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The demand for cocaine by young adults: a rational addiction approach

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Abstract

This paper applies the rational addiction model to the demand for cocaine by young adults in the Monitoring the Future panel. The price of cocaine is added to this survey from the Drug Enforcement Administration's System to Retrieve Information from Drug Evidence. Results suggest that annual participation and frequency of use given participation are negatively related to the price of cocaine. In addition, current participation (frequency) is positively related to past and future participation (frequency). The long-run price elasticity of total consumption (participation multiplied by frequency given participation) of −1.35 is substantial. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

The period from the late 1980s to the present has witnessed a lively debate concerning the costs and benefits of legalization of such substances as cocaine,

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marijuana, and heroin. Legalization of these harmfully addictive goods surely will reduce their prices. By the law of the downward-sloping demand function, their consumption will rise. Prices will also fall and consumption will rise if these substances remain illegal, but resources allocated to enforcement activities are permanently lowered. But by how much will consumption rise? According to conventional wisdom, which is adopted by some proponents of legalization, the consumption of these illegal addictive substances is not very responsive to price. Opponents of legalization argue that consumption may be quite responsive to price based in part on research on the demand for two widely used legal addictive substances—alcohol and cigarettes—particularly by teenagers and young adults (for example, Grossman, 1993).

The theoretical model of addictive behavior of Becker and Murphy (1988), which assumes that addicts behave rationally, allows for the possibility that addictive goods may be responsive to price in the long run. Their model emphasizes the interdependency of past, current, and future consumption of an addictive good. The main element of this and other models of addictive behavior is that an increase in past consumption of an addictive good raises the marginal utility of current consumption and therefore raises current consumption. A key feature of the Becker–Murphy model that distinguishes it from other models of addictive behavior is that addicts are rational or farsighted in the sense that they anticipate the expected future consequences of their current actions. This is in contrast to myopic models of addiction in which consumers 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. The Becker–Murphy model predicts intertemporal complementarity of consumption or negative cross price effects. This model and myopic addiction models predict that the long-run own price elasticity of demand should exceed the short-run elasticity (the former allows past consumption to vary while the latter does not). Hence, the conventional wisdom may be correct for short-run price changes but not for long-run price changes.

The purpose of this paper is to inform the debate on legalization by providing estimates of the price elasticity of demand for cocaine consumption in the context of the rational addiction model. These estimates also are useful in evaluating policies such as crop reduction and criminal justice that raise price. There are few previous empirical studies in this area, and no previous attempts to study the demand for illegal drugs with a panel of individuals in the context of rational addiction because data on prices and quantities consumed of illegal drugs have been difficult to acquire. The data employed in this study consist of the panel formed from the nationally representative cross-sectional surveys of high school seniors conducted each year since 1975 by the Institute for Social Research of the University of Michigan as part of the Monitoring the Future research program. The members of the panel range in age from 17 through 29. Since the prevalence of cocaine consumption is highest in this age range, and few people initiate use after age 29 (National Institute on Drug Abuse, 1991), information on the responsiveness to price in this segment of the population is crucial in evaluating the impacts of alternative price policies in all segments of the population.

We find that cocaine consumption by young adults is addictive in the sense that increases in past or future consumption cause current consumption to rise. The positive and significant future consumption effect is consistent with the hypothesis of rational addiction and inconsistent with the hypothesis of myopic addiction. The long-run price elasticity of −1.35 is substantial and approximately 40% larger than the short-run price elasticity.

2. Prior studies

There are few published studies on the effects of price on the use of cocaine, marijuana, heroin, or other illegal drugs; and no published studies that investigate price effects in nationally representative micro panel data. Nisbet and Vakil (1972) report a price elasticity of demand for marijuana ranging from −0.36 to −1.51 in an anonymous mail survey of students at the University of California at Los Angeles. Silverman and Spruill (1977) estimate the price elasticity of demand for heroin in an indirect manner from the relationship between crime and the price of heroin in a monthly time series of 41 neighborhoods in Detroit and obtain an elasticity of −0.27. DiNardo (1993) finds that cocaine participation in the past month by high school seniors does not respond to the price of cocaine price in a time series of state cross sections for the years 1977–1987. van Ours (1995) examines the demand for opium in Indonesia from 1923 through 1938. By allowing present consumption to depend on past consumption, his study is the only one to explicitly allow for addiction. van Ours obtains a substantial long-run elasticity of −1.00, which is approximately 40% larger than the short-run price elasticity.

The Becker and Murphy (1988) rational addiction model has been applied successfully to the demand for cigarettes by Chaloupka (1991), Keeler et al. (1993), and Becker et al. (1994). It also has been applied successfully to the demand for alcohol by Grossman et al. (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.

3. Analytical framework

Following Becker et al. (1994), we assume that consumers maximize a lifetime utility function given by:

$$V = \sum_{t=1}^{\infty} \beta^{t-1} U(Y_t, C_t, C_{t-1}, e_t) \tag{1}$$

Here Y_t is consumption of a non-addictive good at time or age t, C_t is consumption of an addictive good (cocaine in our case) at age t, C_{t-1} is cocaine consumption at age $t-1$, e_t reflects the effects of measured and unmeasured life cycle variables on utility, and β is the time discount factor [$\beta = 1/(1+r)$, where r is the rate of time preference for the present]. An increase in lagged cocaine consumption (C_{t-1}) lowers utility if the addiction is harmful ($\partial U/\partial C_{t-1} < 0$), while an increase in lagged consumption raises utility if the addiction is beneficial ($\partial U/\partial C_{t-1} > 0$). [1] In this paper, presumably, the partial derivative just defined is negative, although the model simply assumes that this term is nonzero. Regardless of the nature of the addiction, an increase in past consumption must raise the marginal utility of C_t in order for an increase in past consumption of C to increase current consumption.

When the utility function is quadratic and the rate of time preference for the present is equal to the market rate of interest, Eq. (1) generates an equation of motion for current consumption, which we term a structural demand function, of the form: [2]

$$C_t = \theta C_{t-1} + \beta\theta C_{t+1} + \theta_1 P_t + \theta_2 e_t \tag{2}$$

Here P_t is the price of C_t, and the intercept is suppressed. Since θ is positive and θ_1 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, θ measures the effect of an increase in past consumption on the marginal utility of current consumption. By symmetry, it also measures the effect of an increase in future consumption on the marginal impact of current consumption on next period's utility. The larger the value of θ, the greater is the degree of reinforcement or addiction.

Eq. (2) is the basis of the empirical analysis in this paper. Note that ordinary least squares estimation of the equation might lead to biased estimates of the

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[1] These are particular definitions of harmful and beneficial addiction in the sense that they pertain to the effects of past consumption on current utility. Past consumption also might affect such variables as the current wage rate and current hours of work. We rule out these effects in outlining the theory but consider them when we discuss the roles of time-varying socioeconomic variables as determinants and consequences of consumption in Sections 4 and 5.

[2] For a derivation of Eq. (2), including formulas that relate the parameters in the demand function to those in the underlying utility function, see Becker et al. (1994). Eq. (2) assumes no interaction between C_t and e_{t+1} in the current period utility function at time $t+1$. That is, it assumes that $\partial^2 V/\partial e_{t+1}\partial C_t = 0$. This does not mean that changes in future life cycle variables (e_{t+1}) have no effects on current consumption. Instead, it means that these effects operate through future consumption. It is analogous to the assumption that a change in future price affects current consumption through its impact on future consumption.

parameters of interest. The unobserved variables that affect utility in each period are likely to be serially correlated. Even if these variables are uncorrelated, C_{t-1} and C_{t+1} depend on e_t through the optimizing behavior. These relationships imply that an ordinary least squares estimation of the equation might incorrectly imply that past and future consumption affect current consumption, even when the true value of θ is zero.

Fortunately, the specification in Eq. (2) suggests a way to solve the endogeneity problem. The equation implies that current consumption is independent of past and future prices when past and future consumption are held constant; any effect of past or future prices on current consumption must come through their effects on past or future consumption. Provided that the unobservables are uncorrelated with prices in these periods, past and future prices are logical instruments for past and future consumption, since past prices directly affect past consumption, and future prices directly affect future consumption. Therefore, the empirical strategy amounts to estimating Eq. (2) by two-stage least squares, with past and future prices serving as instrumental variables for past and future consumption. This strategy can be modified when measures of some of the life cycle events that affect utility and therefore partially determine e_t, such as marital status and unemployment, are available. Then current marital status, for example, is a relevant regressor in the structural demand function given by Eq. (2), and past and future marital status are instruments for past and future consumption.

The statistical significance of the coefficient of future consumption provides a direct test of a rational model of addiction against an alternative model in which consumers are myopic. The latter model fails to consider the impact of current consumption on future utility and future consumption. That is, the myopic version of Eq. (2) is entirely backward looking. Because of this distinction, myopic models and rational models have different implications about responses to future changes. In particular, rational addicts increase their current consumption when future prices are expected to fall, but myopic addicts do not.

Eq. (2) implies intertemporal complementarity or negative cross price elasticities between cocaine consumption at various points in time. These effects pertain to changes in the price of cocaine in period τ on consumption in period t. They are temporary in nature since prices in other periods are held constant. For example, a reduction in price in period $t+1$ (P_{t+1}) with prices in all other periods held constant will increase consumption in that period. In turn, C_t will rise since $\beta\theta$ is positive.

Eq. (2) also implies that there are important differences between long- and short-run responses to permanent price changes (price changes in more than one period) in the case of addiction. The short-run price effect describes the response to a change in price in period t and all future periods that is not anticipated until period t. The long-run price effect pertains to a price change in all periods. Since C_{t-1} remains the same if a price change is not anticipated until period t, the long-run price effect must exceed the short-run price effect. In addition, the short-run price effect must exceed the temporary current price effect since the latter holds future prices constant. [3]

4. Data and empirical implementation

4.1. Sample

Each year since 1975, the University of Michigan's Institute for Social Research has conducted a nationally representative random sample of between 15,000 and 19,000 high school seniors during the months of March and April as part of the Monitoring the Future research program. These surveys, which are described in detail by Johnston et al. (1995), focus on the use of illegal drugs, alcohol, and cigarettes. Starting with the class of 1976, a sample of approximately 2400 individuals in each senior class has been chosen for followup at 2-year intervals. Individuals reporting the use of marijuana on 20 or more occasions in the past 30 days or the use of any other illegal drugs in the past 30 days in their senior year are selected with a higher probability (by a factor of 3).

We estimate cocaine demand functions using the panels formed from the high school senior surveys conducted from 1976 through 1985. The last followup in our data set, which contains approximately 22,800 persons, took place in 1989. We have between one and five observations on each person since we require information on current, past, and future consumption of cocaine. Since an annual measure of consumption is used in the regressions, past consumption coincides with the second annual lag and future consumption coincides with the second annual lead.

Although Monitoring the Future obtains information on the use of a variety of illegal drugs, we limit the empirical analysis to cocaine for several reasons. Cocaine prices (described in more detail in Section 4.2) are available for many more areas and are based on much larger samples than the prices of other illegal drugs. Moreover, cocaine was the second most widely used illegal substance next to marijuana during the sample period.

One problem with the Monitoring the Future panels is that persons who dropped out of high school prior to March of their senior year are excluded. Dropouts may have different cocaine consumption patterns than persons who remain in school. Nevertheless, the Monitoring the Future sample is the longest

[3] These results can be seen more formally by solving the second-order difference in Eq. (2). The solution, which is contained in Becker et al. (1994), results in an equation in which consumption in period t depends on prices and life-cycle variables in all periods. Formulas for the long-run, short-run, and temporary current price effects also are contained in the paper just cited.

nationally representative panel with information on cocaine consumption in the age group that has the highest rate of cocaine use. Panel retention rates have been very high. In the first followup after high school, approximately 82% of the persons selected for followup have returned questionnaires. The 1988 panel retention from the class of 1976 was between 71 and 74% (Johnston et al., 1989).

4.2. Cocaine prices

Information on county identifiers at baseline and at each followup allowed us to augment the data set with cocaine prices from the System to Retrieve Information from Drug Evidence (STRIDE) maintained by the Drug Enforcement Administration (DEA) of the US Department of Justice. DEA and FBI agents and state and local police narcotics officers purchase illicit drugs on a regular basis in order to apprehend dealers. Taubman (1991) argues that DEA agents must make transactions at close to the street price of cocaine in order to make an arrest because an atypical price can cause suspicion on the part of dealers.

Information on the date and city of the purchase, its total cost, total weight in grams, and purity (as a percentage) is recorded in STRIDE. There are 139 cities in STRIDE with usable data for the period from 1977 through 1991. Following DiNardo (1993) and Caulkins (1994), we obtained the price of 1 g of pure cocaine by year and city from a regression of the natural logarithm of the total purchase cost on the natural logarithm of weight, the natural logarithm of purity, dichotomous variables for each city and year except one, and interactions between the year variables and dichotomous variables for eight of the nine Census of Population divisions. The regression is based on over 25,000 purchases.

The cost of a purchase is more likely to be governed by the user's perception of purity than by its actual value (Caulkins, 1994). Since purchasers are likely to have imperfect information about purity, the coefficient of the logarithm of actual purity is biased downward given that the difference between the logarithms of perceived and actual purity is not correlated with the logarithm of perceived purity. Thus, we use the other regressors in the total cost equation as instruments for purity. To identify the model, the coefficient of the natural logarithm of predicted purity is constrained to equal the coefficient of the natural logarithm of weight. [4] The price of 1 g of pure cocaine is then given as the antilogarithm of the sum of the intercept, the relevant city coefficient, and the relevant time-division

[4] In this regression, the coefficient of the logarithm of weight times predicted purity equals 0.724, with a standard error of 0.002. Hence, the coefficient is significantly less than 1, indicating that the cost of a pure gram falls as the number of pure grams rises. This means that price cannot be obtained by simply dividing total cost by the product of weight and purity.

coefficient. The money price is converted to a real price by dividing it by the annual Consumer Price Index for the US as a whole (1982–1984 = 1).

Several things should be noted about the methodology just described. First, it eliminates variations in the price or unit cost of cocaine due to variations in weight and purity. Second, the resulting year- and city-specific price is akin to a geometric mean. Hence, the influence of outliers is mitigated. Finally, we experimented with alternative specifications of the total cost regression. In one specification, interactions between time and Census division were eliminated. In a second, purity was treated as exogenous with an unconstrained coefficient. In a third, purity was deleted as a regressor, but its predicted value was included as an independent variable in the cocaine demand function. The estimates presented in Section 5 are not sensitive to these alternative specifications of the total cost regression.

To match DEA cities to Monitoring the Future counties, we assigned each to its Metropolitan Statistical Area, Central Metropolitan Statistical Area, or Primary Metropolitan Statistical Area (whichever was smaller). For any county where a match could not be made, price was defined as a population-weighted average of price in all DEA cities in that county's state. The second annual lag and the second annual lead of the real price of cocaine, which are employed as instruments in two-stage least squares regression models, were added to the panels in the same manner. Changes of residence to a different county by panel members during the sample period were taken into account when the prices were added.

Although our sample period includes the widespread introduction of crack cocaine in late 1985 or early 1986, we do not distinguish between the price of crack and the price of powder cocaine. Crack's reputation for being less expensive than powder is due primarily to the smaller quantity at which it is retailed (Caulkins, 1995). Caulkins (1997) finds that the price per pure gram of crack is the same as the price per pure gram of powder cocaine. Crack cocaine gives a more intense but shorter high than powder cocaine. If quantity is defined as the product of intensity and duration, it is not clear which type of cocaine is more or less expensive.

The full price of consuming cocaine consists of three components: (1) the money price; (2) the monetary value of the travel and waiting time required to obtain cocaine; and (3) the monetary value of the expected penalties for possession or use (the probability of apprehension and conviction multiplied by the fine or the monetary value of the prison sentence). We assume that variations in cocaine prices among cities can be used to trace out a demand function because they reflect differences in the three components of the full price among cities. Put differently, larger transportation costs, stiffer fines and prison terms imposed on dealers, and higher probabilities of apprehension and conviction cause the supply function of cocaine, which we assume to be infinitely elastic, to shift upward and raise the money price of cocaine. To the extent that the number of dealers in the market falls, travel and waiting costs also rise. The full price will also increase if the expected penalty for possession and use is positively related to the expected penalty for selling cocaine. Since the direct and indirect price of obtaining cocaine are likely to be positively correlated, consumers may respond to changes in money prices even if they have imperfect knowledge about these prices. [5]

4.3. Measurement of variables

Table 1 contains definitions, means, and standard deviations of variables that are employed in the regression analyses in Section 5. They are based on the sample of 38,885 person–years or person–followups that result by deleting persons who failed to respond to at least three consecutive questionnaires (including baseline) and by deleting observations for which the use of cocaine in the past year, the real price of cocaine, and real annual earnings are missing. Given three observations per person on average, there are approximately 12,962 respondents in the final sample.

There are no missing values for age, male, black, and other race/ethnicity. Missing values for the other variables listed in the table are replaced by panel- and strata-specific means. Recall that there are two strata for each panel. One consists of persons who used marijuana 20 or more times in the past 30 days or used another illegal drug in the past 30 days at baseline, and the other consists of persons who did not exhibit these illegal drug use patterns at baseline. The means and standard deviations in the table were weighted to correct for oversampling—by a factor of three—of persons in the illegal drug stratum.

Panel members report the number of occasions in the past year on which they used cocaine. This is an ordered categorical variable with seven outcomes: 0 occasions, 1–2 occasions, 3–5 occasions, 6–9 occasions, 10–19 occasions, 20–39 occasions, and 40 or more occasions. Since many persons did not use cocaine in the past year, two dependent variables are considered. One is a dichotomous variable that identifies users (termed cocaine participation), and the second gives frequency of use (number of occasions) conditional on positive participation. Cocaine participation has a weighted mean of 15.9%. Since the unweighted mean is 23.0%, the sample of positive users contains 8926 observations (person–years).

[5] Even if the supply function of cocaine is not infinitely elastic, young adults can be viewed as price takers if they represent a small fraction of all illegal drug users. If this is not the case and the supply function slopes upward, we understate the price coefficient or elasticity in the demand function in absolute value. If the supply function slopes downward due to externalities (the greater is market consumption, the smaller is the probability of catching a given dealer), the price coefficient or elasticity in the demand function is overstated. Suppose that the demand function is linear in full price ($\pi = p + f$, where f is the expected penalty imposed on users), and suppose that $f = \alpha + kp$, $k > 0$, $\alpha \geq 0$. If f is omitted from the demand function, the elasticity of consumption with respect to p is less than or equal to the elasticity of consumption with respect to π as α is greater than or equal to zero.

Table 1
Definitions, means, and standard deviations of variables[a]

Cocaine participation (0.159, 0.320)	Dichotomous variable that equals 1 if respondent used cocaine at least once in the past year
Cocaine frequency given positive participation (9.195, 8.963)	Number of occasions in past year on which respondent used cocaine
Price (286.557, 117.204)	Price of one pure gram of cocaine in 1982–1984 dollars[b]
Legal drinking age * age $\leq$ 21 (12.093, 8.409)	Minimum legal age in years for purchase and consumption of beer, alcoholic content 3.2% or less (legal drinking age); multiplied by a dichotomous variable that equals 1 if respondent is 21 years of age or younger (age $\leq$ 21)[b]
Lower border drinking age indicator * age $\leq$ 21 (0.099, 0.261)	Dichotomous variable that equals 1 if respondent resides in a county within 25 miles of a state with a lower legal drinking age (lower border age indicator); multiplied by a dichotomous variable that equals 1 if respondent is 21 years of age or younger
Marijuana decriminalization indicator (0.330, 0.411)	Dichotomous variable that equals 1 if respondent resides in a state in which incarceration and heavy fines are not penalties for most marijuana possession offenses
Male (0.438, 0.434)	Dichotomous indicator
Black (0.091, 0.252), Other race/ethnicity (0.068, 0.221)	Dichotomous variables that identify Afro-Americans or blacks (Black) and American Indians, Puerto Ricans or other Latin Americans, Mexican Americans or Chicanos, or Orientals or Asian Americans (Other race/ethnicity); omitted category pertains to Caucasians or whites
Real earnings (7447.845, 5880.433)	Real earnings in the past calendar year in 1982–1984 dollars; money earnings divided by a year- and city-specific cost of living index

Years of completed schooling (13.357, 1.355)	Years of formal schooling completed
Full-time college student (0.334, 0.410)	Dichotomous indicators; omitted category pertains to persons not attending school in March of the survey year
Half-time college student (0.037, 0.164)	
Less than half-time college student (0.054, 0.196)	
Working full-time (0.530, 0.428)	Dichotomous indicators that pertain to first full week of March of the survey year; omitted category identifies respondents not in the labor force
Working part-time (0.215, 0.352)	
Unemployed (0.031, 0.149)	
Infrequent religious participation (0.410, 0.428)	Dichotomous variables that identify respondents who rarely attend religious services (infrequent religious participation) and who attend services at least once or twice a month (frequent religious participation), respective omitted category pertains to respondents who never attend religious services
Frequent religious participation (0.487, 0.435)	
Married (0.255, 0.381)	Dichotomous indications; omitted category pertains to single respondent
Engaged (0.084, 0.242)	
Separated or divorced (0.024, 0.134)	
Number of children (0.229, 0.499)	Respondent's number of children

[a] Means and standard deviations in parentheses. First figure is mean, second figure is standard deviation. Means and standard deviations are weighted by the inverse of the probability of selection; equivalent to multiplying values of a given variable from the illegal drug stratum by one-third. Basic set of independent variables also includes dichotomous variables for ages 18 through 26 and for years 1978 through 1986. Sample size is 38,885 except for cocaine frequency given positive participation where the sample size is 8926.

[b] See text for more details.

Cocaine frequency is converted into a continuous variable by assigning midpoints to the closed intervals and a value of 50 to the open-ended interval. [6]

Monitoring the Future did not distinguish between the use of crack cocaine and the use of other forms of cocaine until the 1986 baseline survey (not included in our sample) and the 1987 followup survey. In that followup and in the 1988 and 1989 followups, two-fifths of the respondents were asked separate questions on crack and powder cocaine. These answers have been aggregated to form indicators of the use of any form of cocaine and the frequency of use by means of an algorithm developed by the Institute for Social Research.

To account for the possibility that cocaine and alcohol or cocaine and marijuana are substitutes or complements, we include the minimum legal drinking age for the purchase and consumption of low-alcohol beer (described in detail in Chaloupka et al., 1993) and a dichotomous variable that identifies respondents of states that have decriminalized the possession of marijuana. Since no state has ever had a legal drinking age greater than 21, the drinking age is multiplied by a dichotomous variable that equals one for persons 21 years of age or younger.

In addition to the own-state minimum legal drinking age, a dichotomous indicator equal to one if a respondent resides in a county within 25 miles of a state with a lower legal drinking age is employed as a regressor. This variable is interacted with the dichotomous indicator for persons whose age is less than or equal to 21 for the same reason that the drinking age is interacted with this indicator. The border age variable is included in the model to capture potential border crossings by youths from states with high drinking ages to nearby lower age states to obtain alcohol. With the own-state legal drinking age held constant, the coefficient of the border age variable in the demand function should be negative if alcohol and cocaine are substitutes (the own-legal drinking age coefficient is positive in this case) and positive if they are complements (the own-legal drinking age coefficient is negative in this case).

A variety of independent variables were constructed from the demographic and socioeconomic information collected in the surveys. These include nine dichotomous age indicators (ages 18 through 26); sex; race (black or other); real annual earnings; years of formal schooling completed; college student status (full-time, half-time, or less than half-time); work status (full-time, part-time, or unemployed); religious participation (infrequent or frequent); marital status (married, engaged, or separated or divorced); and the respondent's number of children. Finally, all models include dichotomous variables for 9 of the 10 years covered by current consumption (1978 through 1986). The time-varying variables serve as proxies for life-cycle variables that affect the marginal utility of current consumption.

[6] To examine the sensitivity of the results to the value assigned to the open-ended interval, we assigned alternative values of 45, 55, 60, 65, 70, 80, 90, 100, 200, and 300 to this category. The absolute value of the slope coefficient of price rises as the value assigned to the open-ended category rises, but elasticities and tests of significance are not affected.

4.4. Estimation issues

We estimate separate equations for participation and for frequency given positive participation. This is an application of Cragg's (Cragg, 1971) two-part model for an outcome (cocaine consumption) with many nonparticipants or zero values. We prefer it to Heckman's (Heckman, 1979) sample selection procedure or to the adjusted tobit version of Heckman's procedure (van de Ven and van Praag, 1981) because the two-part model is more robust to violations of the normality assumption and because the sample selection model is not well-behaved if the regressors in the selection and primary equations are identical (Manning et al., 1987; Leung and Yu, 1996). Linear probability models for participation and linear models for frequency given participation are obtained. The two-stage least squares participation equations correspond to the simultaneous equations linear probability model of Heckman and MaCurdy (1985).

Given the nature of the panels, we estimate the participation version of Eq. (2) with the second lag of participation as the measure of past consumption and the second lead of participation as the measure of future consumption. Similarly, we estimate the equation for frequency conditional on positive use with the second lag of frequency as the measure of past consumption and the second lead of frequency as the measure of future consumption. [7] The instruments for past and future consumption in two-stage least squares (TSLS) estimation consist of the exogenous variables in the structural demand function for current consumption, the second lag of the annual real cocaine price, the second lead of the annual real cocaine price, the second annual lag and lead of the marijuana decriminalization indicator, the second annual lags of the two measures pertaining to the legal drinking age (legal drinking age $*$ age ≤ 21 and lower border drinking age indicator $*$ age ≤ 21), and the second leads and the second lags of all time-varying socioeconomic variables. These include real annual earnings, years of formal schooling completed, college student status, work status, religious participation, marital status, and number of children. The second leads of the two measures pertaining to the legal drinking age are not used as instruments because the values of these two variables are zero except at the first followup.

The simple version of the rational addiction model outlined in Section 3 implies that the parameters of the participation and frequency given participation equations are the same. That is, it implies that the tobit model (Tobin, 1958) is appropriate. We do not use the tobit model because so little is known about the demand for cocaine. Therefore, we do not want to constrain the parameters of price and other variables to be the same for the two outcomes. Moreover, underreporting of

[7] The sample of positive current users includes persons whose past or future values of use can be zero. In fact, the weighted means of past and future participation are 64% and 69%, respectively.

cocaine frequency is likely to be more of a problem than underreporting of cocaine participation (see below for more details). Since the rational addiction demand function given by Eq. (2) pertains to a continuous outcome, the parameter estimates of the participation equation should be viewed as first-order approximations.

Reported cocaine use in the Monitoring the Future cohort of young adults between the ages of 18 and 27 may underestimate actual use by all persons in this cohort in the US as a whole for two reasons. First, use may be underreported. Second, persons who dropped out of high school prior to March of their senior year are excluded. These persons are more likely to end up in groups with higher than average cocaine use such as criminals and the homeless than persons who graduated from high school. [8]

No definitive conclusions can be reached with regard to whether price effects or elasticities are biased by the above two factors. A number of studies have shown that reported cigarette or alcohol consumption in survey data is smaller than actual consumption measured by national sales (for example, Coate and Grossman, 1988; Wasserman et al., 1991). Wasserman et al. (1991) indicate that researchers usually assume that smoking participation is measured accurately, while the number of cigarettes smoked is underreported. Although there is no direct evidence to support this assumption, Marquis et al. (1981) find that self-reports of alcohol abstention are highly valid. Thus, it is likely that cocaine participation is more accurately reported than frequency given positive participation. This justifies considering them as separate outcomes.

There are no studies concerning whether response error in self reports of alcohol or cigarette consumption is systematic or correlated with variables that enter the demand functions for these substances. The same is true for cocaine. If linear demand functions are employed and the response error is random, coefficients are unbiased, although their standard errors are inflated. Elasticities evaluated at sample means are overstated because reported mean consumption is too small. An offsetting factor is that Midanik (1982) and Polich (1982) find that heavier consumers of alcoholic beverages are more likely to underreport their consumption than other persons. If the same pattern holds for cocaine and if heavy users are more likely to be found in areas with low prices, the estimated price parameter in the demand function is biased downward.

In the specific case of Monitoring the Future, Johnston and O'Malley (1985) argue that underreporting is reduced because the baseline survey is conducted in a high school setting. Clearly, parents are not present and are not informed of the

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[8] In a personal communication, Patrick M. O'Malley informed us that Monitoring the Future does attempt to survey panel members who are imprisoned. These attempts are not very successful, and the reliability of data obtained from prison inmates is very questionable since their correspondence can be read by prison officials.

responses. Followup questionnaires are mailed directly to the respondents. They also argue that self-reported illegal drug use has a high degree of construct validity in their data because it is correlated with a host of other variables in predictable ways. Finally, they point out that missing data rates on the illegal drug use questions are only slightly above average, even though respondents are instructed to skip these items if they cannot answer them honestly.

With regard to the absence of high school dropouts, Johnston and O'Malley (1985) summarize studies by themselves and others showing that dropouts have higher rates of illegal drug use and younger ages of initiation than in-school students. They also show that adjustment of baseline prevalence rates (illegal drug use participation rates at age 17) for the higher participation rates of dropouts has a minor effect on overall rates since only 15% of the relevant cohort are dropouts. Of course, the difference in the use of illegal drugs between dropouts and high school graduates may increase beyond age 17. If price and consumption slope coefficients in the demand function for dropouts are the same as for high school graduates, parameter estimates of these slopes are not biased by omitting dropouts. The price elasticity of demand of graduates is larger than that of dropouts since the former group consumes less.

If slope coefficients differ between dropouts and graduates, no conclusions can be reached with regard to the nature of the biases. Thus, the most cautious approach to our empirical analysis and results is to limit conclusions to persons who were in high school in March of their senior year. Note that persons from the illegal drug stratum are not more likely to drop out as the panel ages. Thus, our estimates are not biased because heavy users of illegal drugs who did not drop out of high school are more likely to leave the panel as it ages.

The real price of cocaine contains measurement error for several reasons. First, the price data pertain to the DEA survey city nearest to the respondents county of residence rather than to the city or town in which the respondent actually resides. Second, the respondent may have imperfect information concerning the market price and the quality (purity) of the purchase, which creates a difference between this price and the perceived price that governs his or her consumption. Third, the future price employed assumes that respondents who moved fully anticipated the move. Random measurement error in an independent variable biases its coefficient and t-ratio toward zero. Thus, the price coefficients and the t-ratios of the price coefficients in Section 5 are conservative lower-bound estimates, although the coefficients and associated t-ratios of other variables may be overstated.

We estimate a rational addiction model of cocaine consumption by assuming perfect foresight and using the actual future price and the actual future values of the socioeconomic variables as instruments for future consumption. Becker et al. (1994) adopt this same strategy. They point out that individuals' forecast errors in future price and other future variables create a downward bias in the coefficient of future consumption because these factors introduce random measurement error into the predicted value of future consumption.

An additional problem with the use of leads of socioeconomic variables as instruments is that these variables may not be exogenous. For example, assume that the unmeasured life cycle variable (e_t) in the demand function given by Eq. (2) causes current cocaine consumption to rise. This shock to current consumption also may lower future earnings and reduce the probability of marriage in the future. With a single socioeconomic variable, the predicted value of future consumption and e_t will be correlated. But with more than one socioeconomic variable, there may be offsetting forces that attenuate or eliminate the correlation between predicted future consumption and e_t. To anticipate the results in Section 5, earnings have a positive effect on consumption, while married persons consume less than other persons. The first factor creates a negative correlation between predicted consumption and e_t, while the second factor creates a positive correlation.

We acknowledge that the assumption of perfect foresight in the rational addiction model and the use of future socioeconomic variables as instruments are controversial and may create biases. We deal with these issues in two ways. First, we estimate a myopic as well as a rational model of cocaine addiction. In the former model, future consumption is deleted from the demand function and future variables are deleted as instruments. Second, we examine the sensitivity of the results to the exclusion of current values of the socioeconomic variables from the demand functions and past and future values of these variables from the set of instruments.

Given the panel nature of the sample, the disturbance terms of a given person are likely to be correlated over time. Disturbance terms of different people within the same county also may be correlated. Grossman et al. (1998) find that Huber (1967) standard errors, which take account of these correlations, are no larger than uncorrected standard errors in their study of rational addiction demand functions for alcohol in the Monitoring the Future panels. We observed a similar phenomenon in preliminary estimates of demand functions for cocaine. Thus, the standard errors in Section 5 are not corrected for intra-person or intra-cluster (county) correlations. We also found that the choice between weighted regressions (to correct for oversampling of illegal drug users at baseline) and unweighted regressions is moot because the two sets of estimates are very similar. The same finding is reported by Grossman et al. (1998).

5. Empirical results

5.1. Basic estimates

Tables 2 and 3 test the rational addiction model of cocaine consumption by estimating structural demand functions given by Eq. (2) for cocaine participation (Table 2) and for frequency of cocaine use given positive participation (Table 3).

The first and third columns of each table contain two-stage least squares (TSLS) regressions in which past and future participation or past and future frequency are treated as endogenous. The model in the first column includes current values of the socioeconomic variables in the structural demand function and past and future values of these variables as instruments in the first stage. The model in the third column deletes past and future values of the socioeconomic variables as instruments in the first stage and omits current values of these measures as exogenous variables in the structural equation and in the first stage. Thus, in column 3, the only instruments for past and future consumption are the past and future price, the past and future marijuana decriminalization indicator, the past legal drinking age, and the past lower border drinking age indicator. The second and fourth columns contain the ordinary least squares regressions corresponding to the TSLS regressions in the first and third columns, respectively.

The tables also contain χ^2 statistics resulting from the test of the hypothesis of Hausman (1978) that OLS estimates are consistent, *F*-ratios resulting from the test of Basmann (1960) that the overidentification restrictions are valid, and *F*-ratios pertaining to the tests that the instruments for past and future consumption are significant as a set in the first stage. Thus, the *F*-ratio of 24.88 (with degrees of freedom 32, infinity) for the instruments for past participation in the first column of Table 2 is obtained by testing the hypothesis that the coefficients of the following measures are significant as a set in the reduced form regression for past participation: past price, future price, past marijuana decriminalization, future marijuana decriminalization, past drinking age, past border drinking age, past socioeconomic variables, and future socioeconomic variables.

The first stage regressions for past and future participation are shown in Table A1 in the Appendix, and the first stage regressions for past and future frequency are shown in Table A2 in the Appendix. The explanatory power of these first stage regressions is modest. When the socioeconomic variables are included as instruments, the R^2 values are 0.11 for past participation, 0.12 for future participation, 0.08 for past frequency, and 0.06 for future frequency. When the socioeconomic variables are excluded as instruments, the R^2 values are 0.04 for past and future participation, 0.06 for past frequency, and 0.02 for future frequency. Despite these low values, the *F*-ratios associated with the instruments are all significant at 1%. Moreover, the large magnitudes of these ratios indicate that the TSLS estimates are not biased because the instruments are weakly correlated with the endogenous explanatory variables (Bound et al., 1995; Staiger and Stock, 1997). The pairwise simple correlation coefficients between past, current, and future price are positive and extremely large. They range between 0.91 and 0.93. Despite these large correlations, the past, future, and current price coefficients are negative in the reduced form, as predicted by the rational addiction model, except that the current price coefficient is positive when future frequency is the outcome and the socioeconomic variables are excluded. In addition, when past participation or past frequency is the dependent variable, the past price coefficient is significant at the

Table 2
Structural demand functions, dependent variable = participation[a], rational addiction model

	Two-stage least squares	Ordinary least squares	Two-stage least squares	Ordinary least squares
Price	−0.000132 (−4.63)	−0.000151 (−5.86)	−0.000151 (−2.51)	−0.000174 (−6.72)
Past participation	0.381 (10.09)	0.377 (85.93)	0.206 (1.19)	0.389 (89.01)
Future participation	0.449 (14.16)	0.408 (95.38)	0.662 (5.36)	0.423 (99.69)
Marijuana decriminalization	0.008 (2.13)	0.008 (2.29)	0.014 (2.53)	0.013 (3.74)
Legal drinking age * age ≤ 21	0.004 (2.36)	0.004 (2.55)	0.005 (2.36)	0.005 (2.94)
Lower border drinking age indicator * age ≤ 21	0.008 (1.48)	0.010 (1.89)	0.006 (0.92)	0.011 (1.89) (2.01)
Real earnings	4.47E-07 (1.47)	4.91E-07 (1.63)		
Years of completed schooling	−0.0001 (−0.11)	−0.001 (−0.43)		
Full-time college student	−0.007 (−1.46)	−0.008 (−1.57)		
Half-time college student	0.002 (0.20)	0.002 (0.27)		
Less than half-time college student	−0.004 (−0.51)	−0.003 (−0.46)		
Working full-time	−0.002 (−0.37)	−0.002 (−0.48)		
Working part-time	−0.001 (−0.25)	−0.001 (−0.30)		
Unemployed	0.013 (1.35)	0.013 (1.41)		
Infrequent religious participation	−0.012 (−2.38)	−0.014 (−2.66)		
Frequent religious participation	−0.052 (−7.24)	−0.061 (−11.63)		

Married	−0.050 (−9.18)	−0.056 (−12.17)		
Engaged	−0.011 (−1.84)	−0.013 (−2.36)		
Separated or divorced	−0.002 (−0.18)	−0.002 (−0.23)		
Number of children	−0.008 (−2.23)	−0.008 (−2.37)		
Elasticities				
Long run	−1.400	−1.264	−2.057	−1.667
Short run	−0.716	−0.675	−1.551	−0.847
Temporary current	−0.304	−0.336	−0.325	−0.395
R^2	0.181	0.486	0.059	0.480
Hausman χ^2	3.815		4.853	
Basmann F-ratio	2.637		1.808	
F-ratio, instruments for past participation	24.880		11.977	
F-ratio, instruments for future participation	33.823		22.142	
N	38,885	38,885	38,885	38,885

[a]Asymptotic t-statistics in parentheses, and intercepts not shown. All regressions include dichotomous variables for male, black, other race/ethnicity, ages 18 through 26, and years 1978 through 1986. For Hausman test, critical values of χ^2 (2) are 5.99 at 5% and 9.21 at 1%. For Basmann test, critical values of $F(32, \infty)$ are 1.45 at 5% and 1.67 at 1% for models including socioeconomic variables, and critical values of $F(4, \infty)$ are 2.37 at 5% and 3.32 at 1% for models excluding socioeconomic variables. For test of instruments, critical values of $F(34, \infty)$ are 1.43 at 5% and 1.65 at 1% for models including socioeconomic variables, and critical values of $F(6, \infty)$ are 2.09 at 5% and 2.80 at 1% for models excluding socioeconomic variables.

Table 3
Structural demand functions, dependent variable = frequency[a], rational addiction model

	Two-stage least squares	Ordinary least squares	Two-stage least squares	Ordinary least squares
Price	−0.008076 (−3.13)	−0.005469 (−2.51)	−0.008388 (−1.84)	−0.005098 (−2.34)
Past frequency	0.218 (2.51)	0.313 (29.56)	−0.160 (−0.53)	0.316 (29.79)
Future frequency	0.225 (3.95)	0.302 (31.94)	0.560 (2.28)	0.311 (33.01)
Marijuana decriminalization	0.250 (0.89)	0.203 (0.75)	0.636 (1.53)	0.190 (0.70)
Legal drinking age * age ≤ 21	0.149 (1.03)	0.144 (1.00)	0.235 (1.38)	0.151 (1.05)
Lower border drinking age indicator * age ≤ 21	0.455 (1.03)	0.283 (0.66)	0.274 (0.51)	0.206 (0.48)
Real earnings	8.69E-05 (3.59)	7.91E-05 (3.35)		
Years of completed schooling	−0.366 (−3.13)	−0.257 (−2.51)		
Full-time college student	−1.324 (−3.34)	−1.199 (−3.10)		
Half-time college student	−1.132 (−1.76)	−1.191 (−1.88)		
Less than half-time college student	−1.037 (−1.92)	−1.075 (−2.05)		
Working full-time	−0.532 (−1.25)	−0.362 (−0.88)		
Working part-time	−0.212 (−0.52)	−0.164 (−0.41)		
Unemployed	0.020 (0.03)	0.084 (0.12)		
Infrequent religious participation	0.013 (0.04)	0.045 (0.14)		
Frequent religious participation	−1.007 (−2.34)	−0.711 (−1.81)		

Married	−2.658 (−6.05)	−2.414 (−5.85)		
Engaged	−1.588 (−3.39)	−1.474 (−3.25)		
Separated or divorced	−0.383 (−0.51)	−0.266 (−0.36)		
Number of children	−0.147 (−0.44)	−0.094 (−0.29)		
Elasticities				
Long run	−0.452	−0.443	−0.435	−0.427
Short run	−0.348	−0.288	−0.500	−0.275
Temporary current	−0.265	−0.191	−0.241	−0.179
R^2	0.045	0.240	0.015	0.232
Hausman χ^2	4.077		2.495	
Basmann *F*-ratio	1.191		0.261	
F-ratio, instruments for past frequency	4.074		3.299	
F-ratio, instruments for future frequency	7.665		3.954	
N	8926	8926	8926	8926

[a] Asymptotic *t*-statistics in parentheses, and intercepts not shown. All regressions include dichotomous variables for male, black, other race/ethnicity, ages 18 through 26, and years 1978 through 1986. For Hausman test, critical values of χ^2 (2) are 5.99 at 5% and 9.21 at 1%. For Basmann test, critical values of $F(32, \infty)$ are 1.45 at 5% and 1.67 at 1% for models including socioeconomic variables, and critical values of $F(4, \infty)$ are 2.37 at 5% and 3.32 at 1% for models excluding socioeconomic variables. For test of instruments, critical values of $F(34, \infty)$ are 1.43 at 5% and 1.65 at 1% for models including socioeconomic variables, and critical values of $F(6, \infty)$ are 2.09 at 5% and 2.80 at 1% for models excluding socioeconomic variables.

1% level. When future participation or future frequency is the dependent variable, the future price coefficient is significant at the 1% level.

According to the Hausman test, the consistency of the OLS estimates is accepted, primarily because the low explanatory power of the first stage regressions results in large TSLS standard errors of the coefficients of past and future consumption relative to the OLS standard errors of these coefficients. Nevertheless, it is useful to consider all the estimates in the two tables because they are fairly similar and because the consistency of OLS is rejected in some of the alternative specifications discussed later. According to the Basmann test, the overidentification restrictions are valid except in the participation demand function that includes the socioeconomic variables (column 1 of Table 2).

The estimated effects of past and future participation on current participation are positive in the four regressions in Table 2 and are significant, except for the past participation coefficient in the TSLS model that omits the socioeconomic variables. The estimated cocaine price effects are significantly negative in the participation demand functions. The same comments apply to the past frequency, future frequency, and cocaine price coefficients in the four regressions in Table 3, except that the past frequency coefficient in the TSLS model that omits the socioeconomic variables is negative and not significant.

The ratio of the coefficient of future consumption to the coefficient of past consumption provides an estimate of the discount factor (β). Since the rational addiction demand function given by Eq. (2) pertains to a continuous outcome, the implied discount factors in Table 3 are on somewhat firmer grounds than those in Table 2. The discount factor is 1.03 in the first frequency regression in Table 3, 0.96 in the second regression, and 0.98 in the fourth. A meaningful estimate cannot be obtained from the third regression because the coefficient of past frequency is negative. These discount factors correspond to interest rates of −3%, 4%, and 2%, respectively. [9]

All but two of the regressions in Tables 2 and 3 imply unreasonable discount factors because the coefficient of future consumption typically is larger than the coefficient of past consumption. But the coefficient of future consumption is significantly greater than the coefficient of past consumption in only two of eight cases, the two OLS participation equations. We imposed a discount factor of 0.95 (interest rate of 5%) a priori and re-estimated the eight regressions in Tables 2 and 3. The price coefficients and price elasticities (discussed in more detail below) in these models are extremely close to their unconstrained counterparts. These results, combined with the detailed analysis in Becker et al. (1994) and in Grossman et al. (1998) suggest that data on cocaine, cigarette, or alcohol con-

[9] The same computations applied to the participation equations yield discount factors ranging from 3.21 to 1.08 and negative interest rates ranging from −68% to −7%.

sumption may not be rich enough to pin down the discount factor with precision even if the rational addiction model is accepted.

Are these results consistent with addiction and rational addiction? If one focuses on the signs and significance of the coefficients and is willing to accept the consistency of OLS, the answer is yes. In these models, the positive effect of past consumption is consistent with the hypothesis that cocaine consumption is an addictive good. The positive effect of future consumption is consistent with the hypothesis of rational addiction and not consistent with the hypothesis of myopic addiction. If one uses the same criteria but prefers to use the TSLS estimates, the answer is yes in the models that employ past and future socioeconomic variables as instruments. If one wants to exclude these variables because they are potentially endogenous, the past consumption effects are not significant and the past frequency effect is negative. These results conflict with the notion of addiction. On the other hand, the future consumption effects are positive and significant, which support rational addiction.

One problem with the TSLS models that exclude the socioeconomic variables is that the degree of precision falls when the set of instruments is restricted because exogenous variation falls. This is reflected by the increase in the standard errors of the TSLS coefficients of past and future consumption. This makes it difficult to sort out past and future consumption effects. To highlight this point, we estimate myopic models of cocaine addiction in Table 4 for participation and in Table 5 for frequency. This exercise also allows the reader to compare price elasticities of demand that emerge from the two models. In the myopic model, future participation or future frequency is excluded from the structural demand function, and all future variables are excluded as instruments. The models in columns 1–4 in Tables 4 and 5 correspond to the models in columns 1–4 in Tables 2 and 3. The only difference is that in Tables 4 and 5, all future variables are omitted both as regressors and instruments. The first stage regressions for past participation and past frequency are shown in Table A3 in the Appendix.

The coefficients of past consumption in Tables 4 and 5 are much larger than the corresponding coefficients in Tables 2 and 3. These results indicate that cocaine is an addictive behavior. They also support the proposition that imprecise nature of the TSLS past and future consumption coefficients makes it somewhat difficult to sort out the separate effects of these variables, particularly when the set of instruments is curtailed. The significance of the eight future consumption coefficients in Tables 2 and 3 suggests that additional insights into the demand for cocaine can be gained by allowing consumption to depend on future variables.

The long-run, short-run, and temporary current price elasticities of participation or frequency given positive participation are shown at the bottom of Tables 2 and 3. They are computed at the weighted sample means of price, participation, and frequency using equations contained in Becker et al. (1994). The long-run participation price elasticity is substantial. It ranges from -1.26 to -2.01 with a mean of -1.60. The short-run participation price elasticity ranges from -0.68 to

Table 4
Structural demand functions, dependent variable = participation[a], myopic model

	Two-stage least squares	Ordinary least squares	Two-stage least squares	Ordinary least squares
Price	−0.000233 (−7.20)	−0.000235 (−8.23)	−0.00023 (−3.16)	−0.00028 (−9.68)
Past participation	0.565 (16.72)	0.560 (127.42)	0.685 (5.59)	0.592 (136.40)
Marijuana decriminalization	0.007 (1.69)	0.007 (1.76)	0.012 (2.02)	0.015 (3.97)
Legal drinking age * age ≤ 21	0.005 (2.51)	0.005 (2.57)	0.005 (2.04)	0.006 (3.16)
Lower border drinking age indicator * age ≤ 21	0.022 (3.55)	0.023 (3.67)	0.021 (2.55)	0.025 (3.94)
Real earnings	6.67E-07 (1.98)	6.73E-07 (2.01)		
Years of completed schooling	−0.004 (−2.47)	−0.004 (−2.50)		
Full-time college student	−0.007 (−1.23)	−0.007 (−1.26)		
Half-time college student	0.007 (0.77)	0.007 (0.77)		
Less than half-time college student	−0.003 (−0.35)	−0.003 (−0.34)		
Working full-time	−0.008 (−1.49)	−0.008 (−1.49)		
Working part-time	−0.003 (−0.58)	−0.003 (−0.58)		
Unemployed	0.009 (0.81)	0.009 (0.83)		
Infrequent religious participation	−0.015 (−2.63)	−0.015 (−2.74)		
Frequent religious participation	−0.102 (−12.09)	−0.103 (−17.79)		

Married	−0.092 (−15.76)	−0.093 (−18.30)		
Engaged	−0.037 (−5.83)	−0.037 (−5.84)		
Separated or divorced	−0.005 (−0.44)	−0.005 (−0.44)		
Number of children	−0.005 (−1.29)	−0.005 (−1.36)		
Elasticities				
Long run	−0.965	−0.961	−1.315	−1.237
Short run	−0.420	−0.424	−0.415	−0.505
R^2	0.143	0.366	0.050	0.347
Hausman χ^2	0.0261		0.572	
Basmann F-ratio	3.559		1.602	
F-ratio, instruments for past participation	37.044		12.378	
N	38,885	38,885	38,885	38,885

[a]Asymptotic t-statistics in parentheses, and intercepts not shown. All regressions include dichotomous variables for male, black, other race/ethnicity, ages 18 through 26, and years 1978 through 1986. For Hausman test, critical values of χ^2 (1) are 3.84 at 5% and 6.64 at 1%. For Basmann test, critical values of $F(17, \infty)$ are 1.62 at 5% and 1.97 at 1% for models including socioeconomic variables, and critical values of $F(3, \infty)$ are 2.60 at 5% and 3.78 at 1% for models excluding socioeconomic variables. For test of instruments, critical values of $F(18, \infty)$ are 1.61 at 5% and 1.94 at 1% for models including socioeconomic variables, and critical values of $F(4, \infty)$ are 2.37 at 5% and 3.32 at 1% for models excluding socioeconomic variables.

Table 5
Structural demand functions, dependent variable = frequency[a], myopic model

	Two-stage least squares	Ordinary least squares	Two-stage least squares	Ordinary least squares
Price	−0.010272 (−3.83)	−0.009197 (−4.00)	−0.010353 (−2.27)	−0.008749 (−3.79)
Past frequency	0.311 (3.27)	0.385 (35.16)	0.285 (1.08)	0.392 (35.73)
Marijuana decriminalization	0.122 (0.41)	0.068 (0.24)	0.130 (0.37)	0.045 (0.16)
Legal drinking age * age ≤ 21	0.123 (0.81)	0.115 (0.76)	0.140 (0.89)	0.124 (0.81)
Lower border drinking age indicator * age ≤ 21	0.658 (1.43)	0.599 (1.32)	0.582 (1.17)	0.503 (1.10)
Real earnings	9.40E-05 (3.71)	9.09E-05 (3.64)		
Years of completed schooling	−0.517 (−4.44)	−0.483 (−4.48)		
Full-time college student	−1.542 (−3.75)	−1.513 (−3.71)		
Half-time college student	−1.113 (−1.65)	−1.144 (−1.71)		
Less than half-time college student	−1.282 (−2.28)	−1.353 (−2.45)		
Working full-time	−0.630 (−1.42)	−0.551 (−1.28)		
Working part-time	−0.193 (−0.45)	−0.161 (−0.38)		
Unemployed	−0.164 (−0.22)	−0.163 (−0.22)		
Infrequent religious participation	0.158 (0.45)	0.206 (0.59)		
Frequent religious participation	−1.155 (−2.54)	−1.012 (−2.44)		

Married	−3.188 (−7.27)	−3.151 (−7.25)		
Engaged	−1.962 (−4.08)	−1.971 (−4.11)		
Separated or divorced	−0.298 (−0.38)	−0.213 (−0.28)		
Number of children	−0.010 (−0.03)	0.048 (0.14)		
Elasticities				
Long run	−0.464	−0.466	−0.448	−0.449
Short run	−0.320	−0.287	−0.268	−0.273
R^2	0.040	0.152	0.019	0.138
Hausman χ^2	0.613		0.167	
Basmann F-ratio	1.941		0.075	
F-ratio, instruments for past frequency	6.655		3.929	
N	8926	8926	8926	8926

[a]Asymptotic t-statistics in parentheses, and intercepts not shown. All regressions include dichotomous variables for male, black, other race/ethnicity, ages 18 through 26, and years 1978 through 1986. For Hausman test, critical values of χ^2 (1) are 3.84 at 5% and 6.64 at 1%. For Basmann test, critical values of $F(17, \infty)$ are 1.62 at 5% and 1.97 at 1% for models including socioeconomic variables, and critical values of $F(3, \infty)$ are 2.60 at 5% and 3.78 at 1% for models excluding socioeconomic variables. For test of instruments, critical values of $F(18, \infty)$ are 1.61 at 5% and 1.94 at 1% for models including socioeconomic variables, and critical values of $F(4, \infty)$ are 2.37 at 5% and 3.32 at 1% for models excluding socioeconomic variables.

−1.55 (average equals −0.95). Thus, the average long-run participation elasticity is approximately 60% larger than the average short-run elasticity.

Frequency conditional on positive use is not as sensitive to price as participation. The long-run elasticity is −0.44, and the short-run elasticity is −0.35.[10] The unconditional price elasticities, defined as the sum of the relevant participation and frequency elasticities, are quite large: −2.04 in the long-run and −1.30 in the short-run. The unconditional temporary current price elasticity is −0.56. It is smaller than the short-run price elasticity because future prices are held constant.

In the myopic model, the unconditional long-run and short-run elasticities also are substantial. The former equals −1.58, and the latter equals −0.73. These elasticities are smaller than those that emerge from the rational model, although the differences are not statistically significant.

There is some evidence in Tables 2–5 that cocaine and marijuana are complements in consumption, while cocaine and alcohol are substitutes. Both cocaine participation and frequency are higher in states that decriminalized marijuana than in other states, although the frequency coefficients are not statistically significant. Another interpretation of this finding is that the expected penalty for cocaine use is smaller in states that decriminalized marijuana. An increase in the legal drinking age raises cocaine participation and use, although again, the frequency effects are not significant. While the coefficient of the lower border age drinking indicator has the wrong sign (it should be negative since the own drinking age effect is positive), the sign and significance of the drinking age coefficient itself are not altered when the border age measure is deleted. But the conclusion that cocaine and alcohol are substitutes must be tempered because states with higher drinking ages may allocate more resources to enforcement of drinking age laws and less resources to apprehending and convicting cocaine users and dealers.

By estimating rational and myopic cocaine demand functions by OLS and TSLS with and without socioeconomic variables, we have presented results for eight different specifications in this subsection. Supportive evidence of rational addiction is presented because the coefficient of future consumption always is positive and significant. Regardless of the specification employed, the long-run price elasticity of consumption (participation multiplied by frequency given participation) is substantial. This elasticity is larger in absolute value in the rational specification than in the myopic specification (−2.04 vs. −1.58). Although this difference is not statistically significant, the test is complicated by the imprecision with which either elasticity is estimated since the rational addiction elasticity is a nonlinear function of three coefficients and the myopic elasticity is a nonlinear function of two coefficients.

[10] In the remainder of this section, all elasticities mentioned in the text are averages of those that emerge from the four alternative specifications of a given non-addictive, rational, or myopic model.

The choice between the specification that includes the socioeconomic variables and the one that omits them depends on a trade-off between an increase in omitted variables bias (omitting potential determinants of current consumption) and a reduction in simultaneous equations bias (omitting potentially endogenous variables). This trade-off arises because current values of the time-varying socioeconomic variables are excluded from the structural demand function for current consumption when past and future values of these variables are excluded from the set of instruments. Omitted variables bias is present in the regressions in Tables 4 and 5 if current socioeconomic variables have causal effects on current consumption and are correlated with past consumption, future consumption, and the current price. Simultaneous equations bias is present in the regressions in Tables 2 and 3 if current consumption of cocaine has causal effects on the current socioeconomic variables or if a shock to current consumption has impacts on future values of the socioeconomic variables. [11] On balance, we prefer the estimates with the socioeconomic variables because they minimize omitted variables bias and yield a long-run price elasticity of demand that can be viewed as a lower bound. There is no evidence that the relatively large elasticity in this specification is due to the choice of instruments and the inclusion of potentially endogenous variables in the structural demand function since the price elasticity becomes larger in absolute value when the socioeconomic variables are deleted. We realize, however, that the reader may have different views on these issues, and we have given equal weight to both sets of estimates in discussing the results.

5.2. Sensitivity analysis

In Table 6, we examine the robustness of the price and consumption effects in the rational addiction model by estimating two-stage least squares fixed-effects models. Using this technique, we transform all time-varying variables into deviations from person-specific means and delete time-invariant variables and cases where there is only one observation for a given person from the regression. This approach is equivalent to including a dummy variable for each person in an untransformed specification and controls for unobserved heterogeneity. Since the Hausman tests strongly reject the consistency of OLS, only the TSLS coefficients are presented in the table.

The results in the specification that includes the socioeconomic variables (column 1 of Table 6) confirm those in Tables 2 and 3. The past and future consumption coefficients are positive and significant. The current price coefficients are negative, although the frequency effects are not significant. The

[11] In the former case, the disturbance term in the structural demand function is correlated with the current socioeconomic variables. In the latter case, this disturbance term is correlated with the predicted value of future consumption.

Table 6
Price and consumption coefficients, two-stage least squares fixed-effects structural demand functions[a], rational addiction models

	Socioeconomic variables included	Socioeconomic variables excluded
Panel A: Participation		
Price	−0.000151 (−2.85)	−0.000165 (−2.84)
Past participation	0.210 (3.68)	−0.038 (−0.09)
Future participation	0.283 (4.05)	0.245 (1.14)
R^2	0.023	0.013
Hausman χ^2	94.542	9.258
Basmann *F*-ratio	2.520	5.196
F-ratio, instruments for past participation	15.753	2.996
F-ratio, instruments for future participation	11.528	12.900
N	35,494	35,494
Elasticities		
Long run	−0.536	−0.375
Short run	−0.416	−0.389
Temporary current	−0.290	−0.295

Panel B: Frequency given positive participation		
Price	−0.004207 (−0.76)	−0.005842 (−1.06)
Past frequency	0.250 (2.07)	−0.401 (−1.33)
Future frequency	0.256 (2.64)	0.293 (0.79)
R^2	0.029	0.017
Hausman χ^2	49.547	2.710
Basmann F-ratio	3.040	2.981
F-ratio, instruments for past frequency	4.404	3.765
F-ratio, instruments for future frequency	5.932	2.312
N	7,763	7,763
Elasticities		
Long run	−0.265	−0.164
Short run	−0.194	−0.224
Temporary current	−0.141	−0.165

[a]Asymptotic t-statistics in parentheses, and intercepts not shown. For Hausman test, critical values of χ^2 (2) are 5.99 at 5% and 9.21 at 1%. For Basmann test, critical values of $F(32, \infty)$ are 1.45 at 5% and 1.67 at 1% for models including socioeconomic variables, and critical values of $F(4, \infty)$ are 2.37 at 5% and 3.32 at 1% for models excluding socioeconomic variables. For test of instruments, critical values of $F(3, \infty)$ at 5% and 1.65 at 1% for models including socioeconomic variables and critical values of $F(6, \infty)$ are 2.09 at 5% and 2.80 at 1% for models excluding socioeconomic variables.

specification that excludes the socioeconomic variables is less supportive because the future consumption effects are not significant and the past consumption effects are negative. The unconditional price elasticities are smaller than those in Tables 2 and 3: −0.67 in the long-run, −0.61 in the short-run, and −0.44 in the case of a temporary current price change.

Which of the two sets of estimates is preferable? As pointed out in Section 4.4, the real price of cocaine contains random measurement error for a variety of reasons. The downward biases in the price coefficient and its *t*-ratio due to this factor are exacerbated in the fixed-effects model in Table 6 (Griliches, 1979; Griliches and Hausman, 1986). Thus, the estimates in Table 6 are not necessarily superior to those in Tables 2 and 3. Despite our misgivings about the fixed-effects model, we summarize the magnitudes of the price elasticities by averaging over the two models. This gives a long-run unconditional price elasticity of −1.35, a short-run price elasticity of −0.96, and a temporary current price elasticity of −0.50. We view these figures as conservative lower-bound estimates.

6. Discussion

We find that cocaine consumption is quite sensitive to its price. A permanent 10% reduction in price would cause the number of cocaine users to grow by approximately 10% in the long-run and would increase the frequency of use among users by a little more than 3%. Total or unconditional frequency would rise by almost 14% in a fixed population in the long-run and by slightly less than 10% in the short-run. Surely, both proponents and opponents of drug legalization should take account of this increase in consumption in debating their respective positions.

A good deal of caution, however, must be exercised in extrapolating our findings to a regime in which cocaine consumption is legal. One consideration is that the response to the large price cut caused by legalization would be smaller than the one suggested by our estimates if the price elasticity of demand is smaller at lower prices because the demand function is linear or because the linear form that we have employed is an approximation to a concave demand function. A second consideration is that government tax policies could counteract part of the price cut, and government education policies could be used to increase knowledge about the harmful effects of cocaine consumption. A third factor is that forbidden fruit is attractive, particularly to the young (Friedman, 1989). A factor that goes in the opposite direction is that legalization may stimulate consumption by removing the stigma associated with cocaine consumption.

A misleading impression about the reaction to permanent price changes may have been created by the effects of temporary police crackdowns on drugs or temporary federal wars on drugs. Since temporary policies raise current but not future prices (they would even lower future prices if drug inventories are built up during the crackdown period), there is no complementary fall in current use from a fall in future use. Consequently, even if drug addicts are rational, a temporary war that greatly raised the street price of cocaine may well only have a small effect on drug use, whereas a permanent war could have much bigger effects. For example, according to our estimates, a 10% price hike for 1 year would reduce total cocaine consumption by approximately 5%, whereas a permanent 10% price hike would lower consumption by 14%.

Clearly, we have not provided enough evidence to evaluate whether or not the use of cocaine should be legalized. A cost-benefit analysis of many effects is needed to decide between a regime in which cocaine is legal and a regime in which it is not. What we have shown is that the permanent reduction in price caused by legalization is likely to have a substantial positive effect on use, particularly among young adults.

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Appendix Table A1
Rational addiction model first stage regressions, participation[a]

	Dependent variable = past participation	Dependent variable = future participation	Dependent variable = past participation	Dependent variable = future participation
Price	−0.000206 (−3.55)	−0.0000034 (−0.06)	−0.00025 (−4.22)	−0.000045 (−0.73)
Past price	−0.000117 (−2.80)	−0.000048 (−1.12)	−0.00014 (−3.15)	−0.000065 (−1.45)
Future price	−0.000205 (−2.93)	−0.000599 (−8.36)	−0.00029 (−4.01)	−0.000723 (−9.68)
Marijuana decriminalization	0.004 (0.31)	0.005 (0.37)	0.010 (0.68)	0.012 (0.82)
Legal drinking age * age ≤ 21	−0.004 (−1.05)	0.0004 (0.11)	−0.0005 (−0.13)	0.004 (0.96)
Lower border drinking age indicator * age ≤ 21	0.024 (2.44)	0.023 (2.32)	0.026 (2.56)	0.028 (2.67)
Past marijuana decriminalization	0.001 (0.05)	−0.011 (−0.97)	0.007 (0.61)	−0.005 (−0.44)
Past legal drinking age * age ≤ 21	0.012 (4.24)	0.004 (1.35)	0.012 (4.26)	0.004 (1.35)
Past lower border drinking age indicator * age ≤ 21	0.020 (2.35)	0.026 (2.95)	0.022 (2.47)	0.030 (3.24)
Future marijuana decriminalization	0.016 (1.48)	0.007 (0.65)	0.022 (1.94)	0.015 (1.29)
Real earnings	−4.330E-07 (−0.93)	2.770E-07 (0.58)		
Years of completed schooling	−0.0005 (−0.13)	−0.003 (−0.68)		

Appendix Table A1 (continued)

	Dependent variable = past participation	Dependent variable = future participation	Dependent variable = past participation	Dependent variable = future participation
Full-time college student	−0.007 (−0.96)	−0.006 (−0.79)		
Half-time college student	0.005 (0.41)	0.007 (0.66)		
Less than half-time college student	0.014 (1.52)	0.003 (0.35)		
Working full-time	−0.001 (−0.14)	−0.016 (−2.31)		
Working part-time	−0.005 (−0.83)	−0.009 (−1.35)		
Unemployed	0.029 (2.42)	−0.004 (−0.34)		
Married	−0.038 (−4.44)	−0.039 (−4.41)		
Engaged	0.001 (0.16)	−0.007 (−0.90)		
Separated or divorced	0.011 (0.73)	0.002 (0.10)		
Number of children	0.002 (0.33)	0.009 (1.26)		
Infrequent religious participation	−0.004 (−0.54)	−0.001 (−0.14)		
Frequent religious participation	−0.064 (−6.91)	−0.071 (−7.46)		
Past real earnings	3.553E-06 (6.66)	1.849E-06 (3.39)		
Past years of completed schooling	0.005 (1.33)	−0.003 (−0.81)		

Past full-time college student	0.004 (0.49)	0.001 (0.07)
Past half-time college student	0.018 (1.38)	0.002 (0.14)
Past less than half-time college student	−0.005 (−0.43)	0.023 (1.97)
Past working full-time	0.010 (1.51)	0.012 (1.90)
Past working part-time	0.003 (0.47)	0.007 (1.27)
Past unemployed	0.029 (2.13)	0.036 (2.58)
Past married	−0.099 (−11.53)	−0.025 (−2.80)
Past engaged	−0.004 (−0.48)	0.012 (1.51)
Past separated or divorced	0.007 (0.40)	0.004 (0.21)
Past number of children	−0.029 (−4.06)	0.015 (2.01)
Past infrequent religious participation	−0.031 (−3.95)	0.008 (0.95)
Past frequent religious participation	−0.107 (−12.23)	−0.027 (−3.00)
Future real earnings	2.240E-07 (0.57)	4.640E-07 (1.16)
Future years of completed schooling	−0.007 (−2.20)	−0.003 (−0.87)

Appendix Table A1 (continued)

	Dependent variable = past participation	Dependent variable = future participation	Dependent variable = past participation	Dependent variable = future participation
Future full-time college student	−0.004 (−0.48)	−.019 (−2.49)		
Future half-time college student	0.010 (0.91)	−0.001 (−0.10)		
Future less than half-time college student	0.013 (1.50)	0.003 (0.31)		
Future working full-time	−0.001 (−0.18)	−0.009 (−1.23)		
Future working part-time	−0.008 (−1.18)	−0.006 (−0.84)		
Future unemployed	0.019 (1.42)	0.012 (0.87)		
Future married	−0.029 (−4.24)	−0.111 (−16.05)		
Future engaged	−0.008 (−1.00)	−0.050 (−6.48)		
Future separated or divorced	0.017 (1.40)	0.008 (0.63)		
Future number of children	0.010 (2.11)	−0.016 (−3.30)		
Future infrequent religious participation	−0.0004 (−0.05)	−0.009 (−1.23)		
Future frequent religious participation	−0.056 (−6.53)	−0.119 (−13.53)		
R^2	0.092	0.119	0.032	50.825
F-ratio	53.547	72.078	40.860	0.039
N	38,885	38,885	38,885	38,885

[a] Other regressors include dichotomous indicators of age, year, race and sex.

Appendix Table A2
Rational addiction model first stage regressions, frequency[a]

	Dependent variable = past frequency	Dependent variable = future frequency	Dependent variable = past frequency	Dependent variable = future frequency
Price	−0.005261 (−1.27)	−0.0011940 (−0.26)	−0.00589 (−1.42)	0.000297 (0.06)
Past price	−0.007337 (−2.56)	−0.002973 (−0.93)	−0.00744 (−2.58)	−0.003184 (−0.98)
Future price	−0.00324 (−0.69)	−0.020239 (−3.90)	−0.00272 (−0.58)	−0.021315 (−4.04)
Marijuana decriminalization	−0.386 (−0.47)	0.053 (0.06)	−0.278 (−0.34)	0.038 (0.04)
Legal drinking age * age ≤ 21	−0.324 (−1.49)	−0.178 (−0.74)	−0.320 (−1.46)	−0.275 (−1.12)
Lower border drinking age indicator * age ≤ 21	0.493 (0.83)	0.225 (0.34)	0.510 (0.85)	0.393 (0.58)
Past marijuana decriminalization	0.047 (0.07)	−0.275 (−0.36)	−0.047 (−0.07)	−0.226 (−0.29)
Past legal drinking age * age ≤ 21	0.390 (2.24)	0.083 (0.43)	0.445 (2.54)	0.176 (0.90)
Past lower border drinking age indicator * age ≤ 21	0.591 (1.14)	0.960 (1.67)	0.413 (0.80)	0.876 (1.50)
Future marijuana decriminalization	1.204 (1.85)	−0.200 (−0.28)	1.187 (1.81)	−0.198 (−0.27)
Real earnings	−3.353E-05 (−1.16)	2.500E-05 (0.78)		

Appendix Table A2 (continued)

	Dependent variable = past frequency	Dependent variable = future frequency	Dependent variable = past frequency	Dependent variable = future frequency
Years of completed schooling	−0.3555 (−1.56)	−0.469 (−1.85)		
Full-time college student	−0.465 (−1.01)	−1.135 (−2.22)		
Half-time college student	0.371 (0.56)	0.097 (0.13)		
Less than half-time college student	0.975 (1.79)	−0.651 (−1.07)		
Working full-time	−1.062 (−2.44)	−0.944 (−1.95)		
Working part-time	−0.459 (−1.09)	−0.262 (−0.56)		
Unemployed	−0.003 (−0.00)	−1.097 (−1.35)		
Married	0.260 (0.45)	0.651 (1.02)		
Engaged	−0.011 (−0.02)	0.314 (0.56)		
Separated or divorced	−0.316 (−0.34)	0.897 (0.86)		
Number of children	0.559 (1.19)	1.391 (2.66)		
Infrequent religious participation	−0.482 (−1.17)	−0.036 (−0.08)		

Frequent religious participation	−0.901 (−1.65)	−0.657 (−1.08)
Past real earnings	1.640E-04 (5.01)	5.659E-05 (1.55)
Past years of completed schooling	0.103 (0.45)	−0.518 (−2.05)
Past full-time college student	−0.939 (−1.93)	−1.748 (−3.23)
Past half-time college student	−0.139 (−0.18)	−0.075 (−0.08)
Past less than half-time college student	−0.744 (−1.12)	0.072 (0.10)
Past working full-time	0.414 (1.01)	−0.501 (−1.09)
Past working part-time	−0.275 (−0.72)	0.372 (0.88)

Appendix Table A2 (continued)

	Dependent variable = past frequency	Dependent variable = future frequency	Dependent variable = past frequency	Dependent variable = future frequency
Past unemployed	0.609 (0.73)	0.598 (0.64)		
Past married	−2.713 (−4.31)	−0.747 (−1.07)		
Past engaged	−0.285 (−0.53)	1.058 (1.76)		
Past separated or divorced	−0.380 (−0.34)	0.297 (0.24)		
Past number of children	−0.980 (−1.97)	0.355 (0.64)		
Past infrequent religious participation	−0.826 (−1.98)	0.810 (1.75)		
Past frequent religious participation	−2.514 (−4.98)	1.123 (2.00)		
Future real earnings	2.123E-05 (0.88)	3.976E-05 (1.47)		
Future years of completed schooling	0.169 (0.91)	0.157 (0.76)		
Future full-time college student	−0.295 (−0.62)	−1.759 (−3.33)		

Future half-time college student	0.016 (0.02)	−1.261 (−1.68)		
Future less than half-time college student	−0.421 (−0.83)	−1.441 (−2.57)		
Future working full-time	−0.545 (−1.21)	−0.170 (−0.34)		
Future working part-time	−0.496 (−1.02)	−0.282 (−0.52)		
Future unemployed	−0.339 (−0.42)	0.962 (1.08)		
Future married	−0.017 (−0.04)	−4.199 (−8.81)		
Future engaged	−0.436 (−0.93)	−2.296 (−4.42)		
Future separated or divorced	0.796 (1.09)	−0.880 (−1.09)		
Future number of children	−0.464 (−1.42)	−1.432 (−3.94)		
Future infrequent religious participation	1.000 (2.59)	0.359 (0.84)		
Future frequent religious participation	1.076 (2.13)	−2.411 (−4.29)		
R^2	0.054	0.061	0.056	0.020
F-ratio	6.942	7.878	17.088	5.794
N	8926	8926	8926	8926

[a] Other regressors include dichotomous indicators of age, year, race and sex.

Appendix Table A3
Myopic model first stage regressions[a]

	Dependent variable = past participation	Dependent variable = past participation	Dependent variable = past frequency	Dependent variable = past frequency
Price	−0.00029 (−5.79)	−0.00038 (−7.23)	−0.00701 (−2.02)	−0.00731 (−2.09)
Past price	−0.000156 (−3.88)	−0.00019 (−4.43)	−0.007545 (−2.69)	−0.00777 (−2.75)
Marijuana decriminalization	0.019 (1.73)	0.027 (2.43)	0.510 (0.76)	0.606 (0.90)
Legal drinking age * age ≤ 21	−0.004 (−1.21)	−0.001 (−0.33)	−0.323 (−1.48)	−0.323 (−1.48)
Lower border drinking age indicator * age ≤ 21	0.026 (2.69)	0.027 (2.65)	0.561 (0.94)	0.543 (0.91)
Past marijuana decriminalization	0.002 (0.20)	0.010 (0.92)	0.263 (0.39)	0.173 (0.26)
Past legal drinking age * age ≤ 21	0.013 (4.43)	0.013 (4.43)	0.379 (2.18)	0.446 (2.56)
Past lower border drinking age indicator * age ≤ 21	0.020 (2.30)	0.022 (2.47)	0.575 (1.12)	0.384 (0.74)
Real earnings	−4.160E-07 (−0.96)		−2.520E-05 (−0.94)	
Years of completed schooling	−0.005 (−1.72)		−0.234 (−1.23)	
Full-time college student	−0.017 (−2.69)		−0.341 (−0.83)	
Half-time college student	0.003 (0.32)		0.428 (0.66)	

Less than half-time college student	0.014 (1.53)	0.969 (1.80)
Working full-time	0.001 (0.10)	− 1.109 (− 2.62)
Working part-time	− 0.005 (− 0.86)	− 0.490 (− 1.18)
Unemployed	0.033 (2.78)	− 0.113 (− 0.16)
Married	− 0.054 (− 7.62)	0.220 (0.45)
Engaged	− 0.010 (− 1.41)	− 0.033 (− 0.07)
Separated or divorced	0.020 (1.42)	0.056 (0.07)
Number of children	0.010 (1.84)	0.236 (0.58)
Infrequent religious participation	− 0.007 (− 1.00)	− 0.103 (− 0.27)
Frequent religious participation	− 0.096 (− 11.41)	− 0.428 (− 0.86)
Past real earnings	3.557E-06 (6.71)	1.660E-04 (5.10)
Past years of completed schooling	0.003 (0.83)	0.161 (0.73)
Past full-time college student	0.003 (0.37)	− 0.898 (− 1.87)

Appendix Table A3 (continued)

	Dependent variable = past participation	Dependent variable = past participation	Dependent variable = past frequency	Dependent variable = past frequency
Past half-time college student	0.016 (1.25)		−0.147 (−0.19)	
Past less than half-time college student	−0.005 (−0.48)		−0.760 (−1.14)	
Past working full-time	0.009 (1.47)		0.395 (0.96)	
Past working part-time	0.002 (0.43)		−0.270 (−0.71)	
Past unemployed	0.031 (2.22)		0.570 (0.68)	
Past married	−0.101 (−11.74)		−2.723 (−4.33)	
Past engaged	−0.005 (−0.63)		−0.322 (−0.60)	
Past separated or divorced	0.011 (0.58)		−0.359 (−0.32)	
Past number of children	−0.028 (−3.97)		−1.031 (−2.09)	
Past infrequent religious participation	−0.033 (−4.29)		−0.566 (−1.40)	
Past frequent religious participation	−0.122 (−14.35)		−2.199 (−4.48)	
R^2	0.088	0.031	0.053	0.056
F-ratio	65.831	42.885	8.625	18.122
N	38,885	38,885	8926	8926

[a]Other regressors include dichotomous indicators of age, year, race and sex.

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