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# INDIVIDUAL BEHAVIORS AND SUBSTANCE USE: THE ROLE OF PRICE

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## ABSTRACT

I discuss economic approaches to the demand for harmfully addictive substances and estimate time-series demand functions for the period from 1975 through 2003. My estimates suggest that changes in price can explain a good deal of the observed changes in cigarette smoking, binge alcohol drinking, and marijuana use by high school seniors. For example, the 70 percent increase in the real price of cigarettes since 1997 due to the Medicaid Master Settlement Agreement explains almost all of the 12 percentage point reduction in the cigarette smoking participation rate since that year. The 7 percent increase in the real price of beer between 1990 and 1992 due to the Federal excise tax hike on that beverage in 1991 accounts for almost 90 percent of the 4 percentage point decline in binge drinking in the period at issue. The wide swings in the real price of marijuana explain 70 percent of the reduction in particpation from 1975 to 1992, 60 percent of the subsequent growth to 1997, and almost 60 percent of the decline since that year. I conclude with implications for tax policy and for the lively and contentious debate concerning the legalization of marijuana, cocaine, and heroin.



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## 1. Introduction

The economics of substance use and abuse deals with the consumption of goods that share two properties. First, they are addictive in the sense that an increase in past consumption of the good leads to an increase in current consumption. Second, their consumption harms the consumer and others. This second property makes them of interest from policy, legal, and public health perspectives. Clearly, not every addictive good harms the user and others. A person can be addicted to jogging, classical music, detective novels, attending church, and other activities that do not harm others and may yield future benefits to the individual in addition to increases in current utility. But the consumption of such substances as cigarettes, alcohol, cocaine, marijuana, and heroin can harm the consumer and others. For example, cigarette smoking has been labeled as the largest preventable cause of death by the last three annual U.S. Surgeon General's Report on Smoking and Health. Motor vehicle accident mortality is the leading cause of death of persons between the ages of 1 and 35 in the U.S., and alcohol is involved in almost fifty percent of these fatal accidents. The consumption of cocaine and other illicit substances results in deaths due to drug overdoses and the violence that accompanies the purchase and sale of illegal drugs. The existence of external costs (harm to others) and ignored internal costs (harm to self) suggests a possible justification for government intervention. This policy may not, however, be justified if it generates substantial external costs, or if the costs of eliminating the harms are greater than the costs arising from the harms.

The U.S. government and those of many other countries have chosen to regulate some addictive substances (for example, cigarettes and alcohol) via taxation; minimum purchase age laws; restrictions on consumption in schools, the workplace, and public places; and stiff fines for driving under the influence of alcohol. They have chosen to outlaw other substances (for

example, cocaine, heroin, opium, and marijuana). Taxation, other forms of regulation, and bans raise the prices of these substances. In addition, bans create black markets and encourage criminal activities that may harm innocent victims.

The full price of addictive goods can be defined broadly to include not only the money price but such indirect cost elements as the monetary value of the travel and waiting time required to obtain the good, the monetary value of the expected penalties for possession of illegal drugs or conviction of drunk driving, and the monetary value of the adverse health effects. The responsiveness of these substances to full price is an important parameter in determining the optimal level of taxation and the impacts of legalization. The economics of substance use and abuse is very relevant to these issues because recent theoretical advances predict that addictive goods should be more sensitive to price than previously believed. A growing body of empirical studies confirms this prediction.

## 2. Price and Consumption Trends in the United States

To keep this paper manageable, the research that I will be discussing deals with the effects of money price on consumption and abuse and on interactions between money price and other components of full price. It is natural to focus on money price given the preeminence of the law of the downward sloping demand function. Moreover, money price is a convenient variable for governments to manipulate via excise taxation. Taxes are "blunt instruments" because they impose welfare cost on non-abusers. But the enforcement and administrative costs of such policies as minimum purchasing ages are likely to be much higher than those associated with taxation (Grossman et al. 1994). Taxation also is very relevant in the case of illegal drugs because policy proposals to legalize these substances can be combined with taxation (for example, Becker, Murphy, and Grossman 2004).

Given my emphasis on money price and on U.S. data and policy, it is instructive to examine trends in the real prices of cigarettes, alcohol, cocaine, heroin, and marijuana (the money price of each substance divided by the Consumer Price Index for all goods) and corresponding trends in the prevalence of the use of these substances. Figure 1 shows trends in real cigarette, beer, wine, and distilled spirits prices from 1975 through 2003.[1] This period encompasses most of the U.S. anti-smoking campaign which dates to the issuance of the first Surgeon General's Report on Smoking and Health in 1964. It includes the entire campaign to reduce deaths from motor vehicle accidents by discouraging alcohol abuse. This campaign began in the mid 1970s and has been expanded to include other outcomes of alcohol abuse.

The figure shows that the real prices of alcohol and cigarettes have declined significantly for certain periods during which the anti-smoking and anti-drinking campaigns have been in effect. These declines can be traced in part to the stability in nominal terms of the Federal excise tax rates on cigarettes and alcohol (see Table 1). In the case of cigarettes, the real price fell by 14 percent between 1975 and 1980 (and by 20 percent between 1965 and 1980) before rising by 88 percent between 1980 and 1992. This large increase resulted in part from the three Federal tax hikes. The 12 percent decline in price between 1992 and 1997 was generated by a cut of 40 cents in the nominal price of a pack of Marlboro cigarettes by the Philip Morris Companies in April 1993, which was matched by competitors of other name brands soon after. This price cut represented an attempt to ward off competition from generic brands of cigarettes. Since 1997, the real price has risen by 72 percent in response to the settlement of the lawsuits filed by 46 state attorneys general against cigarette makers to recover Medicaid funds spent treating diseases related to smoking (the Master Settlement Agreement or MSA), two Federal tax increases, and a number of state tax increases.

The downward trends in real price for beer, wine, and distilled spirits are much more dramatic. These reductions between 1975 and 1990 were 20 percent, 28 percent, and 32 percent, respectively. Since the Federal tax rates on all three beverages were raised in 1991, real price declines amounted to 9 percent for beer, 13 percent for wine, and 8 percent for spirits.

Trends in the real prices of cocaine, heroin, and marijuana for the period from 1975 through 2003 are shown in Figure 2. These prices are based on purchases made by drug enforcement agents to apprehend drug dealers as recorded in the System to Retrieve Information from Drug Evidence (STRIDE) maintained by the Drug Enforcement Administration (DEA) of the U.S. Department of Justice.[2] Despite large allocations of resources to interdiction and criminal justice as part of the Federal War on Drugs, the real price of one pure gram of cocaine fell by 89 percent, and the real price of one pure gram of heroin fell by 87 percent between 1975 and 2003. Most of the cocaine price decline took place between 1975 and 1985. On the other hand, the price of heroin was fairly stable until 1983 and declined thereafter.

The real price of marijuana shows a somewhat different trend. It increased by almost 10 percent during the period as a whole. This overall upward trend can be decomposed into an expansion from 1975 to 1991, followed by a decline until 1996, and an increase after that year. The price rose by 70 percent in the earliest period, declined by 40 percent in the middle period, and increased by 13 percent in the latest period. Marijuana prices are not adjusted for purity, but Pacula et al. (2001) report that purity fell between 1982 and 1992 and rose between 1992 and 1998. Hence the price swings in Figure 2 may understate the changes in the price of one pure gram of marijuana.[3]

The decline in the real price of cocaine has attracted the most attention in the popular press. Caulkins (1995) and Basov, Jacobson, and Miron (2001a) point to a number of causal

factors. One was the development of the production sector and the results of learning-by-doing that followed the reintroduction of cocaine into the U.S. market in the early 1970s after a long period of absence. A second was vertical integration, which reduced the number of levels in the chain of distribution and the cost of wholesaling and retailing. In addition, there was a shift to low-cost labor as the professionals who dealt cocaine in the 1970s were replaced by unemployed residents of urban ghettos in the 1980s. Finally, the degree of competition in the illegal cocaine industry may have increased over time, and technological progress in evading law enforcement may have taken place. While there is little "hard" empirical evidence to support these explanations, Basov, Jacobson, and Miron (2001b) find that the 25 percent decline in the relative wage of low-skilled labor since 1979 can account for approximately 20 percent of the decline in the real price of cocaine since that year.

The downward trend in the real price of cocaine that has accompanied the upward trend in resources allocated to enforcement does not mean that the War on Drugs has been a failure. In a cross-sectional analysis that combines city-specific cocaine prices and state-specific expected penalty variables, Grossman, Chaloupka, and Brown (1996) show that cocaine prices are positively related to monetary fines and prison terms for cocaine sale and to police and criminal justice expenditures per capita. By using data for cities over time for the years 1985 through 1996, Kuziemko and Levitt (forthcoming) obtain more refined estimates that control for unmeasured state and time fixed effects. They find that cocaine prices are positively related to the certainty of punishment as measured by per capita drug-offense arrests and the severity of punishment as measured by the fraction of drug arrests that result in the criminal being sentenced to prison. On balance, however, the rise in enforcement has been swamped by other factors.

Trends in cigarette smoking participation, alcohol consumption, and binge drinking

among high school seniors for the years from 1975 through 2003 are shown in Figure 3. These data come from the cross-sectional surveys conducted by the Institute of Social Research of the University of Michigan each year since 1975 as part of the Monitoring the Future (MTF) project. Cigarette smoking is defined as the percentage who smoked in the past 30 days, alcohol use is the percentage who consumed beer, wine, or distilled spirits in the past year, and binge drinking is the percentage who had five or more drinks in a row on at least one day in the past two weeks.[4] There are several reasons to focus on MTF and on teenagers in examining trends in cigarette smoking and alcohol use. MTF data for high school seniors provide the longest consistent time series on these behaviors. Moreover, there is a good deal of evidence that cigarette smoking and excessive alcohol use are habits that begin early in life (for example, Grossman et al. 1994). Hence policies to reduce their prevalence among youths may be the most effective tools to discourage them in all segments of the population. Finally, studies reviewed in Section 5 conclude that substance use by teenagers and young adults is more sensitive to price than is substance use by older adults.

All three outcomes shown in Figure 3 declined between 1975 and 2003. The reduction in smoking participation is consistent with the dramatic increase in the real price of cigarettes shown in Figure 1, but the reductions in alcohol use and in binge drinking are not consistent with the reductions in the real prices of alcoholic beverages. It is difficult, however, to make causal inferences from the data in Figures 1 and 3 because of developments in the anti-smoking and drinking campaigns that occurred during this time and lagged responses to these developments. They include the diffusion of knowledge about the harmful effects of cigarette smoking, increases in the minimum legal ages required to purchase alcohol and cigarettes, the requirement of warning labels on alcoholic beverage containers and cigarette packages, the enactment of

restrictions on advertising and bans on cigarette smoking in public places and in the workplace, and the passage of legislation to increase the likelihood of apprehending and convicting drunk drivers.

Trends in annual (past year) marijuana, cocaine, and heroin participation as percentages for high school seniors from 1975 through 2003 are presented in Figure 4. The focus on high school seniors is particularly relevant here because Grossman, Chaloupka, and Shin (2001) summarize data that show that illegal drug use is a young person's habit, at least for most segments of the population. Trends in marijuana use suggest that the number of youths who use this substance rises as its real price falls. Marijuana participation fell from 40.0 percent in 1975 to 21.9 percent in 1992 while price was rising. Participation then grew to 38.5 percent in 1997 while price was falling before falling to 34.9 percent in 2003 while price was rising.

With a participation rate that ranges between 0.4 percent and 1.5 percent, heroin use by high school seniors is extremely rare. The series for cocaine is somewhat more revealing. Participation grew from 5.6 percent in 1975 to 13.1 percent in 1985 at the same time as the real price fell by approximately 64 percent. Of course, the real price of cocaine continued to fall after the prevalence of its use peaked. Grossman, Chaloupka, and Brown (1996) attribute this to such developments as the "just say no" to drugs campaign begun by Nancy Reagan shortly after Ronald Reagan became President in 1981, efforts by the Partnership for a Drug-Free America to publicize the harmful effects of cocaine, and the dramatic cocaine-related deaths in June 1986 of the basketball star Len Bias and the football star Don Rogers. They also summarize evidence suggesting that cocaine was viewed as a benign illicit drug from the early 1970s to the early 1980s.

The MTF surveys from which the data in Figure 4 were obtained contain imperfect

measures of chronic drug use and obviously exclude certain groups of heavy users such as the homeless and criminals. Therefore, rates of hospital emergency room marijuana, cocaine, and heroin mentions per 100,000 population for the period from 1978-2002 are plotted in Figure 5, and the percentages of arrestees testing positive for these three substances for the period from 1989-2003 are plotted in Figure 6. The hospital emergency room data cover persons of all ages and pertain to episodes in which one or more of the three drugs was mentioned as a cause of the episode. Hence there can be more mentions than episodes. The figures are taken from the Drug Abuse Warning Network (DAWN) maintained by the Substance Abuse and Mental Health Services Administration.[5] The data in Figure 6, which are based on urine tests and pertain to persons 18 years of age and older, come from the Arrestee Drug Abuse Monitoring Network (ADAM), formerly termed Drug Use Forecasting (DUF), and maintained by the National Institute of Justice.[6]

According to Figure 5, drug-related hospital emergency room episodes have trended upward at rapid rates, especially for cocaine. The shorter time series in Figure 6 reveal declines in the percentages of arrestees who tested positive for cocaine and marijuana but an increase in the percentage who tested positive for marijuana. As is the case with the outcomes in Figures 3 and 4, definitive statements about the relationship between price and participation in heavy use of illegal drugs or consumption by chronic users cannot be made because trends in other determinants are not held constant.

### 3. Time-Series Demand Functions

To examine the relationship between price and the substance use outcomes in Figures 3-6, I fit time-series demand functions using ten of the twelve indicators of use in the figures as outcomes. My procedure is to regress each outcome on a measure of its real price and a time

trend. In the cases of alcohol use and binge drinking, I use the real beer price as a measure of the cost of alcohol since beer is the drink of choice among youths who consume alcoholic beverages (for example, Grossman, Chaloupka, and Sirtalan 1998). I do not consider heroin participation by high school seniors as an outcome because of its very low prevalence rate. I do not show results for cocaine participation by seniors because the real price of cocaine always had an insignificant regression coefficient. That does not necessarily mean that the demand function for cocaine is perfectly inelastic because studies reviewed in Section 5 that capitalize on cross-sectional price variation or within city variation over time do find evidence in favor of a downward-sloping demand function.

Given the high correlations between real substance use prices and time, the estimation of demand functions for the remaining ten items is perhaps more of an art than a science. My procedure is to experiment with three alternative trend specifications. The first includes a linear time trend; the second adds time squared to the first model; and the third adds time cubed to the second model. All three models contain the real price of the dependent variable. I then select the model with the lowest residual variance and obtain Newey-West (1987) t-ratios for the regression coefficients of that model.[7] The standard errors on which these t-ratios are based allow for heteroscedasticity and for autocorrelation up to and including a lag of three. Standard errors based on longer lags were very similar to those presented. When small differences in residual variances produce large differences in the real price coefficient, I present the results of more than one specification.

Compared to the use of repeated cross-sections or panels to estimate demand functions, the use of national time series has certain advantages. First, one can cover a longer period of time and include the most recent data. Second, one can examine whether price changes in the

period at issue have the potential to account for a significant share of the observed changes in the corresponding measures of use over time. Examples are the reduction in the price of cigarettes in 1993 generated by competition from generic brands, the increase in the price of this good in 1998 due to the MSA, the increase in the prices of alcoholic beverages in 1991 due to the Federal excise tax hike, and the dramatic swings in the price of marijuana. This analysis does not have to employ price effects obtained from data that do not cover the entire period. Third, one avoids the somewhat contentious issue of whether or not to include area-specific fixed effects (see Section 5 for more details). The disadvantages of the time series are that there are a small number of observations and a considerable amount of intercorrelation among the variables. In addition, price effects are biased downward in absolute value if the price variables contain random measurement error or if supply functions slope upward.

Table 2 contains regressions for cigarette smoking participation in the past 30 days, alcohol use in the past year, binge drinking in the past two weeks, and marijuana participation in the past year by high school seniors in Monitoring the Future. Seniors complete MTF questionnaires in school between March 15 and April 30 of year t. Therefore, annual alcohol use and marijuana participation roughly cover year t-1, and the real price is lagged one year when each of these variables is the outcome.[8] That is, the price in year t - 1 is employed as a regressor. Since the binge drinking outcome pertains to the past two weeks, the real beer price is given by simple average of the real beer price in the fourth quarter of year t - 1 and the first quarter of year t.

Cigarette smoking participation refers to the past thirty days, and the nominal cigarette price is reported as of November 1 of year t-1. Therefore, the real cigarette price is the price as of November of year t-1 with the following adjustments to the nominal price. Four cents is

added to the November 1982 nominal price to reflect the eight-cent increase in the Federal tax on a package of cigarettes on January 1, 1983. Two cents is added to the November 1990 and November 1992 nominal prices to reflect the four-cent increases in the Federal tax on January 1, 1991 and on January 1, 1993. Five cents is added to the November 1999 nominal price to reflect the ten-cent increase in the Federal tax on January 1, 2000. Two cents is added to the November 2002 nominal price to reflect the five-cent increase in the Federal tax on January 1, 2003. Finally, 31.1 cents is added to the November 1998 price to reflect the 45-cent increase in the nominal price in late November 1998 due to the settlement of the state lawsuits filed against cigarette makers to recover Medicaid funds spent treating diseases related to smoking (the MSA). The logic of these adjustments is that smoking decisions reported in MTF in March or April should depend on the price in the period from October of year t-1 through March of year t.

When alcohol use and binge drinking are the dependent variables, I add a regression that includes the legal age for the purchase of beer with an alcoholic content of 3.2 percent or less by weight.[9] I obtained this variable from Saffer, Chaloupka, and Grossman (1993). I defined it as a population-weighted average of the effective legal drinking age in effect in each state of the U.S. in a given years, where the set of weights is the fraction of the U.S. population residing in each state in a given year. While every state had enacted a legal drinking age of twenty-one by 1988, many enacted "grandfather clauses," which exempted state residents of legal age prior to the increase. Hence, the effective legal drinking age in the U.S. did not become twenty-one until 1991. I lag this variable one year to allow for delayed adjustment and greater enforcement over time, but the results with a contemporaneous measure are almost identical to those in Table 2. I include the drinking age because it is a readily available and widely cited policy instrument of the anti-drinking campaign. Moreover, its effects have been studied extensively in previous research

(for example, Grossman et al. 1994).

Except when the legal drinking age is employed as a regressor, the cubic time specification minimizes the residual variances of the outcomes in Table 2. Each real price coefficient is negative and statistically significant in that table. In addition, small changes in residual variances are not associated with large changes in these estimates. At the point of sample means, the price elasticities of cigarette smoking participation and marijuana participation are both equal to -0.46. The price elasticity of alcohol use is -0.43 in the model without the drinking age and -0.55 in the model with this variable. The price elasticity of binge drinking is quite large: -1.98 when the drinking age is excluded and -1.52 when it is included. This large estimate is not a function of the manner in which the trend is specified. The elasticity is -1.46 in a regression that simply includes a linear trend and -0.93 in a regression that contains the drinking age but no trend terms.

The regressions in Table 2 can be used to examine whether price changes in the period at issue have the potential to account for a significant share of the observed changes in the corresponding measures of use over time. First, consider cigarette participation. Between 1992 and 1997 the real price of cigarettes fell by 12 percent due mainly to a cut of 40 cents in the nominal price of a pack of Marlboro cigarettes by the Philip Morris companies in April 1993. At the same time, smoking participation rose from 29.9 percent in 1993 to 36.5 percent in 1997. The cigarette participation equation predicts a decline in participation of 2.5 percentage points.[10] This amounts to 38 percent of the observed 6.6 percentage point decline. Since 1997, the real price has grown by 72 percent, while participation declined to 24.4 percent in 2003. The predicted decline from the regression is 11.8 percentage points or approximately 98 percent of the observed 12.1 percentage point fall.

Next consider alcohol use and binge drinking. Between 1990 and 1992, the real price of beer rose by 7 percent. At the same time, alcohol use fell by 3.6 percentage points from 77.1 percent to 73.5 percent, and binge drinking dropped by 4.3 percentage points from 32.2 percent to 29.9 percent. For the former outcome, the predicted decline of 2.7 percentage points from the regression with the drinking age accounts for 75 percent of the observed reduction. For the latter outcome, the predicted decline of 3.7 percentage points accounts for 86 percent of the observed decline.

The importance of controlling for the drinking age in estimating beer price effects is highlighted by the predicted decline of 3.9 percentage points in alcohol use and 9.2 percentage points in binge drinking due to the two year increase in the drinking age between 1975 and 1991.[11] Of course, both alcohol use and binge drinking have declined since 1991, while the real beer price fell and the drinking age remained the same. In the regressions these declines are captured by the trend term. Carpenter (2004) finds that the enactment of "Zero Tolerance" Drunk Driving Laws--which set very low legal blood alcohol limits for individuals under the age of twenty-one--can account for part of the downward trend.

Finally, consider the predicted impacts of the wide swings in the real price of marijuana. Between 1975 and 1992, price increased by approximately 100 percent, while participation fell from 40.0 percent to 21.9 percent. The predicted decline of 12.4 percentage points explains 69 percent of the observed 18.1 percentage point reduction. The real price proceeded to fall by 40 percent through 1997, while participation expanded to 38.5 percent. The predicted increase of 9.8 percentage points accounts for 60 percent of the 16.6 percentage point growth. The most recent period was characterized by a 14 percent price increase and a 3.6 percentage point reduction in participation. The regression explains approximately 56 percent of this reduction.[12]

Table 3 contains the regressions for rates of hospital emergency room mentions for marijuana, cocaine, and heroin; and Table 4 contains the regressions for the percentages of arrestees testing positive for each of these three substances. Since the outcomes in these two tables are collected throughout the year, prices are not lagged. Unlike the estimated price effects in Table 2, those in Tables 3 and 4 are sensitive to small changes in residual variances due to alternative trend specifications. Therefore, I present two models for each outcome: one with the best fitting trend specification and a second with a simple linear trend. Changes in reporting practices and in survey design may account for some of the instability in the results (for example, Reuter 1999).

Eleven of the twelve price coefficients in Tables 3 and 4 are negative. The exception occurs in the heroin mention equation with a linear trend. Seven of the eleven negative price coefficients are significant at the five percent level of confidence on a one-tailed test (the relevant test since the alternative hypothesis is that the coefficient is negative). The exceptions occur in the cocaine mention equation with a linear trend, in the two marijuana arrestee equations, and in the heroin arrestee equation with a linear trend.

Price elasticities in the arrestee data are all less than 0.20 in absolute value except when cocaine is the outcome. Then the elasticity is estimated in a range between -0.41 and -0.35. The elasticities in the mentions data are very sensitive to the trend specification. The cubic trend model produces elasticities of -0.26 for marijuana, -1.73 for cocaine, and -0.61 for heroin. The linear trend model yields corresponding elasticities of -1.18 for marijuana, -0.13 for cocaine, and 0.09 for heroin. Given the short time series, especially in the arrestee data and changes in reporting and design, the results in Tables 3 and 4 suggest that the outcomes at issue are negatively related to price.[13]

## 4. Basic Concepts

In the previous section I approached the demand for a harmful addiction from the perspective of a conventional model of consumer behavior, which ignores addiction. I simply allowed the outcome at issue to depend on its real price, trend terms, and for alcohol the legal drinking age (a positive correlate of the indirect costs borne by underage youths when they attempt to purchase alcohol). One can employ two other approaches to this topic: a myopic model of addictive behavior, which ignores the future consequences of current consumption and a rational model of addictive behavior, which incorporates future consequences. The latter approach is developed by Becker and Murphy (1988) in their seminal treatment of the economics of addiction. Since the first two approaches are nested within the Becker-Murphy framework, I emphasize this perspective. Given its somewhat controversial nature, I indicate at the outset that, in my view, Becker and Murphy's main contribution is to suggest that it is a mistake to assume that addictive goods are not sensitive to price. Even if one does not accept all the aspects of their model, one can examine this proposition in the context of the standard theory of consumer behavior.

An increase in past consumption of an addictive good raises current consumption because it increases the marginal utility of current consumption of that good (the increase in satisfaction or utility caused by an increase in consumption of the good). This is the reinforcement property of an addictive good stressed by psychologists. A harmful addiction, the focus of my discussion, is one in which past consumption has detrimental effects on current utility, such as reductions in health and therefore in utility caused by cigarette smoking, excessive alcohol use, and the use of cocaine. Harmful addictions exhibit the physiological property of tolerance in the sense that the utility from a given amount of current consumption is lower when past consumption is higher.

Note that I follow most of the literature in using the terms addiction and habit as synonyms.

Consumers are myopic if they ignore the effects of current consumption on future utility when they determine the optimal or utility-maximizing quantity of an addictive good in the present period. On the other hand, they are rational or farsighted if they take account of future effects of current consumption when they determine the optimal quantity of an addictive good in the present period.

In sharp contrast to the myopic addiction approach, Becker and Murphy (1988) assume that consumers take account of future effects of current consumption when they determine the optimal amount of an addictive good in the current period. They use this notion to construct a model of rational addiction that among other things contains the first explicit derivation of long- and short-run demand functions for addictive goods in the case of farsighted consumers. The conventional wisdom is that addictive goods are not sensitive to price possibly because small changes in the consumption of these goods cause large changes in the marginal benefit of consumption. Contrary to this conventional wisdom, Becker and Murphy stress that the demand for addictive goods may be responsive to price in the long run. They also stress that the quantity demanded of an addictive good is negatively related not only to the current price of the good but also to its past and future price. Economists define a set of goods to be complements if a reduction in the price of one good causes consumption of all of them to rise. In the Becker-Murphy model of rational addiction, the quantities of an addictive good consumed in different periods are complements.

Becker, Grossman, and Murphy (1994) show that the Becker-Murphy model generates a demand function for consumption of an addictive good in period t ($C_t$) of the form

$$C_t = \alpha C_{t-1} + \beta\alpha C_{t+1} + \theta P_t. \qquad (1)$$

Here, $P_t$ is the price of $C_t$. Other determinants of current period consumption are suppressed. Since $\alpha$ and $\beta$ are positive and $\theta$ is negative, current consumption is positively related to past and future consumption ($C_{t-1}$ and $C_{t+1}$, respectively) and negatively related to current price. In particular, $\alpha$ measures the effect of an increase in past consumption on the marginal benefit of current consumption. This parameter also measures the effect of an increase in future consumption on the marginal benefit of current consumption. The larger the value of $\alpha$ the greater is the degree of reinforcement or addiction. Equation (1) highlights the source of intertemporal complementarity in the rational addiction model. It arises because increases in past or future consumption (caused by reductions in past or future prices) cause current consumption to rise.

Equation (1) also implies that the short-run price elasticity, which holds past consumption constant, must be smaller than the long-run price elasticity, which allows past consumption to vary. This property does not hold in general for a non-addictive good. Hence, comparisons between the price elasticities of the two types of goods may be misleading if they are not based on long-run price elasticities. Put differently, since past consumption reinforces current consumption, the price response grows over time in the case of an addictive good. For example, a price increase in 2004 would reduce consumption in 2004, which in turn would cause consumption in 2005 and in all future years to fall ceteris paribus. Indeed, the long-run price response is greater the higher the degree of addiction or reinforcement.

The parameter $\beta$ in equation (1) is the time discount factor and is equal to $1/(1 + r)$, where r is the rate of time preference for the present. Typically, economists and psychologists assume that this discount factor is smaller than one because people are impatient. They prefer to consume 100 units of a good today instead of consuming 100 units of the same good tomorrow.

The smaller the time discount factor (the greater the rate of time preference for the present) the smaller is the effect of future consumption or future price on current consumption. In the case of perfectly myopic behavior, $\beta$ equals zero (r equals infinity), and future variables have no impact on current decisions. This is the sense in which a myopic model of addiction is nested within a rational model of this behavior.

Time preference for the present enters this and other models of optimal consumption over the life cycle because consumers are assumed to maximize a lifetime utility function defined as the discounted sum or present value of utility in each period or at each age, where $\beta$ is the discount factor. While the discount factor is usually taken to be exogenous or given, Becker and Mulligan (1997) point out that consumers have incentives to make investments that *lower* the rate of time preference for the present. This is because the present value of utility is *higher* the smaller is the rate of time preference for the present.

There are important interactions between time preference and addiction. On the one hand, people who discount the future more heavily are more likely to become addicted (Becker and Murphy 1988). On the other hand: "Since a decline in future utility reduces the benefits from a lower discount on future utilities, greater consumption of harmful substances would lead to higher rates of time preference by discouraging investments in lowering these rates" (Becker and Mulligan 1997: 744). Thus, "...harmful addictions induce even rational persons to discount the future more heavily, which in turn may lead them to become more addicted" (Becker and Mulligan 1997: 744).

Extensions of the above framework imply differential price responses by age, income, and education in the case of addictive goods (Becker, Grossman, and Murphy 1991). The total cost of addictive goods to consumers equals the sum of the good's price and the money value of

the future adverse effects, such as the negative effects on earnings and health from smoking, heavy drinking, or heavy dependence on cocaine.[14] Future costs tend to be less important to poorer, less educated, and younger consumers because they generally place a smaller monetary value on health and other harmful future effects than richer, more educated, and older consumers who have higher wage rates. Moreover, the poor, youths, and the less educated are likely to have lower time discount factors (higher rates of time preference for the present) than the rich, adults, and the more educated (Becker and Mulligan 1997). It follows that the poor, youths, and the less educated are more sensitive to changes in money prices of addictive goods, whereas the middle or upper income classes, adults, and the more educated respond more to changes in the perceived or actual harmful consequences that take place in the future. Becker (1992) also shows that interactions between peer pressure, which is much more important for youths than for adults, and addiction predict greater price sensitivity by youths.

If the parameter $\alpha$ in equation (1) is zero or if consumers ignore the addictive properties of the substances under discussion, a conventional model of the demand for these substances emerges. Yet all the factors mentioned just mentioned except for interactions between peer pressure and addiction still operate to produce differential price responses. In particular, youths are expected to be more sensitive to changes money prices of addictive goods than adults because they value the future health consequences less, discount the future more heavily, and are more sensitive to peer pressure. In addition, the fraction of disposable income that a youth allocates to harmful substances is likely to exceed the corresponding fraction that an adult allocates to these substances. An increase in the fraction of income spent on a good raises the absolute value of the uncompensated (money income-constant) price elasticity of demand.

Differences in discount rates as a function of age are related to modifications of the

rational addiction model by Gruber and Kőszegi (2001). They assume that consumers are forward looking but behave in a time-inconsistent manner because the discount factor that they apply between the current period and the next one is smaller than the discount factor that they apply to consecutive future periods. Consumers still respond to future consumption or prices in their model, but the scope for government intervention in markets for addictive goods is greater because ignored internal costs are much bigger than in the Becker-Murphy model.

**5. Empirical Evidence**

In this section I summarize empirical evidence that highlights the importance of money price as a determinant of the demand for harmful substances. Compared to the estimates that I presented in Section 3, this evidence is based on large cross sections, repeat cross sections, or panels. My review is not meant to be comprehensive or definitive. Rather, I call attention to studies that in my view have generated additional research and to some fairly recent and intriguing new findings. I begin with studies that obtain price effects in the context of the Becker-Murphy (1988) rational addiction model and then consider evidence that emerges from research using myopic or conventional approaches.

The rational model has been applied successfully to the demand for cigarettes by Chaloupka (1991); Keeler et al. (1993); Becker, Grossman, and Murphy (1994); and Tauras (1998). It also has been applied successfully to the demand for alcohol by Grossman (1993) and by Grossman, Chaloupka, and Sirtalan (1998) and to the demand for cocaine by Grossman and Chaloupka (1998). All these studies report negative and significant price effects, positive and significant past and future consumption effects, and larger long-run than short-run price elasticities. Typical short-run and long-run price elasticities of demand in these studies are -0.40 and -0.75 for cigarettes; -0.41 and -0.65 for alcohol measured by the number of drinks in the past

year; -0.79 and -1.00 for alcohol measured by cirrhosis mortality (a standard index of excessive alcohol consumption); and -0.70 and -1.35 for cocaine consumption.

Gruber and Kőszegi (2001) also present evidence in support of forward-looking behavior by estimating reduced form demand function for cigarette consumption by pregnant women (number of cigarettes smoked per day by these women). They find that this outcome is negatively related to the past and future state-specific cigarette excise tax as well as to the current tax. These are the complementary price effects stressed by Becker and Murphy.

The studies just mentioned and others contain additional support in favor of the economic approach to addictive behavior. Chaloupka (1991) finds that smoking by the less educated is considerably more responsive to changes in cigarette prices than is smoking by the more educated; a similar result has been obtained by Townsend (1987) with British data. Lewit, Coate, and Grossman (1981); Lewit and Coate (1982); and Chaloupka and Grossman (1996); Chaloupka and Wechsler (1997); Lewit et al. (1997); Evans and Huang (1998); Evans and Farrelly (1998); Harris and Chan (1999); and Gruber and Zinman (2001) report that youths respond more to cigarette prices than adults. By contrast, the information that began to emerge in the early 1960s about the harmful long-run effects of smoking has had a much greater effect on smoking by the rich and more educated than by the poor and less educated (Farrell and Fuchs 1982 for the U.S.; Townsend 1987 for Britain).

The negative relationship between age and the price elasticity of demand for cigarettes is worth highlighting because it is very robust across a number of studies, and it suggests that price hikes are an extremely effective instrument to discourage youths from beginning to smoke. Table 5 contains cigarette price elasticities by age from nine studies--two completed in the early 1980s and seven completed since 1996. Both the price elasticity of participation and the

unconditional price elasticity (the sum of the price elasticity of participation and the price elasticity of the number of cigarettes smoked conditional on positive smoking) are shown. While estimates for a given age group vary from study to study, the negative correlation between the absolute value of the elasticity and age is striking.[15]

I have stressed the importance of the negative effect of price on youth participation in the consumption of harmful substances because changes in participation by youths primarily reflect start behavior. At older ages, changes in participation are due mainly to decisions to cease consumption. Quits are key outcomes because most of the health effects at issue are reversible.

As predicted by myopic and rational addiction models, Yen and Jones (1996) find that an increase in peak past cigarette consumption lowers the quit probability in a large representative survey of British adults. They are not able to estimate direct price effects because there is no variation in price in their data. Their results suggest, however, that an increase in past price may cause quits to rise.

Douglas (1998) and Colman, Grossman, and Joyce (2003) provides somewhat more definitive evidence on the role of price in the decision to stop smoking in U.S. data. Before considering this evidence, it is worth considering the theoretical determinants of the quit probability in period t ($q_t$). The most straightforward approach is to let this price be a positive function of the change in price between consecutive periods as in

$$q_t = \theta_1(p_t - p_{t-1}). \qquad (2)$$

Addiction considerations aside, Colman, Grossman, and Joyce (2003) show that this approach is not entirely correct because the quit probability can be positive even if the current price equals the past price. That is because the quit probability is the complement of the conditional probability of continuing to smoke in period t given that a person smoked in period t-1. In turn

the latter probability is the ratio of the probability of smoking in period t or the smoking participation rate in that period at the aggregate level to the smoking participation rate in period t-1. An increase in $p_t$ and $p_{t-1}$ by the same amount will have no impact on $q_t$ only if the price elasticities of smoking participation in the two periods are the same.

Now assume that the two elasticities just mentioned are the same. The myopic model of addiction would add past consumption ($c_{t-1}$) to the set of regressors, and the rational model of addiction would add future consumption ($c_{t+1}$). The full model becomes

$$q_t = \theta_1(p_t - p_{t-1}) + \theta_2 c_{t-1} + \theta_3 c_{t+1}, \qquad (3)$$

where $\theta_2$ and $\theta_3$ are negative. The reduced form of equation (2) is one in which $q_t$ depends on $p_t$, $p_{t-1}$, and $p_{t+1}$. The current and future price effects are positive, while the sign of the past price effect is ambiguous.[16]

Douglas (1998) approaches the quit decision in the context of the rational addiction model. Despite high correlations among the current price, the price next year (future price), and the price last year (past price), Douglas finds positive and significant future price coefficients in his quit equations. This indicates that smokers in his sample are forward looking. The current and past price coefficients are not significant, but Douglas includes the number of cigarettes smoked per day at a peak period in his hazard equations. Clearly, past price may operate through this variable, suggesting that it should be omitted from the equations.

Colman, Grossman, and Joyce (2003) study the effects of cigarette excise taxes on the decision to quit smoking by pregnant women. This is a particularly important decision since smoking by these women accounts for one in five low weight babies and is the most important modifiable risk factor for poor pregnancy outcomes. They have data on smoking three months prior to conception and three months prior to delivery. Since rarely is there a change in the tax

on cigarettes in this brief period, they focus on the current tax effect. They find that pregnant women living in states that raised cigarette taxes between 1993 and 1999 were more likely to quit smoking once they became pregnant than women residing in other states. The magnitude of the effect at issue is substantial. If a one cent increase in taxes increases price by one cent, then a 10 percent increase in price would increase the probability that a pregnant woman quits smoking by 10 percent. Over one-quarter of the 9 percentage point increase in quit rates that occurred over the sample period can be explained by increases in cigarette taxes during that period. Colman, Grossman, and Joyce, estimate that a 30-cent increase in taxes in constant dollars would have the same effect on quit rates as enrolling women in prenatal smoking cessation programs.

As in the case of cigarettes, cocaine consumption by teenagers and young adults appears to be more price sensitive than consumption by adults (Grossman and Chaloupka 1998; Chaloupka, Grossman, and Tauras 1999; Saffer and Chaloupka 1999). These three studies do not consider consumption by the homeless and by prison inmates, who may behave very differently from the population at large. Recall, however, that I find negative and in most cases significant cocaine price effects in the mentions and arrestee regressions in Tables 3 and 4.

Marijuana has been the most widely used illicit substance in the U.S. since data first became available in the early 1970s. Marijuana price elasticity estimates are particularly important in light of the swings in participation documented in Section 2. Pacula et al. (2001) present a fairly wide range of estimates of marijuana participation price elasticities for high-school seniors but indicate that a conservative lower-bound figure is -0.30. Their upper-bound figure of -0.69 may be too small given the measurement error in price discussed in the study. They also show that the upward trend in price between 1982 and 1992 and the downward trend between 1992 and 1998 can explain at least part of the "1980s marijuana recession" and the

"1990s expansion."

Historical data indicate that opium users responded to price during periods when its consumption was legal. Van Ours (1995) estimates a short-run price elasticity of demand of -0.70 and a long-run price elasticity of -1.00 in the Dutch East Indies (now Indonesia) during Dutch colonial rule, for the years 1922-1938. Liu, Liu, and Chou (1999) report similar findings in a study of the demand for opium in the Japanese Colony of Taiwan during the period from 1914 through 1942.

Excessive alcohol consumption is perhaps the most common example of a legally addictive good next to cigarette smoking. The two goods are not, however, linked to adverse health outcomes and to addiction in the same way. There is overwhelming evidence that smoking has detrimental health effects. One can usually focus on whether and how much an individual smokes since these measures are highly correlated with the smoking-related costs of interest.[17] With alcohol, the situation is more complex. Unlike cigarettes, many persons regularly consume small quantities of alcohol. Most individuals who consume alcohol do not harm themselves or others; indeed, moderate alcohol consumption has been shown to lower the risk of coronary heart disease in men. Instead, the adverse effects of alcohol spring from the overuse or misuse of this substance. Examples include cirrhosis of the liver, drunk driving crashes, workplace accidents, various forms of violent behavior, risky sexual behavior, and failure to complete college.

Given the above, the following findings are particularly notable. The short-run and long-run price elasticities of the number of drinks of alcohol in a panel sample of young adults are substantial, yet are smaller than the corresponding elasticities of cirrhosis mortality in a time series of state cross sections (Grossman, Chaloupka and Sirtalan 1998; Grossman 1993). Cook and Tauchen (1982) report that a $1 increase in the state excise tax on distilled spirits lowers the

age-adjusted cirrhosis mortality rate by approximately the same percentage as it lowers per capita consumption of distilled spirits. Using a similar methodology and a time series of countries, Saffer (1991) finds that the price elasticity of cirrhosis mortality is three times larger than the price elasticity of per capita ethanol consumption.

Kenkel (1993) reports large price elasticities for the number of days with five or more drinks in the past year, which is another standard measure of the incidence of heavy consumption: -0.92 for persons of all ages and -2.24 for youth between the ages of 18 and 21. This suggests that young drinkers, like young smokers and young consumers of cocaine, are quite sensitive to price. Similar findings using measures of frequent and heavy drinking by youths are summarized by Grossman et al. (1994). Kenkel also reports a strong positive association between the measure of heavy drinking and the reported number of occasions of drunk driving in the past year. This provides a plausible mechanism for the negative relationship between fatal motor vehicle crashes (many of which are alcohol related) and the price of alcohol, which is found in many studies (see Grossman et al. 1994 for a summary).

Additional consequences of alcohol overuse or misuse fall as the cost of alcohol rises. These include workplace accidents (Ohsfeldt and Morrisey 1997); violent crime (Cook and Moore 1993b); child abuse (Markowitz and Grossman 2000); spouse abuse (Markowitz 2000); suicide (Sloan, Reilly, and Schenzler 1994); failure to complete college (Cook and Moore 1993a); and sexually transmitted diseases (Chesson, Harrison, and Kassler 2000).

To give a balanced treatment to the literature on money prices and substance use or abuse, I note that not every study has uncovered a negative price effect. For example, using cross-sectional data from Monitoring the Future for the period 1977 to 1992, Dee (1999) reports that the negative effects of the state excise tax on beer on youth drinking disappear once state fixed

effects are included as regressors. These conclusions are not definitive, however. Grossman, Chaloupka, and Sirtalan (1998) find only a modest reduction in their estimate of the long-run price elasticity of demand for alcohol (i.e., from -0.65 to -0.54) when controlling for fixed effects. Furthermore, Cook and Moore (2001), who use data on young adults participating in the National Longitudinal Survey of Youth conducted between 1982-1985 and 1988-1989, find that the effect of the state beer tax on drinking participation and binge drinking actually increases significantly in state fixed-effects models.[18]

This discrepancy in findings may stem from the fact that the relative stability of the beer tax makes it highly correlated with other state indicators (e.g., overall drinking sentiments). Accordingly, it is difficult to distinguish the effects of the beer tax and other state fixed effects. Furthermore, state excise taxes are an imperfect measure of the price of alcohol, and biases resulting from measurement errors are exacerbated in fixed-effects models. Thus, although most of the empirical literature supports the conclusion that excise tax increases tend to curtail alcohol consumption and heavy drinking by underage youths and young adults, more research on this important issue is necessary.[19]

## 6. Policy Implications

Since harmful addictions are sensitive to price, the government can discourage these behaviors by taxation or by bans. In the United States, Federal and state excise taxes account for approximately 30 percent of the price of cigarettes (40 percent if the 45-cent price increase due to the settlement of the Medicaid lawsuits is treated as a tax) and approximately 20 percent of the price of alcohol. Cocaine may sell for as much as 10-40 times its free market price (see the studies summarized by Miron 2003). My discussion implies that cigarette smoking, alcohol abuse, and the consumption of illicit substances would rise substantially if tax rates were lowered

or cocaine, marijuana, and heroin were legalized. But this observation does not justify the current policies. Revenue considerations aside, taxation of harmful addictions is justified only if there are external costs or ignored internal costs associated with these behaviors. Bans can be viewed in a similar manner. Moreover, legalization with taxation is an alternative to bans. I illustrate these issues with respect to cigarette and cocaine consumption because alcohol control is discussed in detail by Grossman et al. (1994).

Consider the optimal tax on cigarettes. There is widespread agreement that smoking has the potential to generate external costs because the premiums paid by smokers for health and life insurance do not fully reflect their excess use of medical care services and their higher probability of death (Manning et al. 1991; Viscusi,1995; Sloan et al. forthcoming). The lower Social Security and pension payments to smokers who die earlier offset some of these costs.

Some parents behave in ways that harm their children's health, and the health of spouses or unrelated persons can be worsened by the actions of smokers. The best example of these external costs is the harm done to their fetuses by pregnant women who smoke. Numerous studies show that these women are more likely to miscarry and to give birth to low-weight infants. Some of these infants die within the first month of life. Many more require extensive neonatal intensive care and suffer long-term impairments to physical and intellectual development. According to some, maternal smoking during pregnancy should not be treated as a cost imposed on one person by another and ignored by the smoker, because pregnant women may already have taken into account the impacts of their behavior on their infants. Since they still choose to smoke, the benefits to them outweigh the potential costs. Others argue that at least some pregnant women who smoke do so because they lack information about the effects of their behavior or heavily discount the future consequences of their current actions.

Similar issues arise in considering the detrimental health effects suffered by nonsmokers from secondhand smoke. The U.S. Environmental Protection Agency estimates that these effects include annually roughly 3,000 additional lung cancer deaths, between 9,000 and 17,000 additional deaths due to heart disease as well as a host of other respiratory illnesses. When these effects are attributed to the smoking behavior of a spouse, the costs are internal because most economists consider the family as the relevant economic decision making unit. While children are members of this unit "… they are relatively powerless to affect consumption decisions that may influence their health, especially when they are very young" (Warner et al. 1995: 382). Increases in morbidity and mortality suffered by nonsmokers in the workplace and other public places clearly are external costs of smoking.

As I indicated above, smoking generates ignored internal costs if consumers have imperfect information about the risks of smoking or behave in a myopic fashion. In response to the first U.S. Surgeon General's Report on Smoking and Health in 1964, smoking participation rates of more educated consumers declined rapidly in the late 1960s and early 1970s. In this period educated consumers were more likely to quit smoking and less likely to begin than less educated consumers. These data imply differential ability to process new information as a function of education and possibly some government action. It is still true today, after more than thirty years of providing information, that the more educated are less likely to smoke than the less educated despite the massive antismoking campaign that has been mounted by Federal and state governments.

It is tempting to attribute the recent data to more future oriented behavior by the more educated rather than to differences in information. Indeed, a survey taken by Viscusi (1995) shows that both smokers and nonsmokers overestimate, not underestimate, the probability of

death and illness from lung cancer due to tobacco. Teenagers, who have less information and are less future oriented than adults, actually attach much higher risks to smoking than the rest of the population. Schoenbaum (1997), however, finds that, among current heavy smokers in the Health and Retirement History Survey, expectations of reaching age 75 were nearly twice as high as actuarial predictions. Moreover, other risks of cigarette smoking, including the risk of becoming addicted, may be underestimated.

The addiction studies previously summarized suggest that smokers and consumers of other addictive goods are farsighted in the sense that they anticipate the expected future consequences of their current actions. Consumers who behave in this manner reduce their current consumption in response to an increase in future price. This is exactly what these studies find. Yet some persons, particularly the young and the poor, may discount the future much more heavily than other segments of the population.

Added complications arise if smokers are forward looking but behave in the time-inconsistent manner described by Gruber and Kőszegi (2001). In their model, even if the discount factor that consumers apply to consecutive future periods is reasonable, the smaller discount factor used in comparing the current period and the next one creates the potential for large ignored internal costs. They then show that the optimal tax may be much higher than the one that offsets purely external costs because the tax acts as a self-control mechanism that makes smokers better off.

I have not provided enough information in this paper to compute the optimal tax on cigarettes. A primary unresolved issue relates to what harmful consequences should be treated as external. What I can conclude is that permanent increases in price caused by excise tax increases will have substantial effects on the consumption of cigarettes. These strong price effects have

been proven over and over in the literature and should not be ignored in the policy debate.

If cocaine were legal and taxed, many of the factors just discussed would enter into the determination of the optimal tax. Clearly that is not the case, and the main policy debate is whether in fact the consumption of cocaine as well as that of marijuana and heroin should be legalized.[20] At first glance, it appears as if I have added "fuel to the fire" of the anti-legalization advocates. After all, the weight of the empirical evidence is that demand functions for illegal drugs, like demand functions for other goods, slope downward. Youths and young adults appear to be more responsive to price than older adults. This is troubling since the former groups may discount the future most heavily and may be most susceptible to the type of time-inconsistent behavior described by Gruber and Köszegi (2001).

There are two factors, however, that add a good deal of "fuel to the fire" of the pro-legalization advocates. The increase in consumption that accompanies legalization depends on the price elasticity of demand and on the magnitude of the price reduction caused by the removal of penalties for production and distribution. Published studies reviewed by Miron (2003) suggest an extremely large price reduction of between 10- and 40-fold.

Miron's extremely careful and detailed empirical analysis indicates, however, that these estimates of price reductions due to legalization are overstated. He compares the markup from raw material (which he terms "farmgate") to retail for cocaine to such legal products as chocolate, coffee, tea, beer, spices, tobacco, and potatoes. While the retail cocaine price is many times the costs of the raw materials required to produce it, markups also are large for these legal goods, although smaller than those for cocaine. These data suggest that the black market price of cocaine is 2-4 times larger than the price that would prevail if it were legalized. Miron reaches similar conclusions based on the price of cocaine used for legal purposes. He attributes these

results to evasion of costs by black market suppliers. These costs include taxes on labor and capital, costs associated with environmental, safety, health, and labor market regulation, and costs due to advertising. The avoidance of these costs by black market suppliers offsets some but not all of the expected penalties imposed by the government on these suppliers. While the impact on price is smaller than suggested by previous analysts, Miron's estimates still imply that legalization would result in significant reductions in price and, consequently, large increases in cocaine use.

A second factor that "throws even more water on the fire" built by anti-legalization advocates is that a regime in which cocaine production and consumption are fully legal, but cocaine use is discouraged by excise taxes on production or consumption has not been and should be evaluated. Monetary taxes have been considered a poor substitute for a drug war because excise taxes have been assumed to be unable to reduce drug use by as much as a war on drugs. The argument is that producers could always choose to go "underground" and sell illegally if a monetary tax made legal prices higher than underground prices.

Becker, Murphy, and Grossman (2004) show, however, that the market price of cocaine with a monetary excise tax could be greater than the price induced by a war on drugs, even when producers could ignore the monetary tax and produce illegally underground. The reason is that the government could allocate resources to preventing production in the illegal market. In effect it imposes a non-monetary tax in this market whose expected value exceeds the tax in the legal market. In certain circumstances, they conclude that the threat of imposing a cost on illegal producers that is above the excise tax if they produce legally is sufficient to discourage illegal production. Hence the threat does not have to be carried out on a large scale and is much less costly to implement than a war on drugs in a regime in which drugs are illegal.

Excise taxes imposed on producers or consumers of drugs play the same role in a regime in which drugs are legal as expected penalties imposed on producers and consumers when drugs are illegal. Both raise the full price of consumption and reduce the quantity demanded. But excise taxes are simply transfers, while penalties and efforts to enforce and evade them use real resources. Hence social welfare potentially is greater in a regime in which drugs are legal and taxed. Tax revenue could be redistributed to the population in a lump sum fashion or used to fund drug treatment and prevention programs. In the long run legalization might lead to a lower level of consumption than the present situation.

To address the problem of consumption by youths, legalization and taxation could be combined with minimum purchase age laws already in place for alcohol and cigarettes. Even if these laws are partially evaded, the higher money price of cocaine that might characterize the legalization regime might be a very powerful deterrent to youth consumption. Legalization eliminates the current expected penalty costs imposed on users. The latter costs are much higher for adults than youths because adults place a higher value on their time than youths and because youths are much more likely to heavily discount the future effects of their current decisions. Hence an increase in money price accompanied by the elimination of prison terms, community service, and the acquisition of a police record for possession would raise the full or effective price of drugs faced by youths even if this price falls for adults.

I have not provided enough evidence to conclude in a definitive manner whether the use of cocaine, marijuana, and other illicit substances should be legalized. I have, however, highlighted three factors that have been ignored or not emphasized in the debate concerning legalization. The first is that legalization is likely to have a substantial positive effect on consumption if prices fall by as much as that suggested by many contributors to the debate. The

second is that these price reductions, while almost certainly sizable, may have been greatly overestimated. The third is that legalization and taxation--the approach that characterizes the regulation of cigarettes and alcohol--may be better than the current approach.

Clearly, more research on the characteristics of the taxation and legalization regime is required before it can be recommended. I hope, however, that I have convinced the reader to treat with a significant amount of skepticism propositions such as the demand for illegal drugs is not sensitive to price; tremendous price reductions will occur if drugs are legalized; and legalization and taxation is not a feasible policy option.

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**Footnotes**

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[1]Nominal cigarette prices are taken from Orzechowski and Walker (2004). They report the price as of November 1 of calendar year t. The cigarette smoking participation data that I employ to estimate demand functions in Section 3 pertain to the month of February or March. Therefore, the cigarette price series in the figure in year t is the price as of November of year t-1 with the following adjustments to the nominal price. Four cents is added to the November 1982 nominal price to reflect the eight-cent increase in the Federal tax on a package of cigarettes January 1, 1983. Two cents is added to the November 1990 and November 1992 nominal prices to reflect the four-cent increases in the Federal tax on January 1, 1991 and on January 1, 1993. Five cents is added to the November 1999 nominal price to reflect the ten-cent increase in the

Federal tax on January 1, 2000. Two cents is added to the November 2002 nominal price to reflect the five-cent increase in the Federal tax on January 1, 2003. Finally, 31.1 cents is added to the November 1998 price to reflect the 45-cent increase in the nominal price in late November 1998 due to the settlement of the state lawsuits filed against cigarette makers to recover Medicaid funds spent treating diseases related to smoking (the MSA). The logic of these adjustments is that smoking decisions in February or March should depend on the price in the three prior months. Nominal annual beer, wine, and distilled spirits prices are taken from the Bureau of Labor Statistics home page (www.bls.gov). The CPI is taken from the same source.

[2]Following Caulkins (1994) and Grossman and Chaloupka (1998), I computed the nominal price of one pure gram of cocaine from purchases in STRIDE by regressing the logarithm of total purchase cost on the logarithm of weight, the logarithm of purity (as a percentage), dichotomous indicators for each year except one, and dichotomous indicators for each state of the U.S. except one. The regression employed STRIDE purchases for the years 1974-2003. I treated purity as endogenous in this regression and used the other variables in the total cost equation as instruments. To identify the model, I constrained the coefficient of the logarithm of purity to equal the coefficient of the logarithm of weight. I then computed the price of one pure gram of cocaine in year t as the antilogarithm of the sum of the intercept and the coefficient of the relevant year indicator. I applied the same methodology to obtain nominal heroin and marijuana prices except that there are no data in STRDE on the purity of marijuana purchases. Price trends based on regressions limited to purchases within specific weight ranges are almost identical to trends based on regressions for all purchases. For evaluations of STRIDE data, see Caulkins (2001a), Grogger (2001), Horowitz (2001), Rhodes and Kling (2001), and

Magee (2001). The main criticism--that there are substantial differences in these prices within cities at a moment in time--should not have a significant effect on trends. Moreover, Becker, Murphy, and Grossman (2004) argue that illegal drugs should be cheaper in poor neighborhoods because production and distribution are concentrated in these neighborhoods.

[3]Pacula et al. (2001) obtain data on the price and purity of marijuana from the *Illegal Drug Price/Purity Report* (IDPPR) published by DEA. Basov, Jacobson, and Miron (2001a) indicate that IDPPR data are derived from STRIDE, but that is not correct. Instead, purchases on which IDPPR prices are based are sent to a laboratory at the University of Mississippi, which distinguishes between commercial purchases and sinsemilla (a more potent grade of marijuana) and ascertains the delta-9-tetrahydrocannabinol (THC) potency of each purchase as a percentage. I do not use IDPPR data in this paper because it is not available before 1982 or after 2001 and because it only reports a price range (minimum and maximum price) for commercial marijuana and sinsemilla in a given year. Note that prices from IDPRR are fairly highly correlated with STRIDE prices for the period from 1982-1998 used by Pacula et al. Note also that IDPRR contains marijuana prices for cities that are not in STRIDE.

[4]The question used to illicit past year alcohol use was changed in 1993. Measures based on the old and new questions were reported in that year. I multiplied figures from 1975-1992 by the ratio of the new figure to the old figure in 1993. This ratio equals 0.96.

[5]Recent data from DAWN for the years 1995-2000 differ from previously published figures. To keep each series as consistent as possible, I multiplied the figures for 2001 and 2002 by the ratio of the mean of the unrevised to the revised ratio for the 1995-2000 period. The ratio is 0.89 for cocaine and marijuana and 0.91 for heroin.

[6]The data in Figure 6 are based on the 24 cities that have been in ADAM since 1989. For the years 2000-2003, the age range is 15 and over. In 1995 the threshold for marijuana was changed from 100 ng/ml to 50 ng/ml. Percentages based on both thresholds were reported in that year. Marijuana percentages for previous years were multiplied by the ratio of the 50 ng/ml percentage to the 100 ng/ml percentage in 1995.

[7]The specification search assumes homoscedasticity and no serial correlation. But the Newey-West standard errors are very similar to the uncorrected standard errors.

[8]Price lags do not generate missing data because my STRIDE file begins in 1974, and alcohol and cigarette prices for 1974 are available from the sources mentioned in Section 2.

[9]A few states had two legal drinking ages for beer, one for beer containing 3.2 percent or less alcohol by weight and a second and higher one for beer containing more than 3.2 percent alcohol by weight. These two measures are highly correlated.

[10]All predictions in this section are computed by multiplying the regression coefficient of the real price by the actual change in price. They are not obtained by multiplying the price elasticity by the percentage change in price. Give the linear specification of the price effect, the former procedure clearly is the correct one to employ.

[11]Between 1990 and 1992, there was almost no change in the drinking age.

[12]The price reductions just cited pertain to the lagged price, which is the regressor in the demand functions.

[13]Using city-specific DUF data for the years 1987-1991 and DAWN time series for the years 1978-1996, Caulkins (1996, 2001b) obtains negative price effects for the cocaine and

marijuana outcomes in Tables 3 and 4. His results are not comparable to mine because he does not control for time trends.

[14]I abstract from indirect costs associated with time required to make purchases and with expected penalties for conviction of use.

[15]DeCicca, Kenkel, and Mathios (2002) fail to find negative price effects in a study of smoking initiation by teenagers. This result emerges, however, only after they include dichotomous variables for each state of the U.S. in a panel that spans a very short four-year time period. It is plausible that there is not enough price variation in the data to estimate a demand function once state dummies are included as regressors in a sample that spans only four years. Glied (2002) finds that initiation of smoking by people in their mid to late twenties is positively related to the state excise tax faced by these people at age fourteen and argues that this finding is inconsistent with economic theory. This is a puzzling conclusion because the decision to start smoking should depend on changes in price between periods. Hence with the current price held constant, initiation should be positively related to the past price.

[16]The ambiguous sign of the past price effect can explain Glied's (2002) insignificant past tax effect in her estimated quit equation.

[17]Some debate exists with regard to this proposition. Evans and Farrelly (1998) report that cigarette excise tax hikes lead smokers to shift to higher tar and nicotine cigarettes. Their estimated effects are so large that many of the health benefits generated by reduced smoking participation are eliminated. On the other hand, Moore (1996) finds that state cigarette excise tax increases lead to decreases in mortality due to heart disease, cancer, and asthma and that a ten percent tax hike would save over 5,000 lives per year.

[18]In their study of the demand for cocaine, Grossman and Chaloupka (1998) report a reduction in the long-run price elasticity from -1.35 to -0.67 when they control for fixed effects.

[19]I do not address the issue of whether cigarettes, alcohol, and illegal drugs are substitutes or complements in this review. Grossman, Chaloupka, and Shim (2002) summarize a number of studies that contain the tentative conclusion that these substances are complements. Thus, an increase in the price of one harmful substance is reinforcing in the sense that it causes consumption of that substance and others to fall. I also do not discuss the effects of other components of the total price of a harmful substance on consumption and consequences in any detail. For reviews of the evidence of these effects, see Grossman (2001) and Grossman, Chaloupka, and Shim (2002).

[20]Much of the following discussion is relevant to marijuana, heroin, and other legal drugs as well as to cocaine. It is based on material on the same in issue contained in Grossman, Chaloupka, and Shim (2002).

Table 1

Federal Excise Tax Rates on
Alcoholic Beverages and Cigarettes, 1951-2003

| | |
|---|---|
| | Distilled Spirits |
| 1951-Sept 1985 | $10.50 per proof gallon |
| Oct 1985-1990 | $12.50 per proof gallon |
| 1991-present | $13.50 per proof gallon |
| | Beer |
| 1951-1990 | 16 cents per six pack |
| 1991-present | 32 cents per six pack |
| | Wine |
| 1951-1990 | 3 cents per bottle |
| 1991-present | 21 cents per bottle |
| | Cigarettes |
| 1951-1982 | 8 cents per pack |
| 1983-1990 | 16 cents per pack |
| 1991-1992 | 20 cents per pack |
| 1992-1999 | 24 cents per pack |
| 2000-2002 | 34 cents per pack |
| 2003 | 39 cents per pack |

Table 2

Cigarette Smoking, Alcohol Use, Binge Drinking, and Marijuana Regressions, High School Seniors

| | Cigarette Smoking | Alcohol Use | Alcohol Use[c] | Binge Drinking | Binge Drinking[c] | Marijuana Participation |
|---|---|---|---|---|---|---|
| Price[a] | -0.122 | -0.335 | -0.430 | -0.684 | -0.525 | -0.098 |
| | (-5.23) | (-2.86) | (-7.30) | (-5.47) | (-15.11) | (-3.65) |
| Time | -3.289 | -0.070 | -0.669 | -1.279 | -0.462 | 1.115 |
| | (-6.09) | (-0.11) | (-5.35) | (-1.90) | (-8.13) | (1.03) |
| Time squared | 0.227 | -0.062 | | -0.117 | | -0.134 |
| | (5.83) | (-1.42) | | (-0.26) | | (-1.58) |
| Time cubed | -0.004 | .001 | | 0.008 | | 0.003 |
| | (-4.52) | (1.57) | | (0.82) | | (1.58) |
| Legal drinking age | | | -1.937 | | -4.612 | |
| | | | (-2.00) | | (-8.58) | |
| $R^2$ | 0.822 | 0.939 | 0.939 | 0.950 | 0.972 | 0.792 |
| F-statistic | 27.71 | 92.15 | 128.49 | 115.13 | 294.58 | 22.85 |
| Price elasticity[b] | -0.464 | -0.428 | -0.549 | -1.985 | -1.525 | -0.459 |

Note: Sample size is 29 in each regression. Newey-West (1987) t-statistics are given in parentheses. Standard errors on which they are based allow for heteroscedasticity and for autocorrelation up to and including a lag of three. Intercepts are not shown.

[a]Price pertains to the real price of cigarettes, beer, and marijuana, respectively. The cigarette price is the price as of November 1 of year t-1 adjusted for Federal tax increases as of January 1 of year t and for the 45 cent increase in the nominal price in late November of 1998. The beer price in the alcohol use equation is the annual price lagged one year. Similarly, the marijuana price in the marijuana participation equation is the annual price lagged one year. The beer price in the binge drinking equation is a simple average of the prices in the fourth quarter of year t-1 and the first quarter of year t. See the text for more details.

[b]Evaluated at sample means.

[c]Model without time squared and time cubed has lowest residual variance.

Table 3

Regressions for Rates of Hospital Emergency Room Mentions for Marijuana, Cocaine, and Heroin

| | Marijuana | Marijuana | Cocaine | Cocaine | Heroin | Heroin |
|---|---|---|---|---|---|---|
| Price[a] | -0.021 | -0.093 | -0.198 | -0.015 | -0.004 | 0.001 |
| | (-1.79) | (-5.67) | (-5.20) | (-1.21) | (-2.03) | (2.34) |
| Time | 0.570 | 1.425 | -28.533 | 2.723 | -4.663 | 1.461 |
| | (1.10) | (9.21) | (-5.51) | (6.67) | (-1.83) | (15.25) |
| Time squared | -0.556 | | 1.705 | | 0.308 | |
| | (-1.28) | | (7.00) | | (2.41) | |
| Time cubed | 0.004 | | -0.031 | | -0.005 | |
| | (3.77) | | (-7.74) | | (-2.37) | |
| $R^2$ | 0.988 | 0.918 | 0.985 | 0.948 | 0.979 | 0.959 |
| F-statistic | 416.03 | 122.87 | 337.22 | 210.53 | 234.07 | 254.59 |
| Price elasticity[b] | -0.265 | -1.188 | -1.732 | -0.133 | -0.614 | 0.095 |

Note: Sample size is 25 in each regression. Newey-West (1987) t-statistics are given in parentheses. Standard errors on which they are based allow for heteroscedasticity and for autocorrelation up to and including a lag of three. Intercepts are not shown.

[a]Price pertains to the real price of marijuana, cocaine, and heroin, respectively, in year t. See the text for more details.

[b]Evaluated at sample means.

Table 4

Regressions for Percentages of Arrestees Testing Positive for Marijuana, Cocaine, and Heroin

| | Marijuana[c] | Marijuana | Cocaine | Cocaine | Heroin | Heroin |
|---|---|---|---|---|---|---|
| Price[a] | -0.019 | -0.012 | -0.111 | -0.096 | -0.001 | -0.0001 |
| | (-0.65) | (-0.99) | (-8.40) | (-7.11) | (-2.06) | (-0.18) |
| Time | 0.729 | 1.074 | -2.580 | -1.538 | 0.160 | -0.074 |
| | (0.59) | (8.72) | (-3.81) | (-23.96) | (3.69) | (-0.71) |
| Time squared | 0.018 | | 0.109 | | 0.160 | |
| | (0.29) | | (1.08) | | (3.69) | |
| Time cubed | | | -0.003 | | -0.005 | |
| | | | (-0.79) | | (-2.71) | |
| $R^2$ | 0.840 | 0.838 | 0.970 | 0.963 | 0.638 | 0.116 |
| F-statistic | 19.18 | 30.97 | 79.81 | 155.44 | 4.40 | 0.78 |
| Price elasticity[b] | -0.106 | -0.068 | -0.406 | -0.353 | -0.175 | -0.016 |

Note: Sample size is 15 in each regression. Newey-West (1987) t-statistics are given in parentheses. Standard errors on which they are based allow for heteroscedasticity and for autocorrelation up to and including a lag of three. Intercepts are not shown.

[a]Price pertains to the real price of marijuana, cocaine, and heroin, respectively, in year t. See the text for more details.

[b]Evaluated at sample means.

[c]Inclusion of time cubed raises residual variance. Model without time squared has a lower residual variance than the one that includes this variable.

Table 5

Cigarette Price Elasticities, by Age

| Study | Age Group | Participation Elasticity | Unconditional Elasticity |
|---|---|---|---|
| Lewit, Coate, and Grossman (1981) | 12-17 | -1.20 | -1.45 |
| Lewit and Coate (1982) | 20-25 | -0.74 | -0.94 |
| | 26-35 | -0.44 | -0.48 |
| | over 35 | -0.15 | -0.30 |
| Chaloupka and Grossman (1996) | 12-17 | -0.68 | -1.31 |
| Chaloupka and Wechsler (1997) | college students | -0.53 | -1.12 |
| Lewit et al. (1997) | 14-15 | -0.88 | not computed |
| Evans and Huang (1998) | high school seniors | -0.50 | not computed |
| Evans and Farrelly (1998) | 18-24 | -0.36 | -0.63 |
| | 25-39 | -0.21 | -0.42 |
| | 40+ | +0.01 | -0.01 |
| | 18+ | -0.11 | -0.22 |
| Harris and Chan (1999) | 15-17 | -0.83 | -1.00 |
| | 18-20 | -0.52 | -0.78 |
| | 21-23 | -0.37 | -0.64 |
| | 24-26 | -0.20 | -0.66 |
| | 27-29 | -0.10 | -0.32 |
| Gruber and Zinman (2001) | high school seniors | -0.67 | -0.73 |

[a]Unconditional elasticity is sum of participation elasticity and quantity smoked conditional on participation elasticity.

**Figure 1**
**Real Alcohol and Cigarette Prices, 1975-2003**

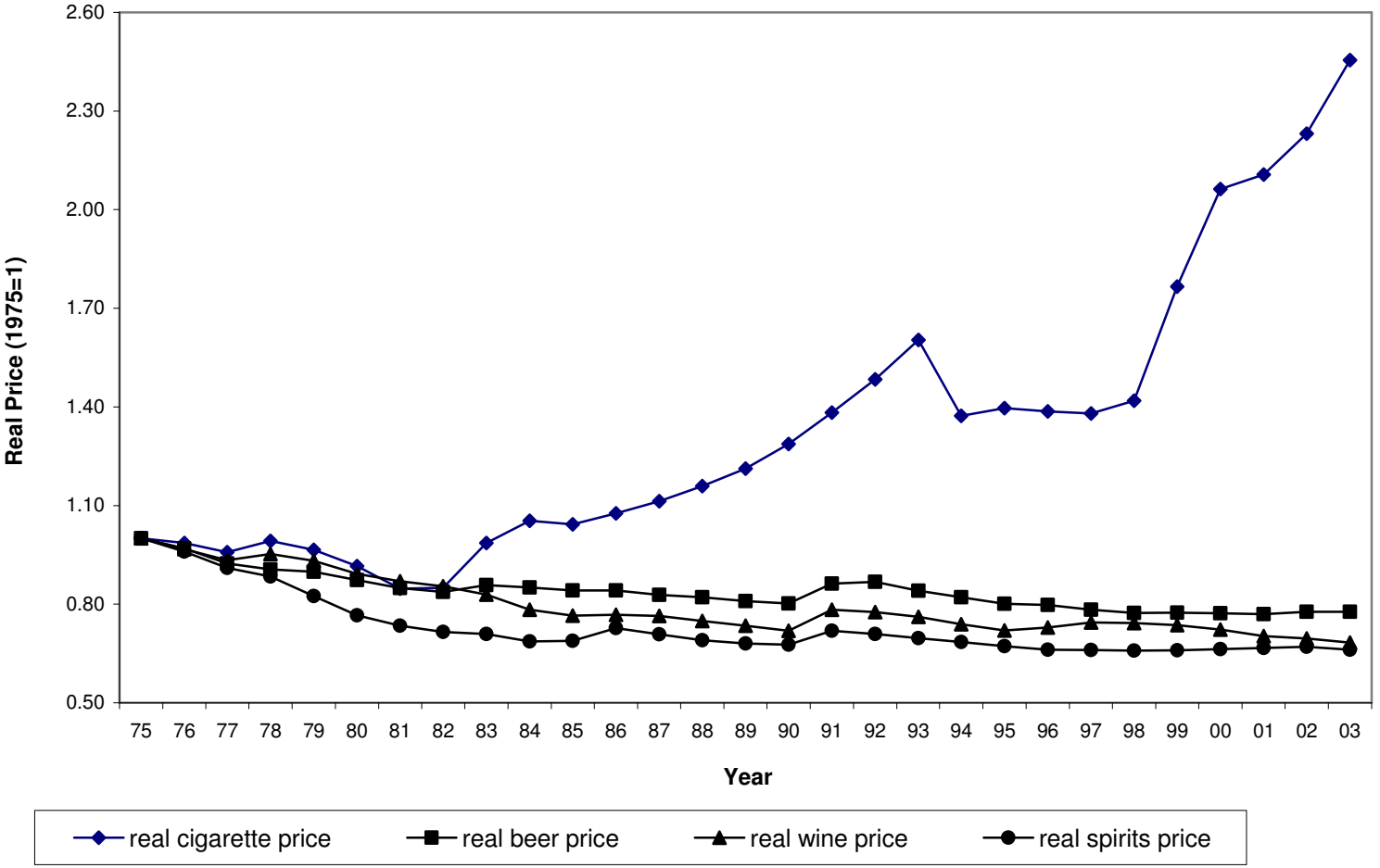

**Figure 2**
**Real Cocaine, Heroin, and Marijuana Prices 1975-2003**

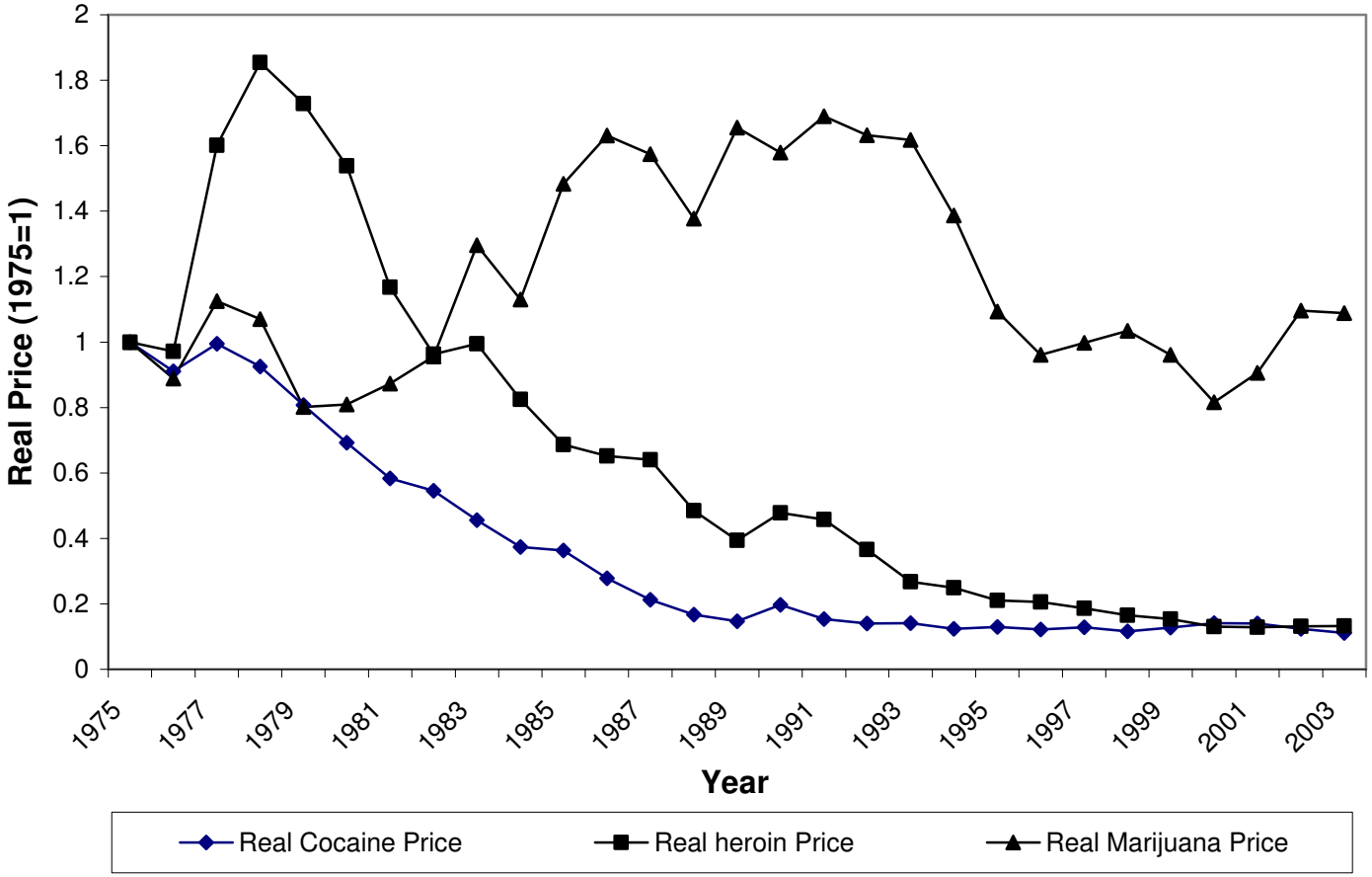

**Figure 3**
**Participation Rates for Smoking, Alcohol Consumption and Binge Drinking Among High School Seniors, 1975-2003**

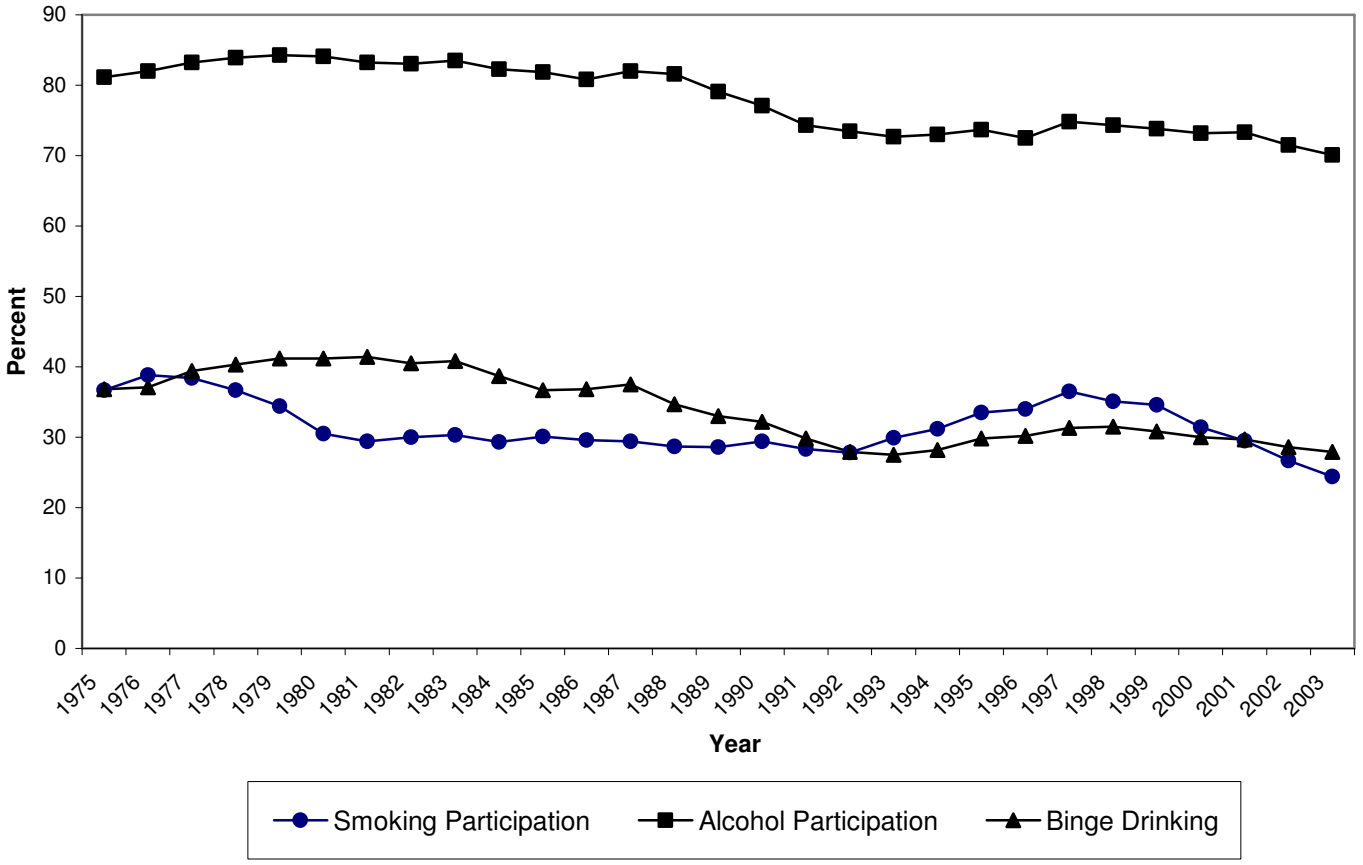

**Figure 4**
**Annual Prevalence of Marijuana, Cocaine, and Heroin Use, High School Seniors, 1975-2003**

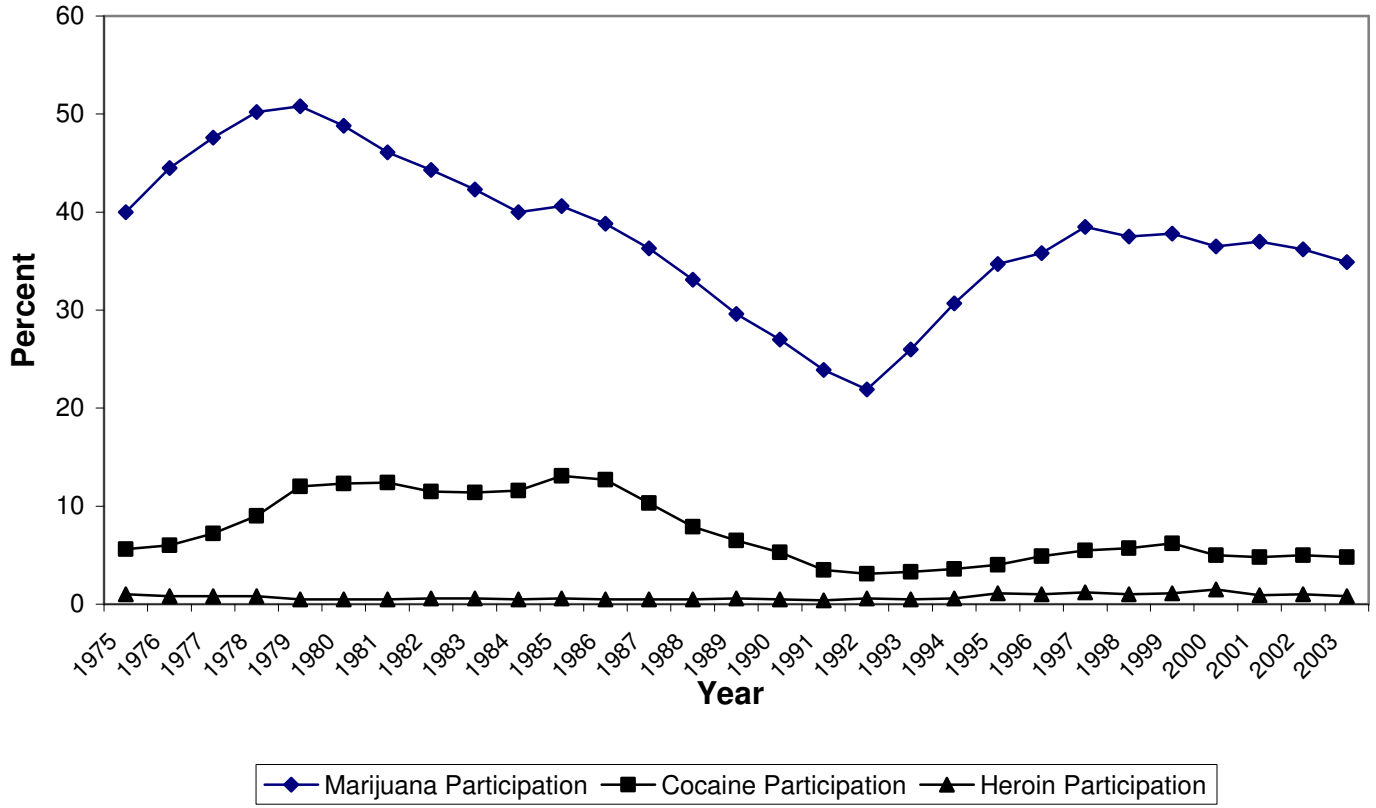

**Figure 5**
**Rates of Hospital Emergency Room Marijuana, Cocaine and Heroin Mentions, 1978-2002**
**(per 100,000 population)**

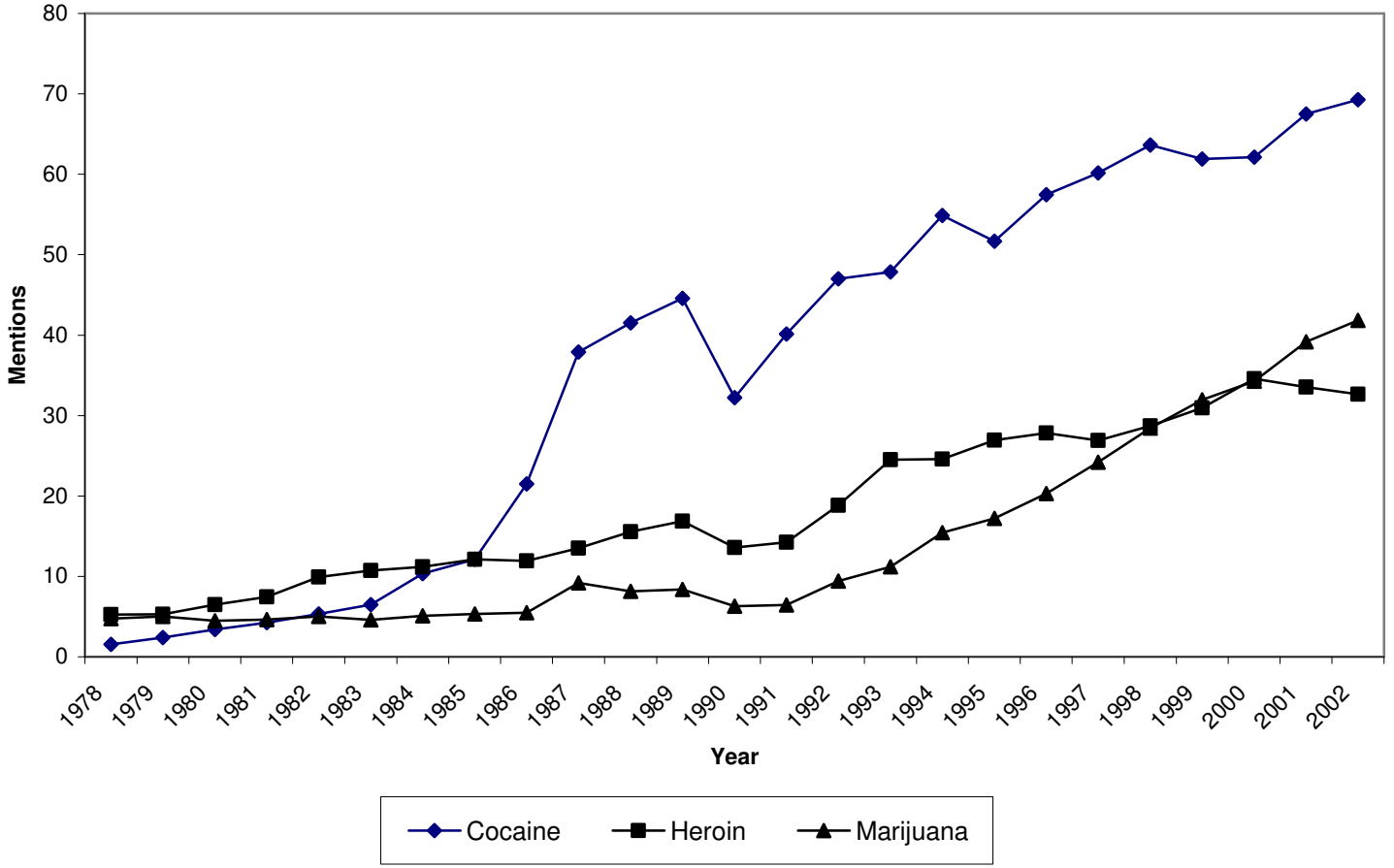

**Figure 6**
**Percentage of Arrestees Testing Positive fo Marijuana, Cocaine, and Heroin, 1989-2003**