
Infrequent Drinkers	-0.74%	+0.64%	-1.37%
Fairly Frequent Drinkers	+1.38%	+2.64%	
Frequent (Heavy) Drinkers	+3.55%	+4.45%	+2.96%
Nationwide Decriminalization			
Abstainers	+8.10%	+5.85%	
Infrequent Drinkers	+1.62%	-1.72%	+3.19%
Fairly Frequent Drinkers	-3.37%	-6.24%	
Frequent (Heavy) Drinkers	-8.09%	-10.03%	-6.89%
Panel B2: 1989 Sample, Wholesale Commercial Price			
Inflation Tax Policy			
Abstainers	+6.02%	+3.01%	
Infrequent Drinkers	+1.23%	-0.85%	+1.35%
Fairly Frequent Drinkers	-2.51%	-3.25%	
Frequent (Heavy) Drinkers	-6.11%	-5.30%	-2.92%

**TABLE 3 (Cont.)**  
**Policy Simulations: Drinking Frequency and**  
**the Probability of Heavy Drinking<sup>a</sup>**

<b>Policy Simulation</b>	<b>Drinking in the Past Year</b>	<b>Drinking in the Past Month</b>	<b>Heavy Drinking in the Past Two Weeks</b>
<b>Nationwide Criminalization</b>			
Abstainers	-2.37%	-1.87%	-1.35%
Infrequent Drinkers	-0.53%	+0.50%	
Fairly Frequent Drinkers	+0.99%	+2.04%	
Frequent (Heavy) Drinkers	+2.54%	+3.42%	+2.92%
<b>Nationwide Decriminalization</b>			
Abstainers	+5.78%	+4.50%	+2.33%
Infrequent Drinkers	+1.19%	-1.30%	
Fairly Frequent Drinkers	-2.42%	-4.83%	
Frequent (Heavy) Drinkers	-5.87%	-7.81%	-5.05%
<b>Marijuana Price Reduction</b>			
Abstainers	+6.83%	+3.98%	+2.65%
Infrequent Drinkers	+1.39%	-1.14%	
Fairly Frequent Drinkers	-2.85%	-4.28%	
Frequent (Heavy) Drinkers	-6.89%	-6.95%	-5.74%
<b>Panel B3: 1989 Sample, Wholesale Sinsemilla Price</b>			
<b>Inflation Tax Policy</b>			
Abstainers	+3.59%	+0.71%	-0.33%
Infrequent Drinkers	+0.72%	-0.20%	
Fairly Frequent Drinkers	-1.56%	-0.77%	
Frequent (Heavy) Drinkers	-3.77%	-1.28%	+0.71%
<b>Nationwide Criminalization</b>			
Abstainers	-4.22%	-3.27%	-2.01%
Infrequent Drinkers	-0.92%	+0.85%	
Fairly Frequent Drinkers	+1.85%	+3.57%	
Frequent (Heavy) Drinkers	+4.69%	+6.05%	+4.35%
<b>Nationwide Decriminalization</b>			
Abstainers	+10.50%	+7.88%	+4.62%
Infrequent Drinkers	+1.94%	-2.38%	
Fairly Frequent Drinkers	-4.54%	-8.42%	
Frequent (Heavy) Drinkers	-10.54%	-13.36%	-10.01%
<b>Marijuana Price Reduction</b>			
Abstainers	+4.81%	+3.97%	+2.79%
Infrequent Drinkers	+0.95%	-1.14%	
Fairly Frequent Drinkers	-2.09%	-4.28%	
Frequent (Heavy) Drinkers	-5.01%	-6.95%	-6.04%

**TABLE 3 (Cont.)**  
**Policy Simulations: Drinking Frequency and**  
**the Probability of Heavy Drinking<sup>a</sup>**

Policy Simulation	Drinking in the Past Year	Drinking in the Past Month	Heavy Drinking in the Past Two Weeks
Panel B4: 1989 Sample, Retail Commercial Price			
Inflation Tax Policy			
Abstainers	+7.72%	+5.04%	+2.29%
Infrequent Drinkers	+1.65%	-0.10%	
Fairly Frequent Drinkers	-3.04%	-3.29%	
Frequent (Heavy) Drinkers	-7.52%	-6.28%	-4.66%
Nationwide Criminalization			
Abstainers	+0.57%	+0.38%	+0.43%
Infrequent Drinkers	+0.13%	+0.00%	
Fairly Frequent Drinkers	-0.22%	-0.25%	
Frequent (Heavy) Drinkers	-0.58%	-0.50%	-0.88%
Nationwide Decriminalization			
Abstainers	-1.81%	-1.23%	-1.40%
Infrequent Drinkers	-0.42%	+0.00%	
Fairly Frequent Drinkers	+0.72%	+0.80%	
Frequent (Heavy) Drinkers	+1.88%	+1.59%	+2.84%
Marijuana Price Reduction			
Abstainers	+0.31%	+2.24%	+1.81%
Infrequent Drinkers	+0.07%	-0.03%	
Fairly Frequent Drinkers	-0.12%	-1.46%	
Frequent (Heavy) Drinkers	-0.31%	-2.84%	-3.69%
Panel B5: 1989 Sample, Retail Sinsemilla Price			
Inflation Tax Policy			
Abstainers	+7.02%	+3.77%	+1.98%
Infrequent Drinkers	+1.51%	-0.98%	
Fairly Frequent Drinkers	-2.78%	-3.91%	
Frequent (Heavy) Drinkers	-6.90%	-6.43%	-4.10%
Nationwide Criminalization			
Abstainers	-2.07%	-1.68%	-1.11%
Infrequent Drinkers	-0.49%	+0.40%	
Fairly Frequent Drinkers	+0.82%	+1.76%	
Frequent (Heavy) Drinkers	+2.17%	+2.99%	+2.30%
Nationwide Decriminalization			
Abstainers	+4.58%	+3.65%	+2.35%
Infrequent Drinkers	+1.01%	-0.95%	
Fairly Frequent Drinkers	-1.82%	-3.79%	
Frequent (Heavy) Drinkers	-4.57%	-6.23%	-4.89%
Marijuana Price Reduction			
Abstainers	-5.32%	-3.49%	-1.49%
Infrequent Drinkers	-1.30%	+0.78%	
Fairly Frequent Drinkers	+2.12%	+3.52%	
Frequent (Heavy) Drinkers	+5.71%	+6.03%	+3.10%

a. Simulation results are based on the estimates in Tables 1 and 2.

Finally, as shown by most of the estimated marijuana price coefficients, a drop in the price of marijuana reduces alcohol consumption, implying that youths are substituting the two substances. For example, looking at the changes in drinking in the past month induced by changes in beer prices and in the retail price of commercial grade marijuana (perhaps the most appropriate price measure for youths), one finds that an 18 percent increase in the beer price would reduce the number of frequent drinkers by 6.28 percent while the comparable marijuana price reduction would reduce the number of frequent drinkers by 2.84 percent. Similarly the number of abstainers in the past month is predicted to rise by 5.04 percent and 2.24 percent for the changes in beer prices and marijuana prices, respectively. These estimates suggest that the responsiveness of youth drinking to a decline in marijuana prices is almost half that resulting from an increase in beer prices. Other models predict an even larger cross price effect. The next section considers the effects of this substitution on one of the consequences of substance use among youths, driving under the influence of alcohol and/or drugs.

## DRIVING UNDER THE INFLUENCE OF DRUGS AND/OR ALCOHOL

### *Analytical Framework*

The underlying model which provides the basis for the empirical analysis of youth driving under the influence consists of several equations. The first is a technical relationship in which the probability that a youth is involved in an accident,  $p$ , is positively related to his/her intoxication while driving, as well as to a vector of additional variables ( $\mathbf{H}$ ) reflecting roadway, traffic, and motor vehicle conditions:

$$(6) \quad p = p(I, \mathbf{H}).$$

As described in equation (2) above, intoxication is produced by consuming alcohol marijuana, and/or other drugs. Substituting equation (2) into equation (6) yields a production function in which the probability of an accident (fatal accident) depends positively on the consumption of alcohol, marijuana, and other drugs:

$$(7) \quad p = p(A, M, D, \mathbf{H}).$$

Finally, a reduced form probability of an accident (fatal accident) equation is obtained by substituting the demands for alcohol, marijuana, and other drugs equations (3), (4), and (5) above, into equation (7):

$$(8) \quad p = p(P_A, P_M, P_D, P_X, Y, Z, \mathbf{H}).$$

Two versions of equation (8) are estimated. The first uses the MTF data to examine the probability that a youth is involved in a least one non-fatal traffic accident in the previous year. In the second, the reduced form equation is aggregated over youths in each state in each year. The result is an empirically estimable equation where the

probability of a fatal youth motor vehicle accident is measured by the observed youth motor vehicle accident fatality rate. Both overall and alcohol related youth fatality rates, constructed from the FARS, are examined.

A reduction in the full price of marijuana (as the result of a state decriminalizing marijuana, for example) is expected to cause an increase in marijuana consumption, which, holding alcohol consumption constant, will lead to more driving while intoxicated and more youth accidents and fatal accidents. However, based on the youth alcohol demand equations estimated above, reductions in the full price of marijuana lead to reductions in alcohol consumption as well. The reduced alcohol consumption results in less drinking and driving and, hence, fewer alcohol related accidents and fatal accidents. Thus, the overall impact of a drop in marijuana prices on the probability of an accident (fatal accident) depends not only on the increased marijuana consumption it induces, but on the substitution away from alcohol which results. Finally, the net effect will also depend on the relative risks associated with drunk driving compared to "stoned" driving. For example, Stein [1983] and Robbe and O'Hanlon [1993] find that drivers using marijuana drive more slowly and more cautiously, suggesting a lower probability of a fatal accident. Others, including Hansteen, et al. [1976] and Moskowitz, et al. [1976] find that marijuana use does not produce the same level of driving impairment resulting from moderate alcohol use, suggesting a lower probability of a non-fatal accident.

### *Data*

To look at the impact of alcohol and marijuana prices on the probability of a non-fatal motor vehicle accident among youths, the 1982 and 1989 surveys of high school seniors described above are used. The dependent variable in these equations is a dichotomous variable equal to one if the youth reports driving during at least one motor vehicle accident in the past year (regardless of responsibility), and is equal to zero otherwise.<sup>13</sup> The independent variables included in this equation are identical to those included in the alcohol demand equations described above.

A pooled time-series of annual state cross-sections for the 48 contiguous states of the U.S. covering the years from 1975 through 1988 is used to examine the effects of alcohol and marijuana prices on the probability of a fatal youth motor vehicle accident. Motor vehicle accident fatality rates are a commonly used empirical measure of intoxicated driving. While not all motor vehicle fatalities are the results of drunk and/or "drugged" driving, there is a strong correlation between the two measures. During this time period, the National Highway Traffic Safety Administration (NHTSA) estimates that alcohol was involved in over half of these deaths, and that this percentage is much higher for people under the age of 25. Owens, et al. [1983] and Johnson and White [1989] conclude that marijuana use plays a role in at least some motor vehicle accident fatalities.

Three alternative fatality rates, based on the information contained in the NHTSA's Fatal Accident Reporting System (FARS) database are constructed for 18-through-20-year-olds, and for 15-through-24-year-olds. The first is the total fatality rate for

the two age categories. While this certainly includes non-intoxicated fatalities, it is a useful measure for examining the overall impacts of policies related to drug and alcohol use. The two remaining fatality measures are limited to drivers only and are constructed in an attempt to focus on intoxicated drivers. The first driver specific fatality rate is limited to deaths which occur between 12:00 a.m. and 3:59 a.m. and is called the night driver fatality rate. The NHTSA estimates that 75-90 percent of these drivers had been drinking prior to their deaths. It is suspected that a large number of these drivers may also have been using illegal drugs (either with or without alcohol). The final fatality rate is an estimated alcohol involved driver fatality rate constructed from the blood alcohol concentration information contained in the FARS.<sup>14</sup> This fatality rate focuses on alcohol use and allows for a clearer examination of the potential substitution between alcohol and marijuana.

Each fatality rate is computed as the relevant number of motor vehicle accident deaths divided by the relevant state population. The fatality equation is specified as a logistic equation. The logistic functional form is ideal since it constrains the fatality rate to lie between zero and one. The logistic specification is obtained by transforming the fatality rate to  $\ln[F/(1-F)]$ , where  $F$  is the fatality rate and  $\ln$  is the natural logarithm. Maddala [1983] shows that weighted least squares should be used with this logistic transformation. The weight is  $[nF(1-F)]^2$ , where  $n$  is the relevant state population.

Three variables are included to measure the full price of alcoholic beverages. The first is the combined state and federal excise tax rate on a case of 24 12-ounce cans of beer. Excise tax data are the most reliable price data available at the state level during this time period. Beer tax data were chosen since beer is the most popular alcoholic beverage in the U.S. and because meaningful wine and distilled spirits taxes are only available for states which permit the sale of all alcoholic beverages in licensed establishments. The beer tax variable is deflated by the national CPI (1982-1984 base year). The Federal tax had been fixed at 64 cents from 1951 until 1991, when it was doubled as part of a deficit reduction package. If a state raised its tax during the year, the tax is the weighted average of the rates in effect throughout the year. The other two full price variables, reflecting alcohol availability, are the minimum legal drinking age for low alcohol content beer and the percentage of the state population residing in counties prohibiting alcohol sales ("dry" counties). These data were obtained from the Beer Institute's annual *Brewers Almanac*.

The full price of marijuana is captured by an indicator for states which have decriminalized marijuana. Decriminalization of marijuana eliminates possible imprisonment for most first offense possession violations. Oregon, in 1973, was the first state to decriminalize marijuana. By 1978, 10 other states had followed, substantially reducing the penalties associated with marijuana possession. Decriminalization, by lowering the penalties associated with marijuana use, is expected to significantly increase marijuana consumption. In addition, if alcohol and marijuana are substitutes, then decriminalization is expected to reduce alcohol consumption. The net effect of decriminalization on motor vehicle accident fatalities, however, can not be predicted.

Four other alcohol related variables are included in all equations as measures of unobserved exogenous sentiment towards alcohol and illicit drugs. Anti-alcohol/drug sentiment is expected to be relatively widespread in states in which religious groups opposing alcohol and drug use are prevalent. Thus, variables are defined for the percentages of the state population who are Mormons, Southern Baptists, other Protestants, and Catholics. These data were available from the National Council of Churches for 1971 and 1980 only. Estimates for 1975 through 1988 were computed by logarithmic trend.

Real per capita personal income is also included in all equations. Income should be positively related to the demand for health, as well as to the quality and condition of motor vehicles, and may be positively related to the demand for alcohol and marijuana. Thus, the predicted effect of income on fatality rates is ambiguous.

Additionally, five variables are used to control for the probability of a fatal motor vehicle accident. They are the percentage of highway traffic exceeding 65 miles per hour, the number of vehicle miles traveled per licensed driver, the fraction of licensed drivers ages 24 years and under, a dichotomous indicator for states requiring annual safety inspections of all motor vehicles, and a dichotomous indicator of a mandatory seat belt use law. The first three of these variables were computed using data from the Federal Highway Administration's *Highway Statistics*, and unpublished data provided by the FHA. The safety inspection indicator was taken from the American Automobile Association's *Digest of Motor Laws*. Finally, information on mandatory seat belt use laws was obtained from communications with the NHTSA.

Finally, temporal variation in unmeasured variables and other time trends are modeled by a set of dichotomous variables for each of the years from 1975 through 1987 (1977 through 1987 for the alcohol involved driver rates).

### **Results**

Dichotomous probit estimates of the probability of a non-fatal traffic accident, using the data from the 1982 and 1989 MTF surveys are presented in Table 4. Columns 1 and 2 of Table 4 contain estimates of equations excluding marijuana money prices for the pooled sample and for the 1989 sample, respectively. Columns 3 through 6 of Table 4 present the estimates for the 1989 sample only from equations which include alternative measures of the money price of marijuana.<sup>15</sup> Only the coefficients for the beer and marijuana price variables, the legal drinking age measures, and the decriminalization indicator are shown. All equations include the same set of other independent variables included in the demand equations described above.

Weighted least squares estimates of youth motor vehicle accident fatality rates are contained in Table 5. Panel A of Table 5 contains the estimates of the beer tax, drinking age, and decriminalization coefficients for the 15-through-24-year-old fatality rates, with comparable estimates for 18-through-20-year-olds presented in Panel B. Estimates for the 18-through-20-year-old sample are presented to highlight the impact of the minimum legal drinking age which most affects this age group. Column 1 of Table 5 presents the results for the total youth motor vehicle accident fatality rates, while columns 2 and 3 contain estimates for the night driver and alcohol involved driver rates, respectively.

**TABLE 4**  
**Probit Estimates of the Probability of a Motor Vehicle Accident**  
**Beer and Marijuana Prices, Drinking Ages, and Marijuana**  
**Decriminalization<sup>a</sup>**

Variable	Pooled 1982 and 1989 Sample	1989 Sample, No Marijuana Price	1989 Sample, Wholesale Commercial Price
Beer Price	-9.973 (-3.64)	-9.660 (-2.73)	-8.076 (-2.26)
Minimum Legal Drinking Age	0.031 (2.94)	-0.063 (-0.74)	-0.031 (-0.36)
Lower Border Age	0.001 (0.05)		
Marijuana Decriminalization	-0.058 (-2.88)	-0.117 (-4.05)	-0.103 (-3.54)
Marijuana Price			0.0002 (2.97)

  

Variable	1989 Sample Wholesale Sinsemilla Price	1989 Sample Retail Commercial Price	1989 Sample Retail Sinsemilla Price
Beer Price	-6.400 (-1.61)	-10.981 (-3.09)	-7.966 (-2.22)
Minimum Legal Drinking Age	-0.065 (-0.76)	0.057 (0.64)	-0.112 (-1.30)
Marijuana Decriminalization	-0.1305 (-4.37)	-0.038 (-1.06)	-0.192 (-5.96)
Marijuana Price	0.0001 (1.78)	0.003 (5.33)	0.001 (3.55)

a. Asymptotic t-ratios are in parentheses. The critical values for the t-ratios are 2.58 (2.33), 1.96 (1.64), and 1.64 (1.28) at the one, five, and ten percent significance levels respectively, based on a two-tailed (one-tailed) test. All equations, based on a Chi-square test of  $-2 \times \log$ -likelihood ratio are significant at the one percent significance level. The sample sizes are 25,430 for the pooled sample and 12,597 for the 1989 sample. All equations include variables reflecting gender, race, religious participation, work status, age, real weekly income, and an intercept.

Beer prices are found to have a negative and generally significant impact on both the probabilities of non-fatal and fatal motor vehicle accidents. The finding that fatal accidents rates are inversely related to the price of alcoholic beverages is consistent with a number of other studies [Saffer and Grossman, 1987; Chaloupka, Saffer, and Grossman, 1993]. However, while expected, this is the first empirical evidence indicating that non-fatal youth motor accidents are also inversely related to beer prices.

Drinking ages, however, do not appear to have much of an impact on non-fatal youth motor vehicle accidents, based on the results presented in Table 4. This was a somewhat surprising finding given the extensive literature confirmed by the results shown in Table 5, which finds that higher minimum legal drinking ages lead to lower youth motor vehicle accident fatality rates, particularly among 18-through-20-year

**TABLE 5**  
**Weighted Least Squares Estimates of**  
**Youth Motor Vehicle Accident Fatality Rates**  
**Beer Taxes, Drinking Ages, and Marijuana Decriminalization<sup>a</sup>**

Variable	Total Fatality Rate	Night Driver Fatality Rate	Alcohol Involv. Driver Fatality Ra
Panel A: Ages 15-24			
Beer Tax	-10.513 (-6.25)	-10.401 (-4.92)	-12.793 (-4.98)
Minimum Legal Drinking Age	-0.012 (-1.82)	-0.031 (-3.94)	-0.015 (-1.52)
Marijuana Decriminalization	-0.055 (-3.27)	-0.125 (-5.99)	-0.050 (-1.97)
Panel B: Ages 18-20			
Beer Tax	-13.305 (-7.15)	-15.360 (-5.69)	-15.992 (-5.76)
Minimum Legal Drinking Age	-0.030 (-4.12)	-0.070 (-6.94)	-0.041 (-3.86)
Marijuana Decriminalization	-0.062 (-3.31)	-0.143 (-5.36)	-0.064 (-2.35)

a. t-ratios are in parentheses. The critical values for the t-ratios are 2.58 (2.33), 1.96 (1.64), and 1.64 (1.28) at the one, five, and ten percent significance levels respectively, based on a two-tailed (one-tailed) test. All equations, based on an F-test are significant at the one percent significance level. The sample sizes are 650 for the 15-24 total and night driver and 18-20 total fatality rates, 565 for the 15-24 alcohol involved driver fatality rate, 648 for the 18-20 night driver fatality rate, and 560 for the 18-20 alcohol involved driver fatality rate. All equations include variables reflecting the percentages of the state population who are Mormon, Southern Baptist, Catholic, and Protestant, real per capita personal income, the percentage of highway traffic exceeding 65 mph, the number of vehicles miles driven per licensed driver, the fraction of licensed drivers ages 24 years and under, indicators for states requiring annual vehicle safety inspections and seat belt use, dichotomous year indicators, and an intercept.

olds. For the samples based on the 1989 survey, this finding may be in part due to the fact that almost every state's drinking age was 21 at this time.

The estimated coefficients on the decriminalization indicator are negative and highly significant in all of the non-fatal and fatal accident equations, except for the probability of a non-fatal accident equations which include the retail price of commercial grade marijuana, where they are negative but insignificant at conventional levels. Similarly, marijuana prices are found to have a positive and generally significant impact on the probability a non-fatal motor vehicle accident.

### *Policy Simulations*

To compare the impact of various alcohol and marijuana related policies on driving under the influence by youths, policy simulations comparable to those described above were conducted. The simulation results are presented in Tables 6 and 7. Table 6 contains the predicted changes in the number of youths involved in at least one non-fatal traffic accident in response to the four policy changes. Column 1 of Table 6 presents the policy simulations for the pooled sample, while Column 2 presents those based on the 1989 survey excluding the money price of marijuana. Columns 3-6 contain the results when the four alternative money prices of marijuana are included in the models for the 1989 sample (the wholesale and retail prices of commercial grade marijuana (3 and 5 respectively) and sinsemilla (4 and 6 respectively)). Table 7 contains the percentage change in the youth motor vehicle accident fatality rates associated with the simulated policy changes as well as the estimated changes in the number of fatalities in each category in the final year of the sample (1988) resulting from the policy changes.

Large increases in the excise tax on beer lead to substantial reductions in both non-fatal and fatal motor vehicle accidents among youths. The approximately 17 percent increase in the price of beer induced when the federal tax is increased to offset the effects of inflation since 1951 leads to an almost six percent reduction in the probability of a non-fatal accident in the pooled sample of high school seniors. Similarly, maintaining the real value of the beer tax at its 1951 level during the period from 1975 through 1988 would have reduced fatal motor vehicle accidents by over 16 percent among 15 through 24 year olds and by nearly 20 percent among 18-to-20-year olds. In 1988, these estimates imply that 2,288 lives would have been saved in the 15-through-24-year-old group.

A reduction in marijuana prices, which is expected to increase marijuana consumption but reduce drinking based on the results described above, leads to a significant drop in the probability of a non-fatal motor vehicle accident among high school seniors. The estimated reductions in this probability for the 18 percent fall in each of the four marijuana prices range from -2.25 percent to -7.25 percent. This implies that the net effect of the substitution towards marijuana on the probability of an accident induced by the drop in the price of marijuana is negative. That is, the increase in the probability of a non-fatal accident resulting from greater marijuana use is more than offset by the drop in this probability resulting from less drinking and driving and, perhaps, less use of other intoxicating substances and driving.

This conclusion is supported by the estimated effects of marijuana decriminalization on the probabilities of both non-fatal and fatal motor vehicle accidents among youths. Going from a nationwide policy criminalizing marijuana to one where marijuana is decriminalized everywhere leads to about a 7.5 percent drop in the probability of a non-fatal accident in the pooled sample of high school seniors. Somewhat larger reductions are estimated in most of the specifications for the 1989 sample. Similarly, this change in policy is predicted to reduce the fatal accident rate by almost 5.5 percent among 15-through-24-year-olds and by just over six percent among 18-to-

**TABLE 6**  
**Policy Simulations: Probability of a Non-Fatal Motor Vehicle Accident<sup>a</sup>**

Policy Simulation	Pooled 1982 and 1989 Sample	1989 Sample No Marijuana Price	1989 Sample Wholesale Commercial Price
Inflation Tax Policy	-5.84%	-5.57%	-4.67%
Nationwide Criminalization	+2.30%	+4.43%	+3.92%
Nationwide Decriminalization	-5.23%	-10.11%	-8.98%
Marijuana Price Reduction			-3.52%

  

Policy Simulation	1989 Sample Wholesale Sinsemilla Price	1989 Sample Retail Commercial Price	1989 Sample Retail Sinsemilla Price
Inflation Tax Policy	-3.71%	-6.27%	-4.50%
Nationwide Criminalization	+4.94%	+1.14%	+7.71%
Nationwide Decriminalization	-11.24%	-3.62%	-15.62%
Marijuana Price Reduction	-2.25%	-7.25%	-4.90%

a. Simulation results are based on the estimates presented in Table 4.

**TABLE 7**  
**Policy Simulations: Probability of a Fatal Motor Vehicle Accident<sup>a</sup>**

Policy Simulation	Total Fatality Rate	Night Driver Fatality Rate	Alcohol Involved Driver Fatality Rate
Panel A: Ages 15-24			
Inflation Tax Policy	-16.18%	-16.02%	-19.14%
Nationwide Criminalization	-2,288	-375	-835
Nationwide Decriminalization	+1.58%	+3.52%	+1.40%
	+224	+82	+61
	-3.88%	-8.62%	-3.53%
	-549	-202	-154
Panel B: Ages 18-20			
Inflation Tax Policy	-19.94%	-22.59%	-23.19%
Nationwide Criminalization	-1,037	-194	-350
Nationwide Decriminalization	+1.77%	+3.99%	+1.78%
	+92	+34	+27
	-4.35%	-9.89%	-4.51%
	-226	-194	-68

a. Simulation results are based on the estimates in Table 5.

20-year-olds. In 1988, an estimated 224 fewer youth and young adult lives (ages 15-24) were lost in fatal traffic accidents in the states which had decriminalized marijuana. Decriminalization in all other states, based on these estimates, would have saved an additional 549 lives in this age group. Again, this is expected to be the result of substitution towards marijuana and away from alcohol and other intoxicating substances in the states where the penalties associated with marijuana use are much lower.

## CONCLUSIONS

The findings for youth alcohol use presented above suggest that successful marijuana related efforts in the "War on Drugs", which can be expected to reduce the supply of marijuana and, hence, increase its price will not only lead to less marijuana consumption, but will have the unintended consequence of raising alcohol consumption (at least among youths). This is consistent with DiNardo and Lemieux's (1992) finding that increased minimum legal drinking ages, while reducing alcohol consumption among youths, had the unintended consequence of leading to an almost one-for-one increase in marijuana use.

The findings related to youth motor vehicle accidents suggest that reductions in the full price of marijuana, resulting from either lower money prices and/or reduced legal sanctions for possession/use, lead youths to substitute away from alcoholic beverages and other intoxicating substances towards marijuana. Furthermore, the subsequent reductions in the consequences of drunken driving (non-fatal and fatal accidents) and driving under the influence of other substances more than offset the increases in the consequences of driving under the influence of marijuana. Similarly, an increase in the full price of beer, resulting, for example, from the increased taxation of alcoholic beverages and/or higher minimum legal drinking ages, lowers beer consumption and raises marijuana consumption. This would be expected to reduce drunken driving, but to raise "stoned" driving. The net effect of the beer price increase, however, is to reduce the probabilities of non-fatal and fatal youth motor vehicle accidents.

Improved traffic outcomes may result from more careful and/or slower driving on the part of young drivers under the influence of marijuana as compared to those who are drinking and driving [Stein 1983; Robbe and O'Hanlon, 1993], or it may be that youths are less likely to drive after consuming marijuana than they are after drinking or that marijuana consumption impairs driving less than alcohol consumption [Hansteen, et al. 1976; Moskowitz, et al. 1976]. For whatever reason, the results presented here imply that the combination of higher full prices for alcoholic beverages and a lower full price for marijuana will reduce the probability of youth motor vehicle accidents, both fatal and non-fatal. This is consistent with Model's findings, based on drug and alcohol related emergency room admissions [1993] and violent crime rates [1991], that the substitution away from alcohol and other drugs towards marijuana resulting from reductions in the full price of marijuana (due to decriminalization) leads to net reductions in some of the consequences of drug and alcohol abuse.

The growing body of research in this area suggest that decriminalization, or even legalization, of marijuana only, which can be expected to reduce the full price of marijuana, would almost certainly lead to increased marijuana consumption, but at the same time reduce several of the consequences associated with all drug use, including motor vehicle accidents, other medical emergencies, and violent crime. In addition, this would free up resources for stronger enforcement efforts towards remaining illegal drugs. The appropriateness of such a policy clearly depends on the harmful consequences of alcohol, marijuana, and other illegal drug use. Ongoing research on the effects of policies on polysubstance use and abuse by economists in the National Bureau of Economic Research's Health Economics Program and elsewhere can inform the development of appropriate, comprehensive substance control policies.

### NOTES

Research for this paper was supported by Grants RO1 DA07111 from the National Institute on Drug Abuse and RO1 AA 08359 from the National Institute on Alcohol Abuse and Alcoholism to the National Bureau of Economic Research. The authors are grateful to Patrick M. O'Malley and Jerome J. Hiniker of the University of Michigan's Institute for Social Research for providing restricted data sets from the 1982 and 1989 Monitoring the Future surveys containing county identifiers. The authors are also indebted to Paul Taubman for providing the marijuana price data and to Michael Grossman, Henry Saffer, Gregory Bloss, and Mark Showalter for comments on earlier drafts. Any opinions expressed in this paper are those of the authors and not those of NIDA, NIAAA, or the NBER.

1. Unfortunately, individual level data on marijuana and other drug consumption is unavailable in the restricted versions of the Monitoring the Future data sets provided to the authors by the University of Michigan's Institute for Social Research.
2. In 1982, prices are obtained for a 750ml bottle of Seagram's 7-Crown, a 6-pack of Budweiser or Schlitz, and a 750ml bottle of Paul Masson Chablis. In 1989, the reports include prices of a 1 liter bottle of J&B Scotch, a 6-pack of Budweiser or Schlitz, and a 1.5 liter bottle of Paul Masson Chablis. A careful effort was made to construct a standardized series of prices for beer, wine, and distilled spirits. Detailed information on the construction of this series is available from the authors.
3. All equations presented below were also estimated using a weighted average price of beer, wine, and spirits, or the beer tax as alternative measures of alcoholic beverage prices. These results, which are similar to those obtained for beer prices, are available upon request.
4. The price assigned to each youth is the price in the ACCRA survey city nearest the youth's county of residence within the youth's state of residence. All equations presented below were re-estimated using subsamples of the MTF surveys based on the quality of the price match. The results obtained for these subsamples were consistent with those obtained in the full samples and are available upon request.
5. The minimum legal drinking age is the weighted average of the legal ages in place during the first two quarters of the year in which the youth is surveyed. The construction of this variable accounts for the grandfather clauses many states adopted when raising their legal ages for all alcoholic beverages to 21 years to comply with the Federal Uniform Drinking Age Act of 1984. While all states had complied with this law by 1989, grandfather clauses in some states kept the effective legal age below 21 years in some states until mid-1989. Similar variables were constructed for high alcohol content beer and for distilled spirits. The choice of the drinking age variable had little impact on the resulting estimates.
6. This variable takes on a value of zero for all youths in 1989 since the grandfather clauses which keep effective drinking ages in some states below 21 apply to state residents only. Hence, this variable is omitted from the equations estimated using the 1989 sample only.

7. All equations were also estimated using the 1988 price or the 1989 price as the price of marijuana. The results for these variables are comparable to those presented below and are available on request.
8. In addition to using the midpoint of the range of prices reported, alternative estimates were obtained using the minimum and maximum values for the range of prices. The results obtained using these alternative measures were generally similar to those presented below and are available upon request.
9. These correlation coefficients were obtained based on the prices assigned to the full sample, as described above. Similar values are obtained in the subsamples as well as in the raw data.
10. Estimates were also obtained for a restricted sample which was limited to observations where the marijuana price assigned to the youth is for a city from the STRIDE data which is in the same state in which the youth resides. In most cases, this city is relatively close to the youth's county of residence, implying that the price in that city should be a reasonably good measure of the price the youth faces for marijuana. Observations where prices are from a city in the STRIDE data which is not in the youth's state of residence are dropped in the restricted sample. Even if the youth lives near the city from which the price is taken, the assigned price may not be a good measure of the price the youth faces if the drug enforcement activities in his/her state are quite different from those in the state from which the price is taken. The estimates from the restricted sample were very similar to those for the full sample and can be found in Chaloupka and Laixuthai [1994].
11. All equations also include an intercept, the indicators of gender, race, work status, and religious participation, as well as the youth's real weekly income and age, as described above. The pooled sample also includes the dichotomous year indicator for 1982. These results are similar to those contained in Laixuthai and Chaloupka's [1993] study of youth alcohol use and are available upon request.
12. Kleiman [1992] describes the evolution of the marijuana market over time, noting that most of the U.S. market was supplied from foreign sources and that most foreign marijuana is commercial grade. He goes on to note that successful interdiction efforts have led to a much larger domestic supply and that, combined with improvements in cultivation, this has led to an increase in the potency of marijuana (both commercial and sinsemilla).
13. The survey includes continuous information on the number of motor vehicle accidents, with an upper limit of four or more accidents. However, almost no youth report more than one accident, so non-zero responses are collapsed into a single category indicating at least one accident in the past year.
14. See Chaloupka, Saffer, and Grossman, [1993], for more detailed information on the construction of the alcohol involved driver fatality rate. BAC data is available since 1977 in the FARS. As a result, the sample consists of the 48 contiguous states of the U.S. from 1977 through 1988 in all equations estimated using the alcohol involved driver fatality rate as the dependent variable.
15. Estimates were also obtained for a restricted sample based on the quality of the marijuana price match, as described above.