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**Three Essays on the Economics of Substance
Use and Abuse**

by

Dhaval M. Dave

**A dissertation submitted to the Graduate Faculty in Economics in
partial fulfillment of the requirement of the degree of Doctor of
Philosophy, The City University of New York**

2003

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This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract**Three Essays on the Economics of Substance Use and Abuse**

by

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Advisor: Professor Michael Grossman

In light of the substantial costs associated with substance abuse, the demand for cigarettes, alcohol, and illicit drugs has received much attention from economists recently. However, these studies have largely overlooked groups, such as the mentally ill or arrestees, that are hardcore users and consume most of the cigarettes, drugs, and alcohol. One objective of this study is to empirically determine the responsiveness of these heavy users to price. The second is to analyze the empirical link between substance abuse and suicide. The first essay employs the National Comorbidity Survey (NCS) to analyze the demand for alcohol, cigarettes, and cocaine among the mentally ill. The results show that mentally ill individuals are 26 percent more likely to consume alcohol, 66 percent more likely to consume cocaine, and 89 percent more likely to consume cigarettes. They are also found to be price responsive. The price elasticity for alcohol participation is estimated at -0.49 , for cocaine -0.20 , and for cigarettes -0.66 . The second essay employs objective indicators of drug use from Drug Use Forecasting and the Drug Abuse Warning Network. Results indicate that for arrestees the own-price cocaine participation elasticity is -0.23 , and for heroin -0.08 . Results show that the own-price elasticity of the general probability of a cocaine related ED episode is -0.33 , and for a heroin related episode -0.16 . The key finding that emerges is that price matters, even for hardcore users. These results provide additional justification for higher taxes,

penalties, and supply reduction activities since such policies can effectively dissuade high-participation groups. The third essay analyzes a serious cost associated with substance abuse by young adults: suicide. The existing literature documents a strong positive correlation between substance use and suicide. The NCS is employed to assess whether this correlation is driven by selection bias or represents a true causal effect. Diagnosed substance abuse disorders are found to have a positive causal impact on suicide attempts. Based on the earlier results, economic policies that raise the full price and deter even heavy substance use, combined with other screening and treatment programs, can reduce the youth suicide rate.

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Chapter I

Introduction

Cigarettes, alcohol, and drugs impose considerable costs on not only individual users but also society as a whole. About 112,000 deaths in the U.S each year are related to alcohol and illicit drug use. In 1995, the economic cost of alcohol and drug abuse was \$276 billion. This includes the costs of health care, motor vehicle crashes and fatalities, crime, lost productivity, and other adverse outcomes. Tobacco use is responsible for additional 430,000 deaths per year among adults in the United States, representing more than 5 million years of potential life lost. Direct medical costs related to smoking total at least \$50 billion per year. Given the size of these costs and the addictive nature of the substances, with no clear solutions in sight, analyzing the demand for these substances and the behavior of its consumers takes on added relevance from a public policy stance.

The demand for cigarettes, alcohol, and illicit drugs has received much attention from economists in recent years. However, the use of nationally representative surveys and focus on the general population has caused many of these studies to overlook an important point. That is, use of these substances is not uniformly distributed over the general population. Subgroups of hardcore users consume most of the cigarettes, drugs, and alcohol in the U.S. For instance, the 43 percent of the population who have had a period of mental illness sometime during their lives consumes about 69 percent of all the alcohol, 84 percent of all the cocaine, and 68 percent of all cigarettes. It has been reported that the population of arrestees accounts for as much as 90 percent of cocaine consumption and virtually all of the heroin consumption. These hardcore users also impose the heaviest costs on society and are the target of much substance abuse policy. However, there have been very few, if any, studies that have analyzed the demand for substances by these groups.

Chapter 2 focuses on individuals with recent and lifetime psychiatric disorders. The empirical work utilizes the National Comorbidity Survey (NCS), which was congressionally mandated to study the prevalence of mental illness in the United States. It is nationally representative and includes diagnoses of a wide array of mental disorders, based on criteria established by the American Psychiatric Association. First, this study empirically examines the effect of mental illness on the consumption of alcohol, cigarettes, and cocaine. Next, it estimates the price elasticity of these substances to assess whether mentally ill individuals are more or less responsive to price relative to those with no mental illness. The empirical strategy accounts for potential endogeneity between mental illness and substance use and also for non-random selection into mental illness. Bivariate probit and Heckman sample selection models are estimated. The results show that individuals with a history of mental illness are 26 percent more likely to consume alcohol, 66 percent more likely to consume cocaine, and 89 percent more likely to consume cigarettes. Individuals with a history of mental illness are also responsive to price although the price elasticities differ somewhat from those without mental illness. For those with a history of mental illness, the alcohol participation price elasticity is estimated at around -0.49, for cocaine the price elasticity is about -0.20, and for cigarettes the price elasticity is -0.66.

Chapter 3 focuses on individuals who are arrested and individuals whose substance use resulted in a visit to a hospital emergency room. Data on arrestees' use of cocaine and heroin are based on tests of urine specimens and obtained from the Drug Use Forecasting program (DUF). Data on cocaine and heroin related emergency room episodes are obtained from the Drug Abuse Warning Network (DAWN). Both of these

sets of drug use indicators are superior in many respects because they are not plagued with measurement errors due to under-reporting. This study estimates the empirical link between the prices of cocaine and heroin and these objective indicators of their use. The panel nature of the data (repeated city cross-sections) allows estimation of a wide array of fixed-effects specifications based on underlying addictive demand theory. This is an improvement over the prior literature because none of these studies had adequate controls for unmeasured area-specific or time-specific factors. Results from DUF indicate that the own-price cocaine participation elasticity is about -0.23, and the own-price heroin participation elasticity is about -0.08 for arrestees. This study also adds to the sparse literature on cross-price elasticities; the results show that cocaine and heroin are economic complements. Results from DAWN indicate that the elasticity of the probability of a cocaine mention with respect to own price is about -0.33, and the own-price elasticity of the probability of a heroin mention is about -0.16.

The key finding that emerges from these two chapters is that economic incentives matter. The notion that mentally ill individuals, arrestees, and other hardcore users are not responsive to price is strongly rejected in all cases. Prices of both cocaine and heroin also have a significantly negative effect on serious cocaine and heroin related health problems. That is, not only do higher prices deter participation among the heavy users, but they also have a positive effect on the “bottom line”, health. These results provide an added justification for higher taxes, penalties, and other supply reduction activities that raise the full price, since they show that such policies are effective with these high participation groups. To say that price matters is a simple affirmation of the law of downward sloping demand, readily accepted by most economists and social scientists for

conventional goods. However, when it comes to addictive substances, many outside the economics profession remain skeptical. This skepticism is even more pronounced with respect to the heaviest users of these addictive substances. The studies compiled here confirm the law of demand for cigarettes, alcohol, cocaine, and heroin, among individuals most likely to use and abuse them.

Chapter 4 indirectly steps aside from the issue of price, and considers one of the most serious problems facing young adults – a high rate of suicide. The existing literature has documented a strong positive correlation between alcohol or illicit drug use and suicidal behaviors among young adults. What these studies have not shown, however, is whether the link between substance use and suicide represents a true causal relationship or whether it is driven by unobserved individual heterogeneity. Accordingly, this study attempts to estimate causal effects while assessing the extent of this selection bias. The National Comorbidity Survey is also employed for this analysis since it contains a rich set of information on diagnosed mental illness, stressful life events, and family background. A novel empirical approach, the constrained bivariate probit model, that does not rely on instruments for identification is employed. The findings suggest that there is significant selection on observable factors. This also makes it highly likely that considerable selection on unobservable characteristics is confounding the relationship between substance use and suicide. This link between substance use and observed factors is used as a guide to the link between substance use and unobserved factors. The results from this study indicate that substance use does not appear to causally impact suicide ideation. With respect to suicide attempts, the estimates reveal that alcohol or drug participation also does not seem to have any positive effect.

However, diagnosed alcohol or drug disorders do have a positive effect on suicide attempts.

This study adds suicide to the long list of costs associated with alcohol and drug abuse. Moreover, it shows that alcohol and drug abuse disorders cause suicide attempts. Combined with the results from chapters 2 and 3, it appears that the public sector *can* affect such behaviors. Since even hardcore users of drugs and alcohol respond to full price, incentives such as excise taxes, penalties for illegal behaviors, and reduced availability for teens and young adults all have the capacity for deterring substance participation. These results can guide public policy in additional ways. Since it is diagnosed alcohol and drug disorders, and not just casual participation, which cause suicide attempts, these economic policies can be combined with interventions that identify and assist these youths, such as accessible screening and treatment programs, in order to have the largest impact on youth suicide rates. Such a mix of policies can also reinforce each other. For instance, increases in the full price of alcohol or drugs may make the habit too costly for some to sustain and motivate them to seek out substance abuse treatment, making it easier for the public sector to identify and assist at-risk youths most likely to attempt suicide. This highlights the integral role that demand analysis plays in not just understanding addictive behavior but also informing and guiding effective public policy.

Chapter II

Mental Illness and the Demand for Alcohol, Cocaine, and Cigarettes

1. Introduction

The U.S. Surgeon General (USDHHS, 1999) reports that the indirect costs of mental illness was \$79 billion in 1990 and in 1996 the US spent \$69 billion on treatment of mental illness. Also, about 112,000 deaths in the US each year are related to alcohol and illicit drug use (USDHHS 2002). In 1995, the economic cost of alcohol and drug abuse was \$276 billion. This includes the costs of health care, motor vehicle crashes, crime, lost productivity, and other adverse outcomes. Tobacco use is responsible for additional 430,000 deaths per year among adults in the United States, representing more than 5 million years of potential life lost. Direct medical costs related to smoking total at least \$50 billion per year. Both mental illness and the consumption of addictive goods and are associated with increased levels of mortality, physical illnesses, non-fatal accidents, lost income, reduced productivity and emotional damage caused to children by afflicted parents (McGinnis and Foege 1993, USDHHS 1999).

Diagnosable mental illness affects about 24 percent of the US population in any given year, and about 43 percent of the population have had a diagnosable mental illness some time during their lives.¹ There is considerable correlation between mental illness and the consumption of addictive goods.² The 24 percent of the population with a current mental illness consume about 38 percent of all the alcohol, 44 percent of all the cocaine and 40 percent of all cigarettes. The 43 percent of the population who have had a period of mental illness sometime during their lives consumes about 69 percent of all the

¹ The U.S. Surgeon General (1999) reports that the one-year prevalence rate of mental illness in the United States is between 19.5 to 23.4 percent for adults aged 18 to 54. In this paper we use a slightly larger age group and find the prevalence rate to be 24.1 percent. This population excludes individuals who are institutionalized or homeless.
² Illicit drugs were limited to cocaine since the data set used in this study includes too few heroin users and there is very limited price data for other illicit drugs.

alcohol, 84 percent of all the cocaine and 68 percent of all cigarettes.

This paper has two goals. The first goal is to empirically examine the effect of mental illness on the level of consumption of alcohol, cocaine and tobacco. Raw data indicate that mental illness is associated with higher consumption of addictive goods. This may be due to uncontrolled factors such as income or education. The research in this paper examines the effect of mental illness holding other factors which affect addictive consumption constant, while controlling for reverse causality and simultaneity. The second goal is to empirically estimate the price elasticity of alcohol, cocaine and tobacco for individuals with a history of mental illness.

While this paper is primarily intended for economists, the subject matter is, in part, usually the domain of psychologists. As such, some definitions are needed from the outset. The US Surgeon General (USDHHS, 1999) describes mental illness as abnormalities in cognition, emotion, mood and social function. The term mental illness is used to describe minor as well as major problems and almost everyone experiences problems of this type, at some time, and to some degree. Mental illness is associated with an inappropriate level and duration of these problems. What is inappropriate, and what is not, is derived from social norms and is neither objective nor fixed. Despite these difficulties, a systematic approach to classification and diagnosis of mental illness has been developed by the American Psychiatric Association. The definition and criteria for diagnosis of specific mental illnesses are contained in the Diagnostic and Statistical Manual of Mental Disorders (DSM) (American Psychiatric Association, 1987). Substance abuse and substance dependence refer to specific disorders defined in the DSM. Economists generally use the term substance abuse more loosely to refer to a

harmful level of consumption of addictive goods. Since this paper relies on the definitions of mental illness provided by the DSM, the term substance abuse is used only in its DSM context. However, mental illness is defined to exclude substance abuse and substance dependence disorders since the inclusion of these disorders would bias the mentally ill group to high addictive consumption.

The interaction between the consumption of addictive goods and mental illness is a complex process. Psychologists (see Kessler et al. 1996) have contributed greatly to this subject, while the economics literature makes very limited reference to it. However, economists have shown that price increases reduce the consumption of alcohol, illicit drugs, and tobacco as well as outcomes related to the consumption of these goods. Economists should therefore be interested in the interaction of mental illness and demand for these addictive goods. If mental illness alters demand, then the affected individuals may be more or less responsive to higher prices. If prices have less effect for this group, then treatment may be more important than tax increases and other supply reduction policies for the mentally ill. Alternatively, individuals with mental illness may be more affected by higher prices and be more responsive to tax increases and other supply reduction policies. If this is true, then it is an added justification for higher taxes and other supply reduction activities, since these policies target high consumption individuals.

There have been prior studies by psychologists of the causality between mental illness and addictive consumption. These studies suggest that causality between mental illness and addictive consumption may go in both directions.³ Studies by Kessler et al. (1996) and Brady and Sonne (1999) find that individuals with mental illness are more

³ Some psychological dysfunctions are organic in nature and thus would not be related to addictive consumption.

likely to develop an alcohol or illicit drug disorder than other individuals. However, a review by NIAAA (USDHHS, 1993) finds that alcohol use, at low doses may reduce certain psychiatric symptoms, but prolonged and high dose alcohol consumption can have the opposite effect. Also a note by Leshner (2001) argues that illicit drug use may be a factor in the onset of mental illness. A study by Lasser et al. (2000) finds that mental illness increases the likelihood that an individual will smoke. However, studies by Breslau and Klein (1999) and Wu and Anthony (1999) have found that tobacco can have a causal effect on mental illness. None of these studies, nor any other prior studies which account for mental illness, consider the potential effect of prices in altering the pathology of these comorbidities.

Prior studies of addictive consumption by economists have considered differentials in price elasticities by use level and by demographic variables. Studies of alcohol demand by Manning et al. (1995) and Kenkel (1996) found that heavy drinkers were less responsive to price changes than moderate drinkers. A study by Grossman, Chaloupka and Sirtalan (1998) finds that heavy drinking by youth is more price responsive in the long run than in the short run. A study of alcohol and cocaine demand by Saffer and Chaloupka (1999) for a number of demographic groups finds negative price effects. Grossman and Chaloupka (1998) also found negative price elasticities in a study of cocaine consumption by youth. The Report of the Surgeon General (USDHHS, 2000) lists 38 studies which indicate that higher tobacco prices or taxes reduce smoking for various demographic groups. None of these studies, nor any other prior studies which account for price, consider the effects of mental illness.

The remainder of the paper is organized as follows. First, the estimation model is specified with a theoretical background model provided in Appendix 2-1. A figure is provided to help clarify the relationships in the model. Next, the data set and empirical variables are described. A detailed description of the mental illness variable is contained in Appendix 2-2. The next section describes the empirical strategy. This is followed by a discussion of the results and the paper ends with a conclusions section.

2. Empirical Model

Mental illness could affect the marginal utility derived from consumption of addictive goods. The reason for this is that consumption of addictive goods disrupts the flow of the neurotransmitter, dopamine. This disruption is believed to be responsible for producing feelings of pleasure and reward. Individuals with mental illness may derive a greater marginal utility from these chemically induced feelings of pleasure and reward since they mask the symptoms of mental illness. Mental illness could also affect the rate at which the marginal utility diminishes, but there are no a priori expectations about the direction.

A demand function can be derived from a utility function with an addictive good, a non-addictive good and mental illness as arguments. In this utility function the marginal utility of addictive consumption is assumed to be positive and diminishing and the marginal utility of mental illness is assumed to be negative. The demand function is derived using a quadratic utility function in Appendix 2-1. The derivation shows that if mental illness increases the marginal utility from consumption of the addictive good, then consumption will be higher. The model also shows that if mental illness affects the rate at which marginal utility diminishes, then price responsiveness will be affected.

The empirical demand function takes the form:

$$A = A(M, P, I, Z, \mu), \quad (1)$$

where A is the addictive good, M is mental illness, P is the price of the addictive good, I is income, and Z are other relevant observable factors such as age, gender and race. The demand for substances may also depend on other unobservable characteristics μ such as personality traits. Prior research has highlighted the potential structural endogeneity and simultaneity between mental illness and addictive consumption. To account for both of these sources of endogeneity requires specification of a probability of mental illness equation. The mental illness equation can be interpreted as a production function and is analogous to a physical health production function such as specified by Grossman (1972). In this case however, rather than physical, it is mental and rather than health, it is illness that is “produced”.

$$M = M(A, H, L, I, Z, \mu) \quad (2)$$

In this equation, mental illness is produced by the consumption of the addictive good A , a family history of mental illness H , stressful life events L , income I , and other observable factors Z . The production of mental illness may also depend on unobservable characteristics μ , which may be the same as those affecting substance use. Considerable research (USDHHS, 1999, Kessler, 1997) shows that family history of mental illness and stressful life events have a causal relationship to mental illness. These relationships are illustrated in Figure 2-1.

3. Data

The empirical work employs the National Comorbidity Survey (NCS) with appended price data. The NCS was a congressionally mandated survey designed to study mental

illness in the United States and is based on a stratified, multi-stage area probability sample of the noninstitutionalized civilian population aged 15 to 54 years.⁴ The NCS uses the revised third edition DSM nomenclature to define mental illness. The survey, conducted in 1991, included 8,098 respondents, although only 5,877 respondents were asked more detailed questions on family background and stressful life events. The NCS limited tobacco use questions to 4,411 respondents. Of these respondents, 2,897 were asked detailed questions on family background and stressful life events.

The NCS includes a series of detailed questions regarding alcohol, cocaine and tobacco consumption. These questions have been used to define alcohol, cocaine and tobacco participation variables. These variables are each equal to zero for individuals who report that during the past 12 months they did not participate and otherwise are equal to one.⁵

The price of alcohol was estimated from data taken from the Inter-City Cost of Living Index, published quarterly by the American Chamber of Commerce Researchers Association (ACCRA). The ACCRA data contain the price of standard brands of beer, wine and distilled spirits. The ACCRA samples only a few stores in each location. Since beer prices vary widely by store type and wine consumption is limited, distilled spirits price was selected as the price of alcohol. The alcohol price was matched to the

⁴ The initial response rate was 82.6 percent. Based on previous evidence that survey nonrespondents have higher rates of psychiatric disorders than respondents, a supplemental survey was given to a random sample of these nonrespondents along with a financial incentive. About 4 percent of the sample was interviewed in late 1990.

⁵ Measurement error is a potential problem with all self-reported data on mental illness and substance use. A reinterview of 20 percent of the sample by clinical psychologists showed that there is no measurement error in the diagnosis of psychiatric disorders. Prior studies of substance abuse data have shown that the measurement error is reduced when the questions are part of a long survey instrument. In addition the use of dichotomous measures of alcohol, cocaine, and cigarette participation reduces

individual records in the NCS by county FIPS code for 70 percent of the sample. Most of the remainder of the individuals were matched by using the price from a similarly sized community in the same state. Only 3.4 percent of the sample could not be matched by either method and were dropped from the alcohol regressions.

The price of cocaine was estimated from the US Department of Justice, Drug Enforcement Agency's STRIDE data set. The total cost, purity, weight and other information are recorded in the STRIDE data set. Total cost can not simply be divided by number of grams to obtain price because the price of a gram is lower for larger purchases. Variation in purity and imperfect information about purity on the part of purchasers further complicate the issue. A regression of the log of total cost on the log of weight, the log of purity, and dummy variables for city and year was estimated. Imperfect information about purity is addressed by predicting purity based on the other regressors. To identify the total cost model, the coefficient of the log of predicted purity is constrained to equal the coefficient of the log of weight. The log of the price of one gram of pure cocaine is then given as the sum of the intercept, the relevant city coefficients, and the relevant time coefficients. This procedure eliminated variations in price or unit cost due to variations in weight or purity. The anti-logarithm of this predicted price is the price of one unit of 100 percent pure cocaine. This price was then divided by the intercity cost of living provided by the ACCRA. The cocaine price was matched to the individual records in the NCS by county FIPS code for 64.3 percent of the sample. The remainder of the individuals were matched by state using a weighted average price computed using the MSA's in the state.

The cigarette price data come from the Tobacco Institute and are matched to the NCS data by state. The price includes generic cigarettes and state and federal taxes.

measurement error.

Since tax rates change during the year, a weighted average state and federal tax was used. The weights represent the proportion of the year the tax rate was in effect. The price and tax data are in cents per pack.

The component of the NCS that was used to collect data on mental illness is called the Composite International Diagnostic Interview (CIDI). The CIDI was developed by the National Institute of Health, the World Health Organization and the University of Michigan and is a non-clinician administered instrument which generates psychiatric diagnoses. The instrument has undergone extensive testing for reliability and validity. The CIDI includes an extensive series of questions which are used to define a series of dichotomous mental illness variables.⁶ A series of 12 non-substance related disorder groups are defined in the data set. These disorders are defined for both past year occurrence and for occurrence anytime during the respondent's life. Two dichotomous mental illness variables were defined as equal to one for the occurrence of any of these 12 disorder groups during the past year and during the lifetime. The 12 disorder groups are listed and described in Appendix 2-2. In this paper, an individual is defined as having a mental illness if they met the criteria for any one of the 12 non-substance abuse disorders. Alcohol and drug abuse and dependence refer to specific disorders defined in the DSM and are not included in the definition of mental illness used in this paper. This distinction is necessary since the topic of this paper is the interaction of addictive consumption and non-substance related mental illness. Inclusion of addictive consumption disorders with other disorders would bias the mental illness group towards high addictive consumption.

⁶ These mental illness variables were created in a recode of the original data done by the University of Michigan. These mental illness variables are defined in accordance with DSM-III-R which was current during the data collection period.

While mental illness is defined as a dichotomous variable, it is interpreted as an observable indicator for a continuous unobserved latent variable.

A series of demographic variables are also defined from data collected in the NCS. A set of dichotomous variables equal to one if the individual reports that they are Black is defined. Also, a dichotomous gender variable is defined. A dichotomous measure equal to one for those currently married or living together is also defined. Continuous age and age squared variables are defined. A dichotomous religion variable is defined as equal to one if the respondent indicates affiliation with any religion. Finally, a continuous income variable was defined.

The NCS data set also contains information on the individual's family history. There is evidence (Kendler and Prescott, 1998) that genetic factors can affect an individual's demand for addictive goods. Studies of genetic factors predict that a family history of addiction problems increases the probability of addiction problems.⁷ However, the environmental link is ambiguous. Observing an alcohol or drug abusing parent may deter a child from following the same path. Dichotomous parent alcohol abuse and dichotomous parent drug abuse variables were defined. These variables are equal to one if the natural mother had a problem with alcohol or drugs.

A family history of mental illness can also affect an individual's probability of mental illness. However, this variable would not directly affect an individual's addictive consumption. A dichotomous variable equal to one if the natural mother had periods of depression is also defined.⁸

⁷ Although the probability of addiction increases, most children brought up in a household with an alcohol or drug abusing parent do not become abusers themselves.

⁸ There is a parallel question on father's depression but it has too many missing values for inclusion.

The NCS data set also contains information on stressful life events which may have happened to the respondent. Nine stressful life event variables were defined. These variables include measures of crime, violence and traumatic loss. Poor recall of events in the distant past or misreporting of these data are possible.

Summary definitions and weighted mean values for all variables used are presented in Table 2-1. The weighted means are presented in Table 2-1 for the full sample as well as for those with and without past year and lifetime mental illness.

4. Empirical Strategy

The empirical work presented in this paper is designed to estimate the effect of mental illness both on the level of consumption and the price elasticity of alcohol, cocaine and tobacco. Neither question is ideally answered with a single estimation technique. The task of estimating the causal effect of mental illness on addictive consumption is complicated by two factors. The first is structural endogeneity wherein both outcomes may directly influence each other. The second is statistical endogeneity or simultaneity wherein an individual's substance use and mental illness may depend on a common set of unobserved characteristics. For exposition, consider linear specifications of equations (1) and (2), the demand function for substances and the structural production function for mental illness respectively:

$$(3) \quad A_{ij} = \beta_1 M_{ij} + \beta_2 P_j + \beta_3 I_{ij} + \beta_4 Z_{ij} + \beta_5 \mu_{ij} + \eta_{ij}$$

$$(4) \quad M_{ij} = \alpha_1 A_{ij} + \alpha_2 H_{ij} + \alpha_3 L_{ij} + \alpha_4 I_{ij} + \alpha_5 Z_{ij} + \alpha_6 \mu_{ij} + \varepsilon_{ij} .$$

The subscripts refer to the i^{th} individual residing in city j , and η_{ij} and ε_{ij} represent random, independently distributed disturbance terms. One parameter of interest is β_1 , the structural effect of mental illness on substance abuse. However, single equation

estimation methods, such as ordinary least squares or simple probit, will yield biased estimates for two reasons. To see why, derive the reduced form production function for mental illness by substituting equation (3) into equation (4).

$$(5) \quad M_{ij} = (\alpha_2 / 1 - \alpha_1 \beta_1) H_{ij} + (\alpha_3 / 1 - \alpha_1 \beta_1) L_{ij} + (\alpha_1 \beta_3 + \alpha_4 / 1 - \alpha_1 \beta_1) I_{ij} + (\alpha_1 \beta_2 / 1 - \alpha_1 \beta_1) P_j \\ + (\alpha_1 \beta_4 + \alpha_5 / 1 - \alpha_1 \beta_1) Z_{ij} + (\alpha_1 \beta_5 + \alpha_6 / 1 - \alpha_1 \beta_1) \mu_{ij} + (\alpha_1 / 1 - \alpha_1 \beta_1) \eta_{ij} + (1 / 1 - \alpha_1 \beta_1) \varepsilon_{ij} \\ M_{ij} = \pi_1 H_{ij} + \pi_2 L_{ij} + \pi_3 I_{ij} + \pi_4 P_j + \pi_5 Z_{ij} + \pi_6 \mu_i + \pi_7 \eta_{ij} + \pi_8 \varepsilon_{ij}$$

The bias in equation (3) arises if there are common unmeasured factors (μ_{ij}) that determine both substance use and mental illness ($\beta_5 \neq 0$ and $\alpha_6 \neq 0$). In such cases, unmeasured factors are likely to be correlated with mental illness ($\pi_6 \neq 0$). A second reason that mental illness may be correlated with the error term is structural endogeneity, or the possibility that addictive consumption is a determinant of mental illness ($\alpha_1 \neq 0$).

In order to consistently estimate β_1 , the structural effect of mental illness on substance use, equations (3) and (5) are jointly estimated using full-information maximum likelihood bivariate probit. The bivariate probit model is based on the assumption that the unmeasured determinants in equations (3) and (5) have a joint, bivariate normal distribution. This procedure is applicable since substance use (A_{ij}) and mental illness (M_{ij}) are measured as dichotomous variables. Bivariate probit accounts for the correlation ρ between the error terms in both equations due to structural and statistical endogeneity (Greene, 2000). That is,

$$\rho = \text{correlation} [\beta_5 \mu_{ij} + \eta_{ij}, \pi_7 \eta_{ij} + \pi_8 \varepsilon_{ij}] .$$

Note that if there is no structural endogeneity ($\alpha_1=0$) and no statistical endogeneity / simultaneity ($\beta_5=0$ or $\alpha_6=0$ such that $\pi_7=0$), then ρ is 0 since μ_{ij} and ε_{ij} are uncorrelated by definition. In this case, equation (3) can be consistently estimated via simple probit.

In order to estimate differential price elasticities, the sample is divided into two groups. Models using these subsamples cannot be estimated with single equation techniques because selection in or out of mental illness may not be exogenous. The means in Table 2-1 indicate that alcohol, cocaine and cigarette participation is more prevalent among individuals with any mental illness. The figures also reveal that mental illness is significantly correlated with other characteristics such as income, education and life events. Individuals with mental illness are more likely to use addictive substances, and more likely to have lower levels of education and income, and more likely to be involved in stressful life events. As a result, the Heckman sample selection model is appropriate since sample selection may be endogenous. This model allows for all the coefficients to differ between the two groups. Since the dependent variables are dichotomous in both equations, the sample selection model is estimated via probit. Likelihood ratio tests can be performed to determine the need for estimation of separate equations.

Both the bivariate probit and the Heckman sample selection models require specification of the addictive good demand function and the mental illness production function. If these models are empirically estimated with the same covariate vector for both equations, identification would come purely from functional form restrictions. In practice however, such functional form restrictions are insufficient and hardly defensible. As a result, instruments which theoretically belong in one equation but not the other are employed for identification. An intuitive understanding of identification in the model presented in this paper is dependent on the definition of mental illness. Since mental illness is not a usual variable in economic research, some added discussion of the concept

may be useful. Mental illness is a common occurrence with about a quarter of the population affected each year and with many individuals recovering without any intervention. This is because mental illness includes minor as well as major problems. An extensive definition is presented in Appendix 2-2. The specification of equations (1) and (2) models the path of causation from a family history of mental illness and stressful life events to mental illness. That is, the mental illness problems of the parents and the individual's stressful life events will increase the probability of mental illness in the individual. The individual's probability of consuming addictive goods may increase as a result of mental illness. This specification assumes that a family history of mental illness and stressful life events do not directly enter the addictive good demand function. These variables have an indirect affect on addictive consumption through their effect on mental illness. Family history and stressful life events have a direct effect on mental illness, and mental illness has a direct effect on addictive consumption. Figure 2-1 illustrates these relationships.

Two criteria must be satisfied to determine whether these assumptions about the specification and identification of the model are valid. The first criteria is the exclusion restriction. The instruments which identify the addictive demand equations must have no direct effect in the structural addictive demand equation beyond their effect through mental illness. The second criteria is that these instruments have sufficient power to move the mental illness variable.

Instrumental validity is determined using conventional tests developed in the context of two-stage least squares estimation (2SLS).⁹ There are two tests of the

⁹As an alternative to bivariate probit, consistent estimates of equation (3) can also be obtained using a GLS version of IV or weighted 2SLS. This is an application of the

exclusion restriction. The null hypothesis in these tests is that the exclusion restrictions are valid. That is, the identifying variables should not appear in the structural addictive demand equation. The first test for exclusion has been proposed by Davidson and MacKinnon (1993). In this test the residuals from the 2SLS model are regressed on the full instrumental set that includes the excluded instruments and the exogenous variables. The statistic nR^2 from this regression is distributed as a chi-square density function with degrees of freedom equal to the degree of overidentification. The second test of exclusion uses the method proposed by Bollen et al. (1995). This test is based on the principle that the reduced-form model is correct whether or not the exclusion restrictions are valid. Regardless of whether the instruments affect addictive good demand indirectly through mental illness or directly on their own, the reduced-form model will capture these effects. The structural addictive demand model estimated by 2SLS is correct only if the instruments for mental illness can validly be excluded from this equation. The test involves obtaining the value of the log-likelihood function from the reduced-form (L_{RF}) and structural models (L_{2SLS}). If the exclusion restrictions are valid, then the restricted log-likelihood from the 2SLS model should be similar to the unrestricted log-likelihood from the reduced-form model. The likelihood-ratio test $LR = -2(L_{2SLS} - L_{RF})$ is

linear probability model. Since the variance of the error term in such a model is heteroscedastic and known to have the form $X_i B (1 - X_i B)$, the observations can be appropriately weighted by the inverse of the standard deviation to obtain homoscedastic errors. Estimates from these weighted 2SLS models were virtually identical to those from the bivariate probit models. Results are available upon request. Differential price elasticities can also be estimated with weighted 2SLS, but this requires a mental illness interaction term which creates two endogenous right hand side variables. In addition, all of the other variables in the demand function may also differ between individuals with and without mental illness. This would require additional interaction terms and create a series of endogenous variables. The Heckman probit sample selection method bypasses these problems and provides a more streamlined estimation method while directly accounting for the dichotomous nature of the dependent variables.

distributed as chi-square with degrees of freedom equal to the degree of overidentification.

There is one test for the second criteria which is that these instruments have sufficient power to move the mental illness variable. Nelson and Startz (1990) and Bound, Jaeger, and Baker (1995) recommend examining the joint F-statistic on the instruments in the first-stage regression to diagnose potentially weak instruments.

5. Results

The first empirical issue which needs to be addressed is the potential endogeneity of mental illness and addictive consumption. A Wu-Hausman test was performed for each of the three addictive goods to test for endogeneity. For each good, two sets of Wu-Hausman tests were performed by predicting both dependent variables with reduced form equations and including the predicted values, along with the actual values, in the structural equations.¹⁰ Both structural equations were then estimated with weighted OLS (see footnote 10). The predicted mental illness variables were significant in the alcohol and cigarette demand functions, but not in the cocaine demand function. The second set of tests were performed by including the predicted addictive consumption variable in the mental illness structural equation. These tests never rejected exogeneity. However, since causality must go in either one or both directions, there is enough evidence to conclude that there is endogeneity with mental illness in cases of alcohol and cigarettes. The results from the conventional Wu-Hausman tests are supported by the significance of ρ , the correlation coefficient of the error terms in the substance use and mental illness

¹⁰ Angrist (2000) and Heckman and MaCurdy (1985) show that TSLS is an acceptable method of estimation in cases of endogenous dichotomous dependent variables. All of the functions were estimated with robust standard errors, clustered on state, to account for unobserved state level heterogeneity.

equations, from the bivariate probit models. In the case of alcohol and cigarettes, ρ is statistically significant at the five percent level, indicating endogeneity. In the case of cocaine, ρ is statistically insignificant, indicating exogeneity, and so consistent estimates can be obtained via simple probit specifications.

The failure to find evidence of endogeneity for cocaine might be due to the low prevalence of cocaine use. Only about two percent of the sample used cocaine in the past year. However, about 24 percent of the sample had a mental illness in the past year and 43 percent had a mental illness sometime during their lives. Even if every cocaine user were mentally ill they would comprise only eight percent of all past year mentally ill individuals and four percent of all lifetime mentally ill individuals. That is, cocaine use is so minor a factor compared to other causes of mental illness that the exogeneity hypothesis can not be rejected.

The second empirical issue is to examine the identifying instrumental variables. The Davidson and MacKinnon test results are reported as Overidentification Test A and the Bollen et al. test results are reported as Overidentification Test B in Table 2-2. In none of the cases can the null hypothesis that the exclusion restrictions are valid be rejected. That is, both tests, for both alcohol and cigarettes, show that the excluded variables do not belong in the addictive good equations. The instruments for lifetime and past year mental illness are indicators of nine stressful life events, an indicator of a family history of mental illness and the number of psychiatrists in the respondent's county of residence. The joint F-statistics from the first stage regression are also reported in Table 2-2. In all cases the instruments excluded from the addictive demand functions are highly significant as a group in the mental illness equations. This shows that the

instruments are strongly correlated with the mental illness variables. These tests show that the nine stressful life events, the family history of mental illness and the number of psychiatrists do belong in the mental illness function. These identifying variables have no effect on addictive good demand beyond their effect on mental illness.

The first theoretical question that this paper seeks to answer is the effect of mental illness on alcohol, cocaine and cigarettes participation. To examine the effect of mental illness on addictive good participation, bivariate probit models were estimated for alcohol and cigarettes and probit models were estimated for cocaine. All of the demand functions include either a past year or lifetime mental illness variable. The results are presented in Table 2-2. The mental illness marginal effects represent the increase in the probability of participation when the dichotomous mental illness variable switches from zero to one. These coefficients are all positive and generally significant and are presented in Table 2-2. A somewhat more intuitive concept results when the marginal effects are divided by the mean addictive good participation rate. The result is the percentage increase in the participation rate for those with mental illness over those without mental illness. Past year mental illness is found to increase alcohol participation by about 20 percent, and lifetime mental illness increases alcohol participation by about 26 percent. For cocaine, the increases are 26 percent and 66 percent, respectively. For cigarettes, the increases are 80 percent and 89 percent, respectively.

The bivariate probit estimates also include the effects of price and other variables on addictive good participation. This is interesting because the NCS data have never been used to estimate addictive good demand functions. The price-participation elasticities are .48, .63 and .71, for alcohol, cocaine and cigarettes, respectively. The

other independent variables are similar to prior empirical studies and are examined in the selection models presented below. One variable which has not been included in prior addictive demand studies is the effect of a family history of problems with the addictive good. The results show that a family history of alcohol problems has a positive effect on alcohol participation and a family history of drug problems has a positive effect on cocaine participation. There were no variables on family history of problems with tobacco in the NCS data set.

The second question that this paper seeks to answer is the effect of mental illness on alcohol, cocaine and cigarettes price elasticities. To answer this question Heckman selection models for alcohol, cocaine and cigarette participation were estimated. These results are presented in Tables 2-3, 2-4 and 2-5, respectively.¹¹ Each table contains demand functions for those with and without both past year and lifetime mental illness. These tables also present the selection equation for past year and lifetime mental illness which is the reduced form mental illness equation (5) described earlier. Each demand function contains the parameter, ρ , which is proportional to the coefficient of λ and measures the correlation between the error terms in the demand function and the selection equation.¹² A significant value for ρ is evidence of endogenous selection. Each table also presents the results for two likelihood ratio tests for each pair of demand functions. The first likelihood ratio statistic tests for a significant difference between the

¹¹ Since these models also have dichotomous dependent variables in both the demand function and the selection function, they are estimated with the Heckprob procedure in Stata, using robust standard errors clustered on state.

¹² The parameter ρ represents the correlation between the error terms in the probit selection equation and the addictive demand equation. If ρ is significantly different from zero, then there is evidence of sample selection and standard single equation techniques will yield biased results. λ , is the inverse Mills ratio, and is equal to ρ times the standard error of the residual in the addictive demand equation. λ is

price coefficients and the second likelihood ratio statistic tests for a significant difference between the coefficients of all the included regressors.

The next empirical issue is whether different demand functions are needed for those with and without mental illness and if so, is selection endogenous? The likelihood ratio tests indicate that the demand functions in all cases are significantly different between the two groups. These results imply that separate demand functions for those with and without mental illness are needed. ρ is significant for one equation in the alcohol and cocaine regressions. For cigarettes, however, ρ is significant in all but one of the equations. Since at least one demand function in each pair for alcohol and cigarettes shows evidence of endogenous selection, to be consistent, all regressions are estimated as endogenous selection models. Inclusion of an insignificant λ does not bias the other variables.

For alcohol participation, the price elasticities for both mental illness groups are larger than the corresponding coefficients for those without mental illness. For cocaine, one case has an insignificant price coefficient and should be ignored. In the other case, mental illness reduces price elasticity. For cigarettes the results are mixed, higher in one case and lower in the other. These results show that individuals with mental illness are price responsive and that the elasticities are not substantively different from those who are not in the mentally ill group.

It is also interesting to examine the marginal effects for the other independent variables since they also differ between those with and without mental illness. The most interesting results are for religious adherence and for family history. Religious adherence has a negative effect on addictive consumption and it is a larger negative effect for those

proportional to the inverse of the probability that the individual is mentally ill.

with mental illness. Family history increases consumption of alcohol and cocaine for the mentally ill, but the effect tends to be weaker for those without mental illness. Gender, race, income, age and education mirror the results found in other studies of these goods with no systematic pattern across all three substances for those with and without mental illness.

Finally, Tables 2-3, 2-4 and 2-5 present results for the mental illness reduced form equations. They are all very similar across the three substances and for past year and lifetime mental illness. These are interesting results since there are few prior studies of mental illness production functions in the health economics literature. Prior studies of mental illness in health economics have mostly considered the effects of income and employment on mental illness.¹³ This prior work does point to the potential endogeneity between mental illness and some of the included variables. Since this paper focuses on addictive consumption, the potential endogeneity between mental illness and other variables such as income and education is not addressed. Because of these biases, these estimation results should be viewed as only suggestive of the relationships.

The mental illness reduced form equations correctly predict the dichotomous mental illness variables for about 70 percent of the sample. Income, education and marriage have a negative effect on mental illness. Age has a parabolic relationship to mental illness indicating that the onset of mental illness decreases after the age of 40. Women are more likely to have a current year mental illness than men. However, there is no gender difference for lifetime mental illness. Being black also has a negative effect on

¹³ Bjorkund (1985), MacFadyen, MacFadyen and Prince (1996), Mitchell and Anderson (1989) Hamilton, Merrigan and Dufresne (1997) and Ettner, Frank and Kessler (1997) estimate mental health functions. The last study also used the NCS data but included only three independent variables.

lifetime mental illness but no effect on past year mental illness. The other variables include family history of depression and stressful life events. A depressed mother has a significantly positive effect on mental illness. The stressful life events are generally positive and significant, although the effects are stronger for past year mental illness.

6. Conclusions

Economists have recommended price increases as a tool to reduce the consumption of addictive goods and their related costs. However, no research has specifically examined the interaction of price and mental illness on addictive consumption. The primary goals of this paper were to determine whether mental illness has any causal effect on the level of consumption of addictive goods or on the price elasticity of addictive goods. The empirical models allow for the possibility of endogeneity and simultaneity between mental illness and addictive consumption. The empirical results show that mental illness increases participation in addictive goods and that mental illness has no substantive effect on the price elasticity. These results suggest that alcohol and tobacco taxes and drug interdiction are effective with this high participation group. The results also suggest that an additional method of reducing consumption of addictive goods is to treat, or subsidize the treatment of, mental illness.

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Figure 2-1
Hypothesized Causal Relationships

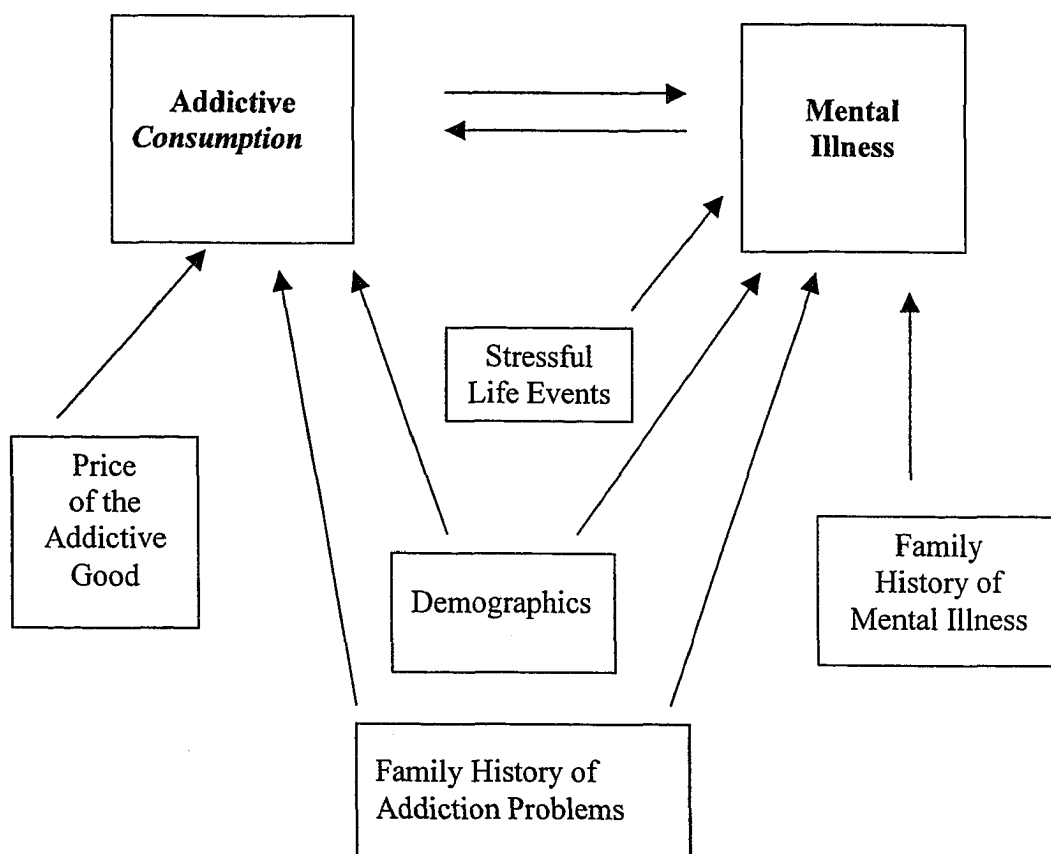


Table 2-1
Definitions and Weighted Means of Variables

Variable	Definition	Means All
Lifetime Mental Illness	A dichotomous indicator equal to one if the respondent is diagnosed with any of the 12 psychiatric disorders listed in the appendix, in their lifetime.	0.432
Past Year Mental Illness	A dichotomous indicator equal to one if the respondent is diagnosed with any of the 12 psychiatric disorders listed in the appendix, in the past 12 months.	0.241
Alcohol Participation	A dichotomous indicator equal to one for alcohol use in the past year.	0.636
Cocaine Participation	A dichotomous indicator equal to one for cocaine use in the past year.	0.022
Cigarette Participation	A dichotomous indicator equal to one for cigarette use in the past year.	0.310
Alcohol Price	Price of 750ml bottle of scotch, measured in dollars.	16.105
Cocaine Price	Price of one pure gram of cocaine, measured in dollars.	137.776
Cigarette Price	Average price per pack of cigarettes, including generic brands, measured in cents.	162.390
Income	Personal income of the respondent, measured in thousands of dollars.	19.529
Age	Age of the respondent.	33.027
Age Square	Square of age.	1205.783
Education	Number of years of formal schooling completed by the respondent.	12.884
Female	A dichotomous indicator equal to one if the respondent is female.	0.509
Married	A dichotomous indicator equal to one if the respondent is married.	0.602
Black	A dichotomous indicator equal to one if the respondent is black.	0.107
Religious Preference	A dichotomous indicator equal to one if the respondent has preference for any religion.	0.909
Mom Drink	A dichotomous indicator equal to one if the respondent reported that their natural mother had a problem with drinking.	0.070

Contd.

Table 2-1 Contd.
Definitions and Weighted Means of Variables

Variable	Definition	Means All
Mom Drugs	A dichotomous indicator equal to one if the respondent reported their natural mother abused prescription drugs or had a problem with illegal drugs.	0.044
Mom Depressed	A dichotomous indicator equal to one if the respondent reported their natural mother being depressed for at least two weeks.	0.325
Combat	A dichotomous indicator equal to one if the respondent had combat experience.	0.031
Ever Molested	A dichotomous indicator equal to one if the respondent was sexually molested.	0.072
Terrible Experience	A dichotomous indicator equal to one if the respondent had any other terrible experience.	0.111
Shock	A dichotomous indicator equal to one if the respondent suffered a great shock due to someone close to them experiencing one of these traumatic events.	0.120
Robbed	A dichotomous indicator equal to one if the respondent was robbed was burglarized in the past 12 months.	0.057
Conflict	A dichotomous indicator equal to one if the respondent had serious, ongoing tensions or conflicts with a relative, friend, neighbor, landlord/tenant, or someone at work or at school in the past 12 months.	0.246
Separation	A dichotomous indicator equal to one if the respondent had a long separation from a loved one in the past 12 months.	0.130
Death of Relative	A dichotomous indicator equal to one if any close friend or close relative of the respondent died in the past 12 months.	0.218
Other Event	A dichotomous indicator equal to one if the respondent suffered any other major stressful event in the past 12 months.	0.117
Psychiatrist Availability	An indicator of the number of psychiatrists in the respondent's county of residence.	0.033

Notes: Maximum number of observations is 5,282.

**Table 2-1 Contd.
Definitions and Weighted Means of Variables**

Variable	Lifetime Mental Illness = 1	Lifetime Mental Illness = 0	Past Year Mental Illness = 1	Past Year Mental Illness = 0
Lifetime Mental Illness	-	-	1.000	0.251
Past Year Mental Illness	0.558	0.000	-	-
Alcohol Participation	0.673***	0.607	0.636	0.635
Cocaine Participation	0.035**	0.012	0.032*	0.019
Cigarette Participation	0.396***	0.247	0.424***	0.275
Alcohol Price	16.086	16.119	16.160	16.087
Cocaine Price	137.418	138.049	138.364	137.590
Cigarette Price	162.486*	162.317	162.542	162.342
Income	16.971***	21.472	13.509***	21.441
Age	32.877	33.141	31.593***	33.483
Age Square	1195.204	1213.817	1113.796***	1235.000
Education	12.625***	13.081	12.342***	13.057
Female	0.550**	0.478	0.657***	0.462
Married	0.584	0.615	0.545**	0.620
Black	0.087***	0.123	0.099*	0.110
Religious Preference	0.894	0.920	0.901	0.911
Mom Drink	0.098***	0.049	0.102***	0.060
Mom Drugs	0.065***	0.028	0.067***	0.036
Mom Depressed	0.449***	0.231	0.502***	0.269
Combat	0.036	0.026	0.024*	0.033
Ever Molested	0.121***	0.035	0.147***	0.048
Terrible Experience	0.149***	0.081	0.150***	0.098
Shock	0.165***	0.087	0.194***	0.097
Robbed	0.074*	0.045	0.078	0.051
Conflict	0.363***	0.158	0.429***	0.188
Separation	0.185***	0.088	0.239***	0.095
Death of Relative	0.230	0.209	0.268***	0.202
Other Event	0.151***	0.090	0.175***	0.098
Psychiatrist Availability	0.051	0.020	0.017	0.038

Notes: Maximum number of observations is 5,282. Asterisks indicate that the difference between the two groups is significant as follows: *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 2-2
Full Sample Models

Dependent Variable	Alcohol Participation ¹		Cocaine Participation ²	
Lifetime Mental Illness	0.16683 (2.68)	0.01457 (2.52)	-	-
Past Year Mental Illness	-	-	0.00572 (1.53)	0.12886 (2.71)
Alcohol Price	-0.01839 (-2.94)	-	-	-0.01922 (-3.27)
Cocaine Price	-	-0.00010 (-3.41)	-0.00010 (-3.17)	-
Income	0.00332 (7.18)	-0.00007 (-0.65)	-0.00008 (-0.74)	0.00330 (6.94)
Age	0.04279 (7.06)	0.00919 (5.78)	0.01006 (6.43)	0.04735 (7.97)
Age Square	-0.00065 (-7.92)	-0.00015 (-5.95)	-0.00016 (-6.45)	-0.00070 (-8.62)
Education	0.02089 (4.66)	-0.00083 (-1.09)	-0.00111 (-1.41)	0.02029 (4.34)
Female	-0.11923 (-7.88)	-0.01900 (-6.12)	-0.01970 (-5.99)	-0.12775 (-7.17)
Married	0.00975 (0.55)	-0.01711 (-3.21)	-0.01805 (-3.36)	0.00641 (0.36)
Black	-0.09241 (-4.31)	0.00592 (1.04)	0.00479 (0.85)	-0.10337 (-5.29)
Religious Preference	-0.04288 (-1.90)	-0.01418 (-3.77)	-0.01551 (-4.00)	-0.05042 (-2.27)
Mom Drink	0.03673 (1.68)	-	-	0.04797 (2.22)
Mom Drugs	-	0.02091 (3.18)	0.02401 (3.57)	-
Correlation ρ^3	-0.2368** (5.01)	-	-	-0.1909** (6.09)
Price Elasticity	-0.466	-0.626	-0.626	-0.487
Overidentification Test A	11.45	-	-	11.51
Overidentification Test B	11.66	-	-	11.74
F-test on Instruments	87.98***	-	-	81.98***
Number of Observations	5,282	5,430	5,430	5,282

Contd.

**Table 2-2 Contd.
Full Sample Models**

Dependent Variable	Cigarette Participation ¹	
	Lifetime Mental Illness	0.27539 (6.45)
Past Year Mental Illness	—	0.24843 (4.94)
Cigarette Price	-0.00132 (-3.26)	-0.00138 (-3.21)
Income	-0.00044 (-0.73)	-0.00049 (-0.80)
Age	0.04491 (7.63)	0.05244 (8.86)
Age Square	-0.00058 (-7.42)	-0.00067 (-8.65)
Education	-0.04865 (-8.70)	-0.04976 (-8.43)
Female	-0.04661 (-2.56)	-0.05870 (-2.97)
Married	-0.03200 (-1.77)	-0.03759 (-2.08)
Black	-0.04800 (-1.17)	-0.06743 (-1.69)
Religious Preference	-0.07355 (-2.22)	-0.09173 (-2.62)
Correlation ρ ³	-0.3686*** (15.09)	-0.3307*** (16.93)
Price Elasticity	-0.691	-0.723
Overidentification Test A	8.60	10.48
Overidentification Test B	8.03	10.72
F-test on Instruments	135.27***	83.71***
Number of Observations	2,898	2,898

¹ Models are estimated via bivariate probit. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust by state. Asymptotic z-values are in parentheses. Overidentification Test A, based on Davidson and MacKinnon (1993), is distributed as Chi-square with 8 degrees of freedom. Overidentification Test B, based on Bollen et al. (1995), is the likelihood ratio test distributed as Chi-square with 8 degrees of freedom. ** Significant at 5 percent level. *** Significant at 1 percent level.

² Models are estimated via single equation probit. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust by state. Asymptotic z-values are in parentheses.

³ Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. ** Significant at 5 percent level. *** Significant at 1 percent level. For cocaine, ρ is statistically insignificant from the bivariate probit models, and so probit results are presented (see text)

Table 2-3
Alcohol Participation – Lifetime Mental Illness

Dependent Variable	Alcohol Participation ¹		Lifetime Mental Illness ₂
	Lifetime Mental Illness = 1	Lifetime Mental Illness = 0	All
Alcohol Price	-0.02068 (-3.93)	-0.01444 (-1.54)	-0.00100 (-0.22)
Income	0.00293 (6.10)	0.00350 (3.88)	-0.00139 (-3.42)
Age	0.02978 (4.12)	0.06081 (3.89)	0.04996 (13.87)
Age Square	-0.00047 (-4.55)	-0.00090 (-4.24)	-0.00062 (-12.75)
Education	0.01022 (1.94)	0.03467 (5.98)	-0.02677 (-9.36)
Female	-0.08776 (-4.75)	-0.16260 (-6.41)	0.02267 (1.27)
Married	0.00830 (0.55)	0.00284 (0.08)	-0.05535 (-3.47)
Black	-0.06513 (-3.41)	-0.12483 (-3.23)	-0.07039 (-3.00)
Religious Preference	-0.05074 (-2.15)	-0.02182 (-0.51)	-0.05360 (-2.82)
Mom Drink	0.03064 (1.21)	0.06497 (1.63)	0.08953 (3.11)
Mom Depressed	–	–	0.13058 (10.90)
Combat	–	–	0.04309 (0.84)
Molested	–	–	0.15116 (5.61)
Robbed	–	–	0.07283 (2.83)
Terrible Experience	–	–	0.07991 (3.64)
Shock	–	–	0.09446 (3.57)
Conflict	–	–	0.14619 (11.77)
Separation	–	–	0.09320 (4.77)

Contd.

Table 2-3 Contd.
Alcohol Participation – Lifetime Mental Illness

Death of Relative	–	–	0.01247 (0.88)
Other Event	–	–	0.05611 (2.38)
Psychiatrist Availability	–	–	0.00903 (1.30)
Rho ³	-0.2109 (2.22)	-0.2241 (2.07)	–
Price Elasticity	-0.494	-0.383	–
Test of Price Differences ⁴	4.18**		–
Test of Difference in all Coefficients ⁴	65.87***		–
Number of Observations	2,984	2,298	5,282

1 Sample selection models are estimated as probit via Heckman's two-step procedure. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust. Asymptotic z-values are in parentheses.

2 Probit selection equation. Marginal effects are reported.

3 Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

4 Likelihood ratio test. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

Table 2-3 Contd.
Alcohol Participation – Past Year Mental Illness

Dependent Variable	Alcohol Participation ¹		Past Year Mental Illness ²
	Past Year Mental Illness = 1	Past Year Mental Illness = 0	All
Alcohol Price	-0.02458 (-4.03)	-0.01526 (-1.72)	0.00370 (0.69)
Income	0.00368 (5.03)	0.00300 (4.44)	-0.00139 (-3.01)
Age	0.03294 (3.53)	0.05503 (6.21)	0.02478 (4.71)
Age Square	-0.00050 (-3.80)	-0.00081 (-6.78)	-0.00032 (-4.31)
Education	0.01158 (1.67)	0.02486 (5.37)	-0.02321 (-7.00)
Female	-0.05878 (-2.33)	-0.16812 (-7.49)	0.10295 (5.03)
Married	0.00966 (0.42)	0.00284 (0.13)	-0.03915 (-3.01)
Black	-0.06615 (-2.30)	-0.12021 (-4.98)	-0.01229 (-0.52)
Religious Preference	-0.07179 (-2.54)	-0.02944 (-1.00)	-0.00903 (-0.45)
Mom Drink	0.04713 (1.81)	0.03961 (1.27)	0.01609 (0.69)
Mom Depressed	–	–	0.12444 (10.12)
Combat	–	–	0.01483 (0.35)
Molested	–	–	0.10168 (4.46)
Robbed	–	–	0.01197 (0.51)
Terrible Experience	–	–	0.04416 (1.88)
Shock	–	–	0.07999 (3.26)
Conflict	–	–	0.13923 (10.73)
Separation	–	–	0.11411 (5.86)

Contd.

Table 2-3 Contd.
Alcohol Participation – Past Year Mental Illness

Death of Relative	–	–	0.04183 (4.22)
Other Event	–	–	0.06081 (2.90)
Psychiatrist Availability	–	–	0.00049 (0.08)
Rho ³	-0.2157 (2.03)	-0.2194* (3.82)	–
Price Elasticity	-0.625	-0.387	–
Test of Price Differences ⁴	5.94**		–
Test of Difference in all Coefficients ⁴	45.72***		–
Number of Observations	1,711	3,571	5,282

1 Sample selection models are estimated as probit via Heckman's two-step procedure. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust. Asymptotic z-values are in parentheses.

2 Probit selection equation. Marginal effects are reported.

3 Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

4 Likelihood ratio test. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

Table 2-4
Cocaine Participation – Lifetime Mental Illness

Dependent Variable	Cocaine Participation ¹		Lifetime Mental Illness ₂
	Lifetime Mental Illness = 1	Lifetime Mental Illness = 0	All
Cocaine Price	-0.00005 (-0.92)	-0.00007 (-3.55)	0.00022 (1.59)
Income	-0.00014 (-0.88)	0.000005 (-0.09)	-0.00122 (-3.24)
Age	0.00956 (4.91)	0.00270 (2.30)	0.04956 (13.54)
Age Square	-0.00016 (-5.15)	-0.00004 (-2.37)	-0.00062 (-12.25)
Education	-0.00137 (-1.20)	0.000005 (-0.01)	-0.02720 (-9.70)
Female	-0.02294 (-5.27)	-0.00525 (-2.63)	0.02520 (1.40)
Married	-0.01649 (-2.83)	-0.00541 (-2.12)	-0.05556 (-3.36)
Black	0.00620 (0.86)	0.00141 (0.36)	-0.06978 (-3.08)
Religious Preference	-0.01548 (-3.06)	-0.00268 (-0.98)	-0.05725 (-2.96)
Mom Drugs	0.02486 (2.48)	0.00567 (1.38)	0.07581 (1.93)
Mom Depressed	–	–	0.12969 (11.28)
Combat	–	–	0.04860 (1.02)
Molested	–	–	0.15820 (6.00)
Robbed	–	–	0.06169 (2.30)
Terrible Experience	–	–	0.08291 (3.80)
Shock	–	–	0.09045 (3.35)
Conflict	–	–	0.14758 (12.02)
Separation	–	–	0.09609 (4.61)

Contd.

Table 2-4 Contd.
Cocaine Participation – Lifetime Mental Illness

Death of Relative	–	–	0.01501 (1.03)
Other Event	–	–	0.05898 (2.56)
Psychiatrist Availability	–	–	0.00990 (1.31)
Rho ³	0.2355 (0.42)	-0.5102* (3.05)	–
Price Elasticity	-0.196	-0.805	–
Test of Price Differences ⁴	342.75***		–
Test of Difference in all Coefficients ⁴	377.97***		–
Number of Observations	2,928	2,282	5,210

1 Sample selection models are estimated as probit via Heckman's two-step procedure. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust. Asymptotic z-values are in parentheses.

2 Probit selection equation. Marginal effects are reported.

3 Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

4 Likelihood ratio test. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

Table 2-4 Contd.
Cocaine Participation – Past Year Mental Illness

Dependent Variable	Cocaine Participation ¹		Past Year Mental Illness ²
	Past Year Mental Illness = 1	Past Year Mental Illness = 0	All
Cocaine Price	-0.00011 (-1.99)	-0.00007 (-2.29)	0.00024 (1.41)
Income	-0.00020 (-0.97)	-0.00005 (-0.39)	-0.00138 (-2.88)
Age	0.01173 (3.22)	0.00730 (4.99)	0.02475 (4.62)
Age Square	-0.00018 (-3.17)	-0.00012 (-4.89)	-0.00032 (-4.18)
Education	-0.00074 (-0.36)	-0.00120 (-1.69)	-0.02317 (-7.18)
Female	-0.02369 (-2.95)	-0.01847 (-3.60)	0.10715 (5.15)
Married	-0.03033 (-3.81)	-0.00765 (-1.50)	-0.04360 (-3.42)
Black	0.01550 (1.23)	-0.00085 (-0.19)	-0.01670 (-0.71)
Religious Preference	-0.02114 (-2.49)	-0.00794 (-1.80)	-0.00732 (-0.37)
Mom Drugs	0.06174 (3.12)	-0.00012 (-0.02)	0.00944 (0.28)
Mom Depressed	–	–	0.12248 (11.20)
Combat	–	–	0.01528 (0.36)
Molested	–	–	0.10690 (3.99)
Robbed	–	–	0.00245 (0.10)
Terrible Experience	–	–	0.04615 (1.95)
Shock	–	–	0.08028 (3.25)
Conflict	–	–	0.13584 (10.76)
Separation	–	–	0.11667 (5.72)

Contd.

Table 2-4 Contd.
Cocaine Participation – Past Year Mental Illness

Death of Relative	–	–	0.04191 (3.77)
Other Event	–	–	0.06091 (3.03)
Psychiatrist Availability	–	–	0.00327 (0.45)
Rho ³	-0.0157 (0.00)	-0.1645 (0.39)	–
Price Elasticity	-0.476	-0.507	–
Test of Price Differences ⁴	26.73***		–
Test of Difference in all Coefficients ⁴	62.40***		–
Number of Observations	1,677	3,533	5,210

1 Sample selection models are estimated as probit via Heckman's two-step procedure. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust. Asymptotic z-values are in parentheses.

2 Probit selection equation. Marginal effects are reported.

3 Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

4 Likelihood ratio test. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

Table 2-5
Cigarette Participation – Lifetime Mental Illness

Dependent Variable	Cigarette Participation ¹		Lifetime Mental Illness ₂
	Lifetime Mental Illness = 1	Lifetime Mental Illness = 0	All
Cigarette Price	-0.00161 (-3.37)	-0.00073 (-1.64)	0.00012 (0.24)
Income	-0.00095 (-0.87)	-0.00004 (-0.06)	-0.00139 (-2.37)
Age	0.05469 (6.01)	0.02717 (3.86)	0.05005 (9.73)
Age Square	-0.00074 (-6.05)	-0.00032 (-3.55)	-0.00063 (-8.44)
Education	-0.05935 (-7.40)	-0.02998 (-6.25)	-0.02549 (-5.80)
Female	-0.04134 (-1.23)	-0.03361 (-1.79)	0.03137 (1.64)
Married	-0.03211 (-1.20)	-0.03375 (-1.33)	-0.05842 (-3.24)
Black	-0.09906 (-2.39)	-0.00643 (-0.14)	-0.10897 (-3.83)
Religious Preference	-0.07907 (-1.80)	-0.06081 (-1.58)	-0.03846 (-1.27)
Mom Depressed	-	-	0.13933 (6.91)
Combat	-	-	0.03812 (0.61)
Molested	-	-	0.17245 (5.13)
Robbed	-	-	0.06348 (1.65)
Terrible Experience	-	-	0.08238 (2.65)
Shock	-	-	0.08693 (2.50)
Conflict	-	-	0.15401 (7.88)
Separation	-	-	0.07995 (2.94)

Contd.

Table 2-5 Contd.
Cigarette Participation – Lifetime Mental Illness

Death of Relative	–	–	0.01990 (1.07)
Other Event	–	–	0.06116 (1.93)
Psychiatrist Availability	–	–	0.00755 (1.40)
Rho ³	-0.2061 (2.26)	-0.4461*** (7.77)	–
Price Elasticity	-0.661	-0.480	–
Test of Price Differences ⁴	15.49***		–
Test of Difference in all Coefficients ⁴	55.17***		–
Number of Observations	1,647	1,251	2,898

1 Sample selection models are estimated as probit via Heckman's two-step procedure. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust. Asymptotic z-values are in parentheses.

2 Probit selection equation. Marginal effects are reported.

3 Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

4 Likelihood ratio test. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

Table 2-5 Contd.
Cigarette Participation – Past Year Mental Illness

Dependent Variable	Cigarette Participation ¹		Past Year Mental Illness ²
	Past Year Mental Illness = 1	Past Year Mental Illness = 0	All
Cigarette Price	-0.00144 (-2.36)	-0.00126 (-2.30)	0.00051 (0.96)
Income	-0.00127 (-0.96)	-0.00016 (-0.30)	-0.00138 (-2.26)
Age	0.05373 (5.25)	0.04856 (7.85)	0.02719 (4.09)
Age Square	-0.00072 (-5.28)	-0.00061 (-7.35)	-0.00035 (-3.71)
Education	-0.05357 (-5.67)	-0.04535 (-8.13)	-0.02449 (-5.41)
Female	-0.11448 (-3.14)	-0.03236 (-1.64)	0.10164 (4.54)
Married	-0.00091 (-0.02)	-0.05042 (-2.60)	-0.04188 (-2.25)
Black	-0.12573 (-2.74)	-0.03835 (-0.90)	-0.04339 (-1.57)
Religious Preference	-0.10829 (-1.72)	-0.08155 (-2.34)	0.02722 (1.04)
Mom Depressed	–	–	0.12352 (8.72)
Combat	–	–	0.01263 (0.27)
Molested	–	–	0.13837 (4.71)
Robbed	–	–	-0.00657 (-0.22)
Terrible Experience	–	–	0.06029 (2.23)
Shock	–	–	0.11412 (3.49)
Conflict	–	–	0.15063 (7.26)
Separation	–	–	0.10429 (3.43)

Contd.

Table 2-5 Contd.
Cigarette Participation – Past Year Mental Illness

Death of Relative	–	–	0.04860 (2.76)
Other Event	–	–	0.06109 (2.17)
Psychiatrist Availability	–	–	0.00091 (0.15)
Rho ³	-0.2545** (5.34)	-0.3697** (5.22)	–
Price Elasticity	-0.552	-0.744	–
Test of Price Differences ⁴	5.39**		–
Test of Difference in all Coefficients ⁴	43.88***		–
Number of Observations	950	1,948	2,898

1 Sample selection models are estimated as probit via Heckman's two-step procedure. Marginal effects are reported. Calculated standard errors (not shown) are clustered robust. Asymptotic z-values are in parentheses.

2 Probit selection equation. Marginal effects are reported.

3 Chi-square values for the Wald test of $\rho=0$ are reported in parentheses. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

4 Likelihood ratio test. * Significant at 10 percent level. ** Significant at 5 percent level *** Significant at 1 percent level.

Appendix 2-1 Derivation of the Demand Function

The individual maximizes the following utility function subject to an income constraint:

$$\text{Max} : U(A, X, M)$$

$$\text{ST} : PA + X = I.$$

To derive the demand curve, let the utility function be quadratic in A .

$$U_i = \alpha_1 A - \frac{1}{2} \alpha_2 A^2 - \alpha_3 M + \alpha_4 X.$$

A is consumption of the addictive good, with corresponding price P , X is consumption of the non-addictive good, with price normalized to one, I is current income, and M represents mental illness. In addition, the following restrictions are imposed on the parameters:

$$U_a = \frac{\partial U}{\partial A} = \alpha_1 - \alpha_2 A > 0$$

$$U_{aa} = \frac{\partial^2 U}{\partial A^2} = -\alpha_2 < 0$$

$$U_m = \frac{\partial U}{\partial M} = -\alpha_3 < 0.$$

The first and second conditions indicate positive but diminishing marginal utility of addictive consumption. The third condition shows that mental illness reduces utility. Furthermore, the marginal utility of current consumption and the extent to which it diminishes may vary with mental illness. To allow for this possibility, let α_1 and α_2 depend on M :

$$\alpha_1 = \delta_1 + \delta_2 M$$

$$\alpha_2 = \theta_1 - \theta_2 M.$$

If δ_2 and θ_2 are positive parameters, then mental illness raises marginal utility and lowers the rate at which it diminishes. The first-order condition for maximization with respect to

$$\delta_1 + \delta_2 M - (\theta_1 - \theta_2 M)A = \lambda P.$$

A is:¹⁴

Solving this condition for A yields the following current period demand for the addictive good,

$$A = \psi_1(M) - \psi_2(M)P$$

where,

$$\psi_1 = \frac{\delta_1 + \delta_2 M}{\theta_1 - \theta_2 M} > 0$$

$$\psi_2 = \frac{\lambda}{\theta_1 - \theta_2 M} > 0.$$

Holding all else constant, ψ_1 represents the effect of mental illness on consumption. Mental illness has a positive effect on consumption if current marginal utility is higher or if marginal utility diminishes less for mentally ill individuals.

The effect of mental illness on the price responsiveness of consumption is given by the following derivative:

¹⁴ λ is the marginal utility of income.

$$\frac{\partial^2 A}{\partial P \partial M} = -\frac{\partial \psi_2}{\partial M}.$$

If mental illness reduces the rate at which marginal utility diminishes such that θ_2 is positive, then the price effect, given by negative ψ_2 , rises in absolute value. In this case, mentally ill individuals will be more responsive to price. If, on the other hand, the extent of diminishing marginal utility is greater for the mentally ill, then the price effect is smaller in absolute value and this group will be less price responsive.¹⁵

The empirical results show that mental illness increases the consumption of all substances, *ceteris paribus*. This implies that δ_2 is positive in all cases so that mental illness raises the marginal utility of consumption. For alcohol, we find that mentally ill individuals are also more price responsive, so that θ_2 is also positive for them. Thus, for alcohol users, mental illness lowers the rate of diminishing marginal utility. In the case of cocaine and cigarettes, the evidence is mixed. However, even if θ_2 is negative for cocaine and cigarette users, δ_2 must still be positive since the mentally ill consume more

¹⁵ The above analysis applies to a continuous measure of consumption. Since the dependent variable used in this study is dichotomous for participation, it is not appropriate to analyze the effects with differential calculus. The reservation price π , defined by evaluating the marginal utility of A at $A=0$, equals $\delta_1 + \delta_2 M$. Optimal consumption is zero if $\pi < \lambda P$ or if $\pi^* < P$, where $\pi^* = \pi/\lambda$ is the reservation price expressed in dollars. If mentally ill individuals have a higher marginal utility, they will have a higher reservation price. They will therefore be more likely to participate. Furthermore, if the mentally ill individual is initially not participating because $\pi^* < P$, then the decline in P required to shift the status from non-participation to participation is smaller than if the individual were not mentally ill and had a lower reservation price. Thus, mental illness also tends to increase the participation response with respect to actual price.

cocaine and cigarettes. They must be deriving a higher marginal utility from consumption and this effect must be outweighing any other.

Appendix 2-2

Psychiatric Disorders from the National Comorbidity Survey

The following disorders are defined as dichotomous in the NCS data set. The mental illness variable used in this study was defined as equal to one if any of these disorders were present:

- 1) Generalized anxiety disorder is defined by a protracted period of anxiety and worry, accompanied by multiple associated symptoms. These symptoms include muscle tension, easily fatigued, poor concentration, insomnia and irritability.
- 2) Social Phobia describes people with marked and persistent anxiety in social situations, including performances and public speaking. The critical element of the fearfulness is the possibility of embarrassment or ridicule.
- 3) Simple Phobia include common conditions which are characterized by marked fear of specific objects or situations. Exposure to either the object of the phobia, either in real life or via imagination or video, invariably elicits intense anxiety, which may include a panic attack
- 4) Panic Attack is a discrete period of intense fear or discomfort that is associated with numerous somatic and cognitive symptoms. These symptoms include palpitations, sweating, trembling, shortness of breath, sensations of choking or smothering, chest pains, nausea or gastrointestinal distress, dizziness or lightheadedness, tingling sensations and chills or blushing and hot flashes. The experience generally provokes a strong urge to flee or escape from the place where the attack began.
- 5) Panic Disorder is diagnosed when a person has experienced at least two unexpected panic attacks and develops persistent concern or worry about having further attacks or changes his or her behavior to avoid or minimize such attacks.
- 6) Agoraphobia comes from the ancient Greek meaning a fear of an open marketplace. Agoraphobia today describes severe and pervasive anxiety about being in situations from which escape might be difficult or avoidance of situations such as being alone outside of home, traveling in a car, bus or airplane, or being in a crowded area.
- 7) Post traumatic stress disorder refers to the anxiety and behavioral disturbances and functional impairment which develop after exposure to an extreme trauma, such as rape, other severe physical assault, near death experience, witness to murder and combat, and which persist for more than a month.
- 8) Major depression features one or more major depressive episodes each of which lasts at least two weeks. The symptoms of major depression include expressed mood and loss of interest or pleasure. Other symptoms vary but might include sleep disorders, unusual weight changes, psychomotor changes, fatigue, feelings of worthlessness, diminished ability to concentrate and thoughts of death.

9) Dysthymia is a chronic form of depression. Its early onset and unrelenting, smoldering course are among the features that distinguish it from major depressive disorder. It is sometimes associated with passive, avoidant and dependent traits. There are less symptoms required than there are for major depressive disorder, but the duration is at least two years.

10) Bipolar disorder is a recurrent mood disorder featuring one or more episodes of mania or mixed episodes of mania and depression. Bipolar is different from major depressive by virtue of a history of manic episodes. It has a higher familial prevalence than major depressive disorder.

11) Mania is a mood disturbance which ranges from euphoria to irritability. It may include inflated self-esteem, decreased need for sleep, being more talkative, racing thought process, distractibility, increased goal directed behavior and increased activities which are risky.

12) Non-Affective Psychosis is a summary category made up of schizophrenia, schizophreniform disorder, schizoaffective disorder, delusional disorder and atypical psychosis. It is characterized by profound disruption in cognition and emotion affecting the most fundamental human attributes such as language and thought. It can include hallucinations and delusions.

Chapter III

The Effects of Cocaine and Heroin Price on Drug Use among Arrestees and Drug Related Emergency Room Visits

1. Introduction

Much of current drug control policy in the United States focuses on interdiction programs aimed at stopping the flow of drugs. The U.S. spends approximately \$26 billion a year towards apprehension and punishment of drug offenders, the bulk of this aimed at dealers and sellers (Office of National Drug Control Policy, 2001).¹ From an economic perspective, such drug enforcement, by raising the cost of supplying drugs to the U.S. market, acts as a non-monetary tax and increases the transaction price of drugs.² By the law of the downward-sloping demand function, the increase in price must reduce the consumption of illicit drugs. Hence, a critical question concerns the extent to which drug use responds to prices, especially heavy or problematic use. Since manipulating prices is one mode of control that the public sector can exercise on the market for addictive unhealthy substances, empirical estimates of the relation between price variations and illicit drug consumption are key to informing and shaping public policy.

This paper estimates the empirical relationship between the prices of cocaine and heroin and objective indicators of their use. Cocaine and heroin prices are computed from the System to Retrieve Drug Evidence (STRIDE), comprised of purchases made by Drug Enforcement Administration (DEA) agents during undercover operations. Use data from two separate sources are employed in the analysis. The first set of outcomes is the percentage of arrestees testing positive for each substance, derived from the Drug Use Forecasting (DUF) program. The second set of outcomes is drug related emergency

¹ Approximately 67% of the federal drug control budget is allocated to supply reduction activities.

² Costs for drug suppliers increase because: 1) they are forced to use underground distribution and transportation channels that can be hidden from authorities, 2) some drug shipments are captured by the authorities and destroyed, 3) suppliers are forced to

room admissions where cocaine and heroin are cited, derived from the Drug Abuse Warning Network (DAWN). A panel data methodology is used to identify the empirical link between cocaine and heroin prices and these two indicators of use.

While this study is related to the new and growing empirical literature dealing with the price sensitivity of illegal drug consumption, it improves upon the prior estimates in a number of ways. The illegal drug use indicators employed in much of the literature are based on self-reports and may be measured inaccurately. In contrast, the indicators used in the present study are objective outcomes related to consumption. In the DUF data, cocaine and heroin participation are measured via urinalysis.³ In the DAWN data, emergency department personnel identify whether cocaine or heroin was associated with a particular drug episode. Moreover, much of the literature, by relying on self-reported national surveys, does not consider consumption by certain subgroups like the homeless or arrestees, who may behave very differently from the population at large. The persons sampled in DUF and DAWN are not representative of the general population. In particular, the focus is on persons arrested and persons whose substance use resulted in a visit to a hospital emergency room. These individuals are much more likely to be hardcore users of drugs than an individual selected at random. Thus, they also impose the heaviest costs on society and are the target of much illegal drug policy. In this respect, an estimate of the effect of drug prices on drug related emergency department (ED) episodes is valuable in that it directly relates drug prices, an instrument of enforcement efforts, to the health consequences of heavy drug use. Many studies

use the threat of violence or other relatively costly methods to enforce their contracts rather than use the court system, and 4) because of fines and imprisonment.

based on survey data also rely on the respondent's state of residence as the geographic unit. Consequently, when estimating the price elasticity of demand, these researchers have had to employ a state-average price despite the fact that there is considerable inter-city variation in drug prices even within a given state. This measurement error may lead to biased estimates. The present study overcomes this limitation by computing and merging drug prices at the city level. This analysis further exploits the time-series of city cross sections and estimates various fixed-effects specifications to control for unmeasured factors that may be correlated with price and consumption. In addition, lagged and lead price series are used in the context of panel data techniques to inform on the possibility of policy endogeneity. Another deficiency in the existing literature concerns cross price elasticities of demand. There are very few studies that analyze the effects of changes in the price of one drug on the consumption of another, and so estimates of these cross-price effects are limited. The present study estimates whether heroin and cocaine are substitutes or complements using the aforementioned objective drug use outcomes.

Results from DUF indicate that cocaine and heroin use among the arrestee population are negatively related to price. The own-price cocaine participation elasticity is estimated at about -0.23, and the own-price heroin participation elasticity is estimated at about -0.08. That these elasticities are somewhat smaller in absolute magnitude than those in the prior literature is not surprising given that arrestees are likely to be more addicted to drugs. Also, comparison of self-reported data with the urinalysis data reveals large under-reporting, another factor leading to the lower price elasticities from more

³ Arrestees are also asked to report on their own drug use. Comparing these self-reports to the urinalysis data can also inform on the magnitude and importance of any

objective outcomes. Specifications that include both cocaine and heroin prices show that these substances are economic complements. Results from DAWN also indicate that health consequences associated with heavy drug use are negatively related to drug prices. The elasticity of the probability of a cocaine mention with respect to own-price is estimated at around -0.30, and the corresponding own-price elasticity for the probability of a heroin mention is about -0.16. The probability of any drug related ED episode is also significantly negatively related to both cocaine and heroin prices. Cross-price elasticities again show that cocaine and heroin may be complements. Models from both data sets also indicate the presence of significant negative lagged-price effects, confirming the addictive aspects of both drugs within an economic framework.

The remainder of the chapter proceeds as follows. Section 2 reviews prior empirical studies dealing with the price sensitivity of the consumption of illegal drugs. Section 3 describes the data assembled for use in this study. Section 4 outlines the analytical models that guide the empirical specifications. Section 5 discusses the econometric strategy for estimating the models. Section 6 presents the price elasticities of demand for arrestees, based on the DUF data. Section 7 presents the results for drug related ED visits, based on the DAWN data. Section 8 discusses these results and offers some concluding remarks.

2. Prior Studies

An editorial in *Drug and Alcohol Review* (1999) stated that while economics has a critical influence in the development of policies in other areas, “illicit drugs is one of the few remaining areas yet to be significantly influenced by advances in this discipline.” Yet, there is a rapidly growing empirical literature by economists dealing with the price

measurement error.

sensitivity of consumption of illegal drugs.⁴ These demand studies primarily draw on illegal drug prices derived from local purchases made by drug enforcement agents while undercover. The studies typically combine these prices with self-reported measures of drug use from such national surveys as the National Household Survey of Drug Abuse and Monitoring the Future. Some also consider the effects of changes in the cost of one drug on consumption of another. The outcomes employed in these analyses are usually past year or past month participation and frequency of use given positive participation. The elasticity of participation is then interpreted as the percentage change in the probability of use caused by a one-percent reduction in price. In a fixed population, this elasticity also measures the percentage increase in the number of users due to a one-percent reduction in price. Results from these prior studies are summarized below.

The early conventional view that the demand for addictive substances, such as illicit drugs, did not respond to price was increasingly challenged by subsequent studies. Roumasset and Hadreas (1977) believed that the demand for heroin was unitary elastic. Moore (1977) argued that the aggregate demand for heroin is likely to be price inelastic, but not perfectly price-inelastic, so that an increase in price will reduce consumption but also increase total expenditure. Silverman and Spruill (1977) implicitly estimate the long-run price elasticity of demand for heroin at -0.25 , based on monthly aggregated data for 41 poor, non-white Detroit communities from November 1970 to July 1973. Van Ours (1995) analyzes data on opium consumption and the number of opium users in the Dutch East Indies (now Indonesia) for the period 1923 to 1938. He estimates a short-run

⁴ Economists have also studied various issues concerning the current policy towards illicit drugs versus a regime where drugs are legalized. See, for example, MacCoun and Reuter (2001), Miron (2001), Becker, Grossman, and Murphy (2003), Kuziemko and Levitt (2001), and Lee (1993).

price elasticity of demand of -0.70 and a long-run price elasticity of demand of -1.00 .

Bretteville-Jensen and Sutton (1996) estimate the price-responsiveness for heroin to be -1.23 , based on a sample of non-dealing heroin users who participated in a needle exchange program in Oslo, Norway.

Several authors, in more recent studies, have estimated price elasticities using national survey data. Grossman and Chaloupka (1998) analyze the demand for cocaine by young adults (ages 17-29) in the Monitoring the Future (MTF) panels using the rational addiction framework. The data employed in their study consists of panels formed from nationally representative cross-sectional surveys of high school seniors conducted between 1976 and 1985, with the last follow-up conducted in 1989. Grossman and Chaloupka find that annual participation and frequency of use given positive participation respond negatively to the price of cocaine. The long-run price elasticity of participation is estimated at -1.00 , and the long-run price elasticity of frequency given participation is estimated at -0.35 . They also find that current consumption is positively affected by past consumption, consistent with the hypothesis that cocaine is an addictive good, and also positively affected by future consumption, consistent with the rational addiction model.

Chaloupka, Grossman, and Tauras (1999) estimate cocaine price elasticities for past month and past year outcomes based on the 1982 and 1989 MTF cross-sectional surveys of high school seniors. Their results indicate a price elasticity of past-year participation of -0.89 and an elasticity of past-month participation of -0.98 . The corresponding frequency elasticities are -0.40 and -0.45 respectively. However,

DiNardo (1993) finds that past-month participation by high school seniors does not respond to price in a similar MTF sample for the years 1977 – 1987.

Based on pooled data from the 1988, 1990, and 1991 National Household Surveys of Drug Abuse (NHSDA), Saffer and Chaloupka (1999a) estimate models for all ages. They find that the annual participation price elasticity for cocaine is -0.55 and that for heroin is -0.90 . Monthly participation price elasticities for cocaine and heroin are -0.80 and -0.36 respectively. Using the same sample, Saffer and Chaloupka (1999b) estimate these price elasticities separately for demographic subgroups. They find that the cocaine price elasticity is insignificant for blacks and Asians, -1.83 for Native Americans, and between -0.5 and -0.8 for white males, Hispanics, women, and youth. For heroin, the price elasticity is estimated at -1.63 for white males, -0.62 for females, -0.36 for youth, and close to zero for all others. DeSimone and Farrelly (2001) analyze data from 1990-1997 NHSDA. They estimate a past-year cocaine participation elasticity of -0.41 for individuals between the ages of 18 to 39. However, similar models for persons ages 12 to 17 do not yield significantly negative price effects.

While the weight of the evidence from these studies suggests that cocaine and heroin use do respond negatively to price, there is little consensus about the magnitudes of the own-price elasticities. Studies that investigate the cross-price responsiveness of various illicit substances are sparse. Saffer and Chaloupka (1999a, 1999b), based on NHSDA data, estimate demand functions for cocaine, heroin, marijuana, and alcohol that contain the money price of each substance except marijuana. Their results show that these substances are economic complements, such that an increase in the price of one decreases the consumption of all others.

The illegal drug use indicators in the studies just cited may be plagued by inaccuracies if self-reports are subject to response error, and such surveys also fail to capture many hardcore drug users.⁵ These considerations have led researchers to consider the price sensitivity of outcomes related to drug consumption. Model (1993) finds that marijuana-related hospital emergency room episodes are positively related to marijuana decriminalization, based on quarterly data from 1975 to 1978 for 21 metropolitan statistical areas (MSA) in the Drug Abuse Warning Network (DAWN). This study capitalizes on the decriminalization of the possession of small amounts of marijuana by eleven U.S. states between 1973 and 1978. This presumably reduced the full price of marijuana. Model does not include the money price of marijuana or other drugs in her study. Caulkins (2001) estimates an elasticity of the number of hospital emergency room mentions for cocaine with respect to own-price of -1.30 and an elasticity of the number of hospital emergency room mentions for heroin with respect to own-price of -0.84. Caulkins employs an annual U.S. time series constructed from DAWN for the years 1978 to 1996. His models simply regress the given outcomes on price and do not control for any other factors that may have varied over time or for time trends. As a result, they may be biased.

⁵ Since drug use is significantly higher among respondents who live in households considered unstable, the NHSDA's bias towards sampling stable households is likely to overlook many heavy drug users. Many studies have documented that respondents in the NHSDA understate heavy drug use. The Substance Abuse and Mental Health Administration (SAMHSA) reports that virtually no heroin addicts respond in the NHSDA. A comparison of heavy cocaine users in the NHSDA with those in other sources shows a marked difference with respect to demographic characteristics. In the NHSDA, incomes are higher, unemployment is lower, and fewer respondents report using more than one drug. Estimates of heavy drug use reported in the NHSDA are also difficult to reconcile with other data sources maintained by SAMHSA. See Rhodes et al. (2001).

Caulkins (1996) indirectly estimates cocaine and heroin participation price elasticities based on data from 1987 to 1991 for 24 cities represented in Drug Use Forecasting (DUF). He uses as outcomes the percentages of persons arrested and brought to booking facilities who tested positive for cocaine and heroin based on urine specimens. His price elasticity estimates are -0.39 for cocaine and -0.28 for heroin, for arrestees. Invoking assumptions concerning the fraction of drug users testing positive and arrests attributable to drug use, other causes, and drug spending, Caulkins imputes general participation price elasticities that are very large in absolute magnitude: -2.5 for cocaine and -1.5 for heroin. His models control for unmeasured city effects. However, there are no controls for time trends. Furthermore, the city-level drug price is treated as endogenous and instrumented with the national price. Hence, the results reflect time-series variation between prices and the drug use outcomes. Similar to his study with DAWN, the models also do not control for other variables that may have changed over time.

Crane, Rivolo, and Comfort (1997) employ aggregate time series from DUF, DAWN, and the Treatment Episode Data Set in order to estimate the price elasticity of demand for cocaine ranging from -0.29 to -0.63. This study also fails to control for time trends. Hyatt and Rhodes (1995) find that cocaine price is negatively related to the fraction of arrestees testing positive for cocaine, from DUF, and the number of cocaine emergency room episode mentions, from DAWN. While this study adds city indicators to control for unobserved factors at the city level, it also does not control for time trends or any other factors that may have shifted over time. Furthermore, the price of cocaine is

not adjusted for inflation. Since year indicators are not included, this leads to biased estimates.

All of these studies which employ DUF or DAWN to measure the price responsiveness of cocaine and heroin estimate models that are misspecified due to lack of adequate controls. As a result, it is difficult to ascertain from these studies whether the negative correlation between the outcomes and price represents a true causal effect or whether it reflects a spurious correlation due to some unobserved variation. The specifications in this study include a full set of city and time indicators and in some cases interactions between city indicators and linear and quadratic trends, along with various socio-economic variables, to control for unmeasured factors that may be simultaneously correlated with price and consumption. None of the studies reviewed has combined this fixed-effects specification with objective measures of drug use.

3. Data

The empirical work is based on objective outcomes related to cocaine and heroin consumption derived from the Drug Use Forecasting (DUF) program and the Drug Abuse Warning Network (DAWN). The DUF program, which is maintained by the National Institute of Justice, was established in 1987 to investigate the level of drug use among booked arrestees in urban areas.⁶ Adults who are arrested and brought to booking facilities in several cities across the U.S. are interviewed on a voluntary basis, within 48 hours of their arrest, and asked to provide urine specimens. The interview is usually conducted in about 20 minutes. Over 90 percent of those approached agree to be interviewed, while 80 percent of them agree to provide urine specimens. There are no marked differences between arrestees who agree and those who refuse to be interviewed

with respect to ethnicity, age, gender, race, employment, or reason for arrest (Chaiken and Chaiken, 1992). Urine specimens are collected immediately after the interview and screening for various substances is conducted off-site. Urinalysis can generally detect the use of drugs within the past 48 to 72 hours.

While DUF does not sample all arrestees brought to booking facilities, Hunt and Rhodes (2001) suggest that it is reasonable to use the DUF sample to draw inferences about the general arrestee population. Moreover, Rhodes and McDonald (1991) estimated that in 1989 the DUF sample accounted for 90 percent of cocaine consumption and virtually all of the heroin consumption in the U.S. While these figures may be too high, it is apparent that the population sampled by DUF includes more hardcore drug users. Because users involved in the criminal justice system account for the majority of drugs consumed, the overall elasticities of the drugs may be dominated by the price responsiveness of this sub-population (Caulkins, 2001). The data used in the present study are annual aggregates from 39 large cities for the period 1988 to 2000.⁷ Until 1997, the DUF program collected information in 24 cities across the United States, although the number of sites does vary from year to year. In 1998 the program was expanded to more cities, and a redesigned sampling frame based on probability based sampling of the adult

⁶ See Hunt and Rhodes (2001) for a detailed description of the DUF program.

⁷ The DUF cities are New York City, Washington D.C., Portland, San Diego, Indianapolis, Houston, Ft. Lauderdale, Detroit, New Orleans, Phoenix, Chicago, Los Angeles, Dallas, Birmingham, Omaha, Philadelphia, Miami, Cleveland, San Antonio, St. Louis, Kansas City, San Jose, Denver, Atlanta, Albuquerque, Minneapolis, Sacramento, Tucson, Anchorage, Des Moines, Laredo, Las Vegas, Oklahoma City, Salt Lake City, Seattle, Spokane, Honolulu, Albany, and Charlotte.

male population was fully implemented in 2000; it is currently the Arrestee Drug Abuse Monitoring system.⁸

Results from urinalysis are used to compute the percentage of arrestees in each city testing positive for cocaine and the percentage testing positive for heroin.⁹ Approximately 40 percent of arrestees tested positive for cocaine in the sample, and approximately 8 percent tested positive for heroin. In addition to the urine tests, respondents are also asked to report on their own drug use. Based on self-reports, variables measuring the percentage of arrestees who admitted using cocaine or heroin in the past 72 hours are also created.¹⁰ About 21 percent of the arrestees reported using cocaine in the past 72 hours, and 5 percent reported using heroin. These figures show the extent of underreporting in these self-reports. The arrestees are also asked to report whether they used cocaine and heroin in the past 30 days and the mean number of days that each drug was used. From these questions, variables measuring the percentage of arrestees reporting cocaine and heroin participation in the past 30 days and the mean number of days in each city that cocaine and heroin were consumed by users are created. About 28 percent reported past month cocaine participation, and about 6 percent reported past month heroin participation.¹¹ Conditional on positive participation, cocaine was

⁸ Restricting the data from 1988 to 1997 or deleting observations for the year 2000 does not affect the results. Models that include the number of arrestees in the DUF sample as a fraction of total arrests are estimated to account for the change in the sampling frame. Year effects will capture any other breaks in the data that have occurred over time.

⁹ Urinalysis tests for all opiates instead of heroin specifically. While heroin is the most commonly consumed opiate, the class of opiates may also include other drugs such as morphine.

¹⁰ Self-reports for the past 72 hours are available for the year 1989 to 1999.

¹¹ Many arrestees who tested positive for each drug and denied use in the last three days admitted use in the past month (Rhodes et al., 2001).

used on about 23 days and heroin was used on about 17 days in the past month. Means for the DUF sample are presented in Table 3-1.

Since the early 1970's, DAWN has provided information on the use of emergency departments in the U.S. for the treatment of drug-related health problems. It is an ongoing national probability survey conducted annually in 21 large metropolitan areas by the Substance Abuse and Mental Health Services Administration.¹² Due to various changes in sample design over the years, a consistent time-series of the 21 cities is available only from 1990 to 2001.¹³ DAWN collects information on patients seeking hospital emergency department (ED) treatment related to their use of an illicit drug or the non-medical use of a legal drug.¹⁴ To be included in DAWN, the patient must be age 6 years or older, be treated in the hospital's emergency department, and have a problem induced by or related to drug use, regardless of when the drug ingestion occurred. Eligible hospitals in the DAWN sample are non-Federal, short-stay general hospitals that have a 24-hour emergency department. Within each participating facility, a trained reporter, usually a nurse or a member of the ED or medical records staff, is responsible for reviewing medical charts for indications noted by the treating physician that the episode was drug related.

¹² The DAWN cities are Atlanta, Baltimore, Boston, Buffalo, Chicago, Dallas, Denver, Detroit, Los Angeles, Miami, Minneapolis, New Orleans, New York City, Newark, Philadelphia, Phoenix, St. Louis, San Diego, San Francisco, Seattle, and Washington D.C.

¹³ Additional data inconsistencies that arise due to changes in the number of eligible hospitals or changes in hospitals that report to DAWN are controlled by including in all models the fraction of total eligible hospitals in each MSA that participate in DAWN. Year effects will also capture any other breaks over time.

¹⁴ By far, the most common reason cited for the drug-related ED visit in 2000 was overdose, in approximately 44 percent of the episodes.

A drug episode is defined as an emergency department visit that is directly related to the use of an illegal drug or the non-medical use of a legal drug.¹⁵ In addition, DAWN also identifies the substances associated with the drug abuse episodes. Up to four substances may be reported or “mentioned” for each drug-related episode; thus, the total number of mentions exceeds the number of episodes.¹⁶ Much of the time, however, only one drug is mentioned. Based on these data, a variable measuring the probability of a drug related episode is defined as total drug related ED episodes in each metropolitan statistical area (MSA) divided by population. For the sample analyzed in this study, there are 312 such episodes per 100,000 persons. Similar rates are also defined for cocaine mentions and heroin mentions. There are 118 cocaine mentions and 64 heroin mentions per 100,000 persons. DAWN medical crises occur in a small fraction of the drug abusing population. Data from the National Comorbidity Survey show that about six percent of the adult population was diagnosed with a drug abuse or dependence disorder in 1991. Applied to the mean MSA population for 1991, this translates to about 215,000 individuals with a drug disorder. The mean number of drug related episodes for the same year was 9,574. This means that about 22 additional serious abusers are required to generate one extra DAWN drug episode. Thus, these outcomes defined from DAWN are intended to capture serious health consequences related to hardcore drug use. Means for the DAWN sample are presented in Table 3-2.

Since the outcomes are measured at the city or MSA level, additional MSA-level socioeconomic variables are created and included in all models. Personal income per

¹⁵ Since one person may make repeated visits, the number ED episodes reported in DAWN is not synonymous with the number of individuals seeking such treatment.

¹⁶ Alcohol is not noted separately. It is reported only when used in combination with illegal drugs.

capita is derived from the Bureau of Economic Analysis website and deflated by the national consumer price index reported by the Bureau of Labor Statistics. Total MSA population is obtained from the U.S. Bureau of Census. Indicators measuring the percentage of MSA population that is male, black, other race, Hispanic, ages 16 to 24, ages 25 to 54, high school graduate, and college graduate are constructed from the Current Population Survey March supplements. In order to capture local labor market conditions, the unemployment rate in each MSA is also included in all models. Data on unemployment are obtained from the Bureau of Labor Statistics, and in some cases also calculated from the March supplements of the Current Population Survey.

Indicators of local enforcement efforts are also appended to the DUF and DAWN data sets.¹⁷ Variables measuring the probability of arrest for drug possession and drug sale are computed from the FBI's Uniform Crime Reporting System. Ideally, the probability of arrest is constructed by dividing the total number of arrests in each category by the total number of drug users and dealers in the MSA or some proxy for total drug activity. However, as there are no reliable estimates of the number of drug users and dealers by MSA, the denominator is proxied by total MSA population and in some cases by the total number of arrests. Variables measuring the total number of arrests in each MSA due to any drug possession, any drug sale or trafficking, any drug-related violation, sale or trafficking in cocaine or opiates, sale or trafficking in marijuana, and violent or type 1 crimes are used to create the corresponding arrest rates.¹⁸

¹⁷ Data in the Uniform Crime Reports are available at the county level. To obtain MSA-level data, total arrests in each county are summed and aggregated for all counties represented in an MSA. Using state-level arrest variables does not materially affect results.

¹⁸ Type 1 crimes include murder, rape, aggravated assault, robbery, burglary, larceny, and motor vehicle theft.

Data on cocaine and heroin prices are computed from purchases made by undercover drug enforcement agents. Information on these purchases including cost, weight, and purity is recorded by the Drug Enforcement Agency (DEA) in their System to Retrieve Information from Drug Evidence (STRIDE). The advantage of STRIDE's transaction-level data is that they directly reflect prices on the street. These prices are expected to be relatively accurate because any unreasonable price offer by a DEA agent may raise suspicion on the dealer's part and endanger the agent. However, because the transactions are of varying size and quality, the cost of each drug must be standardized.¹⁹

Standardized prices of one pure gram of cocaine and heroin in a given metropolitan area for a given year are derived in the following manner:²⁰

$$(1) \quad \text{Log Cost}_{ijt} = \pi_0 + \pi_1 (\log \text{Predicted Purity}_{ijt} + \log \text{Weight}_{ijt}) + \pi_2 \sum \text{MSA}_j \\ + \pi_3 \sum \text{Year}_t + \pi_4 \sum \text{MSA}_j * \text{Year}_t + v_{ijt}$$

The subscripts denote the i^{th} transaction in the j^{th} MSA for year t . Cost refers to the total cost of the purchase, weight is the total gram weight of the purchase, and purity is the weight of the pure drug found in the purchase as a fraction of the total purchase weight. MSA and Year refer to dichotomous indicators of each, and MSA*Year refers to indicators of the interaction between the two. Predicted Purity is obtained from a first-stage regression of actual purity on all of these other explanatory variables.²¹ The price of one pure gram of the drug in MSA j for year t is then imputed as:

¹⁹ For instance, Caulkins and Padman (1993) and Rhodes et al. (1994) show that there are sizable discounts for "wholesale" or large quantity purchases of cocaine.

²⁰ This procedure is also used in many other studies. See, for example, Grossman and Chaloupka (1988), DeSimone and Farrelly (2001), DeSimone (2001), Gutshall (2001), and Grossman et al. (2003).

²¹ Equation (1) can be justified by defining the price of one pure gram of drug as: $\text{Price} = \text{Cost} / (\text{Pure Quantity of Drug})^{\pi_1}$, where pure quantity is purity times total weight. Here π_1 captures any non-linear effects of quantity on price, for example due to quantity

$$(2) \quad \exp(\pi_0 + \pi_{2j} + \pi_{3t} + \pi_{4jt}).$$

In the above procedure, purity is treated as endogenous because purchases may depend on expected rather than actual purity (Caulkins, 1994). Identification is achieved by constraining the coefficient on predicted purity to equal that on weight in the second-stage regression (see footnote 21). In this study, price series based on purity treated as exogenous and estimating (1) with the coefficients unconstrained were experimented with in all models. There are no material changes in the results or conclusions. Hence, all reported results are based on cocaine and heroin prices computed as outlined above.

STRIDE data are available from 1974 to 2001, and all years are used to impute the price series for the periods represented in DUF and DAWN. Excluding outliers, there are 93,784 cocaine transactions and 40,957 heroin transactions.²² Two price series are computed, one based on all eligible purchases and one limited to purchases of 40 grams and less. The latter is computed to reflect the retail price of heroin and cocaine by excluding large, “wholesale” purchases. In order to maximize the sample size in subsequent estimation, prices that are missing in any given MSA for any given year are imputed by the simple mean of the prices for all other available MSA’s in that particular state.²³ Results are not sensitive to this imputation. All price series are deflated by the national cpi. The mean real price (in 1982-1984 dollars) of one pure gram of cocaine for

discounts. In log-linear form, this is $\text{Log Price} = \text{Log Cost} - \pi_1 \text{Log Purity} - \pi_1 \text{Log Weight}$. It is assumed that the standardized price varies between cities and over time. Thus, $\text{Log Price} = a + b \text{MSA} + c \text{Year} + d \text{MSA} * \text{Year}$. Substituting this expression in the log-linear formulation results in an estimable form, equation (21).

²² Transactions used in the imputation have a purchase cost of at least one dollar (zero cost represents seizures and are thus excluded) and purity between zero and 100 percent.

²³ This imputation is more relevant for heroin prices due to more missing data; about three percent of the DAWN sample and eight percent of the DUF sample are affected by

the 44 MSA's represented in the combined DUF and DAWN samples is \$87.71. The mean real heroin price is \$512.82.

One of the advantages of this study is that the drug prices are computed and merged at the city level. Many prior studies relying on national self-reported survey data used state-average prices despite the fact that drug prices seem to vary widely from city to city. Granted that there may still be substantial intra-city variation in drug prices at any given time, the measurement error is likely to be much smaller than with state-level prices.²⁴

Kuziemko and Levitt (2001) find that STRIDE cocaine prices from 1986 through 1996 are positively related to state-level indicators of the certainty of punishment, measured by the per capita number of drug arrests, and the severity of punishment, measured by the fraction of drug arrests resulting in imprisonment. Basov, Jacobson, and Miron (2001) argue that due to the illicit, secretive nature of the drug trade, both production and sales are more labor intensive compared to legal markets. Most of these jobs are also likely to be filled by low-skilled employees, youths, or others with fewer outside opportunities. Their study shows that cocaine and heroin prices from STRIDE are positively related to the state-specific relative unskilled wage in a time series of states from 1974 to 1999. These two studies confirm that DEA drug prices do indeed reflect costs of retailing including expected penalties associated with this activity and labor costs.

this imputation. For cocaine, the DAWN sample is not affected and a little over one percent of the DUF sample is affected.

²⁴ A report by the National Research Council (Manski, Pepper, and Petrie, 2001) criticizes STRIDE price data precisely for this reason, that there are substantial differences in these prices even within cities. Horowitz (2001) notes that because the purchases in STRIDE are motivated by criminal investigations, they do not represent a random sample of drug prices in the U.S. Nonetheless, as long as the sampling

Tables 3-36 and 3-37 present the results from regressions of STRIDE cocaine and heroin prices, respectively, on some of these expected penalty and cost of supply variables. Similar to Basov, Jacobson, and Miron (2001), the relative unskilled wage is calculated from the Current Population Survey March supplements as the median wage in the 25th income percentile divided by the median wage in the 90th income percentile. In contrast to their study which was conducted at the state level, all variables and drug prices here are measured at the MSA level. The data are for the MSA's and years represented in DUF and DAWN, namely 44 MSA's from 1988 to 2001. All specifications include the relative unskilled wage, the arrest rate for drug possession, personal income, population, and the percentage of MSA population that are high school graduate and college graduate; specifications 8 and 9 add year effects to the regressions.

Table 3-36 shows that the cost of labor, as measured by the relative unskilled wage, has a significantly positive effect on cocaine prices in all specifications. The arrest rates for any drug sale, for cocaine sale, and for marijuana sale are included in order to capture increases in costs due to increases in expected penalties and enforcement aimed at suppliers. The violent crimes arrest rate is also included to capture similar enforcement efforts since drug dealers and suppliers have a higher likelihood of being involved in such type 1 crimes.²⁵ Due to substantial collinearity between these arrest rates, each specification includes a different subset of these variables. The arrest rate for sale or trafficking in cocaine is significantly positive as expected in all specifications

problems associated with STRIDE are stable over time, these data can still accurately capture changes in the cost of drugs.

²⁵ Strictly speaking, type 1 violent crimes are not drug-related in the Uniform Crime Reporting system. However, the arrest rate for violent crimes is strongly and positively correlated with the arrest rate for drug sale and trafficking, much more so than the arrest rate for property or type 2 crimes.

where it is included, as is its one-year lag. The arrest rate for any drug sale is significantly positive in specification 1, but insignificant in all others where its effect is either picked up by the cocaine sale arrest rate or the violent crimes arrest rate. The arrest rate for the possession of any drugs is significantly negative in all specifications. This may be capturing some unobserved city sentiment, political environment, or other factors correlated with price and enforcement. Or, it may be capturing a shift in demand. That is, an increase in the possession arrest rate raises the full price of drugs, lowers demand, and consequently lowers the money price. This is contingent on an upward sloping supply curve. If the drug sale arrest rates have greater measurement error, then the possession arrest rate may be more accurately picking up a shift in enforcement resources from sellers to users, which would lower the costs of supplying drugs and thus lower the money price. The city population is statistically significant and negative in all specifications. This is consistent with the presence of economies of scale associated with distribution, so that prices decrease as the market size increases (Caulkins, 1995). Another explanation consistent with Ehrlich (1973) is that the probability of apprehension and conviction is negatively related to the total market size (as proxied by population in this case) because the greater the number of illegal producers the more that total enforcement is diluted and the smaller are the odds of catching any one of them.

Table 3-37 presents analogous models for heroin prices. The results are essentially the same. The relative unskilled wage is statistically significant and positive in all specifications that exclude year effects. It is positive and insignificant once year effects are added due to the strong downward trend in the wages of unskilled labor. The cocaine arrest rate (which also includes opiates as defined in the Uniform Crime Reports)

is also significantly positive in all specifications that exclude year effects. The arrest rate for any drug sale is significant and positive in specification 1 where it is included by itself, but in other specifications its effect is picked up by other indicators of enforcement directed towards suppliers, either the cocaine arrest rate or the violent crimes arrest rate. Market size, as proxied by MSA population, is again significant and negative in all models. These simple regressions show effects that one would expect if the STRIDE cocaine and heroin prices are positively related to the costs of producing, distributing, and selling drugs. This highlights the utility of using these price series to estimate demand functions.

4. Analytical Framework

The objective of this study is to assess the extent to which outcomes related to cocaine and heroin consumption respond to cocaine and heroin prices. Since illicit drugs are ultimately consumer goods, this question can be framed within the context of consumer theory and demand analysis. Consider first a simple model of the demand for drugs. The individual maximizes the following utility function in each period t :²⁶

$$(3) \quad U_t = U_t(A_t, X_t),$$

subject to a budget constraint

$$(4) \quad P_t A_t + X_t = I_t.$$

A is consumption of the addictive good with corresponding price P , X is consumption of some other non-addictive good with price normalized to one, and I represents the individual's income. This yields the following current-period demand for the addictive good, specified in linear form:

²⁶ The utility function is assumed to be quasi-concave such that marginal utility is positive but diminishing in all arguments.

$$(5) \quad A_t = \alpha_1 P_t + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t .$$

Thus, the demand for any illicit drug depends on its price, the individual's income, and other characteristics Y such as the individual's age, gender, race, and education. The parameter of interest, α_1 , is hypothesized to be negative under the law of the downward sloping demand function.

The utility function can be reformulated to include more than one addictive good as arguments:

$$(6) \quad U_t = U_t (A_{1t}, A_{2t}, X_t) .$$

Maximizing (4) subject to a budget constraint,

$$(7) \quad P_{1t} A_{1t} + P_{2t} A_{2t} + X_t = I_t ,$$

yields the following demand function for any addictive good:

$$(8) \quad A_{1t} = \alpha_1 P_{1t} + \alpha_2 P_{2t} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t .$$

Thus, the demand for any drug depends on its own price (P_1), the price of the other drug (P_2), income, and other factors. As before, the own-price effect α_1 is hypothesized to be negative; the cross-price effect α_2 is positive if the two drugs are economic substitutes, negative if they are economic complements, and zero if the two drugs are independent.

The above model applies to all consumer goods and as such does not explicitly take account of the addictive aspect of drugs. Consider the following revisions to the utility function:

$$(9) \quad U_t = U_t (A_t, S_t, X_t) ,$$

where the individual's current utility now depends on current consumption of the addictive and non-addictive goods, and also on the stock of the addictive good (S_t) accumulated through past consumption. In addition to positive but diminishing marginal

utility in A and X, the utility function also satisfies certain other restrictions. First, the stock of addictive consumption positively affects current marginal utility of the addictive good. This is the reinforcement effect by which past consumption of drugs stimulates current consumption.

$$(10) \quad U_{AS} = \partial^2 U_t / \partial A_t \partial S_t > 0$$

Second, the stock of addictive consumption negatively affects current total utility. This is the tolerance effect. Higher past addictive consumption lowers current utility, and hence a greater amount of current addictive consumption is required to obtain a given level of total utility. Alternatively, this can also reflect harmful addiction since past consumption of drugs can lower current utility due to detrimental health effects.

$$(11) \quad U_S = \partial U_t / \partial S_t < 0$$

Maximizing the above utility function in every period subject to a basic budget constraint derives a demand function where current consumption of the addictive good is now also affected by the addictive stock in addition to price, income, and other factors.

$$(12) \quad A_t = \alpha_1 P_t + \delta_1 S_t + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t .$$

The parameter δ_1 is hypothesized to be greater than zero due to the positive reinforcement of past addictive consumption on current consumption. This intertemporal complementarity between past and current consumption is the hallmark of economic models of addiction.

The above model can also be generalized for more than one addictive good:

$$(13) \quad U_t = U_t (A_{1t}, A_{2t}, S_{1t}, S_{2t}, X_t) .$$

A_1 and A_2 are current consumption of both drugs, and S_1 and S_2 are their respective addictive stocks. There are reinforcement and tolerance effects operating with both addictive goods.

$$(14) \quad U_{A_1 S_1} = \partial_2 U_t / \partial A_{1t} S_{1t} > 0$$

$$(15) \quad U_{A_2 S_2} = \partial_2 U_t / \partial A_{2t} S_{2t} > 0$$

$$(16) \quad U_{S_1} = \partial U_t / \partial S_{1t} < 0$$

$$(17) \quad U_{S_2} = \partial U_t / \partial S_{2t} < 0$$

It is conceivable that there may also be cross-reinforcement effects so that the addictive stock of one drug may affect the current consumption of the other by affecting its current marginal utility.

$$(18) \quad U_{A_1 S_2} = \partial_2 U_t / \partial A_{1t} S_{2t} \geq 0$$

$$(19) \quad U_{A_2 S_1} = \partial_2 U_t / \partial A_{2t} S_{1t} \geq 0$$

This yields the following demand function for any single drug:

$$(20) \quad A_{1t} = \alpha_1 P_{1t} + \alpha_2 P_{2t} + \delta_1 S_{1t} + \delta_2 S_{2t} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t.$$

Current consumption of any drug, in this case, depends on its own price, the price of the other drug, its own addictive stock as well as that of the other drug, income, and other factors. As before, the own-price effect α_1 is negative, the cross-price effect α_2 depends on whether the drugs are substitutes, complements, or independent, the own-reinforcement effect δ_1 is positive, and the cross-reinforcement effect δ_2 may be zero or positive.²⁷

²⁷ In contrast to a cross-reinforcement effect, a cross-dampening effect would mean that (15) and (16) are negative; that is, an increase in the addictive stock of one drug lowers the current marginal utility of the other. In this case, δ_2 is also negative. Since both cocaine and heroin disrupt the flow of the neurotransmitter dopamine in order to produce feelings of pleasure and reward, a cross-reinforcement effect theoretically seems more likely.

This model is referred to as myopic addiction in the literature. Even though addiction is formulated explicitly through interactions between past and current consumption and has harmful effects in future periods, the individual is still myopic in that he is maximizing a single period utility function subject to a period budget constraint. Becker and Murphy (1988) developed a model of rational addiction wherein the individual maximizes the following lifetime utility function comprised of a summation of discounted period utilities as specified in (6):²⁸

$$(21) \quad V = \sum_{t=1}^{\infty} B^{t-1} U_t(A_t, S_t, X_t)$$

subject to a wealth constraint

$$(22) \quad \sum_{t=1}^{\infty} B^{t-1} (P_t A_t + X_t) = I_0,$$

where I_0 denotes the present value of wealth. The period utility function satisfies the usual restrictions as well as the reinforcement and tolerance effects. In this case, current demand for the addictive good depends both on past and future addictive consumption, as represented by the accumulated stocks, in addition to price, income, and other factors.

$$(23) \quad A_t = \alpha_1 P_t + \delta_1 S_t + \delta_2 S_{t+1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t.$$

The parameter δ_1 is positive if the good has addictive properties as defined by the reinforcement effect. The parameter δ_2 is also positive in the rational addiction paradigm but zero if addiction is myopic. The demand functions derived from these various models guide the empirical specifications that are estimated.

5. Empirical Framework

In all models presented above, the key parameter of interest is α_1 , which quantifies the sensitivity of drug consumption to changes in its price. The empirical

²⁸ B is the discount factor and equals $(1/1+p)$, where p is the rate of time preference and is assumed to equal the rate of interest.

specifications estimated are based on the demand functions derived under the various models of addictive behavior. Specifically, the following equations derived in the previous section guide the regressions. Equations (5) and (8) represent the baseline demand functions, excluding and including cross-price effects, which are estimated under the basic model of consumer behavior.

$$(5) \quad A_t = \alpha_1 P_t + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

$$(8) \quad A_{1t} = \alpha_1 P_{1t} + \alpha_2 P_{2t} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

Equations (12) and (20) represent the demand functions derived under the premise of myopic addiction.

$$(12) \quad A_t = \alpha_1 P_t + \delta_1 S_t + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

$$(20) \quad A_{1t} = \alpha_1 P_{1t} + \alpha_2 P_{2t} + \delta_1 S_{1t} + \delta_2 S_{2t} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

In estimating (12) and (20), since the accumulated addictive stock is unobserved, it can be proxied by past consumption outcomes. That is,

$$(24) \quad S_{it} = S(A_{it-1})$$

Substituting (24) into (12) and (20) yields:

$$(25) \quad A_t = \alpha_1 P_t + \delta_1 A_{t-1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

$$(26) \quad A_{1t} = \alpha_1 P_{1t} + \alpha_2 P_{2t} + \delta_1 A_{1t-1} + \delta_2 A_{2t-1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

Estimating equations with lagged dependent variables presents many econometric hurdles discussed later. Alternately, since demand in any period is a function of the price in that period, past consumption can be proxied by a series of past prices. With this substitution, the demand functions under myopic addiction can be formulated as:

$$(27) \quad A_t = \alpha_1 P_t + \lambda_1 P_{t-1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

$$(28) \quad A_{1t} = \alpha_1 P_{1t} + \alpha_2 P_{2t} + \lambda_1 P_{1t-1} + \lambda_2 P_{2t-1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

Equations (27) and (28) can be estimated with various lags of the prices of both cocaine and heroin. Since past consumption stimulates current consumption due to the reinforcement effect, the coefficients of own-lagged prices are expected to be negative. If there are cross-reinforcement effects, then the coefficients of cross-lagged prices are also expected to be negative. Statistically significant lagged price effects thus present indirect evidence of the addictive aspects of heroin and cocaine.

Equation (23) expresses the demand function based on the theory that addicts are rational and forward-looking.

$$(23) \quad A_t = \alpha_1 P_t + \delta_1 S_t + \delta_2 S_{t+1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t .$$

Assuming that the past and future addictive stocks can be proxied by past and future consumption, and that past and future consumption depend on past and future prices, (23) can be transformed into an estimable form with various leads and lags of prices.

$$(29) \quad A_t = \alpha_1 P_t + \lambda_1 P_{t-1} + \lambda_2 P_{t+1} + \beta_1 I_t + \beta_2 Y_t + \varepsilon_t$$

Since both past and future consumption stimulate current consumption under rational addiction, all own-price effects are expected to be negative. If the lead prices are statistically significant and negative, then the empirics are consistent with a rational addiction framework.²⁹

In this study, the addictive drugs considered are cocaine and heroin, and two sets of indicators related to their consumption are employed as outcomes. As discussed earlier, one set of outcomes from DUF is the percent of arrestees testing positive for cocaine or heroin use and is a measure of the probability of participating in each drug. As such, it is a direct proxy for an arrestee's drug use. While the dependent variable is

intended to measure a random arrestee's probability of participating in cocaine or heroin, DUF does not sample all arrestees. Therefore,

$$\text{Prob (Cocaine|Arrested)} = \text{Prob (Cocaine|DUF Arrestee)} * \text{Prob (DUF Arrestee|Arrested)}.$$

In log-linear form, this becomes,

$$\begin{aligned} \text{Log Prob (Cocaine | DUF Arrestee)} = & \text{Log Prob (Cocaine | Arrested)} - \\ & \text{Log Prob (DUF Arrestee | Arrested)}. \end{aligned}$$

The outcomes employed in this study are the percentage of DUF arrestees who tested positive for cocaine or heroin, that is $\text{Prob (Cocaine|DUF Arrestee)}$. Hunt and Rhodes (2001) note that inferences about the general arrestee population can be drawn from DUF. Nevertheless, some models include the number of DUF arrestees in each MSA as a fraction of total arrests (from the Uniform Crime Reports) to proxy for the $\text{Prob (DUF Arrestee|Arrested)}$ and to control for changes in sample design between DUF and ADAM.³⁰

The data employed are a time-series of city cross-sections. All regressions are estimated in logistic form, where the dependent variable is measured as the log of the odds ratio. Since the original outcomes are rates between zero and one, the logistic transformation ensures that the predicted rate or probability also lies in this range.³¹

Panel-data techniques are employed to estimate the following models based on the above formulations:

²⁹ However, this by no means should be construed as direct proof of the theory because as discussed later, significant lead-price effects may also indicate a form of policy endogeneity.

³⁰ The above log-linear identity implies that the DUF arrest rate should have a negative coefficient in the regression models. The results presented later confirm this. However, there are no significant changes in the other coefficients between models estimated with and without the DUF arrest rate.

Baseline Demand Functions Excluding & Including Cross Prices

$$(30) \quad \text{Log}(A_{it}/1-A_{it}) = \alpha_1 P_{it} + \beta_1 I_{it} + \beta_2 Y_{it} + \varepsilon_{it}, \text{ where } \varepsilon_{it} = \mu_i + \eta_t + v_{it}$$

$$(31) \quad \text{Log}(A_{lit}/1-A_{lit}) = \alpha_1 P_{lit} + \alpha_2 P_{2it} + \beta_1 I_{it} + \beta_2 Y_{it} + \varepsilon_{it}, \text{ where } \varepsilon_{it} = \mu_i + \eta_t + v_{it}$$

The subscripts denote the i^{th} MSA for year t . Y represents the vector of observable determinants of demand, besides price and income, and is proxied by the unemployment rate, various MSA-level socioeconomic characteristics, and drug-related arrest rates. The disturbance is modeled with two-way error components where μ_i denotes the unobservable area fixed effects, η_t denotes the unobservable time effects, and v_{it} is the remainder stochastic error term. This fixed-effects specification combined with a rich set of MSA covariates has not been estimated for DUF and DAWN in the prior literature. This formulation is followed in all estimations.³²

³¹ The elasticity of participation with respect to price is calculated as $\alpha_1 (1-A)P$. The marginal effect of price on participation is $\alpha_1 (1-A)A$.

³² In estimating these demand functions, it is assumed that the U.S. supply of cocaine and heroin is infinitely elastic, that is suppliers are able to satisfy any market demand at the current price. This assumption is invoked in virtually all empirical studies of the demand for drugs. Cocaine and heroin are basically agricultural products that are inexpensive to produce and require minimal processing. Rhodes et al. (2001) note that cocaine, for instance, is fairly easy to transport and only about 300 metric tons satisfy entire U.S. market demand. The largest costs involved in producing, transporting, and distributing cocaine are the costs of operating in the illegal sector. Some of these result from interdiction and law enforcement, while others are imposed by the industry which, unable to use the court system, has to rely on violence to enforce its contracts. Miron (2001) suggests that the black market price of cocaine is as much as 5 times higher and that of heroin as much as 19 times higher than prices that would prevail in a legalized regime. Basov, Jacobson, and Miron (2001) similarly note that the U.S. is also a relatively small market for opiates. Worldwide production of coca leaf increased dramatically from 90,000 metric tons in 1983 to 613,400 metric tons in 1999; opium production has also increased from about 80 metric tons to 150 metric tons over the same period. Rhodes et al. (2001) argue that the amount of coca harvested exceeds the amount shipped by a substantial amount. This implies that suppliers can draw on this excess capacity to satisfy any expansions in market demand without increasing their per unit cost. Major expansions in coca cultivation are also relatively easy. It is grown in regions that are unsuitable for most other agricultural products. Additional fields can be brought into cultivation by burning rain forests, and crops can be harvested in one to two years. All of these considerations point to the domestic supply curves for cocaine and heroin being highly elastic.

Demand Functions under Myopic Addiction Excluding & Including Cross Prices

$$(32) \quad \text{Log} (A_{it}/1-A_{it}) = \alpha_1 P_{it} + \lambda_1 P_{it-1} + \beta_1 I_{it} + \beta_2 Y_{it} + \mu_i + \eta_t + v_{it}$$

$$(33) \quad \text{Log} (A_{1it}/1-A_{1it}) = \alpha_1 P_{1it} + \alpha_2 P_{2it} + \lambda_1 P_{1it-1} + \lambda_2 P_{2it-1} + \beta_1 I_{it} + \beta_2 Y_{it} + \mu_i + \eta_t + v_{it}$$

Demand Function under Rational Addiction

$$(34) \quad \text{Log} (A_{it}/1-A_{it}) = \alpha_1 P_{it} + \lambda_1 P_{it-1} + \lambda_2 P_{it+1} + \beta_1 I_{it} + \beta_2 Y_{it} + \mu_i + \eta_t + v_{it}$$

These fixed-effects procedures are inconsistent if city drug prices or the policies that determine them might depend on the level of substance use, or as is more likely the lagged level of substance use. This possibility is sometimes referred to as policy endogeneity. There are two critical issues. The first is that there is an unmeasured fixed effect that is correlated with right-hand-side variables. In the context of this research, the fixed effect may be city or state sentiment (e.g., religiosity) towards drug use that also influences drug prices and enforcement. The second issue is that price may be predetermined and not strictly exogenous because past shocks to drug use may be correlated with current prices. Thus, current price is predetermined if it is uncorrelated with the current disturbance term but correlated with past disturbances.

$$(35) \quad E(P_{it} v_{is}) \neq 0 \text{ for } s < t \text{ and } E(P_{it} v_{is}) = 0 \text{ for } s \geq t$$

Consider the baseline demand equation (23). For convenience, LO_{it} refers to $\text{Log} (A_{it}/1-A_{it})$ and the year effects are ignored.

$$(23) \quad LO_{it} = \alpha_1 P_{it} + \beta_1 I_{it} + \beta_2 Y_{it} + \mu_i + v_{it}$$

The area fixed effects can be removed by first differencing.³³

$$(36) \quad LO_{it} - LO_{it-1} = \alpha_1 (P_{it} - P_{it-1}) + \beta_1 (I_{it} - I_{it-1}) + \beta_2 (Y_{it} - Y_{it-1}) + (v_{it} - v_{it-1})$$

³³ Fixed-effects estimation is equivalent to first-differencing if there are exactly two periods for each cross-section. Otherwise, including fixed effects is equivalent to a regression where all observations are transformed to deviations from the mean, where

If price is predetermined then the orthogonality assumption is violated since P_{it} is correlated with v_{it-1} . The fixed-effects or first-differenced specification is no longer consistent.

In order to check for potential policy endogeneity, two informal tests are performed. First, following Model (1993), specifications with a series of lagged and leading prices are estimated. Note that this is analogous to the demand function implied under rational addiction. If changes in drug outcomes are caused by changes in enforcement or prices as opposed to changes in prices being caused by these outcomes, then larger outcomes should not occur until after any decreases in price and vice versa. In specifications with lagged and leading price series, only the coefficients on contemporaneous and lagged prices should be significant. The lead prices as a group should be insignificant. If the leading prices are significant, however, then this could be evidence of policy endogeneity *or* evidence of rational addiction. Since both are observationally equivalent in this case, estimation should then proceed under the presumption that policy endogeneity is a likely possibility. If the leading prices are insignificant, then policy endogeneity appears unlikely as does the premise that addicts are forward-looking.

A second informal test estimates specifications with various lagged enforcement variables to proxy for past shocks to demand that may also be affecting current prices. Consider the baseline demand equation again, where the disturbance term is divided into two components.

$$(23) \quad LO_{it} = \alpha_1 P_{it} + \beta_1 I_{it} + \beta_2 Y_{it} + \mu_i + v_{it}, \text{ where } v_{it} = \omega_{it} + \varphi_{it}$$

the mean is calculated for each cross-section over all periods. For this exposition, the distinction is not important.

Thus,

$$(37) \quad LO_{it} - LO_{it-1} = \alpha_1 (P_{it} - P_{it-1}) + \beta_1 (I_{it} - I_{it-1}) + \beta_2 (Y_{it} - Y_{it-1}) + (\omega_{it} - \omega_{it-1}) + (\varphi_{it} - \varphi_{it-1})$$

Here, φ_{it} is a pure stochastic disturbance term that is uncorrelated with all past, current, and future values of the explanatory variables. However, ω_{it} represents unobserved shocks to past demand that may also affect current prices, making price predetermined and statistically endogenous. This endogeneity is similar to omitted variables bias in an intertemporal context. In other words, there are unmeasured factors ω that simultaneously affect past demand and current prices. Conditional on ω , price is strictly exogenous with respect to the remainder disturbance term. Therefore, if variables measuring such shocks can be included in the models, then the coefficients on price can be analyzed to gauge the extent of such endogeneity. Past enforcement efforts may proxy for these shocks to some extent. For instance, higher arrest rates related to drug violations or sales may affect current drug consumption and also influence future drug prices. If the price effects are robust in specifications that control for these lagged enforcement variables, then it is likely that price is not predetermined and may be regarded as strictly exogenous. In addition, including city specific trends in some models may also control for some of these unobserved shocks.

The possibility that price is not strictly exogenous is also treated explicitly in the estimation of the demand function under myopic addiction.

$$(38) \quad \text{Log}(A_{it}/1-A_{it}) = \alpha_1 P_{it} + \delta_1 A_{it-1} + \beta_1 I_{it} + \beta_2 Y_{it} + \mu_i + \eta_t + v_{it}$$

Earlier, past addictive consumption was substituted out with past prices in order to bypass the problems associated with lagged dependent variables. The issues involved are very

similar to those discussed above with predetermined covariates. A first-differenced (or fixed-effects) specification of (38) gets rid of the unobserved fixed effect but also shows that orthogonality between the explanatory variables and the disturbance term is violated.³⁴

$$(39) \quad LO_{it} - LO_{it-1} = \alpha_1 (P_{it} - P_{it-1}) + \delta_1 (A_{it-1} - A_{it-2}) + \beta_1 (I_{it} - I_{it-1}) + \beta_2 (Y_{it} - Y_{it-1}) \\ + (v_{it} - v_{it-1})$$

Note that A_{it-1} is correlated with v_{it-1} (as is P_{it} if price is predetermined). Arellano and Bond (1991) show that the orthogonality conditions in a dynamic panel data model can be exploited to obtain valid instruments for $(A_{it-1} - A_{it-2})$. Specifically, A_{it-2} is a valid instrument, since it is highly correlated with $(A_{it-1} - A_{it-2})$ and uncorrelated with $(v_{it} - v_{it-1})$ as long as the v_{it} are not serially correlated.³⁵ In fact, following the same logic, all available lags of the dependent variable are valid instruments for $(A_{it-1} - A_{it-2})$, that is A_{it-2} , A_{it-3} , etc. All levels (lagged and current) of the strictly exogenous variables are also valid instruments.³⁶

³⁴ Year effects are omitted from the first-difference for exposition purposes. The estimated models include year effects.

³⁵ If the v_{it} are not serially correlated, there is still first-order autocorrelation between the first-differenced errors. Thus, a test of no autocorrelation in v_{it} translates to testing whether there is second-order or higher degree autocorrelation in the differenced errors. These tests are presented in the results.

³⁶ The results from Tables 3-36 and 3-37 show that drug prices are positively correlated with the costs of distribution and retailing, including the relative unskilled wage and the probability of apprehension for selling or trafficking in various drugs. Holding income and the arrest rate for drug possession constant, these variables should not affect the full price for users and thus should not affect demand. This suggests that they may be used as instruments for drug prices to deal with problems of any measurement error or policy endogeneity. However, in practical application, these instruments do not pass checks for instrumental validity in basic year-effects models since they are likely to be correlated with unobserved MSA-specific factors. In models with both year and MSA effects, these instruments pass the test for overidentification restrictions; however they are very weak and not strongly correlated with drug prices in the first stage. Since poor instruments exacerbate the problems, this method is not followed here.

The Arellano-Bond estimator also allows for the possibility that one or more of the explanatory variables may be predetermined and endogenous, for instance price. In this case all relevant lagged levels of the predetermined variables are used to instrument for the difference, $(P_{it} - P_{it-1})$, following the same principles above. Lagged levels of the predetermined variables (and not the current levels) also enter the instrumental matrix for the differenced dependent variable $(A_{it-1} - A_{it-2})$. Estimating (38) via the Arellano-Bond method allows a direct estimation of the demand function under myopic addiction and yields short-run and long-run estimates of the price elasticities. It also provides a check for the robustness of the estimated elasticities from other specifications where the lagged dependent variable is proxied by lagged prices. Furthermore, it is also informative to note whether the price elasticity is sensitive to treating drug prices as strictly exogenous versus instrumenting them.

The second set of outcomes employed from DAWN is the number of times cocaine and heroin are cited in drug related emergency room episodes, divided by total MSA population. DAWN does not sample all eligible hospitals. Ideally, the probability of having a cocaine or heroin induced ED episode should be measured relative to the at-risk population, that is individuals living in an area within a sampled MSA that directs medical crises to a participating DAWN ER (Model, 1993). This probability can be written as:

$$(40) \quad \text{Prob}(\text{Mention}|\text{Total Pop}) = \text{Prob}(\text{Mention}|\text{At-Risk Pop}) * \\ \text{Prob}(\text{At-Risk Pop}|\text{Total Pop})$$

The probability of a drug mention relative to the appropriate at-risk population can be further expressed as:

$$(41) \quad \text{Prob}(\text{Mention}|\text{At-Risk Pop}) = \text{Prob}(\text{Report} | \text{At-Risk Pop, ED, Crisis, Use}) * \\ \text{Prob}(\text{ED} | \text{At-Risk Pop, Crisis, Use}) * \\ \text{Prob}(\text{Crisis} | \text{At-Risk Pop, Use}) * \\ \text{Prob}(\text{Use} | \text{At-Risk Pop})$$

Substituting (41) into (40) and taking the log of both sides results in

$$(42) \quad \text{Log Prob}(\text{Mention}|\text{Total Pop}) = \text{Log Prob}(\text{Report} | \text{At-Risk Pop, ED, Crisis, Use}) + \\ \text{Log Prob}(\text{ED} | \text{At-Risk Pop, Crisis, Use}) + \\ \text{Log Prob}(\text{Crisis} | \text{At-Risk Pop, Use}) + \\ \text{Log Prob}(\text{Use} | \text{At-Risk Pop}) + \\ \text{Log Prob}(\text{At-Risk Pop} | \text{Total Pop})$$

This identity stresses that many factors contribute to a DAWN drug mention. First, an individual must be part of the at-risk population and using drugs. He must then experience some crisis or medical emergency which results in a visit to a participating ER. Finally, hospital personnel must identify this episode as drug related. The probability of drug use and the probability of crisis (which is a monotonic function of the intensity of use) depend on the demand factors derived earlier. The probability of being part of the at-risk population relative to the total population is proxied by the number of hospitals participating in DAWN as a fraction of total eligible hospitals. The conditional probabilities of an ED visit and a drug report are related to emergency room visitation practices and any non-reporting or misreporting. There is no a priori reason to believe that these probabilities have systematically varied over time within cities; thus, they may be modeled as part of the unobserved area and year effects. These substitutions yield identical estimable specifications to those discussed earlier with respect to DUF, except

with a different set of dependent variables.³⁷ The elasticity of drug mentions with respect to drug use is unambiguously positive, since the negative health consequences of addictive consumption are well documented. Also, by definition, the majority of the ED episodes and mentions in the DAWN sample are causally related to drugs. Thus, the sign and significance of the estimated elasticity of a drug mention with respect to price informs on the unobserved price elasticity of problematic drug use. The price elasticity of drug episodes and mentions is also relevant because it measures the direct “reduced-form” effect of drug prices (an instrument of enforcement and public policy) on health.

6. Results from DUF

The results from models estimated with DUF outcomes are presented in Tables 3-1 through 3-21. Table 3-2 presents estimation of the baseline demand function given by equation (30) for urinalysis based logistic cocaine use, employing the cocaine price series computed from all purchases. All specifications include MSA-level socioeconomic variables and progressively add year effects, MSA effects, indicators of an MSA-specific linear trend, and indicators of an MSA-specific quadratic trend. Cocaine price is negative and statistically significant in all specifications, and the price elasticities range from -0.12 to -0.24.³⁸ Specification 1, which does not include any fixed-effects, yields an elasticity of an arrestee’s probability of recent (past 48 – 72 hours) cocaine participation with respect to own price of -0.16. All covariates from this specification are statistically significant. The coefficient on income is negative, implying that cocaine is an inferior

³⁷ The dependent variables constructed from DAWN outcomes are also logistic transformations.

³⁸ In all tables, own-price elasticities are calculated if the own-price effect is negative and significant in a one-tailed test at a level of 10 percent or less. This generally requires a t-statistic larger than 1.28 for the sample sizes represented here. Note, however, that the significance denoted in all tables is based on two-tailed tests.

good and health is a normal good. The unemployment rate has a positive effect on cocaine participation; this effect is consistent with many other studies, which show that drug use may be related to stress factors. An increase in unemployment may also lower job opportunities in the legal sector and induce those most affected to seek work in the illegal drug trade; to the extent that some dealers may also become users, unemployment can thus lead to increased drug participation. Surprisingly, male arrestees seem to participate less in cocaine. This is most likely due to other omitted confounding factors because the coefficient becomes positive but insignificant in fixed-effects models. Relative to whites, blacks participate more and other races participate less. Hispanics participate less relative to non-Hispanics. Arrestees aged 16 to 24 and ages 25 to 54 are also less likely to use cocaine relative to older arrestees. This is also due to omitted confounders. In fixed-effects specifications, the indicator of ages 16 to 24 becomes insignificant while that of ages 25 to 54 is significantly positive, implying that the latter age group is the most likely to use cocaine relative to the other two, which have equal participation probabilities. High school graduates are less likely to use cocaine while college graduates are more likely. The arrest rate for drug possession has a negative effect on cocaine use. A higher probability of apprehension raises the full price of cocaine and reduces participation. The DUF arrest rate, defined as the fraction of total arrests represented in DUF, is included to control for changes in sample design and breaks in the data. Its coefficient is negative, which is consistent with the point made in footnote 36. Adding year effects in specification 2 causes the price elasticity to increase in absolute magnitude to -0.24. Specifications 3 to 6 present models that include both MSA and year effects. Identification in these models comes from changes in the cocaine

price within an MSA over time. In other words, each MSA serves as its own control group, with the price in one year compared to the prevailing price in the same MSA for another year. The arrest rate for drug possession and the DUF arrest rate are alternately included and excluded in these specifications to assess whether the price elasticity is sensitive to these changes. The price elasticity ranges from -0.20 to -0.23 in these full fixed-effects models and is robust to excluding the arrest rates. The DUF arrest rate becomes insignificant in these models and the drug possession arrest rate is significant at 10 percent. Since there are some MSA-year cells for which these arrest rates are missing, most subsequent specifications exclude them in order to maximize sample size. Specifications 3 – 6 show that the price elasticity is only negligibly affected by this exclusion. Specification 7 adds indicators of an MSA-specific linear trend. This is perhaps an excessively stringent test since only deviations around a linear trend, within cities, are used for identification. The price effect remains significant at the one percent level, and the elasticity decreases in magnitude to -0.12. The addition of MSA-specific linear trends causes the MSA-level covariates to lose joint significance. This is not surprising since both sets of variables are highly collinear. Thus, it may be appropriate to draw inferences from the specifications with MSA and year effects and the MSA-level covariates. In subsequent analyses of cocaine participation, fixed-effects specifications that exclude and include MSA-specific linear trends are preferred and used to pin down a reliable range for the price elasticity. Specification 8 adds MSA-specific quadratic trends. This is surely excessive since it forces identification to come only from deviations around a quadratic trend within each MSA. Nevertheless, cocaine price remains statistically significant at the one percent level, and the price elasticity estimate is

unchanged as -0.12. Taking the estimate from specification 2 that includes all covariates and year effects as the upper bound, the own-price cocaine participation elasticity for arrestees ranges from -0.12 to -0.24.³⁹

Table 3-3 presents the estimates for the same specifications, but now the cocaine price is based only on retail purchases of 40 grams or less. The results are very similar to those discussed above. Price is negative and statistically significant in all specifications. Once again taking the estimates from specification 2 as the upper bound, the cocaine price participation elasticity has a range from -0.10 to -0.24. That the estimates based on both series of cocaine prices so closely match each other gives confidence in the standardization procedure used to impute these prices.

Table 3-4 presents estimation of the baseline demand function given by equation (30) for urinalysis based logistic heroin use, employing the heroin price series computed from all purchases. The estimated price coefficients are negative in all specifications and significant in the specifications that control for MSA and year fixed effects.

Specification 1 shows the effects of the MSA-level covariates. Income has a positive effect on heroin participation as does the unemployment rate. Blacks are less likely to use heroin than whites. Arrestees aged 25 to 54 are less likely to participate compared to older arrestees, and high school graduates are also less likely to participate compared to those who did not finish high school. The probability of apprehension, as proxied by the arrest rate for any drug possession, is significantly negative since it raises the full price of using heroin. The DUF arrest rate and the other covariates are insignificant.

³⁹ Specification 1, which does not include any fixed effects, is presented only for comparison and is not emphasized in the subsequent discussion. These estimates are likely to be biased since there are no controls for national trends. Upper and lower bounds refer to the absolute magnitudes of the elasticities.

Specification 2, which adds year effects, yields a heroin price participation elasticity estimate of -0.40. Adding MSA indicators substantially reduces this magnitude, though the price effect remains significant at the five percent level. Adding MSA-specific linear and quadratic trends causes the price coefficient to become insignificant. The vector of MSA-level socioeconomic covariates is controlling for these trends to a large extent. Furthermore, the largest gain in the adjusted R-square is for specifications that add year and MSA effects. The incremental gains become substantially smaller when the MSA-level linear and quadratic trends are added. As a result, area and year fixed-effects models are regarded as the preferred specifications. Thus, the own-price elasticity of the probability of using heroin for arrestees ranges from -0.07 to -0.40, and is likely to be closer to the lower bound.

Table 3-5 presents similar models for the log of recent urinalysis-based heroin use, with heroin price now computed with retail purchases. The results remain very much the same. The price effect is negative in all models and remains statistically significant at the five percent level in the fixed-effects specifications. The heroin price participation elasticity ranges from -0.09 to -0.42, and again is likely to be closer to the smaller of these estimates.

The elasticities reported thus far are for the extensive margin, that is participation or the probability of use. The total consumption elasticity also includes the elasticity computed at the intensive margin or for intensity of use, conditional on positive use. Urinalysis-based data on frequency of use are not available in DUF. However, the arrestees are asked to self-report their past month cocaine and heroin participation and frequency of use. Frequency in this case is defined for users only, as the mean number of

days in the past month that cocaine/heroin was consumed. Table 3-6 presents the estimates from Cragg's two-part models of logistic past month cocaine use and log cocaine frequency. All specifications are based on the baseline demand function given by equation (30). Specifications 1 and 2 present models for participation and frequency, excluding fixed effects. Cocaine price has a significantly negative effect on both use and frequency. The participation elasticity is estimated at -0.30, and the frequency elasticity is estimated at -0.09. Both specifications show that cocaine has a negative income elasticity and is an inferior good. Arrestees who have graduated from high school are less likely to use cocaine and use it less frequently compared to non-graduates. The possession arrest rate is negative but statistically significant only for participation. The price effect remains significant at the one percent level for both use and frequency in specifications 3 and 4, which add year effects. The cocaine participation price elasticity is estimated at -0.36 and the frequency elasticity is -0.14. Specifications (5) and (6) are the full fixed-effects models, which include MSA and year indicators. Cocaine price has a significantly negative effect on participation, with an elasticity of -0.23, but is insignificant with respect to frequency. The same occurs in (7) and (8), which add MSA-specific linear trends. The participation elasticity falls in magnitude to -0.11 in (7). Calculating the total consumption elasticity as the sum of the participation and frequency elasticities, the range is from -0.11 to -0.50. Consistent with prior studies, drug prices exert a much stronger negative effect on participation than on frequency conditional on participation, and the participation elasticity comprises most or all of the total consumption elasticity.

Table 3-7 presents the elasticities for self-reported past month heroin participation and conditional frequency of use. Heroin price is negative and statistically significant in specifications that include year indicators. The participation elasticity is estimated at -0.41 and the frequency elasticity is -0.09. In the full fixed-effects models, the price effect is significant at the 10 percent level in a one-tailed test for participation and insignificant for frequency. It is likely that measurement error in self-reports may be inflating the standard errors. The total heroin consumption elasticity for arrestees ranges from -0.10 to -0.50, with the participation elasticity again comprising most or all of this price effect.

Tables 3-8 through 3-11 estimate the demand function under myopic addiction given by equation (32), where the addictive stock is proxied by past drug prices. Table 3-8 estimates this equation for logistic urinalysis-based recent cocaine use, with contemporaneous and one-year lagged cocaine price. The top panel uses the cocaine price imputed with all purchases. The coefficient on current price is negative and statistically significant in all specifications, including those that add MSA-specific linear and quadratic trends. The inclusion of lagged price does not seem to diminish the magnitude of the contemporaneous price elasticity. It ranges from -0.11 to -0.20. The coefficient on lagged price is also negative and significant in the fixed-effects specifications, including those with MSA-specific linear and quadratic trends. The elasticity of cocaine participation with respect to lagged price, holding current price constant, has a magnitude just as large as the current price elasticity. It ranges from -0.09 to -0.26. The bottom panel employs cocaine prices based on retail purchases. The elasticity estimates are significant in the fixed-effects models but are of a lower

magnitude. The current price elasticity is about -0.12 and the lagged price elasticity is about -0.11 .

The models in Table 3-9 add the two-year lagged cocaine price in addition to the current and one-year lagged prices. In the top panel, where the cocaine price is based on all purchases, the current and one-year lagged price are negative and significant in all specifications, including those with MSA-linear and MSA-quadratic trends. The two-year lagged price is significant in all but one of the specifications. Adding these lagged prices again does not substantially reduce the absolute current price elasticity. It is very similar to those from the baseline demand functions, and ranges from -0.11 to -0.18 . The one-year lagged cocaine price elasticity ranges from -0.09 to -0.21 , and the two-year lagged cocaine price elasticity ranges from -0.08 to -0.18 . These tables show that the effect of lagged price on current cocaine use is negative and significant and not much weaker, if at all, than the effect of contemporaneous price. They are consistent with a solid reinforcement effect wherein past consumption of cocaine greatly stimulates current consumption, and confirm the strong addictive properties of the drug. The bottom panel uses the retail cocaine price. While the elasticity estimates are somewhat smaller in magnitude as before, the results are qualitatively similar.

Tables 3-10 and 3-11 estimate the corresponding models for logistic urinalysis-based heroin participation. Table 3-10 includes the current heroin price and its one-year lag. The top panel includes the heroin price computed with all purchases. The contemporaneous price elasticity is significant in the fixed-effects specification, and ranges from -0.07 to -0.31 . The one-year lagged price effect is significant in the model that includes year effects, but loses precision once MSA effects are added. Its

corresponding price elasticity thus ranges from 0 to -0.24 . The bottom panel is based on retail heroin price. The current price is precisely estimated in all but one of the specifications, including specification 5 that includes MSA linear and quadratic trends. The current price participation elasticity ranges from -0.08 to -0.30 . The one-year lagged price effect is significant in all specifications, and the elasticity ranges from -0.10 to -0.35 .

Table 3-11 adds the two-year lagged heroin price to these models. In the top panel, the current price effect is significant at the 10 percent level (in a one-tailed test) in the fixed-effects specification. The corresponding elasticity ranges from -0.06 to -0.28 . The lagged heroin price coefficients are negative and significant in the year-effects model, but lose significance once MSA effects are added. The one-year lagged heroin price elasticity is estimated to be between 0 and -0.15 , and the two-year lagged price elasticity falls between 0 and -0.27 . The bottom panel of Table 3-11 uses the retail-based heroin price. The current price elasticity is significantly negative in all specifications except one, including the last that includes both MSA-specific linear and quadratic trends. It has a range from -0.07 to -0.27 . The one-year lagged price effect is significant in all specifications, and the elasticity is estimated to be between -0.10 and -0.30 . The two-year lagged price elasticity is precisely estimated in only the year-effects model and has an upper bound of -0.18 . Similar to the results with cocaine use, these tables show that the current heroin price elasticity is not substantially diminished with the inclusion of lagged prices. This is especially true in the full fixed-effects models and suggests that in these specifications the coefficient on current price is a robust measure of the short-run (contemporaneous) effect of price on participation, even when past prices are not

controlled. It appears that the fixed-effects are picking up these lagged-price effects to a large extent. The effects of past heroin prices on current consumption are also relatively substantial and of a similar magnitude to the effect of current price. This again supports the positive reinforcement of past on current consumption and confirms the strong addictive properties of heroin.

Tables 3-12 and 3-13 estimate the demand function derived under rational addiction, equation (34), where past addictive consumption is a function of past price and future consumption is a function of future price. These models are similar to those discussed above except that they add one and two-year leading prices in addition to the current and lagged prices. Note that as discussed earlier significantly negative lead-price effects are observationally equivalent with the rational addiction paradigm as well as policy endogeneity. Since policy endogeneity leads to inconsistent estimates, lead price-effects may indirectly inform on its presence.

Table 3-12 presents the models for logistic urinalysis-based recent cocaine use. All specifications include the one and two-year lead cocaine prices, and an F-test on their joint significance is reported. One, two, and three-year lagged cocaine prices are progressively included in the specifications. The current price effect is negative and significant in all specifications but one, including those that add linear and quadratic trends within MSA's. The current cocaine price elasticity is estimated to be between -0.11 and -0.21 . Again, this range is similar to the ones reported above and is not sensitive to the inclusion of the lead prices. The lagged-prices are jointly significant in all but one of the specifications. The lead-price effects are jointly insignificant in 8 of the 11 specifications; they are significant only in models that include MSA and year effects

but not in any with higher order effects. The bulk of these models for cocaine participation do not show support for the premise that addicts are rational and forward-looking. Analogously, the bulk of the evidence also does not point to any substantial policy endogeneity. The current price effects remain relatively robust and the lead-price effects are mostly insignificant. Nevertheless, to err on the side of caution, inferences concerning the price elasticity of cocaine will mostly be based on models that include MSA-specific linear trends. The lead price effects are insignificant in all of these specifications, and it appears that these indicators of linear trends within MSA's are capturing many of the unobserved factors including shocks that may affect past consumption and current prices.

Table 3-13 shows results from the same specifications estimated for heroin use. The effect of current heroin price is negative in all specifications and significant in five of these. It is significant in the final specifications that control for both MSA-specific linear and quadratic trends. Based on these, the current heroin price elasticity ranges from -0.08 to -0.16 . The lower bound, which comes from the fixed-effects models, is similar to those reported earlier since in these models the fixed-effects act as substitutes when lagged and/or leading prices are not included. The lagged heroin price coefficients are jointly significant in all specifications. The leading price coefficients are insignificant in 10 of the 11 specifications; it is significant in only the year-effects model. These results are similar to those obtained above with cocaine participation. There does not seem to be any evidence in favor of rational addiction since no lead-price effects are found. The possibility of policy endogeneity also appears unlikely from these results; the contemporaneous heroin price elasticity remains relatively robust to the inclusion of the

leads and current heroin use does not seem to be affected by future prices. Inferences on the price responsiveness of heroin are mostly based on the fixed-effects specifications to again minimize the role of unobserved shocks. Taken together, specifications for both cocaine and heroin use, from tables 3-8 to 3-13, that have experimented with various lag and lead structures of prices seem to support myopic addictive behavior over rational addictive behavior, at least for the general arrestee population.

Since policy endogeneity cannot definitively be ruled out, it would be reassuring if other specifications also confirm that it is not likely or that its effects do not substantially alter inferences. Note that the current price can be endogenous if it is a predetermined variable, for instance if past shocks to consumption affect future prices. If these unobserved shocks can be proxied to some extent and the price elasticities remain robust, one can have more confidence on these results. It was argued earlier that one set of factors that may affect past consumption as well as current prices is past drug enforcement efforts. Tables 3-14 and 3-15 present specifications that include lagged enforcement variables to control for such unobserved shocks.

Table 3-14 presents these results for cocaine use. One set of lagged enforcement variables includes one-year lags of the arrest rate for any drug violation and the arrest rate for selling or trafficking in any drugs. The other set includes one-year lags of the arrest rate for any drug violation, the arrest rate for selling cocaine and opiates, and the arrest rate for selling marijuana. Specification 1 excludes both of these sets and presents the baseline elasticity for comparison. Specification 2 includes the first lagged enforcement set and specification 3 includes the second set. All specifications include MSA and year fixed effects. The first set is jointly significant at the five- percent level whereas the

second set is not. The cocaine price elasticity is negative and significant in all specifications and is robust to the inclusion of these lagged arrest rates. It remains virtually unchanged, at -0.22 , from the baseline model and is also similar to all of the earlier estimates.

Table 3-15 presents similar models for heroin use. Heroin price is negative and significant in all specifications, as are the lagged enforcement variables. The price elasticity diminishes marginally in magnitude from -0.14 to -0.11 to -0.09 . These estimates are also virtually identical to those obtained earlier from the baseline models of demand, myopic addiction, and rational addiction. Overall, these two tables show that the participation price elasticity for cocaine and heroin are not sensitive to the inclusion of lagged enforcement variables, which may be controlling to some extent for unobserved shocks simultaneously affecting demand and price. This seems to suggest that price can be treated as strictly exogenous in the models. Furthermore, since most of the inferences are drawn from models that include MSA-specific linear trends, which may also be substituting for many of these unobservables, it is safe to say that these specifications are not much affected by policy endogeneity.

All of the models presented thus far have included only the drug's own price. Demand theory suggests that there may be strong interactions between the markets for various drugs. Tables 3-16 and 3-17 estimate the baseline and myopic addiction demand models with cross-prices, as derived in equations (31) and (33). Table 3-16 shows the results for cocaine participation. Specification 1 includes only contemporaneous cocaine and heroin prices based on (31), specification 2 includes only the one-year lagged cocaine and heroin prices, and specification 3 includes current and one-year lags of cocaine and

heroin prices consistent with a myopic addiction model of two drugs, equation (33). These specifications are repeated with fixed effects. Current cocaine price is significantly negative in all models. The current own-price elasticity ranges from -0.16 to -0.22 , based on the fixed-effects specifications. The lagged cocaine price is also significant in all models, and the elasticity ranges from -0.18 to -0.27 . Note that these ranges are very similar to those estimated from models that exclude cross prices. Again this suggests that the coefficient of own price accurately measures the contemporaneous price response in fixed-effects models and is not confounded by the omission of lagged prices or the prices of other drugs. The current heroin price is negative and significant in the fixed-effects specifications 4 and 7 that include just current prices. This implies cocaine and heroin are economic complements. The cross-price elasticity of cocaine participation with respect to the current price of heroin is estimated between -0.04 and -0.09 . In specifications 6 and 9, which include year effect and then also MSA effects, current heroin price is negative but insignificant. The lagged heroin price is negative and significant at the one-percent level. The cross-price elasticity of cocaine participation with respect to past heroin price is estimated to be between -0.06 and -0.08 . This suggests that cocaine and heroin are not only current complements but also intertemporal complements. This is consistent with a cross-reinforcement effect wherein past heroin consumption motivates current cocaine consumption by raising the current marginal utility of cocaine use.

Table 3-17 presents these cross-price models for heroin use. The current heroin price is negative and significant in all models. The current own-price elasticity is estimated to be between -0.07 and -0.37 . Again note the similarity of this range to

earlier models. The current price of cocaine is negative in four specifications but is imprecisely estimated. It is significant only in the year-effects model, with an implied current cross-price elasticity of -0.29 . Lagged heroin price also loses precision with the inclusion of MSA effects; from the year-effects specifications the lagged own-price elasticity seems to have an upper bound of -0.30 .⁴⁰ Lagged cocaine price is also negative in four specifications, but significant only in the model with year-effects. The lagged cross-price elasticity has an upper bound of -0.31 . Models of heroin participation also suggest that heroin and cocaine are both current and intertemporal complements, that there appears to be a cross-reinforcement effect of past cocaine consumption on current heroin consumption. However, due to the imprecision of these cross-effects in the full fixed-effects models, the evidence is not as strong as in the cocaine models.

One of the advantages of DUF is that the indicators of drug use based on urine specimens are objective and more accurate than self-reported indicators, which may be plagued by measurement errors due to misreporting. Such inaccuracies in self-reported data may have biased prior estimates of the price elasticity of demand. The extent of this measurement error can be gauged in DUF because arrestees were also asked to report on their own cocaine and heroin use in the past 72 hours.⁴¹ Looking at the simple means, there seems to be vast under-reporting in the self-reported data. About 41 percent of the arrestees tested positive for cocaine use whereas only 21 percent admitted to using cocaine recently. Over 8 percent of the arrestees tested positive for heroin whereas only 5 percent admitted to its use in the last three days. While most agree that survey data are also plagued with under-reporting, it is unknown whether it is to such a degree. It is

⁴⁰ Given that the cross-price elasticity is negative, the upper bound refers to the absolute magnitude of this elasticity.

likely that hardcore drug users are more likely under-report, and that recent use is more likely to be under-reported than past month or past year use (see footnote 11). At least for the sample of arrestees, it can be assessed whether the elasticities and marginal effects are sensitive to such measurement error. Since the participation (A) – price (P) elasticity is calculated as $(d A / d P) * (P/A)$, it can differ because of differences in mean participation (A) as well differences in the marginal response ($d A / d P$). Under-reporting, by reducing the measured mean participation, results in larger magnitudes of the elasticity, *ceteris paribus*. However, it is also likely that the marginal response may be different between those who accurately report drug use and those who do not. Since the sign of this difference is not known a priori, this effect may either raise or lower the elasticity.

Tables 3-18 and 3-19 present models for both the urinalysis-based indicators of drug use and the self-reported measures. Table 3-18 shows the results for recent cocaine participation. The top panel estimates the same logistic specification used thus far, and reports both the elasticity and the marginal effect. Comparing the specifications for the objective and self-reported indicators, there is some evidence that the marginal effect of price is smaller with respect to self-reported cocaine participation. All else equal, this would lower the absolute elasticity based on self-reported data. However, the under-reporting raises the absolute elasticity. Both specifications show that this latter effect dominates so that the elasticity under self-reports tends to be higher. This difference is much smaller in the full fixed-effects specification 2. The bottom panel estimates a double-log demand function so that the estimated price coefficient also represents the elasticity. The price elasticities with respect to self-reported cocaine participation are

⁴¹ These questions were only asked from 1989 to 1999.

again higher, and in this case the difference relative to the urinalysis-based outcomes is larger than before.

Table 3-19 presents this comparison for heroin participation. The top panel estimates logistic regressions. The price elasticities calculated with self-reported data are again larger in absolute magnitude. The marginal effect of price on self-reported versus objective use does not seem to be much different. Thus, most of the difference in the price elasticities is driven by the under-reporting. The bottom panel estimates a double-log functional form. These specifications also show that the price elasticity of heroin participation is higher with survey data. These comparisons suggest that self-reported data are likely to be plagued by misreporting, which in the case of heavy users is likely to be substantial. Such under-reporting tends to impart an upward bias to the absolute magnitudes of the estimated elasticities.

Models of addiction suggest that current use is a direct and positive function of past use due to the reinforcement effect. Earlier, models were estimated under a myopic addiction framework where the addictive stock was proxied by a series of past prices due to problems associated with including a lagged dependent variable as a regressor. The significance of lagged price effects is evidence of this addiction framework. Tables 3-20 and 3-21 directly estimate the demand function under myopic addiction expressed in equation (38) by the Arellano-Bond method, which as explained in section 5 is a first-differenced instrumental variables estimator.⁴²

⁴² Baltagi et al. (2000) estimate demand specifications for cigarettes using various dynamic panel-data estimators. Also see Baltagi and Levin (1986). Anderson and Hsiao (1981, 1982) discuss these estimation techniques. Baltagi (1995) provides a good overview of these estimators.

Table 3-20 presents the results for logistic urinalysis-based recent cocaine use. The top panel uses the cocaine price imputed from all purchases. Specifications 1 and 2 exclude year effects, and specifications 3 and 4 include them. The one-year lagged cocaine use is positive and significant at the one percent level in all models. This is consistent with the addiction paradigm. Cocaine price is negative and also significant at the one-percent level in all specifications. Specification 1 and 3 treat the price as strictly exogenous, whereas specification 2 and 4 treat it as a predetermined variable that is instrumented as well. Treating the cocaine price as endogenous and instrumenting it does not substantially alter the results. Specifications 1 and 2, which exclude year effects, are only presented for comparison. These models do not pass the overidentification test of instrumental validity. This is not surprising since past levels are valid instrument for the first-difference only if the non-difference errors are not autocorrelated (or equivalently the first-differenced errors are not autocorrelated beyond the first-order). Excluding year effects (thus not controlling for any common underlying time trend) results in second-degree autocorrelation. In this case, the instrumental matrix of past levels is no longer valid. Models that include year effects are preferred because they do not have any higher-degree autocorrelation and the instruments pass the validity check. From these models, the short-run or contemporaneous cocaine price elasticity is estimated to be between -0.14 and -0.18 . A model with a lagged dependent variable can be derived from a distributed lagged model where current consumption depends on all past values of price and the effect of successively distant lags diminish geometrically. In this case, the long-run price elasticity can be calculated as the current price elasticity times $(1/1-\delta_1)$ where δ_1 is the coefficient of lagged drug use. It measures the total impact of a change in price on

participation after all the lagged effects have been felt. The long-run cocaine price elasticity is estimated between -0.31 and -0.38 . Note that this long-run elasticity is much smaller than that implied from the reduced-form myopic addiction models that include a series of lagged prices. The reason is that these models do not show any evidence that lagged prices have a substantially smaller effect than current prices, at least for the one and two-year lags. That is, the price coefficients are not restricted to follow a geometrically decaying pattern. This is the implicit assumption behind the calculation of the long-run price elasticity from the coefficient of lagged consumption. Thus, estimates of the long-run price elasticities from the Arellano-Bond models should be interpreted with caution. The bottom panel of Table 3-20 uses retail-based cocaine prices. The results are highly similar. The short-run cocaine price elasticity is estimated at -0.12 and the long-run price elasticity is about -0.26 , based on the preferred specifications.

Table 3-21 presents results from the Arellano-Bond estimation of equation (38) for heroin participation. In the top panel, lagged heroin use is significantly positive in all specifications. Specifications 3 and 4, with year effects, are preferred since they pass the diagnostic tests. The short-run heroin price elasticity is estimated to be between -0.06 and -0.08 , and the long-run price elasticity is between -0.11 and -0.14 . In the bottom panel, the short-run price elasticity ranges from -0.08 to -0.10 , and the long-run elasticity ranges from -0.12 to -0.15 . Overall, these results confirm the strong addictive aspects of cocaine and heroin. Magnitudes of the current price elasticity for both drugs are very similar to those estimated in the earlier models with and without lagged prices. Furthermore, explicitly treating price as a predetermined endogenous variable does not substantially alter the elasticities.

7. Results from DAWN

The results from models estimated with DAWN outcomes are presented in Tables 3-22 through 3-35. Before turning to the results, Figures 3-1 through 3-4 visually depict the strong negative relationship between cocaine and heroin related ED episodes and drug prices. Figure 3-1 shows the total drug-related ED episodes in the 21 MSA's and the mean cocaine price in these cities. Figure 3-2 plots these total drug episodes against the mean heroin price. Both reveal that total ED drug episodes increased from 1990 to 2001 as the prices of cocaine and heroin declined. Figure 3-3 graphs the total cocaine mentions versus the mean cocaine price, and Figure 3-4 graphs the total heroin mention versus the mean heroin price. The striking point is that the series of cocaine and heroin mentions are virtual mirror images of the price series. This is only suggestive since these figures do not control for time trends or other confounders. The multivariate models, presented next, address this possibility.

The first panel of Table 3-23 presents estimation of the baseline "demand" function given by equation (30) for the log of the odds of a cocaine mention, employing the cocaine price series computed from all purchases.⁴³ All specifications include the same MSA-level socioeconomic covariates as before in addition to the DAWN response rate, and progressively add year effects, MSA effects, and MSA-specific linear trends. Cocaine price is negative and statistically significant in all specifications, and the elasticity of the probability of a cocaine mention with respect to own price ranges from -0.25 to -0.63. Specification 1, which does not include any fixed effects, yields a price

⁴³ Even though the specifications estimated with DAWN are the same as in DUF due to the monotonic relation between drug-related episodes and drug use, they are technically not demand functions. They should be interpreted as production functions of negative health consequences related to drug use.

elasticity of -0.63 . The coefficient on income is significantly positive. While this implies that health, at least as defined here, is an inferior good, this is probably due to other omitted confounders. Income becomes insignificant in the fixed effects specifications. The unemployment rate also has positive and significant effect on the probability of a cocaine mention; this is consistent with the results from DUF that showed that increases in unemployment raise cocaine participation among hardcore users. Blacks are more likely to have a cocaine related ED episode compared to whites, and college graduates are less likely. Individuals between the ages of 16 and 24 and between the ages of 25 and 54 are also less likely to have a cocaine related health emergency relative to older individuals. While cocaine use is more prevalent among adults and young adults, the positive marginal effect of ages over 54 implies that cocaine use may either have cumulative negative effects on health or perhaps older individuals, while they use less cocaine, are more susceptible to its detrimental effects. The arrest rate for any drug possession also has a negative effect on the probability of a cocaine mention. This is also consistent with the results in DUF, which showed that a higher probability of apprehension raises the full price of cocaine and reduce participation. This presumably also reduces the cocaine related emergency room visits. The sign of the sample response rate in DAWN is positive, as expected from equation (42), but it is not significant. Adding year effects in specification 2 causes the price elasticity to decrease in magnitude to -0.51 . Specification 3 includes both year and MSA effects; here only changes in the price of cocaine within a given MSA are relied upon for identification. The price elasticity falls in this case to -0.35 . Specification 3 adds indicators of an MSA-specific linear trend. This is a very stringent test since only deviations around a linear trend,

within cities, are used to identify the effects of each variable. The price effect remains significant at the one-percent level, and the elasticity decreases in value to -0.25 . The addition of MSA-specific linear trends causes the MSA-level covariates to lose joint significance. Since these covariates are controlling for trends within MSA's to some extent, it is appropriate to draw inferences from the fixed-effects specifications that include these covariates, MSA dummies, and year dummies. The largest gain in adjusted R-square results from the addition of MSA effects; including MSA-linear trends raises the adjusted R-square by a relatively small amount. In subsequent analyses of cocaine participation, fixed-effects specifications with and without city-specific trends are preferred and used to more reliably pin down the price elasticity. Taking the estimate from specification 2 that includes all covariates and year effects as the upper bound, the own-price elasticity of the probability of a cocaine mention is around -0.35 to -0.51 .

The second panel of Table 3-23 presents the estimates for the same specifications, but now cocaine price is based on retail purchases of 40 grams or less. The results are very similar to above. Price is negative and statistically significant in all specifications. The arrest rate for possession of any drugs is also negative and significant in the first two specifications, but loses precision with the inclusion of MSA effects. Once again taking the estimates from model 2 as the upper bound, the price elasticity has a range from -0.24 to -0.49 .

Table 3-24 presents estimation of the baseline model given by equation (30) for the log of the odds of a heroin mention. The first panel employs the heroin price computed with all purchases. The estimate price coefficients are negative in all specifications and significant in the specifications that control for MSA and year fixed

effects. Specification 1 shows the effects of the MSA-level covariates. Income has a positive effect on the probability of a cocaine mention as does the unemployment rate. Males, blacks, and Hispanic are more likely to have a cocaine related ED episode, as are individuals above the age of 54. The sample response rate has the correct positive sign and is significant. The arrest rate for drug possession is insignificant in specification 1 but becomes negative and significant in the fixed-effects specification. This again implies that a higher probability of apprehension directly reduces heroin related ED episodes. Specification 2, which adds year effects, yields a heroin price elasticity of -0.42 . Adding MSA indicators substantially reduces this magnitude, though the price effect remains significant at the one-percent level. Adding MSA-specific linear trends causes the price coefficient to become insignificant. Taking the fixed-effects model as the preferred specification, the own-price elasticity of the probability of having a heroin related ED visit ranges from -0.13 to -0.42 , and is likely to be closer to the lower bound.

The second panel of Table 3-24 presents similar models, with heroin price now based on retail purchases. The results remain very much the same. The price effect is negative in all models and remains statistically significant at the one-percent level in the fixed-effects specification. The heroin price elasticity ranges from -0.13 to -0.41 , and again is likely to be closer to the smaller of these magnitudes.

Tables 3-25 through 3-28 estimate the models given by equation (32), which includes current and past prices. Table 3-25 estimates this equation for logistic cocaine mentions, with contemporaneous and one-year lagged cocaine price. The top panel uses the cocaine price imputed with all purchases. The coefficients on current and lagged price are negative and statistically significant in all specifications, including those that

add MSA-specific linear trends. The inclusion of lagged price does not seem to diminish the magnitude of the contemporaneous price elasticity. It ranges from about -0.30 to -0.36 . The elasticity with respect to lagged price ranges from about -0.25 to -0.34 . The bottom panel employs retail purchases based cocaine price. Here also, all price coefficients are significant in all models. The current price elasticity ranges from about -0.20 to -0.36 , and the lagged price elasticity ranges from about -0.16 to -0.34 .

The models in Table 3-26 add the two-year lagged cocaine price in addition to the current and one-year lagged prices. In the top panel, the current and one-year lagged prices are negative and significant in all specifications, including those with MSA-linear trends. The two-year lagged price is not significant. Adding these lagged prices again does not substantially reduce the magnitude of the current price elasticity. It is very similar to those from the baseline models, and ranges from -0.30 to -0.37 . The range is tighter than before since the upper bound estimates obtained from the year-effects models are more in line with the other specifications. Thus, adding lagged prices makes some difference when MSA indicators are not there to pick up some of their effect. The one-year lagged cocaine price elasticity ranges from -0.25 to -0.35 . The bottom panel essentially shows the same with slightly smaller elasticity magnitudes. The current price elasticity ranges from -0.20 to -0.33 , and the one-year lagged price elasticity ranges from about -0.18 to -0.25 . These tables show that the effect of one-year lagged price on the current probability of a cocaine related ED episode is negative and significant, and not much weaker than the effect of contemporaneous price. In this context, this should not be interpreted as evidence of the addictive properties of cocaine per se because the outcome variable is not a direct measure of use. Since the dependent variable is a proxy

for health, it is theoretically possible that a non-addictive substance may still have lagged effects on health. Thus, it is more reasonable to interpret the significantly negative lagged and current effects as saying that problematic cocaine use (due to lower prices) negatively affects current health and also has a cumulative detrimental effect on health which may not be felt until later.

Table 3-27 and 3-28 estimate the corresponding models for logistic heroin mentions. Table 3-27 includes the current heroin price and its one-year lag. The top panel includes the heroin price computed with all purchases. The contemporaneous price elasticity is significant in the fixed-effects specification, and ranges from -0.14 to -0.32 . The one-year lagged price effect is also significant in the fixed-effects specification, and is estimated to be between -0.10 and -0.36 . The bottom panel is based on retail heroin price. The current price elasticity is precisely estimated in all specifications, including the last which controls for MSA-specific linear trends. The current price elasticity ranges from -0.13 to -0.28 . The one-year lagged price effect is significant in the fixed-effects specification, and the estimated elasticity is between -0.10 and -0.33 .

Table 3-28 adds the two-year lagged heroin price to these models. In the top panel, the current price effect is significant in all specifications. The corresponding elasticity ranges from -0.16 to -0.29 . The one and two-year lagged heroin price coefficients are also significantly negative in the fixed-effects model. The one-year lagged price elasticity is between -0.11 and -0.26 , and the two-year lagged price elasticity falls between -0.15 to -0.40 . The bottom panel of this table uses the retail-based heroin price. Again, the current price elasticity is significantly negative in all specifications, including the last that includes linear trends within MSA's. It has a range

from -0.17 to -0.26 . The one-year lagged price effect is significant in the fixed-effects specification, and the elasticity is estimated to be between -0.09 and -0.22 . The two-year lagged price is precisely estimated in all specifications, with a range of -0.17 to -0.36 . Similar to the results with cocaine use, these tables show that the current heroin price elasticity is not substantially diminished with the inclusion of the lagged prices. This is especially the case in the full fixed-effects models and suggests that in these specifications the coefficient on price is a robust measure of the contemporaneous effect of price on the probability of a cocaine mention. It appears that the fixed effects (rather than the current price) are picking up the lagged-price effects when they are excluded in the baseline models. The effects of past heroin prices on the current likelihood of a heroin related ED visit are also relatively substantial and of a similar magnitude to the effect of current price. Unlike the models of cocaine mentions, lagged prices older than one year also affect current heroin mentions. This again suggests that drug use, especially heavy or problematic use, has cumulative ill-effects on health.

Tables 3-29 and 3-30 estimate the model expressed in equation (34), which includes lagged and leading prices. These models are similar to those discussed above except that they add one and two-year leads of prices in addition to the current and lagged prices. Significantly negative lead price-effects are consistent with rational addiction, but they may also indirectly inform on the presence of policy endogeneity.

Table 3-29 presents models for logistic cocaine mentions. All specifications include the one and two-year lead cocaine prices, and an F-test on their joint significance is reported. One, two, and three-year lagged cocaine prices are progressively included in the specifications. The current price effect is negative and significant in all fixed-effects

specifications, even with MSA-specific trends. The contemporaneous price elasticity is estimated at around -0.21 to -0.24 . This magnitude is similar to the estimates reported above and is not sensitive to the inclusion of the lead prices. The lagged-prices are jointly significant in all fixed-effects specifications. The lead prices are insignificant in all models. Similar to the estimation with DUF, these results do show support for the premise that addicts are forward-looking. Alternately, the evidence also does not point to the presence of substantial policy endogeneity since the current price effect remains relatively robust and the lead-price effects are never significant.

Table 3-30 shows results from the same specifications estimated for heroin mentions. The effect of current heroin price is negative and significant in the specifications that include MSA and year effects. The current heroin price elasticity ranges from -0.07 to -0.13 . These estimates are closer to the lower bounds reported from the baseline models. The lagged heroin price coefficients are jointly significant in the fixed-effects models. The leading price coefficients are insignificant everywhere. These results are comparable to those obtained above with cocaine mentions. There does not seem to be any signs in favor of rational addiction since no lead-price effects are found. The possibility of policy endogeneity also appears remote; the contemporaneous heroin price elasticity remains relatively robust to the inclusion of the leads and current heroin related ED episodes do not seem to be affected by future prices. These tables suggest that inferences based on the fixed-effects specifications are generally sound and robust.

To further strengthen the argument against strong policy endogeneity, Tables 3-31 and 3-32 present specifications that include lagged enforcement variables in order to control for any unobserved shocks to past demand and current prices. The sets of lagged

enforcement variables are same ones used in similar specifications for DUF. Table 3-31 presents these results for cocaine mentions. All specifications include MSA and year effects in addition to the other MSA-level covariates. Both lagged enforcement are jointly significant at the five percent level. The cocaine price elasticity is significantly negative in all specifications and is robust to the inclusion of the lagged arrest rates. It decreases only marginally from -0.35 to -0.34 to -0.33 .

Table 3-32 presents the same models for heroin mentions. Heroin price is negative and significant in all specifications, as are the lagged enforcement variables. The price elasticity diminishes slightly in magnitude from -0.13 to -0.11 to -0.10 . These estimates are also highly similar to those obtained earlier from the baseline models and from those including lagged and lead prices. Overall, these two tables show that the elasticity for the probability of a cocaine or heroin related ED episode with respect to own-price is not sensitive to the addition of lagged arrest rates, which may be capturing to some extent unobserved shocks simultaneously affecting demand and price. This seems to suggest that price can be treated as strictly exogenous in the models.

All of the models presented thus far have included only the relevant drug's own price. Tables 3-33 through 3-35 estimate the cross-price models derived in equations (31) and (33). Table 3-33 presents the models for logistic drug episodes. This dependent variable measures the log of the odds ratio of the probability of any drug related ED episode. Since drug related emergency room visits can be induced by one or more illicit drugs, it is appropriate to include the price of both cocaine and heroin in these specifications. Cocaine is the most frequently mentioned illicit substance, present in about 29 percent of ED episodes for 2000. Heroin and marijuana are the second most

frequently cited, each mentioned in about 16 percent of the ED episodes. Specification (1) includes only contemporaneous cocaine and heroin prices based on (31), specification (2) includes only the one-year lagged cocaine and heroin prices, and specification (3) includes current and one-year lags of both drug prices. These specifications are repeated with fixed effects. Current cocaine price is significantly negative in all models. The elasticity of the probability of a drug-related episode with respect to current cocaine price ranges from -0.17 to -0.38. Current heroin price is statistically significant and negative in all but one of the specifications. Its corresponding elasticity is between -0.04 and -0.08. The one-year lagged cocaine price is also significantly negative in all but one of the specifications; the elasticity lies between -0.10 and -0.29. The elasticity with respect to the one-year lagged heroin price is precisely estimated in all regressions and has a range from -0.03 to -0.10. Overall, increases in the price of both drugs reduce the likelihood of a drug-related health emergency, as proxied by an ED visit. The cocaine price elasticities are generally larger in magnitude than the heroin price elasticities; this may be due to the fact that cocaine is the most frequently cited in all drug-related episodes. Hence, the cocaine price would be expected to have a stronger effect. Past prices of both drugs also have a significantly negative effect on the likelihood of a drug-related ED visit, and the lagged price elasticities are not much smaller than the contemporaneous price elasticities. This is consistent with the results from the lagged-price models of cocaine and heroin mentioned earlier. These results suggest that the negative health effects of cocaine and heroin use are positively related to current consumption and also positively related to the accumulated addictive stock.

Table 3-34 shows the results for logistic cocaine mentions. The current cocaine price is significant and negative in all but one of the specifications. Estimates of the current own-price elasticity lie between -0.29 and -0.34. The one-year lagged cocaine price is significantly negative in all but two of the specifications; it is significant in the full fixed-effects model. The corresponding lagged own-price elasticity is estimated at around -0.24. Note that these magnitudes are very similar to those estimated from models that exclude the cross prices. Again this implies that the coefficient of own price accurately measures the contemporaneous price response in fixed-effects specifications and is not confounded by the omission of lagged prices or the prices of other drugs. The current heroin price is negative in all specifications; it is significant in the year-effects models but becomes imprecise with the addition of MSA indicators. The cross-price elasticity of cocaine mentions with respect to current heroin price seems to have an upper bound of -0.10. While the negative sign suggests that cocaine and heroin are complements, caution must be exercised in such an interpretation. Since up to four drugs can be mentioned for any given ED drug episode, a cocaine mention does not mean that only cocaine was used. In fact, for the year 2000 only 28 percent of cocaine mentions involved solely cocaine. Thus, a negative cross-price elasticity may not mean that a higher heroin price is decreasing cocaine use; it is possible that the higher heroin price is decreasing heroin use, which in turn may decrease heroin mentions, and this may be reflected in a decline of heroin mentions that also involved cocaine. Nevertheless, these cross-price elasticities do not contradict the results obtained with DUF. Lagged heroin price is negative and significant in all but one of the specifications; its elasticity lies between -0.06 and -0.16. These lagged negative cross-price elasticities are also

consistent with a positive cross-reinforcement effect. That is, higher past heroin prices may reduce past heroin use, which may depress current cocaine use and thus reduce the number of cocaine related ED visits. The caveat related to multiple mentions applies here as well.

Table 3-35 presents these cross-price models for the probability of a heroin mention. The current own-price elasticity is negative and significant in all models, and is estimated between -0.11 and -0.33. Again note the similarity of this range to earlier models. The current price of cocaine is significant and negative in all but one of the specifications. Its corresponding elasticity lies between -0.30 and -0.69. Lagged heroin price is significantly negative in all specifications and has an elasticity from -0.08 to -0.40. Lagged cocaine price is significant in four out of six specifications; it is significant in the most general specification with MSA and year effects. The elasticity with respect to lagged cocaine price ranges from -0.20 to -0.53. While the above caveat is relevant here as well, it should be noted that more episodes involving heroin (roughly half) involved only heroin. These results do not contradict earlier DUF results, which suggested that cocaine and heroin are both current and intertemporal complements. The significance and negative sign of the lagged price effects again suggests that the accumulated addictive stock, and not just current consumption, also has a negative affect on current healthy outcomes.

8. Conclusions

The objective of this study was to estimate the empirical relationship between the prices of cocaine and heroin and objective indicators of their use. By employing data on cocaine and heroin use based on urine specimens, from DUF, and data on drug related

hospital emergency department episodes, from DAWN, this study bypasses any measurement errors prevalent in survey data due to misreporting. The persons sampled in DUF and DAWN constitute an important subgroup of hardcore drug users, which is often not captured by national surveys. Since these persons are more likely to be serious users, impose the heaviest costs on society, and are the targets of much illegal drug policy, studying their addictive consumption behavior is very important from a public policy stance.

The key conclusion that emerges from this study is that cocaine and heroin prices have a significantly negative effect on the probability of use for arrestees and on the probability of a cocaine or heroin related ED episode. And, the striking point is that the elasticity estimates that emerge are robust in virtually all of the specifications tested. Results from DUF indicate that the own-price cocaine participation elasticity is about -0.23, and the own-price heroin participation elasticity is about -0.08. These elasticities are somewhat smaller than those estimated in prior studies. This is not surprising since the arrestee population is more likely to be addicted to drugs than the population at large and thus may be less responsive to price. Also, the data from DUF show that self-reports of drug use are biased downwards, and this may also impart an upward bias to estimated elasticities. These elasticities are also slightly smaller in magnitude than those obtained from other studies of DUF. However, all of these other studies are plagued with specification errors, inadequate controls, and bias due to unmeasured factors. The present study uses the time series of repeated city cross-sections to estimate full fixed-effects specifications that control for unmeasured factors and policy endogeneity. It also adds to the limited literature on cross-price elasticities; the results show that cocaine and

heroin are economic complements.⁴⁴ Results from DAWN indicate that the elasticity of the probability of a cocaine mention with respect to own price is about -0.33, and the own-price elasticity of the probability of a heroin mention is about -0.16. Prices of both cocaine and heroin have a significantly negative effect on serious cocaine and heroin related health problems. The cross-price effects also do not contradict the earlier finding that cocaine and heroin are complement. Both sets of results also show the presence of significantly negative own and cross-price effects but insignificant lead-price effects. These results seem to favor the myopic addiction paradigm over rational addiction.

That hardcore drug users are price-responsive is significant from a public policy perspective. Since many studies, and some results from this study, have shown that drug prices are positively related to enforcement efforts, they represent a tool by which the public sector can exercise control over the market for illicit, addictive, unhealthy substances. Not only do drug prices deter drug use by the heaviest users, but the data from DAWN also indicate that drug prices directly affect the “bottom line”, that is higher prices improve health outcomes. The contemporaneous elasticity understates the full effect. Strong negative lagged price effects show that higher prices deter drug use in current and future periods, and by reducing the stock of addictive consumption also improve health outcomes in current and future periods.

⁴⁴ This is consistent with the studies by Saffer and Chaloupka (1996a, 1996b).

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Table 3-1
Drug Use Forecasting Arrestee Data
Sample Means

Variable	Definition	Mean
Recent Cocaine Use Urinalysis	Percent of arrestees in each MSA whose urine tested positive for cocaine use in the past 48 – 72 hours	0.39783 (0.13731)
Logistic Recent Cocaine Use Urinalysis	Log of the odds of recent cocaine use urinalysis	-0.45751 (0.63065)
Recent Heroin Use Urinalysis	Percent of arrestees in each MSA whose urine tested positive for opiate use in the past 48 – 72 hours	0.08286 (0.05858)
Logistic Recent Heroin Use Urinalysis	Log of the odds of recent heroin use urinalysis	-2.66056 (0.81340)
Recent Cocaine Use Self-Report	Percent of arrestees in each MSA who reported using cocaine in the past 72 hours	0.21327 (0.07990)
Logistic Recent Cocaine Use Self-Report	Log of the odds of recent cocaine use self-report	-1.38119 (0.52805)
Recent Heroin Use Self-Report	Percent of arrestees in each MSA who reported using heroin in the past 72 hours	0.05062 (0.04763)
Logistic Recent Heroin Use Self-Report	Log of the odds of recent heroin use self-report	-3.40779 (1.14763)
Past Month Cocaine Use	Percent of arrestees in each MSA who reported using cocaine in the past 30 days	0.28053 (0.09015)
Logistic Past Month Cocaine Use	Log of the odds of past month cocaine use	-0.99075 (0.47616)
Past Month Heroin Use	Percent of arrestees in each MSA who reported using heroin in the past 30 days	0.06429 (0.05479)
Logistic Past Month Heroin Use	Log of the odds of past month heroin use	-3.07811 (1.04728)
Frequency Past Month Cocaine Use	Mean number of days in each MSA that cocaine was used in the past 30 days, conditional on users	23.32717 (4.59495)
Log Frequency Past Month Cocaine Use	Log of frequency past month cocaine use	3.12955 (0.20401)
Frequency Past Month Heroin Use	Mean number of days in each MSA that heroin was used in the past 30 days, conditional on users	17.09330 (4.34307)
Log Frequency Past Month Heroin Use	Log of frequency past month heroin use	2.78760 (0.37763)
Cocaine Price - All	Price of one pure gram of cocaine, based on all purchases, divided by the annual national consumer price index	80.46902 (27.81223)

Table 3-1 Contd.

**Drug Use Forecasting Arrestee Data
Sample Means**

Variable	Definition	Mean
Cocaine Price - Retail	Price of one pure gram of cocaine, based on purchases of 40 grams or less, divided by the annual national consumer price index	84.80347 (88.86170)
Heroin Price - All	Price of one pure gram of heroin, based on all purchases, divided by the annual national consumer price index	490.18150 (373.77830)
Heroin Price - Retail	Price of one pure gram of heroin, based on purchases of 40 grams or less, divided by the annual national consumer price index	501.88120 (396.86080)
Personal Income	Per capita personal income in each MSA, divided by the annual national consumer price index	16878.39 (2601.46)
Unemployment	Unemployment rate in each MSA	0.05443 (0.02078)
Male	Percent of MSA population that are male	0.47684 (0.02007)
Black	Percent of MSA population that are black	0.14429 (0.09675)
Other	Percent of MSA population that are of a race other than white or black	0.05030 (0.06236)
Hispanic	Percent of MSA population that are Hispanic	0.13984 (0.16870)
Age 16 - 24	Percent of MSA population that are aged 16 to 24	0.16835 (0.02607)
Age 25 - 54	Percent of MSA population that are aged 25 to 54	0.58718 (0.04211)
High School	Percent of MSA population that are high school graduates	0.78827 (0.06317)
College	Percent of MSA population that are college graduates	0.23354 (0.05466)
DUF Arrest Rate	Total number of arrestees in DUF divided by total number of arrests in each MSA	0.01136 (0.00908)
Drug Possession Arrest Rate	Percent of arrests in each MSA resulting from any drug sale or trafficking	0.07578 (0.03826)
Drug Violation Arrest Rate	Total number of arrests in each MSA due to any drug violation divided by MSA population	0.00535 (0.00267)

Table 3-1 Contd.

**Drug Use Forecasting Arrestee Data
Sample Means**

Variable	Definition	Mean
Drug Sale Arrest Rate	Total number of arrests in each MSA due to any drug sale or trafficking divided by MSA population	0.00127 (0.00119)
Cocaine Sale Arrest Rate	Total number of arrests in each MSA due to cocaine sale or trafficking divided by MSA population	0.00071 (0.00094)
Marijuana Sale Arrest Rate	Total number of arrests in each MSA due to marijuana sale or trafficking divided by MSA population	0.00024 (0.00023)
Violent Crimes Arrest Rate	Total number of violent crimes arrests in each MSA divided by MSA population	0.00263 (0.00144)
Relative Unskilled Wage	Median wage in the 25 th percentile relative to the median wage in the 90 th percentile in each MSA	0.19816 (0.03043)
Log Relative Unskilled Wage	Log of relative unskilled wage	-1.63076 (0.15712)
Population	Total MSA Population	2978176 (2369104)
Observations		332

Notes: Standard deviations are in parentheses. Number of observations listed represents the maximum number. For some variables, the actual sample size is slightly less due to missing information.

Table 3-2
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3	4
Cocaine Price - All Purchases	-0.00329*** (-3.10) $\epsilon = -0.159$	-0.00494*** (-4.74) $\epsilon = -0.239$	-0.00464*** (-5.14) $\epsilon = -0.225$	-0.00463*** (-5.13) $\epsilon = -0.224$
Personal Income	-0.00005*** (-3.47)	Yes***	Yes***	Yes***
Unemployment	3.51808** (2.52)			
Male	-2.79158* (-1.89)			
Black	1.99925*** (5.48)			
Other	-1.88663*** (-3.88)			
Hispanic	-0.52752* (-1.80)			
Age 16-24	-5.16014*** (-4.53)			
Age 25-54	-2.04886** (-2.56)			
High School Graduate	-3.90086*** (-4.47)			
College Graduate	4.12129*** (5.25)			
Drug Possession Arrest Rate	-1.67017** (-2.15)	Yes*	Yes*	Yes*
DUF Arrest Rate	-19.26947*** (-5.78)	Yes***	Yes	No
Year Effects	No	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
MSA-Quadratic Trend	No	No	No	No
R-Squared	0.524	0.621	0.851	0.851
Observations	308	308	308	308

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-2 Contd.
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	5	6	7	8
Cocaine Price - All Purchases	-0.00449*** (-4.97) $\varepsilon = -0.218$	-0.00409*** (-4.86) $\varepsilon = -0.198$	-0.00256*** (-3.19) $\varepsilon = -0.124$	-0.00256*** (-2.68) $\varepsilon = -0.124$
MSA SES Covariates	Yes***	Yes***	Yes	Yes*
Drug Possession Arrest Rate	No	No	Yes	Yes
DUF Arrest Rate	Yes	No	Yes	Yes
Year Effects	Yes***	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	Yes***
R-Squared	0.849	0.844	0.923	0.936
Observations	308	322	308	308

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-3
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3	4
Cocaine Price - Retail Purchases	-0.00711** (-2.48) $\epsilon = -0.363$	-0.00473* (-1.77) $\epsilon = -0.242$	-0.00377*** (-5.16) $\epsilon = -0.193$	-0.00378*** (-5.17) $\epsilon = -0.193$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes***
Drug Possession Arrest Rate	Yes*	Yes	Yes	Yes
DUF Arrest Rate	Yes***	Yes***	Yes	No
Year Effects	No	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
MSA-Quadratic Trend	No	No	No	No
R-Squared	0.514	0.596	0.850	0.850
Observations	307	307	307	307

Specification	5	6	7	8
Cocaine Price - Retail Purchases	-0.00372*** (-5.07) $\epsilon = -0.190$	-0.00229*** (-4.37) $\epsilon = -0.117$	-0.00195*** (-3.17) $\epsilon = -0.100$	-0.00198*** (-2.74) $\epsilon = -0.101$
MSA SES Covariates	Yes***	Yes***	Yes*	Yes*
Drug Possession Arrest Rate	No	No	Yes	Yes
DUF Arrest Rate	Yes	No	Yes	Yes
Year Effects	Yes***	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	Yes***
R-Squared	0.850	0.840	0.922	0.935
Observations	307	321	307	307

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-4
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3	4
Heroin Price - All Purchases	-0.00064*** (-5.22) $\epsilon = -0.288$	-0.00088*** (-5.89) $\epsilon = -0.396$	-0.00016** (-1.95) $\epsilon = -0.072$	-0.00014* (-1.70) $\epsilon = -0.063$
Personal Income	0.00005** (2.08)	Yes***	Yes	Yes
Unemployment	5.15329** (2.27)			
Male	-1.12457 (-0.47)			
Black	-1.81806*** (-3.09)			
Other	-0.10779 (-0.14)			
Hispanic	-0.38475 (-0.83)			
Age 16-24	1.78563 (0.95)			
Age 25-54	-2.55497* (-1.96)			
High School Graduate	-4.83331*** (-3.39)			
College Graduate	2.39956* (1.90)			
Drug Possession Arrest Rate	-4.77862*** (-3.82)	Yes***	Yes	Yes
DUF Arrest Rate	-8.03968 (-1.36)	Yes	Yes**	No
Year Effects	No	Yes*	Yes*	Yes
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
MSA-Quadratic Trend	No	No	No	No
R-Squared	0.248	0.270	0.863	0.860
Observations	287	287	287	287

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-4 Contd.
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	5	6	7	8
Heroin Price - All Purchases	-0.00016* (-1.93) $\epsilon = -0.072$	-0.00017** (-2.01) $\epsilon = -0.076$	-0.00006 (-0.91)	-0.00007 (-0.89)
MSA SES Covariates	Yes	Yes*	Yes	Yes
Drug Possession Arrest Rate	No	No	Yes*	Yes
DUF Arrest Rate	Yes**	No	Yes	Yes
Year Effects	Yes*	Yes	Yes**	Yes
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	Yes***
R-Squared	0.864	0.860	0.924	0.934
Observations	287	301	287	287

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-5
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3	4
Heroin Price - Retail Purchases	-0.00067*** (-5.67) $\epsilon = -0.308$	-0.00091*** (-6.46) $\epsilon = -0.419$	-0.00019** (-2.44) $\epsilon = -0.087$	-0.00017*** (-2.18) $\epsilon = -0.078$
MSA SES Covariates	Yes***	Yes***	Yes	Yes
Drug Possession Arrest Rate	Yes***	Yes***	Yes	Yes
DUF Arrest Rate	Yes	Yes	Yes**	No
Year Effects	No	Yes**	Yes**	Yes*
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
MSA-Quadratic Trend	No	No	No	No
R-Squared	0.260	0.287	0.865	0.862
Observations	287	287	287	287

Specification	5	6	7	8
Heroin Price - Retail Purchases	-0.00019** (-2.42) $\epsilon = -0.087$	-0.00019** (-2.44) $\epsilon = -0.087$	-0.00008 (-1.16)	-0.00008 (-1.10)
MSA SES Covariates	Yes	Yes	Yes	Yes
Drug Possession Arrest Rate	No	No	Yes*	Yes
DUF Arrest Rate	Yes**	No	Yes	Yes
Year Effects	Yes**	Yes	Yes**	Yes
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	Yes***
R-Squared	0.865	0.861	0.924	0.934
Observations	287	301	287	287

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-6
Drug Use Forecasting Arrestee Data
Logistic Past Month Cocaine Use & Log Frequency Past Month Cocaine Use

Specification	1	2	3	4
Dependent Variable	Logistic Past Month Use	Log Frequency	Logistic Past Month Use	Log Frequency
Cocaine Price - All Purchases	-0.00433*** (-4.66) $\varepsilon = -0.302$	-0.00111*** (-3.09) $\varepsilon = -0.089$	-.00521*** (-5.34) $\varepsilon = -0.364$	-.00170*** (-4.44) $\varepsilon = -0.137$
Personal Income	-0.00003** (-2.51)	-0.00002*** (-3.90)	Yes***	Yes***
Unemployment	1.308274 (1.07)	1.458812*** (3.06)		
Male	-4.02066*** (-3.11)	-0.95937* (-1.88)		
Black	0.70374** (2.21)	0.35514*** (2.86)		
Other	-1.16186*** (-2.74)	-0.10887 (-0.67)		
Hispanic	-0.61021** (-2.38)	-0.13522 (-1.34)		
Age 16-24	-5.22185*** (-5.24)	-1.32813*** (-3.42)		
Age 25-54	-1.28845* (-1.84)	-0.01061 (-0.04)		
High School Graduate	-2.76318*** (-3.63)	-1.18657*** (-3.93)		
College Graduate	2.55391*** (3.72)	0.38709 (1.46)		
Drug Possession Arrest Rate	-1.19405* (-1.76)	-0.29813 (-1.14)	No	No
DUF Arrest Rate	-12.57876*** (-4.31)	-6.64820*** (-5.87)		
Year Effects	No	No	Yes**	Yes***
MSA Effects	No	No	No	No
MSA-Linear Trend	No	No	No	No
R-Squared	0.356	0.449	0.336	0.447
Observations	308	291	322	303

Notes: Log participation is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA who reported using cocaine in the past 30 days. Log frequency is $\log(\text{days})$ where days is the mean number of days in each MSA that cocaine was used in the past 30 days, conditional on users. T-ratios are in parentheses. *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-6 Contd.
Drug Use Forecasting Arrestee Data
Logistic Past Month Cocaine Use & Log Frequency Past Month Cocaine Use

Specification	5	6	7	8
Dependent Variable	Logistic Past Month Use	Log Frequency	Logistic Past Month Use	Log Frequency
Cocaine Price (All Purchases)	-0.00331*** (-4.17) $\epsilon = -0.231$	-0.00010 (-0.26)	-0.00160* (-1.95) $\epsilon = -0.112$	-0.00020 (-0.46)
MSA SES Covariates	Yes	Yes**	Yes	Yes
Drug Possession Arrest Rate	No	No	No	No
DUF Arrest Rate				
Year Effects	Yes***	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	Yes***	Yes***
R-Squared	0.752	0.749	0.818	0.759
Observations	322	303	322	303

Notes: Log participation is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA who reported using cocaine in the past 30 days. Log frequency is $\log(\text{days})$ where days is the mean number of days in each MSA that cocaine was used in the past 30 days, conditional on users. T-ratios are in parentheses. *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-7
Drug Use Forecasting Arrestee Data
Logistic Past Month Heroin Use & Log Frequency Past Month Heroin Use

Specification	1	2	3	4
Dependent Variable	Logistic Past Month Use	Log Frequency	Logistic Past Month Use	Log Frequency
Heroin Price - All Purchases	-0.00090*** (-6.13) $\varepsilon = -0.413$	-0.000137*** (-3.31) $\varepsilon = -0.067$	-0.00089*** (-4.70) $\varepsilon = -0.413$	-0.00019*** (-3.65) $\varepsilon = -0.093$
Personal Income	0.00007** (2.26)	0.00001 (0.89)	Yes***	Yes***
Unemployment	0.81873 (0.30)	0.16551 (0.23)		
Male	-6.33883** (-2.25)	-0.45643 (-0.61)		
Black	-1.17325* (-1.68)	0.11963 (0.65)		
Other	-0.13452 (-0.15)	0.36177 (1.58)		
Hispanic	0.29287 (0.53)	0.24696* (1.69)		
Age 16-24	-0.44208 (-0.20)	-0.38294 (-0.66)		
Age 25-54	-4.15554*** (-2.68)	-0.67535* (-1.68)		
High School Graduate	-4.97173*** (-2.93)	-0.67319 (-1.48)		
College Graduate	2.60634* (1.73)	0.31645 (0.81)		
Drug Possession Arrest Rate	-6.61396*** (-4.44)	-0.32881 (-0.86)	No	No
DUF Arrest Rate	-16.84529** (-2.39)	-7.44854*** (-4.03)		
Year Effects	No	No	Yes	Yes
MSA Effects	No	No	No	No
MSA-Linear Trend	No	No	No	No
R-Squared	0.290	0.229	0.205	0.167
Observations	286	269	300	281

Notes: Log participation is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA who reported using heroin in the past 30 days. Log frequency is $\log(\text{days})$ where days is the mean number of days in each MSA that heroin was used in the past 30 days, conditional on users. T-ratios are in parentheses. *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-7 Contd.
Drug Use Forecasting Arrestee Data
Logistic Past Month Heroin Use & Log Frequency Past Month Heroin Use

Specification	5	6	7	8
Dependent Variable	Logistic Past Month Use	Log Frequency	Logistic Past Month Use	Log Frequency
Heroin Price - All Purchases	-0.00021 (-1.63) $\epsilon = -0.096$	0.000020 (0.39)	-0.00011 (-0.95)	0.00006 (1.31)
MSA SES Covariates	Yes	Yes	Yes	Yes
Drug Possession Arrest Rate	No	No	No	No
DUF Arrest Rate				
Year Effects	Yes**	Yes	Yes***	Yes
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	Yes***	Yes***
R-Squared	0.776	0.458	0.840	0.600
Observations	300	281	300	281

Notes: Log participation is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA who reported using heroin in the past 30 days. Log frequency is $\log(\text{days})$ where days is the mean number of days in each MSA that heroin was used in the past 30 days, conditional on users. T-ratios are in parentheses. *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-8
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3	4	5
Cocaine Price - All Purchases	-0.00307** (-2.46) $\epsilon = -0.149$	-0.00418*** (-3.55) $\epsilon = -0.203$	-0.00416*** (-4.68) $\epsilon = -0.202$	-0.00226*** (-3.09) $\epsilon = -0.110$	-0.00201** (-2.22) $\epsilon = -0.097$
1 Year Lagged Cocaine Price	-0.00184 (-1.56) $\epsilon = -0.092$	-0.00524*** (-4.57) $\epsilon = -0.263$	-0.00437*** (-5.31) $\epsilon = -0.219$	-0.00181** (-2.46) $\epsilon = -0.091$	-0.00193** (-2.33) $\epsilon = -0.097$
MSA SES Covariates	Yes***	Yes***	Yes**	Yes*	Yes*
Year Effects	No	Yes***	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.4479	0.6081	0.8534	0.9204	0.9315
Observations	318	318	318	318	318

Specification	1	2	3	4	5
Cocaine Price - Retail Purchases	-0.00063** (-2.14) $\epsilon = -0.032$	-0.00042 (-1.59) $\epsilon = -0.021$	-0.00240*** (-4.55) $\epsilon = -0.123$	-0.00107** (-2.43) $\epsilon = -0.055$	-0.00136** (-2.44) $\epsilon = -0.069$
1 Year Lagged Cocaine Price	-0.00169** (-2.17) $\epsilon = -0.085$	-0.00358*** (-4.88) $\epsilon = -0.180$	-0.00217*** (-4.30) $\epsilon = -0.109$	-0.00062 (-1.43) $\epsilon = -0.031$	-0.00085* (-1.82) $\epsilon = -0.043$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes*	Yes
Year Effects	No	Yes***	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.4419	0.5765	0.8464	0.9181	0.9308
Observations	318	318	318	318	318

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-9
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3	4	5
Cocaine Price - All Purchases	-0.00353*** (-2.72) $\epsilon = -0.171$	-0.00309** (-2.52) $\epsilon = -0.150$	-0.00378*** (-4.37) $\epsilon = -0.183$	-0.00223*** (-3.04) $\epsilon = -0.108$	-0.00218** (-2.42) $\epsilon = -0.106$
1 Year Lagged Cocaine Price	-0.00268** (-2.13) $\epsilon = -0.134$	-0.00420*** (-3.49) $\epsilon = -0.211$	-0.00392*** (-4.89) $\epsilon = -0.196$	-0.00187** (-2.53) $\epsilon = -0.094$	-0.00230*** (-2.73) $\epsilon = -0.115$
2 Year Lagged Cocaine Price	-0.00193* (-1.73) $\epsilon = -0.103$	-0.00332*** (-2.72) $\epsilon = -0.178$	-0.00359*** (-4.35) $\epsilon = -0.192$	-0.00100 (-1.36) $\epsilon = -0.053$	-0.00156** (-1.99) $\epsilon = -0.083$
MSA SES Covariates	Yes***	Yes***	Yes**	Yes*	Yes**
Year Effects	No	Yes***	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.4467	0.6107	0.8613	0.9194	0.9317
Observations	316	316	316	316	316

Specification	1	2	3	4	5
Cocaine Price - Retail Purchases	-0.00064** (-2.14) $\epsilon = -0.033$	-0.00032 (-1.23)	-0.00246*** (-4.71) $\epsilon = -0.126$	-0.00109** (-2.41) $\epsilon = -0.056$	-0.00151** (-2.46) $\epsilon = -0.077$
1 Year Lagged Cocaine Price	-0.00174** (-2.15) $\epsilon = -0.088$	-0.00317*** (-4.25) $\epsilon = -0.159$	-0.00217*** (-4.33) $\epsilon = -0.109$	-0.00062 (-1.38) $\epsilon = -0.031$	-0.00097* (-1.89) $\epsilon = -0.049$
2 Year Lagged Cocaine Price	0.00034 (0.44)	-0.00240*** (-3.18) $\epsilon = -0.129$	-0.00155*** (-3.06) $\epsilon = -0.083$	-0.00007 (-0.17)	-0.00026 (-0.58)
MSA SES Covariates	Yes***	Yes***	Yes***	Yes*	Yes
Year Effects	No	Yes***	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.4361	0.5838	0.8490	0.9163	0.9296
Observations	316	316	316	316	316

Notes: See notes for Table 3-8.

Table 3-10
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3	4	5
Heroin Price - All Purchases	-0.00045*** (-3.02) $\epsilon = -0.202$	-0.00069*** (-4.09) $\epsilon = -0.310$	-0.00015* (-1.75) $\epsilon = -0.067$	-0.00006 (-0.93)	-0.00007 (-0.97)
1 Year Lagged Heroin Price	-0.00034*** (-2.73) $\epsilon = -0.180$	-0.00046*** (-3.37) $\epsilon = -0.244$	-0.00006 (-0.90)	-0.00004 (-0.64)	-0.00010 (-1.63) $\epsilon = -0.053$
MSA SES Covariates	Yes***	Yes***	Yes	Yes	Yes
Year Effects	No	Yes	Yes	Yes*	Yes
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.2264	0.2369	0.8599	0.9199	0.9295
Observations	295	295	295	295	295

Specification	1	2	3	4	5
Heroin Price - Retail Purchases	-0.00041*** (-2.95) $\epsilon = -0.189$	-0.00064*** (-4.32) $\epsilon = -0.295$	-0.000167* (-2.04) $\epsilon = -0.077$	-0.00008 (-1.26)	-0.00013* (-1.96) $\epsilon = -0.060$
1 Year Lagged Heroin Price	-0.00044*** (-3.91) $\epsilon = -0.242$	-0.00064*** (-5.16) $\epsilon = -0.352$	-0.00018*** (-2.76) $\epsilon = -0.099$	-0.00011** (-2.01) $\epsilon = -0.060$	-0.00021*** (-3.42) $\epsilon = -0.115$
MSA SES Covariates	Yes***	Yes***	Yes	Yes	Yes
Year Effects	No	Yes**	Yes**	Yes**	Yes
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.2668	0.3014	0.8653	0.9217	0.9334
Observations	294	294	294	294	294

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for heroin use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-11
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3	4	5
Heroin Price - All Purchases	-0.00039** (-2.52) $\epsilon = -0.175$	-0.00062*** (-3.63) $\epsilon = -0.279$	-0.00014 (-1.60) $\epsilon = -0.063$	-0.00005 (-0.71)	-0.00006 (-0.89)
1 Year Lagged Heroin Price	-0.00021 (-1.44) $\epsilon = -0.111$	-0.00028* (-1.80) $\epsilon = -0.149$	-0.00006 (-0.79)	-0.00004 (-0.61)	-0.00010 (-1.62) $\epsilon = -0.053$
2 Year Lagged Heroin Price	-0.00027** (-2.16) $\epsilon = -0.156$	-0.00047*** (-3.46) $\epsilon = -0.271$	-0.00002 (-0.33)	0.00001 (0.26)	0.00002 (0.28)
MSA SES Covariates	Yes***	Yes***	Yes	Yes	Yes
Year Effects	No	Yes**	Yes	Yes	Yes
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.2346	0.2658	0.8611	0.9208	0.9295
Observations	290	290	290	290	290

Specification	1	2	3	4	5
Heroin Price - Retail Purchases	-0.00036** (-2.50) $\epsilon = -0.166$	-0.00058*** (-3.74) $\epsilon = -0.267$	-0.00015* (-1.88) $\epsilon = -0.069$	-0.00007 (-1.06)	-0.00013** (-1.98) $\epsilon = -0.060$
1 Year Lagged Heroin Price	-0.00040*** (-3.03) $\epsilon = -0.220$	-0.00054*** (-3.90) $\epsilon = -0.297$	-0.00018*** (-2.74) $\epsilon = -0.099$	-0.00011* (-1.95) $\epsilon = -0.060$	-0.00021*** (-3.46) $\epsilon = -0.115$
2 Year Lagged Heroin Price	-0.00013 (-1.00)	-0.00030** (-2.25) $\epsilon = -0.179$	0.00002 (0.23)	0.00001 (0.26)	-0.0000002 (-0.00)
MSA SES Covariates	Yes***	Yes***	Yes	Yes	Yes
Year Effects	No	Yes***	Yes*	Yes*	Yes
MSA Effects	No	No	Yes***	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No	No	Yes***
R-Squared	0.2656	0.3122	0.8660	0.9223	0.9334
Observations	290	290	290	290	290

Notes: See notes for Table 3-10.

Table 3-12
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3	4
Cocaine Price - All Purchases	-.00239* (-1.77) $\epsilon = -0.116$	-.00250* (-1.81) $\epsilon = -0.121$	-.00408*** (-4.47) $\epsilon = -0.198$	-.00361*** (-4.04) $\epsilon = -0.175$
Joint F-statistic on 1 & 2 Year Lead Cocaine Price	1.51	1.44	7.16***	7.14***
Lag 1 Year Cocaine Price	Yes	Yes	Yes	Yes
Lag 2 Year Cocaine Price	Yes	Yes	No	Yes
Lag 3 Year Cocaine Price	Yes	Yes	No	No
Joint F-statistic on Lagged Cocaine Price	4.15***	5.60***	24.79***	21.51***
MSA SES Covariates	Yes***	Yes***	Yes*	Yes*
Year Effects	No	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
MSA-Quadratic Trend	No	No	No	No
R-Squared	0.446	0.555	0.846	0.856
Observations	277	277	279	278

Specification	5	6	7
Cocaine Price - All Purchases	-.00426*** (-4.85) $\epsilon = -0.206$	-.00156* (-1.72) $\epsilon = -0.076$	-.00155* (-1.72) $\epsilon = -0.075$
Joint F-statistic on 1 & 2 Year Lead Cocaine Price	7.90***	0.67	1.04
Lag 1 Year Cocaine Price	Yes	Yes	Yes
Lag 2 Year Cocaine Price	Yes	No	Yes
Lag 3 Year Cocaine Price	Yes	No	No
Joint F-statistic on Lagged Cocaine Price	20.70***	3.80*	3.22**
MSA SES Covariates	Yes*	Yes	Yes
Year Effects	Yes***	Yes*	Yes*
MSA Effects	Yes***	Yes***	Yes***
MSA-Linear Trend	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No
R-Squared	0.865	0.910	0.912
Observations	277	279	278

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-12 Contd.
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	8	9	10	11
Cocaine Price - All Purchases	-.00222** (-2.35) $\varepsilon = -0.108$	-.00164 (-1.61) $\varepsilon = -0.079$	-.00204* (-1.96) $\varepsilon = -0.099$	-.00286** (-2.57) $\varepsilon = -0.139$
Joint F-statistic on 1 & 2 Year Lead Cocaine Price	1.88	0.03	0.06	0.41
Lag 1 Year Cocaine Price	Yes	Yes	Yes	Yes
Lag 2 Year Cocaine Price	Yes	No	Yes	Yes
Lag 3 Year Cocaine Price	Yes	No	No	Yes
Joint F-statistic on Lagged Cocaine Price	3.65**	2.59	2.82*	3.20**
MSA SES Covariates	Yes	Yes	Yes	Yes
Year Effects	Yes**	Yes**	Yes**	Yes***
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	Yes***	Yes***	Yes***	Yes***
MSA-Quadratic Trend	No	Yes**	Yes**	Yes***
R-Squared	0.912	0.920	0.921	0.922
Observations	277	279	278	277

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-13
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3	4
Heroin Price - All Purchases	-.00025 (-1.45) $\epsilon = -0.119$	-.00033* (-1.83) $\epsilon = -0.157$	-.00008 (-0.97)	-.00008 (-0.92)
Joint F-statistic on 1 & 2 Year Lead Heroin Price	0.35	3.14**	1.09	1.05
Lag 1 Year Heroin Price	Yes	Yes	Yes	Yes
Lag 2 Year Heroin Price	Yes	Yes	No	Yes
Lag 3 Year Heroin Price	Yes	Yes	No	No
Joint F-statistic on Lagged Heroin Price	2.57*	6.17***	7.72***	3.93**
MSA SES Covariates	Yes***	Yes***	Yes	Yes*
Year Effects	No	Yes***	Yes**	Yes*
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
MSA-Quadratic Trend	No	No	No	No
R-Squared	0.245	0.313	0.886	0.880
Observations	239	239	244	242

Specification	5	6	7
Heroin Price - All Purchases	-.00007 (-0.86)	-.000005 (-0.06)	-.00002 (-0.24)
Joint F-statistic on 1 & 2 Year Lead Heroin Price	0.99	0.36	0.23
Lag 1 Year Heroin Price	Yes	Yes	Yes
Lag 2 Year Heroin Price	Yes	No	Yes
Lag 3 Year Heroin Price	Yes	No	No
Joint F-statistic on Lagged Heroin Price	2.47*	11.00***	5.88***
MSA SES Covariates	Yes*	Yes	Yes
Year Effects	Yes	Yes	Yes
MSA Effects	Yes***	Yes***	Yes***
MSA-Linear Trend	No	Yes***	Yes***
MSA-Quadratic Trend	No	No	No
R-Squared	0.886	0.936	0.936
Observations	239	244	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for heroin use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-13 Contd.
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	8	9	10	11
Heroin Price - All Purchases	-0.000008 (-0.11)	-0.00017** (-2.00) $\epsilon = -0.081$	-0.00021** (-2.36) $\epsilon = -0.100$	-0.00020** (-2.06) $\epsilon = -0.095$
Joint F-statistic on 1 & 2 Year Lead Heroin Price	0.27	0.37	0.56	0.49
Lag 1 Year Heroin Price	Yes	Yes	Yes	Yes
Lag 2 Year Heroin Price	Yes	No	Yes	Yes
Lag 3 Year Heroin Price	Yes	No	No	Yes
Joint F-statistic on Lagged Heroin Price	4.59***	18.43***	10.37***	6.93***
MSA SES Covariates	Yes	Yes**	Yes*	Yes*
Year Effects	Yes	Yes	Yes	Yes
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	Yes***	Yes***	Yes***	Yes***
MSA-Quadratic Trend	No	Yes***	Yes***	Yes***
R-Squared	0.936	0.944	0.945	0.944
Observations	239	244	242	239

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for heroin use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-14
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3
Cocaine Price - All Purchases	-0.00466*** (-5.36) $\epsilon = -0.226$	-0.00455*** (-5.29) $\epsilon = -0.220$	-0.00453*** (-5.21) $\epsilon = -0.220$
Drug Possession Arrest Rate	Yes*	Yes	Yes
MSA SES Covariates	Yes***	Yes***	Yes***
Lagged Enforcement Variables Group 1	No	Yes**	No
Lagged Enforcement Variables Group 2	No	No	Yes
Year Effects	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.864	0.867	0.865
Observations	291	291	291

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Group 1 enforcement variables are: drug violation arrest rate and drug sale arrest rate. Group 2 enforcement variables are: drug violation arrest rate, cocaine sale arrest rate, and marijuana sale arrest rate. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-15
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3
Heroin Price - All Purchases	-0.00030*** (-2.80) $\epsilon = -0.135$	-0.00024** (-2.38) $\epsilon = -0.108$	-0.00021*** (-2.07) $\epsilon = -0.094$
Drug Possession Arrest Rate	Yes	Yes	Yes
MSA SES Covariates	Yes*	Yes	Yes
Lagged Enforcement Variables Group 1	No	Yes***	No
Lagged Enforcement Variables Group 2	No	No	Yes***
Year Effects	Yes**	Yes**	Yes**
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.863	0.875	0.878
Observations	247	247	247

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. See notes for Table 3-14.

Table 3-16
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	1	2	3
Cocaine Price - All Purchases	-0.00374*** (-2.72) $\epsilon = -0.181$	-	-0.00347 ** (-2.43) $\epsilon = -0.168$
Heroin Price - All Purchases	0.00012 (1.29)	-	0.00017 (1.64)
1 Year Lagged Cocaine Price	-	-0.00305 ** (-2.24) $\epsilon = -0.153$	-0.00285* (-1.96) $\epsilon = -0.143$
1 Year Lagged Heroin Price	-	0.00005 (0.61)	-0.00285 (0.19)
MSA SES Covariates	Yes***	Yes***	Yes***
Year Effects	No	No	No
MSA Effects	No	No	No
R-Squared	0.4363	0.4312	0.4488
Observations	301	301	294

Specification	4	5	6
Cocaine Price - All Purchases	-0.00489*** (-3.76) $\epsilon = -0.237$	-	-0.00330** (-2.43) $\epsilon = -0.160$
Heroin Price - All Purchases	-0.00029*** (-3.16) $\epsilon = -0.086$	-	-0.00015 (-1.59)
1 Year Lagged Cocaine Price	-	-0.00533*** (-4.26) $\epsilon = -0.267$	-0.00366*** (-2.70) $\epsilon = -0.183$
1 Year Lagged Heroin Price	-	-0.00028*** (-3.70) $\epsilon = -0.098$	-0.00023*** (-2.83) $\epsilon = -0.080$
MSA SES Covariates	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes***	Yes***
MSA Effects	No	No	No
R-Squared	0.5683	0.5952	0.6083
Observations	301	301	294

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-16 Contd.
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis

Specification	7	8	9
Cocaine Price - All Purchases	-0.00552*** (-5.36) $\epsilon = -0.267$	-	-0.00461*** (-4.66) $\epsilon = -0.223$
Heroin Price - All Purchases	-0.00013* (-1.87) $\epsilon = -0.038$	-	-0.00006 (-0.80)
1 Year Lagged Cocaine Price	-	-0.00474*** (-5.07) $\epsilon = -0.238$	-0.00435*** (-4.73) $\epsilon = -0.218$
1 Year Lagged Heroin Price	-	-0.00018*** (-3.21) $\epsilon = -0.063$	-0.00016*** (-2.85) $\epsilon = -0.056$
MSA SES Covariates	Yes*	Yes**	Yes
Year Effects	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.8389	0.8438	0.8532
Observations	301	301	294

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-17
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	1	2	3
Cocaine Price - All Purchases	-0.00207 (-0.99)	-	-0.00078 (-0.36)
Heroin Price - All Purchases	-0.00060*** (-4.38) $\epsilon = -0.270$	-	-0.00041** (-2.59) $\epsilon = -0.184$
1 Year Lagged Cocaine Price	-	-0.00306 (-1.49)	-0.00105 (-0.47)
1 Year Lagged Heroin Price	-	-0.00041*** (-3.47) $\epsilon = -0.217$	-0.00031** (-2.35) $\epsilon = -0.164$
MSA SES Covariates	Yes***	Yes***	Yes***
Year Effects	No	No	No
MSA Effects	No	No	No
R-Squared	0.2107	0.2028	0.2219
Observations	301	301	294

Specification	4	5	6
Cocaine Price - All Purchases	-0.00390* (-1.74) $\epsilon = -0.288$	-	-0.00192 (-0.78)
Heroin Price - All Purchases	-0.00082*** (-5.10) $\epsilon = -0.369$	-	-0.00065*** (-3.71) $\epsilon = -0.292$
1 Year Lagged Cocaine Price	-	-0.00402* (-1.79) $\epsilon = -0.307$	-0.00101 (-0.41)
1 Year Lagged Heroin Price	-	-0.00056*** (-4.20) $\epsilon = -0.297$	-0.00042*** (-2.95) $\epsilon = -0.223$
MSA SES Covariates	Yes***	Yes***	Yes***
Year Effects	Yes	Yes	Yes
MSA Effects	No	No	No
R-Squared	0.2135	0.1963	0.2340
Observations	301	301	294

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-17 Contd.
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis

Specification	7	8	9
Cocaine Price - All Purchases	0.00175 (1.43)	-	0.00186 (1.50)
Heroin Price - All Purchases	-0.00017** (-2.03) $\varepsilon = -0.076$	-	-0.00016* (-1.80) $\varepsilon = -0.072$
1 Year Lagged Cocaine Price	-	0.00040 (0.36)	0.00051 (0.45)
1 Year Lagged Heroin Price	-	-0.00005 (-0.82)	-0.00008 (-1.16)
MSA SES Covariates	Yes*	Yes*	Yes
Year Effects	Yes	Yes	Yes
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.8601	0.8570	0.8607
Observations	301	301	294

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-18
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use: Urinalysis vs. Self-Report

Dependent Variable	Cocaine Use Urinalysis	Cocaine Use Self-Report	Cocaine Use Urinalysis	Cocaine Use Self-Report
Specifications	1	1	2	2
Cocaine Price - All Purchases	-0.00477*** (-4.39) ME=0.0012 $\epsilon = -0.223$	-0.00521*** (-4.56) ME=0.0009 $\epsilon = -0.326$	-0.00490*** (-5.25) ME=0.0012 $\epsilon = -0.229$	-0.00403*** (-4.16) ME=0.0007 $\epsilon = -0.252$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
R-Squared	0.595	0.423	0.842	0.781
Observations	257	257	257	257

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use (urinalysis) or the percentage of arrestees in each MSA reporting positive cocaine use in the past 72 hours (self-report). T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Log Recent Cocaine Use: Urinalysis vs. Self-Report

Dependent Variable	Cocaine Use Urinalysis	Cocaine Use Self-Report	Cocaine Use Urinalysis	Cocaine Use Self-Report
Specifications	1	1	2	2
Log Cocaine Price All Purchases	-0.26820*** (-4.09)	-0.60719*** (-4.00)	-0.23203*** (-3.81)	-0.33406** (-2.45)
MSA SES Covariates	Yes***	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes***	Yes*	Yes***
MSA Effects	No	No	Yes***	Yes***
R-Squared	0.580	0.337	0.817	0.730
Observations	257	257	257	257

Notes: Dependent variable is $\log(p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use (urinalysis) or the percentage of arrestees in each MSA reporting positive cocaine use in the past 72 hours (self-report). Price is logarithmic. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-19
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use: Urinalysis vs. Self-Report

Dependent Variable	Heroin Use Urinalysis	Heroin Use Self-Report	Heroin Use Urinalysis	Heroin Use Self-Report
Specifications	1	1	2	2
Heroin Price - All Purchases	-0.00084*** (-4.66) ME=0.00006 $\varepsilon = -0.375$	-0.00089*** (-3.97) ME=0.00004 $\varepsilon = -0.412$	-0.00023** (-2.19) ME=0.00002 $\varepsilon = -0.101$	-0.00034* (-1.82) ME=0.00002 $\varepsilon = -0.159$
MSA SES Covariates	Yes***	Yes***	Yes*	Yes
Year Effects	Yes	Yes	Yes**	Yes
MSA Effects	No	No	Yes***	Yes***
R-Squared	0.335	0.428	0.878	0.774
Observations	221	221	221	221

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use (urinalysis) or the percentage of arrestees in each MSA reporting positive heroin use in the past 72 hours (self-report). T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Log Recent Heroin Use: Urinalysis vs. Self-Report

Dependent Variable	Heroin Use Urinalysis	Heroin Use Self-Report	Heroin Use Urinalysis	Heroin Use Self-Report
Specifications	1	1	2	2
Log Heroin Price All Purchases	-0.34031*** (-3.21)	-0.50809*** (-3.36)	-0.04581 (-0.75)	-0.20625 (-1.55)
MSA SES Covariates	Yes***	Yes***	Yes**	Yes*
Year Effects	Yes	Yes	Yes**	Yes*
MSA Effects	No	No	Yes***	Yes***
R-Squared	0.298	0.336	0.873	0.728
Observations	221	221	221	221

Notes: Dependent variable is $\log(p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use (urinalysis) or the percentage of arrestees in each MSA reporting positive heroin use in the past 72 hours (self-report). Price is logarithmic. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-20
Drug Use Forecasting Arrestee Data
Logistic Recent Cocaine Use Urinalysis
Arellano – Bond Estimation

Specification	1	2	3	4
Lagged 1 Year Cocaine Use	0.43042*** (7.24)	0.41536*** (6.77)	0.55038*** (9.33)	0.53297*** (8.68)
Cocaine Price - All Purchases	-0.00541*** (-5.75) SR ϵ =-0.260 LR ϵ =-0.456	-0.00632*** (-6.04) SR ϵ =-0.304 LR ϵ =-0.520	-0.00293*** (-2.74) SR ϵ =-0.141 LR ϵ =-0.314	-0.00366*** (-2.88) SR ϵ =-0.176 LR ϵ =-0.377
Year Effects	No	No	Yes	Yes
Cocaine Price Instrumented	No	Yes	No	Yes
Sargan Overidentification Test	0.053	0.046	0.240	0.145
AR(1) Test	0.000	0.000	0.000	0.000
AR(2) Test	0.061	0.059	0.245	0.199
Observations	229	229	229	229

Specification	1	2	3	4
Lagged 1 Year Cocaine Use	0.41482*** (7.09)	0.41537*** (6.83)	0.52473*** (9.14)	0.53432*** (8.82)
Cocaine Price - Retail Purchases	-0.00410*** (-5.54) SR ϵ =-0.206 LR ϵ =-0.352	-0.00453*** (-5.26) SR ϵ =-0.228 LR ϵ =-0.390	-0.00236*** (-3.08) SR ϵ =-0.119 LR ϵ =-0.250	-0.00242*** (-2.57) SR ϵ =-0.122 LR ϵ =-0.262
Year Effects	No	No	Yes	Yes
Cocaine Price Instrumented	No	Yes	No	Yes
Sargan Overidentification Test	0.020	0.132	0.240	0.121
AR(1) Test	0.000	0.000	0.000	0.000
AR(2) Test	0.121	0.287	0.245	0.283
Observations	229	229	229	229

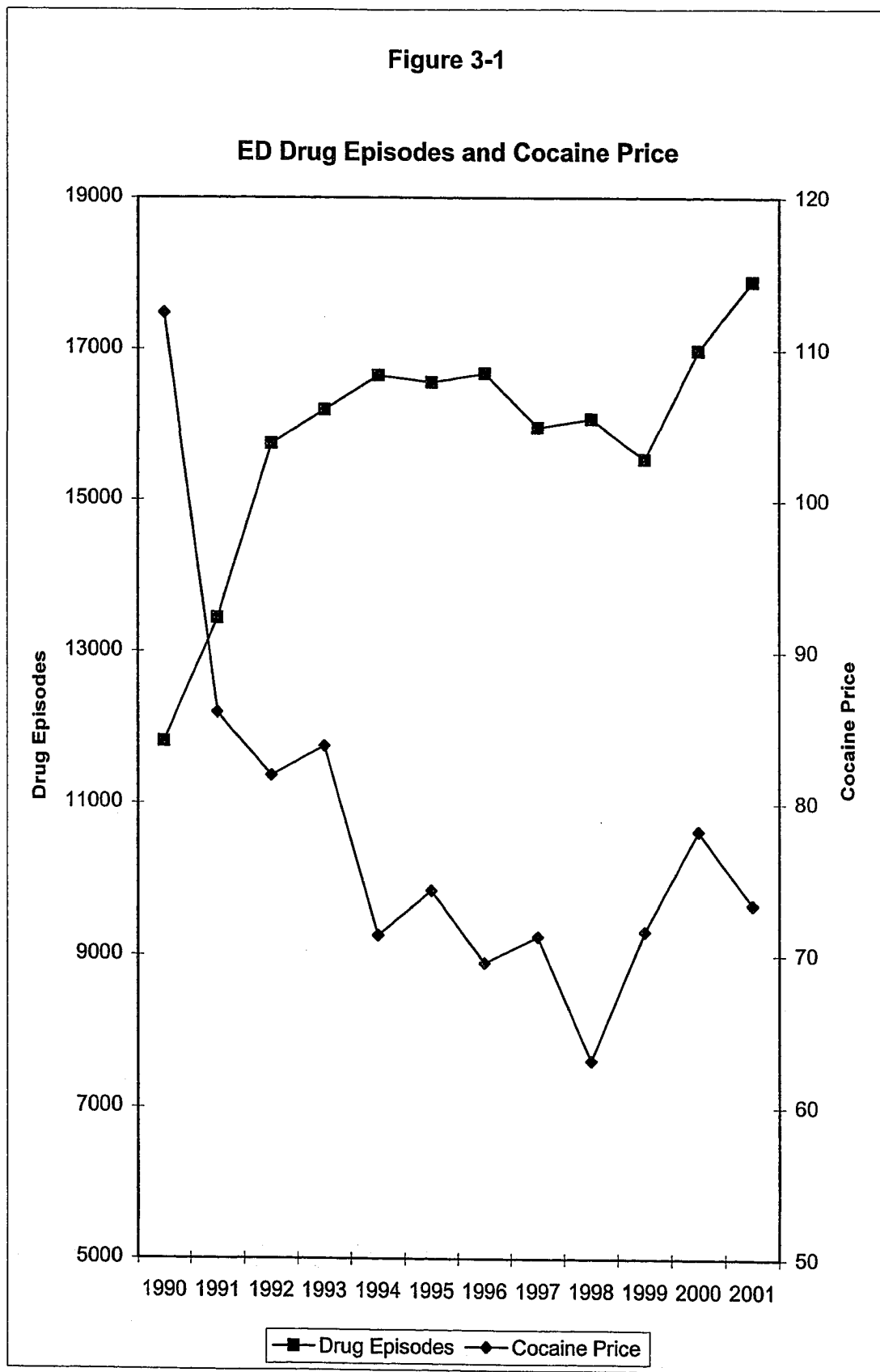
Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for cocaine use. Z-values are in parentheses. For the Sargan overidentification and AR tests, p-values are reported. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. All models include MSA SES covariates: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate.

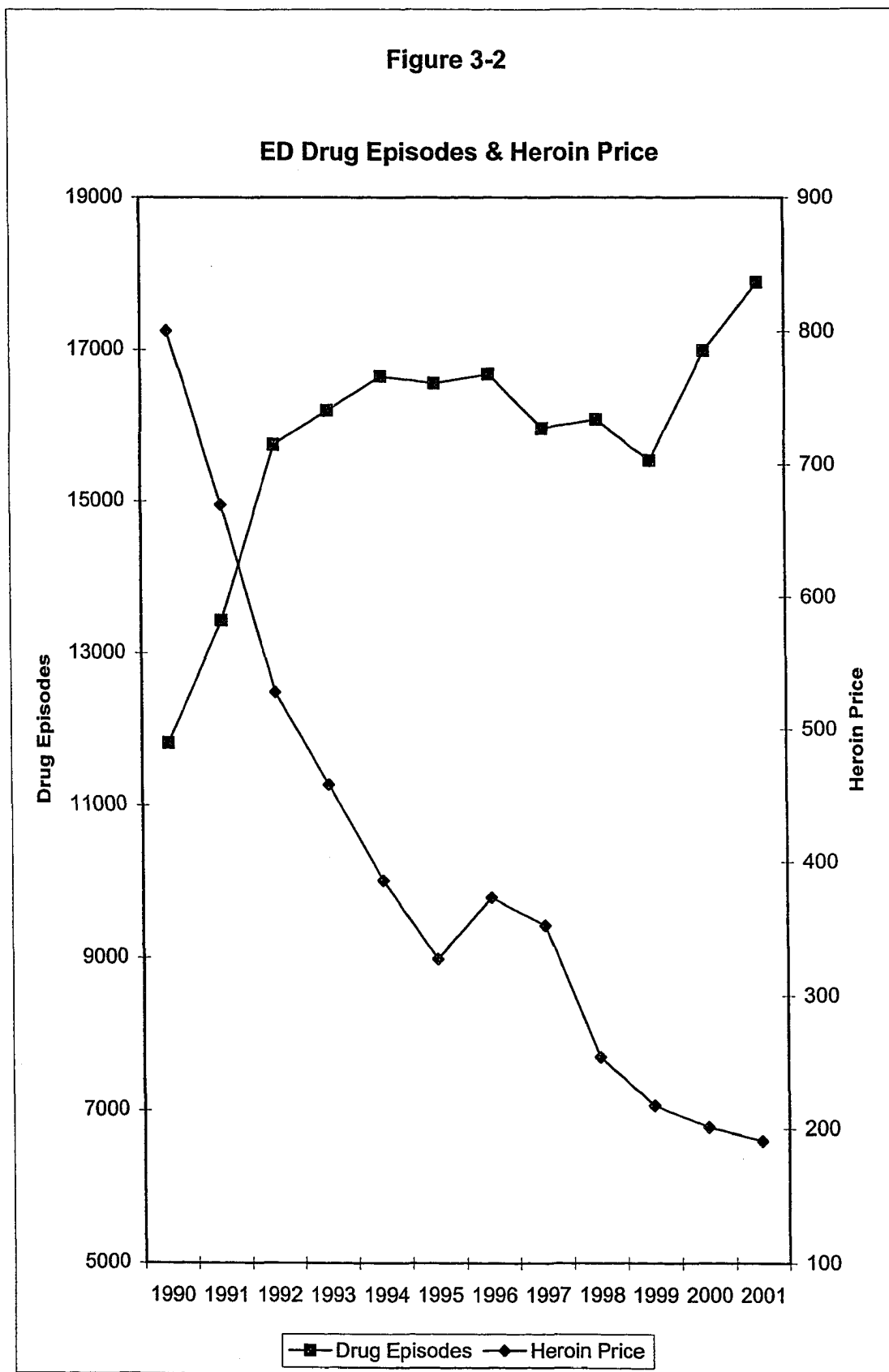
Table 3-21
Drug Use Forecasting Arrestee Data
Logistic Recent Heroin Use Urinalysis
Arellano – Bond Estimation

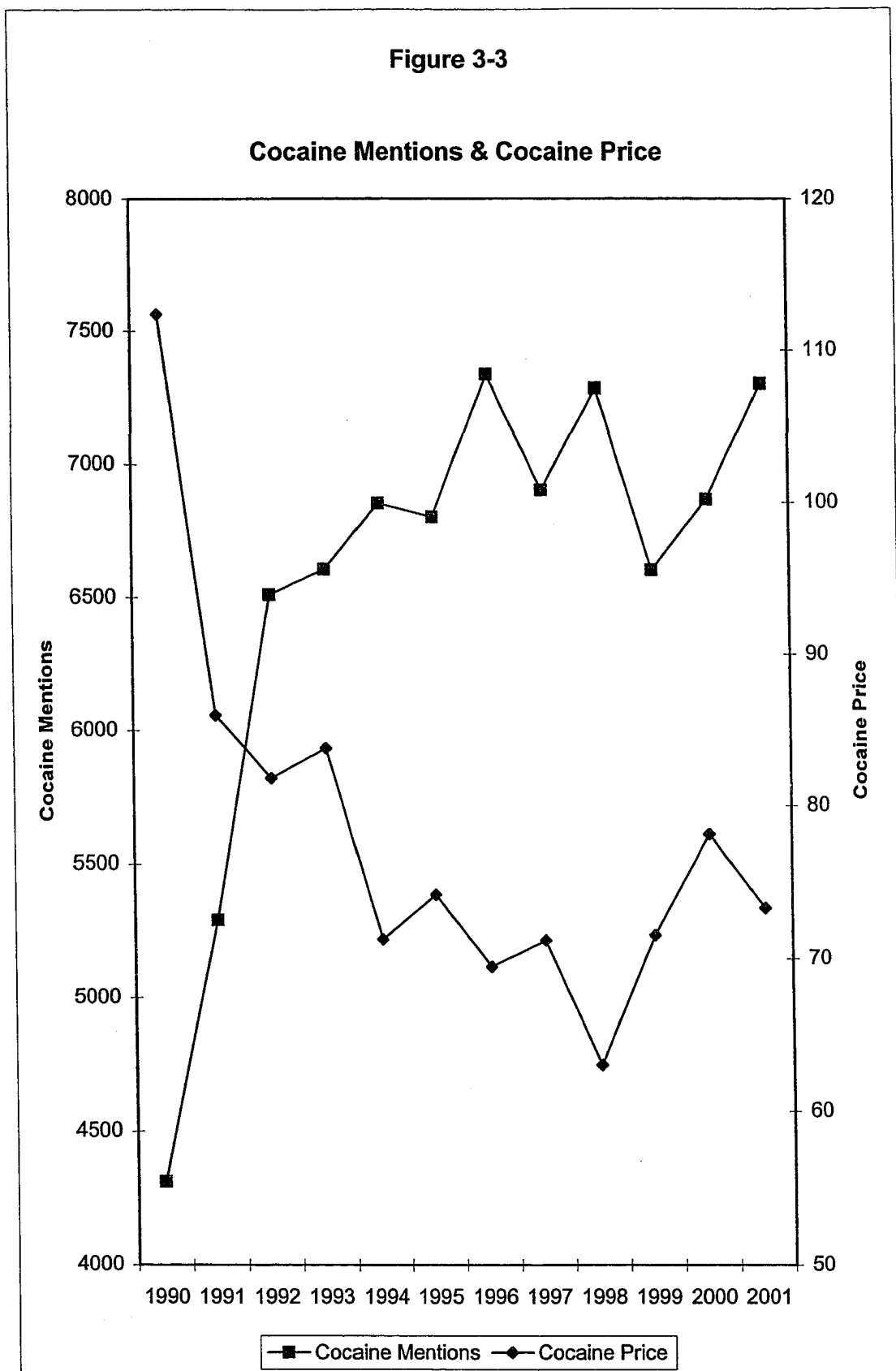
Specification	1	2	3	4
Lagged 1 Year Heroin Use	0.33113*** (4.55)	0.30690*** (4.05)	0.41881*** (5.87)	0.41244*** (5.52)
Heroin Price - All Purchases	-0.00023*** (-2.57) SR ϵ =-0.096 LR ϵ =-0.144	-0.00023** (-2.28) SR ϵ =-0.096 LR ϵ =-0.139	-0.00019* (-1.87) SR ϵ =-0.079 LR ϵ =-0.136	-0.00015 (-1.31) SR ϵ =-0.063 LR ϵ =-0.107
Year Effects	No	No	Yes	Yes
Heroin Price Instrumented	No	Yes	No	Yes
Sargan Overidentification Test	0.146	0.086	0.497	0.359
AR(1) Test	0.000	0.000	0.000	0.000
AR(2) Test	0.076	0.068	0.251	0.246
Observations	193	193	193	193

Specification	1	2	3	4
Lagged 1 Year Heroin Use	0.27980*** (3.77)	0.25945*** (3.29)	0.34618*** (4.79)	0.33696*** (4.42)
Heroin Price - Retail Purchases	-0.00028*** (-3.12) SR ϵ =-0.120 LR ϵ =-0.167	-0.00032*** (-3.03) SR ϵ =-0.137 LR ϵ =-0.185	-0.00023** (-2.31) SR ϵ =-0.098 LR ϵ =-0.150	-0.00018 (-1.59) SR ϵ =-0.077 LR ϵ =-0.116
Year Effects	No	No	Yes	Yes
Heroin Price Instrumented	No	Yes	No	Yes
Sargan Overidentification Test	0.120	0.116	0.303	0.169
AR(1) Test	0.000	0.000	0.000	0.000
AR(2) Test	0.062	0.049	0.189	0.191
Observations	191	191	191	191

Notes: Dependent variable is $\log(p/1-p)$ where p is the percentage of arrestees in each MSA testing positive for opiate use. Z-values are in parentheses. For the Sargan overidentification and AR tests, p-values are reported. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. All models include MSA SES covariates: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, and college graduate.







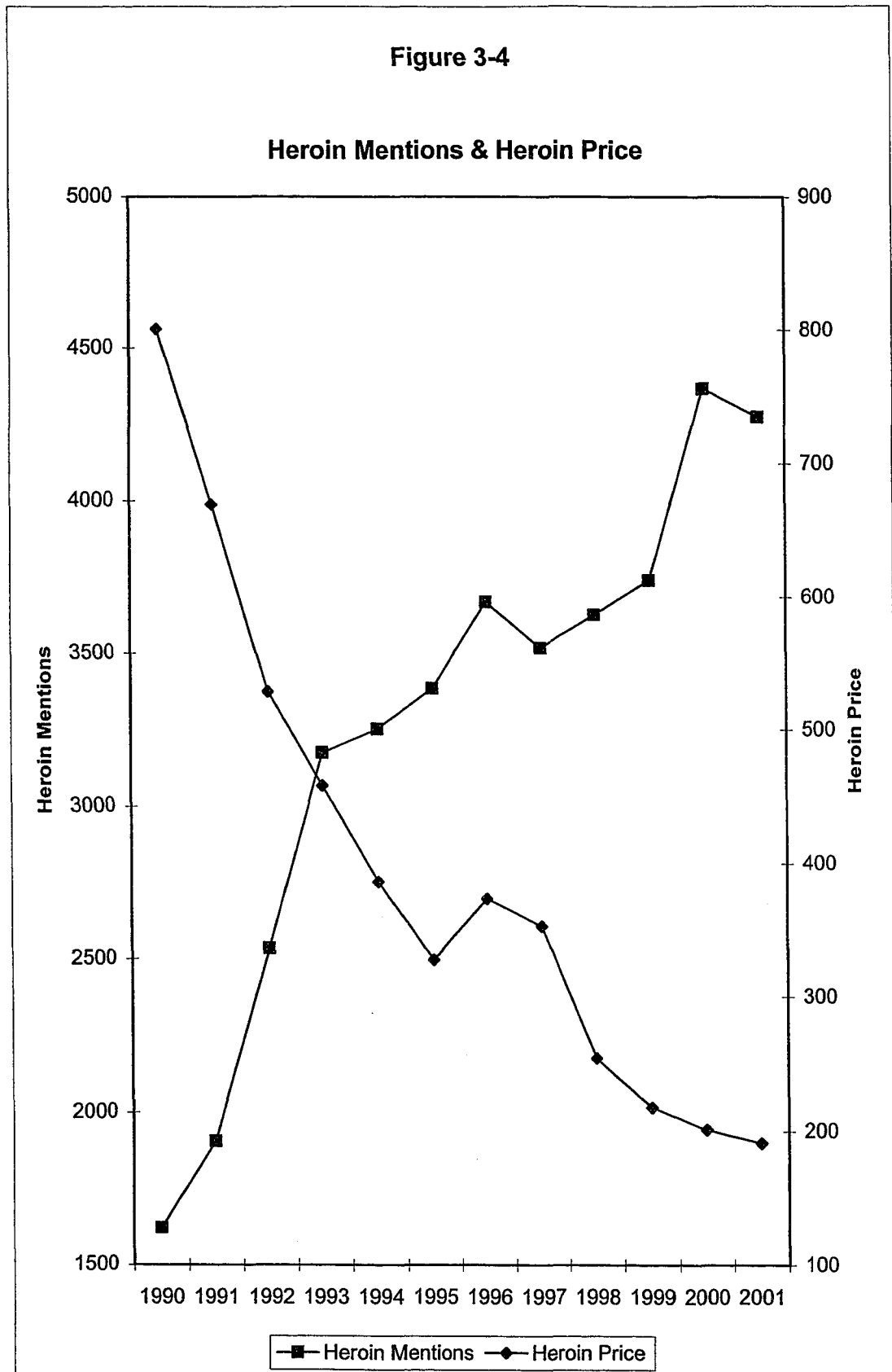


Table 3-22
Drug Abuse Warning Network ED Episodes Data
Sample Means

Variable	Definition	Mean
Drug Episode Rate	Total drug related emergency department episodes in each MSA divided by MSA population	0.00312 (0.00130)
Logistic Drug Episodes	Log of the odds of drug episode rate	-5.84686 (0.39722)
Cocaine Mention Rate	Total number of times cocaine was mentioned in the emergency department drug episodes in each MSA divided by MSA population	0.00118 (0.00074)
Logistic Cocaine Mentions	Log of the odds of cocaine mention rate	-6.96593 (0.71745)
Heroin Mention Rate	Total number of times heroin was mentioned in the emergency department drug episodes in each MSA divided by MSA population	0.00064 (0.00070)
Logistic Heroin Mentions	Log of the odds of heroin mention rate	-7.91555 (1.11526)
Cocaine Price - All	Price of one pure gram of cocaine, based on all purchases, divided by the annual national consumer price index	80.69862 (24.78975)
Cocaine Price - Retail	Price of one pure gram of cocaine, based on purchases of 40 grams or less, divided by the annual national consumer price index	79.90997 (27.82333)
Heroin Price - All	Price of one pure gram of heroin, based on all purchases, divided by the annual national consumer price index	451.07930 (387.55420)
Heroin Price - Retail	Price of one pure gram of heroin, based on purchases of 40 grams or less, divided by the annual national consumer price index	451.78890 (397.35880)
Personal Income	Per capita personal income in each MSA, divided by the annual national consumer price index	18211.73 (3170.00)
Unemployment	Unemployment rate in each MSA	0.05210 (0.01764)
Male	Percent of MSA population that are male	0.47763 (0.01874)
Black	Percent of MSA population that are black	0.15666 (0.10028)
Other	Percent of MSA population that are of a race other than white or black	0.05510 (0.04955)

Table 3-22 Contd.
Drug Abuse Warning Network ED Episodes Data
Sample Means

Hispanic	Percent of MSA population that are hispanic	0.12228 (0.14198)
Age 16 – 24	Percent of MSA population that are aged 16 to 24	0.16254 (0.02110)
Age 25 – 54	Percent of MSA population that are aged 25 to 54	0.59057 (0.03876)
High School	Percent of MSA population that are high school graduates	0.80013 (0.05517)
College	Percent of MSA population that are college graduates	0.25992 (0.05852)
Response Rate	Responding sample hospitals as a fraction of total eligible hospitals	0.57047 (0.16351)
Log Response Rate	Log of response rate	-0.60215 (0.28718)
Drug Possession Arrest Rate	Total number of arrests in each MSA due to any drug possession divided by MSA population	0.00388 (0.00217)
Drug Violation Arrest Rate	Total number of arrests in each MSA due to any drug violation divided by MSA population	0.00588 (0.00295)
Drug Sale Arrest Rate	Total number of arrests in each MSA due to any drug sale or trafficking divided by MSA population	0.00171 (0.00138)
Cocaine Sale Arrest Rate	Total number of arrests in each MSA due to cocaine sale or trafficking divided by MSA population	0.00108 (0.00119)
Marijuana Sale Arrest Rate	Total number of arrests in each MSA due to marijuana sale or trafficking divided by MSA population	0.00033 (0.00027)
Violent Crimes Arrest Rate	Total number of violent crimes arrests in each MSA divided by MSA population	0.00297 (0.00138)
Relative Unskilled Wage	Median wage in the 25 th percentile relative to the median wage in the 90 th percentile in each MSA	0.19399 (0.03271)
Log Relative Unskilled Wage	Log of relative unskilled wage	-1.65470 (0.17480)
Population	Total MSA Population	3732931 (2363680)
Observations		252

Notes: Standard deviations are in parentheses. Number of observations listed represents the maximum number. For some variables, the actual sample size is slightly less due to missing information.

Table 3-23
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3	4
Cocaine Price - All Purchases	-0.00780*** (-5.39) $\epsilon = -0.629$	-0.00627*** (-3.57) $\epsilon = -0.505$	-0.00433*** (-3.83) $\epsilon = -0.349$	-0.00311*** (-3.22) $\epsilon = -0.251$
Personal Income	0.00010*** (5.29)	Yes***	Yes***	Yes
Unemployment	10.67600*** (4.47)			
Male	0.21017 (0.10)			
Black	4.54543*** (10.50)			
Other	0.04310 (0.04)			
Hispanic	-0.47635 (-1.30)			
Age 16 - 24	-7.87504*** (-4.75)			
Age 25 - 54	-4.31507*** (-3.92)			
High School Graduate	0.77194 (0.56)			
College Graduate	-1.85415* (-1.83)			
Log Response Rate	0.16127 (1.22)			
Drug Possession Arrest Rate	-41.50875** (-2.56)			
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.585	0.594	0.898	0.943
Observations	251	251	251	251

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-23 Contd.
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3	4
Cocaine Price - Retail Purchases	-0.00740*** (-5.80) $\varepsilon = -0.591$	-0.00616*** (-4.16) $\varepsilon = -0.492$	-0.00306*** (-3.30) $\varepsilon = -0.244$	-0.00191** (-2.49) $\varepsilon = -0.152$
Drug Possession Arrest Rate	-41.8035** (-2.60)	-63.78731*** (-3.74)	-21.05118 (-1.43)	-1.75271 (-0.09)
MSA SES Covariates	Yes***	Yes***	Yes***	Yes
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.592	0.602	0.896	0.942
Observations	251	251	251	251

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-24
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3	4
Heroin Price - All Purchases	-0.00100*** (-7.35) $\varepsilon = -0.451$	-0.00092*** (-6.18) $\varepsilon = -0.415$	-0.00028*** (-3.75) $\varepsilon = -0.126$	-0.00007 (-1.21)
Personal Income	0.00019*** (6.80)			
Unemployment	20.39010*** (5.52)			
Male	5.90746* (1.82)			
Black	2.51106*** (3.73)			
Other	2.44845 (1.48)			
Hispanic	-0.96254* (-1.72)	Yes***	Yes***	Yes
Age 16 - 24	-8.84093*** (-3.33)			
Age 25 - 54	-9.85771*** (-5.67)			
High School Graduate	1.45019 (0.67)			
College Graduate	-1.15406 (0.73)			
Log Response Rate	0.573549*** (2.74)			
Drug Possession Arrest Rate	12.48809 (0.48)	-27.2934 (-1.03)	-42.33516** (-2.25)	-22.92686 (-0.95)
Year Effects	No	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.588	0.621	0.932	0.964
Observations	246	246	246	246

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-24 Contd.
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3	4
Heroin Price - Retail Purchases	-0.00100*** (-7.50) $\epsilon = -0.452$	-0.00090*** (-6.20) $\epsilon = -0.406$	-0.00029*** (-4.07) $\epsilon = -0.131$	-0.00008 (-1.35) $\epsilon = -0.036$
Drug Possession Arrest Rate	13.25984 (0.52)	-24.99471 (-0.95)	-41.97284** (-2.24)	-22.0681 (-0.91)
MSA SES Covariates	Yes***	Yes***	Yes***	Yes
Year Effects	No	Yes***	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.5907	0.6208	0.9311	0.9638
Observations	245	245	245	245

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-25
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3	4
Cocaine Price - All Purchases	-0.00593*** (-3.77) $\varepsilon = -0.478$	-0.00451** (-2.26) $\varepsilon = -0.364$	-0.00412*** (-3.72) $\varepsilon = -0.332$	-0.00355*** (-3.74) $\varepsilon = -0.287$
1 Year Lagged Cocaine Price	-0.00396** (-2.49) $\varepsilon = -0.323$	-0.00418** (-2.15) $\varepsilon = -0.341$	-0.00338*** (-3.14) $\varepsilon = -0.275$	-0.00302*** (-3.27) $\varepsilon = -0.246$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes**
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.582	0.575	0.901	0.945
Observations	250	250	250	250

Specification	1	2	3	4
Cocaine Price - Retail Purchases	-0.00577*** (-4.16) $\varepsilon = -0.461$	-0.00460*** (-2.72) $\varepsilon = -0.367$	-0.00346*** (-3.68) $\varepsilon = -0.276$	-0.00244*** (-3.09) $\varepsilon = -0.195$
1 Year Lagged Cocaine Price	-0.00397*** (-2.92) $\varepsilon = -0.320$	-0.00418** (-2.60) $\varepsilon = -0.337$	-0.00218** (-2.35) $\varepsilon = -0.176$	-0.00192** (-2.45) $\varepsilon = -0.155$
MSA Level Covariates	Yes***	Yes***	Yes***	Yes*
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.590	0.5836	0.898	0.943
Observations	250	250	250	250

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-26
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3	4
Cocaine Price - All Purchases	-0.00552*** (-3.24) $\epsilon = -0.445$	-0.00457** (-2.21) $\epsilon = -0.368$	-0.00404*** (-3.62) $\epsilon = -0.326$	-0.00369*** (-3.86) $\epsilon = -0.297$
1 Year Lagged Cocaine Price	-0.00373** (-2.22) $\epsilon = -0.304$	-0.00424** (-2.05) $\epsilon = -0.346$	-0.00326*** (-2.97) $\epsilon = -0.266$	-0.00311*** (-3.36) $\epsilon = -0.253$
2 Year Lagged Cocaine Price	-0.00119 (0.77)	0.00033 (0.18)	-0.00059 (-0.61)	-0.00103 (-1.28)
MSA SES Covariates	Yes***	Yes***	Yes***	Yes**
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.578	0.571	0.899	0.945
Observations	249	249	249	249

Specification	1	2	3	4
Cocaine Price - Retail Purchases	-0.00494*** (-3.36) $\epsilon = -0.394$	-0.00413** (-2.35) $\epsilon = -0.330$	-0.00328*** (-3.48) $\epsilon = -0.262$	-0.00254*** (-3.20) $\epsilon = -0.203$
1 Year Lagged Cocaine Price	-0.00315** (-2.20) $\epsilon = -0.254$	-0.00313* (-1.77) $\epsilon = -0.252$	-0.00223** (-2.35) $\epsilon = -0.180$	-0.00201** (-2.49) $\epsilon = -0.162$
2 Year Lagged Cocaine Price	-0.00283** (-2.00) $\epsilon = -0.233$	-0.00214 (-1.30) $\epsilon = -0.176$	-0.00138 (-1.53) $\epsilon = -0.114$	-0.00112 (-1.49) $\epsilon = -0.092$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes*
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.590	0.580	0.898	0.943
Observations	249	249	249	249

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-27
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3	4
Heroin Price - All Purchases	-0.00073*** (-5.40) $\epsilon = -0.329$	-0.00071*** (-4.87) $\epsilon = -0.320$	-0.00030*** (-4.05) $\epsilon = -0.135$	-0.00009 (-1.59) $\epsilon = -0.041$
1 Year Lagged Heroin Price	-0.00080*** (-5.95) $\epsilon = -0.393$	-0.00073*** (-5.16) $\epsilon = -0.359$	-0.00021*** (-2.91) $\epsilon = -0.103$	-0.00001 (-0.19)
MSA SES Covariates	Yes***	Yes***	Yes***	Yes
Year Effects	No	Yes**	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.642	0.661	0.933	0.967
Observations	244	244	244	244

Specification	1	2	3	4
Heroin Price - Retail Purchases	-0.00064*** (-4.69) $\epsilon = -0.289$	-0.00061*** (-4.13) $\epsilon = -0.275$	-0.00029*** (-3.92) $\epsilon = -0.131$	-0.00010* (-1.71) $\epsilon = -0.045$
1 Year Lagged Heroin Price	-0.00074*** (-5.68) $\epsilon = -0.368$	-0.00066*** (-4.90) $\epsilon = -0.328$	-0.00020*** (-2.96) $\epsilon = -0.099$	-0.00001 (-0.17)
MSA Level Covariates	Yes***	Yes***	Yes***	Yes
Year Effects	No	Yes**	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.641	0.661	0.931	0.965
Observations	242	242	242	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-28
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3	4
Heroin Price - All Purchases	-0.00062*** (-4.90) $\epsilon = -0.279$	-0.00065*** (-4.71) $\epsilon = -0.293$	-0.00035*** (-4.80) $\epsilon = -0.158$	-0.00013** (-2.12) $\epsilon = -0.059$
1 Year Lagged Heroin Price	-0.00055*** (-4.19) $\epsilon = -0.270$	-0.00052*** (-3.78) $\epsilon = -0.256$	-0.00022*** (-3.09) $\epsilon = -0.108$	-0.00003 (-0.44)
2 Year Lagged Heroin Price	-0.00078*** (-6.29) $\epsilon = -0.419$	-0.00074*** (-5.72) $\epsilon = -0.398$	-0.00028*** (-3.96) $\epsilon = -0.151$	-0.00008 (-1.41) $\epsilon = -0.043$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes
Year Effects	No	Yes*	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.691	0.703	0.937	0.967
Observations	242	242	242	242

Specification	1	2	3	4
Heroin Price - Retail Purchases	-0.00057*** (-4.33) $\epsilon = -0.257$	-0.00057*** (-4.03) $\epsilon = -0.257$	-0.00037*** (-5.03) $\epsilon = -0.167$	-0.00015** (-2.48) $\epsilon = -0.068$
1 Year Lagged Heroin Price	-0.00048*** (-3.68) $\epsilon = -0.239$	-0.00045*** (-3.33) $\epsilon = -0.223$	-0.00018*** (-2.77) $\epsilon = -0.089$	-0.00002 (-0.34)
2 Year Lagged Heroin Price	-0.00070*** (-5.82) $\epsilon = -0.384$	-0.00065 (-5.21) $\epsilon = -0.357$	-0.00030*** (-4.59) $\epsilon = -0.165$	-0.00011** (-2.02) $\epsilon = -0.060$
MSA SES Covariates	Yes***	Yes***	Yes***	Yes
Year Effects	No	Yes**	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	Yes***
R-Squared	0.690	0.702	0.937	0.967
Observations	239	239	239	239

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-29
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3	4
Cocaine Price - All Purchases	-0.00325 (-1.55) $\varepsilon = -0.263$	-0.00159 (-0.65)	-0.00298** (-2.55) $\varepsilon = -0.242$	-.00287** (-2.42) $\varepsilon = -0.233$
Joint F on 1 & 2 Year Lead Cocaine Price	0.82	0.88	0.22	0.29
Lag 1 Year Coc Price	Yes	Yes	Yes	Yes
Lag 2 Year Coc Price	Yes	Yes	No	Yes
Lag 3 Year Coc Price	Yes	Yes	No	No
Joint F on Lagged Cocaine Price	0.88	0.61	8.91***	4.51**
MSA SES Covariates	Yes***	Yes***	Yes***	Yes***
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
R-Squared	0.595	0.589	0.918	0.916
Observations	204	204	206	205

Specification	5	6	7	8
Cocaine Price - All Purchases	-0.00297** (-2.50) $\varepsilon = -0.241$	-0.00259** (-2.43) $\varepsilon = -0.210$	-0.00273** (-2.53) $\varepsilon = -0.221$	-0.00301*** (-2.69) $\varepsilon = -0.244$
Joint F on 1 & 2 Year Lead Cocaine Price	0.32	1.46	1.89	2.23
Lag 1 Year Coc Price	Yes	Yes	Yes	Yes
Lag 2 Year Coc Price	Yes	No	Yes	Yes
Lag 3 Year Coc Price	Yes	No	No	Yes
Joint F on Lagged Cocaine Price	2.87**	6.88***	4.35**	3.30**
MSA SES Covariates	Yes***	Yes**	Yes**	Yes**
Year Effects	Yes***	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	Yes***	Yes***	Yes***
R-Squared	0.915	0.949	0.949	0.949
Observations	204	206	205	204

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-30
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3	4
Heroin Price - All Purchases	-0.00034** (-2.32) $\varepsilon = -0.160$	-0.00028* (-1.89) $\varepsilon = -0.132$	-0.00010 (-1.38) $\varepsilon = -0.047$	-0.00014** (-2.05) $\varepsilon = -0.066$
Joint F on 1 & 2 Year Lead Heroin Price	2.06	1.85	0.35	0.58
Lag 1 Year Her Price	Yes	Yes	Yes	Yes
Lag 2 Year Her Price	Yes	Yes	No	Yes
Lag 3 Year Her Price	Yes	Yes	No	No
Joint F on Lagged Heroin Price	24.81***	17.43***	7.93***	8.74***
MSA SES Covariates	Yes***	Yes***	Yes***	Yes***
Year Effects	No	Yes	Yes***	Yes***
MSA Effects	No	No	Yes***	Yes***
MSA-Linear Trend	No	No	No	No
R-Squared	0.754	0.763	0.960	0.963
Observations	178	178	180	179

Specification	5	6	7	8
Heroin Price - All Purchases	-0.00015** (-2.27) $\varepsilon = -0.071$	0.00003 (0.42)	-0.00002 (-0.29)	-0.00002 (-0.31)
Joint F on 1 & 2 Year Lead Heroin Price	0.43	0.99	0.43	0.37
Lag 1 Year Her Price	Yes	Yes	Yes	Yes
Lag 2 Year Her Price	Yes	No	Yes	Yes
Lag 3 Year Her Price	Yes	No	No	Yes
Joint F on Lagged Heroin Price	9.94***	0.00	1.05	0.72
MSA SES Covariates	Yes***	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes**	Yes**	Yes*
MSA Effects	Yes***	Yes***	Yes***	Yes***
MSA-Linear Trend	No	Yes***	Yes***	Yes***
R-Squared	0.966	0.979	0.979	0.979
Observations	178	180	179	178

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-31
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3
Cocaine Price - All Purchases	-0.00433*** (-3.83) $\varepsilon = -0.349$	-0.00421*** (-3.74) $\varepsilon = -0.339$	-0.00408*** (-3.61) $\varepsilon = -0.329$
Drug Possession Arrest Rate	Yes	Yes***	Yes**
MSA SES Covariates	Yes***	Yes***	Yes***
Lagged Enforcement Variables Group 1	No	Yes**	No
Lagged Enforcement Variables Group 2	No	No	Yes**
Year Effects	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.898	0.901	0.901
Observations	251	251	251

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. Group 1 enforcement variables are: drug violation arrest rate and drug sale arrest rate. Group 2 enforcement variables are: drug violation arrest rate, cocaine sale arrest rate, and marijuana sale arrest rate. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-32
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3
Heroin Price - All Purchases	-0.00028*** (-3.75) $\varepsilon = -0.126$	-0.00024*** (-3.24) $\varepsilon = -0.108$	-0.00022*** (-3.08) $\varepsilon = -0.099$
Drug Possession Arrest Rate	Yes**	Yes***	Yes***
MSA SES Covariates	Yes***	Yes***	Yes***
Lagged Enforcement Variables Group 1	No	Yes***	No
Lagged Enforcement Variables Group 2	No	No	Yes***
Year Effects	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.932	0.935	0.938
Observations	246	246	246

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. See notes for Table 3-31.

Table 3-33
Drug Abuse Warning Network ED Episodes Data
Logistic Drug Episodes

Specification	1	2	3
Cocaine Price - All Purchases	-0.00421*** (-4.31) $\epsilon = -0.339$	-	-0.00293*** (-2.92) $\epsilon = -0.236$
Heroin Price - All Purchases	-0.00015** (-2.55) $\epsilon = -0.067$	-	-0.00012* (-1.93) $\epsilon = -0.054$
1 Year Lagged Cocaine Price	-	-0.00317*** (-3.17) $\epsilon = -0.258$	-0.00192* (-1.91) $\epsilon = -0.156$
1 Year Lagged Heroin Price	-	-0.00020*** (-3.45) $\epsilon = -0.098$	-0.00013** (-2.21) $\epsilon = -0.064$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	No	No	No
MSA Effects	No	No	No
R-Squared	0.522	0.512	0.552
Observations	245	246	242

Specification	4	5	6
Cocaine Price - All Purchases	-0.00472*** (-4.22) $\epsilon = -0.380$	-	-0.00322*** (-2.71) $\epsilon = -0.259$
Heroin Price - All Purchases	-0.00018*** (-2.82) $\epsilon = -0.081$	-	-0.00016** (-2.51) $\epsilon = -0.072$
1 Year Lagged Cocaine Price	-	-0.00362*** (-3.22) $\epsilon = -0.294$	-0.00215* (-1.86) $\epsilon = -0.175$
1 Year Lagged Heroin Price	-	-0.00020*** (-3.25) $\epsilon = -0.098$	-0.00013** (-2.14) $\epsilon = -0.064$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	Yes	Yes	Yes
MSA Effects	No	No	No
R-Squared	0.524	0.512	0.553
Observations	245	246	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of drug related ED episodes in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-33 Contd.
Drug Abuse Warning Network ED Episodes Data
Logistic Drug Episodes

Specification	7	8	9
Cocaine Price - All Purchases	-0.00239*** (-3.24) $\varepsilon = -0.192$	—	-0.00214*** (-2.91) $\varepsilon = -0.172$
Heroin Price - All Purchases	-0.00006 (-1.57) $\varepsilon = -0.027$	—	-0.00008** (-2.00) $\varepsilon = -0.036$
1 Year Lagged Cocaine Price	—	-0.00122* (-1.68) $\varepsilon = -0.099$	-0.00117 (-1.65) $\varepsilon = -0.095$
1 Year Lagged Heroin Price	—	-0.00008** (-1.98) $\varepsilon = -0.039$	-0.00006* (-1.68) $\varepsilon = -0.029$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.864	0.860	0.870
Observations	245	246	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of drug related ED episodes in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-34
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	1	2	3
Cocaine Price - All Purchases	-0.00581*** (-3.61) $\epsilon = -0.468$	-	-0.00396** (-2.37) $\epsilon = -0.319$
Heroin Price - All Purchases	-0.00028*** (-2.85) $\epsilon = -0.126$	-	-0.00021** (-2.07) $\epsilon = -0.095$
1 Year Lagged Cocaine Price	-	-0.00425** (-2.59) $\epsilon = -0.346$	-0.00249 (-1.50) $\epsilon = -0.203$
1 Year Lagged Heroin Price	-	-0.00036*** (-3.74) $\epsilon = -0.192$	-0.00025** (-2.51) $\epsilon = -0.123$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	No	No	No
MSA Effects	No	No	No
R-Squared	0.591	0.588	0.609
Observations	245	246	242

Specification	4	5	6
Cocaine Price - All Purchases	-0.00448** (-2.44) $\epsilon = -0.361$	-	-0.00221 (-1.13)
Heroin Price - All Purchases	-0.00023** (-2.24) $\epsilon = -0.104$	-	-0.00018* (-1.72) $\epsilon = -0.081$
1 Year Lagged Cocaine Price	-	-0.00385** (-2.12) $\epsilon = -0.314$	-0.00280 (-1.46) $\epsilon = -0.228$
1 Year Lagged Heroin Price	-	-0.00032*** (-3.19) $\epsilon = -0.157$	-0.00024** (-2.31) $\epsilon = -0.118$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	Yes	Yes*	Yes
MSA Effects	No	No	No
R-Squared	0.596	0.602	0.612
Observations	245	246	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-34 Contd.
Drug Abuse Warning Network ED Episodes Data
Logistic Cocaine Mentions

Specification	7	8	9
Cocaine Price - All Purchases	-0.00421*** (-3.74) $\epsilon = -0.339$	—	-0.00355*** (-3.22) $\epsilon = -0.286$
Heroin Price - All Purchases	-0.00003 (-0.46)	—	-0.00007 (-1.19)
1 Year Lagged Cocaine Price	—	-0.00322*** (-2.92) $\epsilon = -0.262$	-0.00290*** (-2.72) $\epsilon = -0.236$
1 Year Lagged Heroin Price	—	-0.00010* (-1.74) $\epsilon = -0.049$	-0.00009 (-1.61)
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes***	Yes***
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.900	0.898	0.907
Observations	245	246	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of cocaine mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-35
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	1	2	3
Cocaine Price - All Purchases	-0.00771*** (-3.11) $\epsilon = -0.622$	-	-0.00419* (-1.69) $\epsilon = -0.338$
Heroin Price - All Purchases	-0.00077*** (-5.13) $\epsilon = -0.347$	-	-0.00056*** (-3.77) $\epsilon = -0.252$
1 Year Lagged Cocaine Price	-	-0.00715*** (-2.87) $\epsilon = -0.583$	-0.004615* (-1.86) $\epsilon = -0.376$
1 Year Lagged Heroin Price	-	-0.00089*** (-6.03) $\epsilon = -0.437$	-0.00065*** (-4.42) $\epsilon = -0.319$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	No	No	No
MSA Effects	No	No	No
R-Squared	0.603	0.613	0.647
Observations	245	246	242

Specification	4	5	6
Cocaine Price - All Purchases	-0.00855*** (-3.14) $\epsilon = -0.690$	-	-0.00444 (-1.56)
Heroin Price - All Purchases	-0.00074*** (-4.84) $\epsilon = -0.334$	-	-0.00059*** (-3.89) $\epsilon = -0.266$
1 Year Lagged Cocaine Price	-	-0.00646** (-2.38) $\epsilon = -0.527$	-0.00380 (-1.37)
1 Year Lagged Heroin Price	-	-0.00082*** (-5.51) $\epsilon = -0.403$	-0.00061*** (-4.16) $\epsilon = -0.300$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes***	Yes**
MSA Effects	No	No	No
R-Squared	0.637	0.637	0.668
Observations	245	246	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-35 Contd.
Drug Abuse Warning Network ED Episodes Data
Logistic Heroin Mentions

Specification	7	8	9
Cocaine Price - All Purchases	-0.00444*** (-3.08) $\varepsilon = -0.358$	-	-0.00370** (-2.56) $\varepsilon = -0.298$
Heroin Price - All Purchases	-0.00024*** (-3.26) $\varepsilon = -0.108$	-	-0.00027*** (-3.64) $\varepsilon = -0.122$
1 Year Lagged Cocaine Price	-	-0.00245* (-1.70) $\varepsilon = -0.200$	-0.00223 (-1.60)
1 Year Lagged Heroin Price	-	-0.00017** (-2.23) $\varepsilon = -0.084$	-0.00016** (-2.20) $\varepsilon = -0.079$
MSA Level Covariates	Yes***	Yes***	Yes***
Year Effects	Yes***	Yes***	Yes**
MSA Effects	Yes***	Yes***	Yes***
R-Squared	0.933	0.929	0.935
Observations	245	246	242

Notes: Dependent variable is $\log(p/1-p)$ where p is the total number of heroin mentions in each MSA divided by population. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent. MSA SES covariates include: personal income, unemployment, male, black, other, Hispanic, age 16-24, age 25-54, high school graduate, college graduate, and log response rate. Elasticities are reported where the own-price coefficient is significant at 10 percent or less in a one-tailed test.

Table 3-36
STRIDE Drug Price Data
Log Cocaine Price – All Purchases

Specification	1	2	3
Log Relative Unskilled Wage	0.39483*** (5.16)	0.38508*** (5.06)	0.38796*** (5.09)
Drug Sale Arrest Rate	33.03907*** (2.47)	-27.59560 (-1.08)	-46.66442 (-1.47)
Cocaine Sale Arrest Rate	-	84.90841*** (2.77)	96.33683*** (2.95)
Lagged 1 Year Cocaine Sale Arrest Rate	-	-	-
Marijuana Sale Arrest Rate	-	-	87.74031 (1.00)
Violent Crimes Arrest Rate	-	-	-
Drug Possession Arrest Rate	-41.55662*** (-6.21)	-42.29475*** (-6.35)	-43.92850*** (-6.41)
Lagged 1 Year Drug Possession Arrest Rate	-	-	-
Personal Income	-0.00151 (-0.24)	-0.00192 (-0.31)	-0.00209 (-0.34)
Population	-0.00002*** (-2.99)	-0.00002*** (-2.87)	-0.00002*** (-2.82)
High School Graduate	0.34725 (1.13)	0.50425 (1.63)	0.50750 (1.64)
College Graduate	-0.38544 (-1.09)	-0.51317 (-1.45)	-0.55752 (-1.56)
Year Effects	-	-	-
R – Squared	0.170	0.179	0.179
Observations	593	593	593

Notes: Dependent variable is log cocaine price based on all purchases. Data span 44 MSA's from 1988 to 2001. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent.

Table 3-36 Contd.
STRIDE Drug Price Data
Log Cocaine Price – All Purchases

Specification	4	5	6
Log Relative Unskilled Wage	0.38538*** (5.06)	0.38579*** (5.06)	0.39495*** (5.19)
Drug Sale Arrest Rate	–	–	13.22091 (0.87)
Cocaine Sale Arrest Rate	56.67583*** (3.57)	55.61647*** (3.24)	–
Lagged 1 Year Cocaine Sale Arrest Rate	–	–	–
Marijuana Sale Arrest Rate	–	11.50273 (0.16)	–
Violent Crimes Arrest Rate	–	–	35.81353*** (2.72)
Drug Possession Arrest Rate	-43.52214*** (-6.63)	-43.84752*** (-6.39)	-46.04631*** (-6.72)
Lagged 1 Year Drug Possession Arrest Rate	–	–	–
Personal Income	-0.00277 (-0.45)	-0.00287 (-0.47)	-0.00047 (-0.08)
Population	-0.00002*** (-3.11)	-0.00002*** (-3.11)	-0.00003*** (-3.50)
High School Graduate	0.47743 (1.54)	0.47543 (1.53)	0.46263 (1.50)
College Graduate	-0.45146 (-1.29)	-0.45168 (-1.29)	-0.38172 (-1.09)
Year Effects	–	–	–
R – Squared	0.179	0.177	0.179
Observations	593	593	593

Notes: Dependent variable is log cocaine price based on all purchases. Data span 44 MSA's from 1988 to 2001. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent.

Table 3-36 Contd.
STRIDE Drug Price Data
Log Cocaine Price – All Purchases

Specification	7	8	9
Log Relative Unskilled Wage	0.36668*** (4.68)	0.19415*** (2.62)	0.19399*** (2.61)
Drug Sale Arrest Rate	-	-	-
Cocaine Sale Arrest Rate	-	34.54177** (2.29)	34.79371** (2.16)
Lagged 1 Year Cocaine Sale Arrest Rate	47.50587*** (2.93)	-	-
Marijuana Sale Arrest Rate	-	-	-2.85182 (-0.04)
Violent Crimes Arrest Rate	-	-	-
Drug Possession Arrest Rate	-	-28.49731*** (-4.52)	-28.41369*** (-4.32)
Lagged 1 Year Drug Possession Arrest Rate	-40.23779*** (-5.96)	-	-
Personal Income	-0.00457 (-0.74)	-0.00077 (-0.13)	-0.00075 (-0.13)
Population	-0.00002*** (-2.70)	-0.00002*** (-2.70)	-0.00002*** (-2.69)
High School Graduate	0.51238 (1.60)	1.09621*** (3.78)	1.09675*** (3.77)
College Graduate	-0.35024 (-0.98)	-0.59724* (-1.87)	-0.59721* (-1.87)
Year Effects	-	Yes***	Yes***
R – Squared	0.168	0.322	0.321
Observations	551	593	593

Notes: Dependent variable is log cocaine price based on all purchases. Data span 44 MSA's from 1988 to 2001. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent.

Table 3-37
STRIDE Drug Price Data
Log Heroin Price – All Purchases

Specification	1	2	3
Log Relative Unskilled Wage	0.95897*** (5.67)	0.94166*** (5.58)	0.95808*** (5.69)
Drug Sale Arrest Rate	63.71706** (2.21)	-32.80301 (-0.59)	-125.69990* (-1.82)
Cocaine Sale Arrest Rate	-	134.40940** (2.02)	186.25890** (2.66)
Lagged 1 Year Cocaine Sale Arrest Rate	-	-	-
Marijuana Sale Arrest Rate	-	-	459.22670** (2.26)
Violent Crimes Arrest Rate	-	-	-
Drug Possession Arrest Rate	-105.02300*** (-7.04)	-106.71420*** (-7.16)	-116.36120*** (-7.53)
Lagged 1 Year Drug Possession Arrest Rate	-	-	-
Personal Income	-0.03054** (-2.23)	-0.03116** (-2.28)	-0.03179** (-2.34)
Population	-0.00004** (-2.42)	-0.00004** (-2.34)	-0.00004** (-2.28)
High School Graduate	-2.14295*** (-3.17)	-1.90254*** (-2.78)	-1.86856*** (-2.74)
College Graduate	0.52621 (0.67)	0.29441 (0.37)	0.08878 (0.11)
Year Effects	-	-	-
R – Squared	0.217	0.221	0.227
Observations	541	541	541

Notes: Dependent variable is log heroin price based on all purchases. Data span 44 MSA's from 1988 to 2001. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent.

Table 3-37 Contd.
STRIDE Drug Price Data
Log Heroin Price – All Purchases

Specification	4	5	6
Log Relative Unskilled Wage	0.94160*** (5.58)	0.95007*** (5.63)	0.94250*** (5.64)
Drug Sale Arrest Rate	–	–	5.34487 (0.16)
Cocaine Sale Arrest Rate	100.83760*** (2.95)	78.30848** (2.09)	–
Lagged 1 Year Cocaine Sale Arrest Rate	–	–	–
Marijuana Sale Arrest Rate	–	239.35480 (1.46)	–
Violent Crimes Arrest Rate	–	–	106.76400*** (3.72)
Drug Possession Arrest Rate	-108.04590*** (-7.34)	-115.03960*** (-7.44)	-121.11460*** (-7.88)
Lagged 1 Year Drug Possession Arrest Rate	–	–	–
Personal Income	-0.03228** (-2.39)	-0.03425** (-2.52)	-0.02718** (-2.00)
Population	-0.00004** (-2.47)	-0.00004*** (-2.57)	-0.00005*** (-3.22)
High School Graduate	-1.93098*** (-2.83)	-1.95525*** (-2.86)	-1.83583*** (-2.72)
College Graduate	0.38042 (0.49)	0.40019 (0.52)	0.52962 (0.68)
Year Effects	–	–	–
R – Squared	0.222	0.224	0.235
Observations	541	541	541

Notes: Dependent variable is log heroin price based on all purchases. Data span 44 MSA's from 1988 to 2001. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent.

Table 3-37 Contd.
STRIDE Drug Price Data
Log Heroin Price – All Purchases

Specification	7	8	9
Log Relative Unskilled Wage	0.89156*** (5.14)	0.07300 (0.48)	0.07680 (0.51)
Drug Sale Arrest Rate	-	-	-
Cocaine Sale Arrest Rate	-	-12.94577 (-0.44)	-17.87916 (-0.56)
Lagged 1 Year Cocaine Sale Arrest Rate	77.73388** (2.22)	-	-
Marijuana Sale Arrest Rate	-	-	55.74394 (0.41)
Violent Crimes Arrest Rate	-	-	-
Drug Possession Arrest Rate	-	-56.48863*** (-4.45)	-58.21248*** (-4.35)
Lagged 1 Year Drug Possession Arrest Rate	-111.07760*** (-7.37)	-	-
Personal Income	-0.02913** (-2.12)	0.00147 (0.13)	0.00089 (0.08)
Population	-0.00004** (-2.38)	-0.00003*** (-2.63)	-0.00003*** (-2.65)
High School Graduate	-1.81329** (-2.56)	-0.00031 (0.00)	-0.00794 (-0.01)
College Graduate	0.53399 (0.67)	-0.60648 (-0.94)	-0.59982 (-0.93)
Year Effects	-	Yes***	Yes***
R – Squared	0.214	0.471	0.470
Observations	502	541	541

Notes: Dependent variable is log heroin price based on all purchases. Data span 44 MSA's from 1988 to 2001. T-ratios are in parentheses. 2-Tailed Test: *** significant at 1 percent ** significant at 5 percent * significant at 10 percent.

Chapter IV

The Causal Impact of Substance Use on Suicidal Behaviors among Youths

1. Introduction

Recent years have witnessed widespread public concern over the alarming rate of youth suicide, as signaled by the Surgeon General's Call to Action to Prevent Suicide (US Public Health Service, 1999). More young adults die from suicide in the U.S. than from all leading natural causes of death combined, including cancer, heart disease, AIDS, and congenital defects. In 1999, 3,901 youths aged 15-24 took their own lives, making suicide the third leading cause of death behind accidents and homicides (Centers for Disease Control and Prevention, 2002). Moreover, suicide deaths have been rising at a fast pace. Among 15-24 year olds, the suicide rate has tripled between 1950 and 1994.

Suicide ideation, ranging from serious thoughts about suicide to suicide planning, and suicide attempts are even more prevalent than completed suicides. It has been estimated that there are as many as 200-400 attempts for every suicide completion.¹ Data from the 1999 Youth Risk Behavior Survey indicate that 18 percent of high-school students have seriously considered committing suicide in the past year. While these highly prevalent behaviors are considered to be leading risk factors for completed suicides, they are also psychologically harmful behaviors in and of themselves and impose real health care and other costs. The costs associated with completed and medically treated suicides by youths under 21, including medical costs and lost future earnings, amounted to 3.7 billion dollars in 1996 (Children's Safety Network Economic and Insurance Resource Center, 2003).

¹ Data from the National Comorbidity Survey, used in this study, indicate that 2 percent of the respondents aged 15-24 reported a suicide attempt in the past year. With a suicide death rate of 13.1 per 100,000 in 1991, this translates to 153 attempts for every completion.

A growing body of literature has identified various risk factors associated with suicidal behaviors, one of the most important of these being substance use and abuse. Previous research points to a strong correlation between alcohol or illicit drug use and suicide ideation, suicide attempts, and completed suicide among youths. For example, it has been reported that intoxication due to alcohol or drugs at the time of death has been found in approximately half of youthful suicides (Moscicki, 1995; Crumley, 1990). A hospital emergency department study showed that adolescent suicide attempters used drugs significantly more than a control group, with 43 percent of the attempters found to have serious drug problems (Crumley, 1990). The strong association between suicidal behaviors and substance use is significant from a policy perspective because it suggests that substance use prevention policies and programs may succeed in reducing suicidal behaviors as well. Of course, this possibility presumes that substance use is a causal determinant of suicide. Existing studies, however, have not established whether or not the link between substance use and suicidal behaviors is truly causal, either because of reliance on aggregate-level data or because of statistical problems associated with confounding factors. The absence of such information undermines the formulation of effective public policies.

The objective of this study is to investigate whether alcohol and drugs are causal factors affecting suicide ideation and attempts among young adults aged 15-24. To achieve this objective, individual-level data from the National Comorbidity Survey (NCS) are used. The empirical strategy relies on two different statistical approaches to measure the importance of unobserved factors and resulting selection bias. The first approach exploits the unusually rich data in the NCS on diagnosed mental illness,

stressful life events, and family history to compare marginal effects in basic and more extended model specifications. Since these confounders are usually not observed in other data sets or studies, including them in the extended models allows one to gauge the sensitivity of the effect of substance use on suicidal behaviors. If the magnitude of the effects is substantially altered, there is evidence of strong selection bias. The second approach is a bivariate probit model that provides a way to control for unobserved factors potentially correlated with both suicide and substance use. This is based on a novel empirical method, recently proposed by Altonji et al. (2001). There are two parts to this approach. The first step involves obtaining estimates of the effect of substance abuse on suicide from a bivariate probit regression model in which the effect of unobservable variables is fixed at various levels. This part of the analysis informs on how sensitive estimates of the effect of substance abuse are to selection on unobserved variables. The second step calculates the amount of selection on observed variables and obtains estimates of the effect of substance abuse on suicide attempts under the assumption that the selection on unobserved variables is equal to the selection on observed variables.

The advantage of the Altonji et al. (2001) procedure is that it allows researchers to assess the existence and strength of a causal relationship without requiring the use of identifying assumptions that are often not credible—for example, the existence of valid instruments in an instrumental variables context. As a result, without any other identifying assumptions, researchers can estimate the amount of selection on

unobservable factors using the observed data, and in this study identify a lower bound on the causal parameter estimate.²

The results indicate it is unlikely that alcohol participation or drug participation plays a causal role in suicide ideation and attempts. The analysis shows that there is considerable selection into substance use and suicidal behaviors along observable traits, which implies the existence of a potentially large degree of selection on unobservables as well. Furthermore, the analysis of constrained bivariate probit models shows that even very modest amounts of selection on unobservable characteristics would eliminate the effect of alcohol and drug participation on suicidal behaviors. However, in the case of clinically defined alcohol and drug use disorders, even a large amount of selection on unobservable factors does not completely eliminate the positive effect of these disorders on suicide attempts. The finding supports a causal relationship between clinically defined alcohol and drug use disorders and suicide attempts.

2. Background

Sociologists, psychologists, and economists have developed a variety of analytical frameworks to explain suicide.³ In the broad context of these theories, there are compelling reasons a priori to expect positive effects of substance use on suicidal behaviors. In his classic work on suicide Durkheim (1951) asserts that the suicide rate is inversely related to the degree of social integration. While his work does not consider the linkage between alcohol and suicide, one can postulate a theoretical link between substance abuse and suicide based on this channel. Several studies document that

² The lower bound is based on the assumption that selection on unobservable variables is at least as great as selection on observables. Justification for this assumption is provided below.

excessive alcohol and drug use lead to a deterioration of social ties.⁴ Substance abuse is often associated with weak or absent relations with family and friends and limited ability to function socially in a work or educational environment. In addition to this indirect link via social disintegration, more direct ones have also been documented. There is an extensive literature linking alcohol and drug use to aggression and violence.⁵ Arguably suicide is a special class of violence, the result of aggression and violence against oneself rather than against another individual (Dawson, 1997). An acute state of intoxication due to alcohol or drugs may reduce the individual's self-control, impair cognition, and thereby trigger off suicidal tendencies (Norstrom, 1995). Alcohol and drugs are sometimes used by mentally ill individuals to relieve depression and psychological distress (Saffer and Dave, 2002; Gruenwald et al, 1995). However, such self-medication may actually end up exacerbating depression, anxiety, and psychological stress. Other biochemical risk factors such as serotonin depletion may also be aggravated due to alcohol use. Rogers (1992) notes that these effects of alcohol may additionally induce myopia by restricting the individual's attention to immediate situations, leading to an increased focus on the distressing issues, inhibiting their ability to solve current problems, and limiting hope for the future.

Given the plausible mechanisms specified above, numerous social scientists have studied the relationship between substance use and suicidal behaviors. For example, Deykin and Buka (1994) find a strong correlation between clinically defined substance abuse or dependence and suicidal behaviors. Their findings show that approximately 30

³ See, for instance, Hamermesh (1974), Cutler et al. (2001), Durkheim (1966), Wilkins (1967), and Rossow and Lauritzen (2001).

⁴ See Norstrom (1995), Rossow and Lauritzen (1999 & 2001), and Murphy (1992).

⁵ See for example Dawson (1997) and Markowitz (2001).

percent of substance abusing males report suicide ideation and attempts, and 75 and 61 percent of such females report suicide ideation and attempts respectively. Felts et al. (1992) similarly find that drug use, particularly cocaine, is significantly related to increased suicide ideation and attempts among a sample of high school students. Thatcher et al. (2002) confirm this finding in a sample of South Carolina public high school students. They report that alcohol, marijuana, and cocaine use is significantly related to adolescent attempted suicide. Retrospective studies of completed youth suicides show that 12 to 44 percent of females and 27 to 42 percent of males met diagnostic criteria for a substance use disorder before their deaths (Marttunen et al., 1991; Shaffer et al., 1996).

Despite this strong correlation in both clinical and general population samples, the issue of whether substance use and abuse have *causal* effects on an individual's risk of engaging in suicide ideation or attempting suicide remains unresolved (Crumley, 1990).⁶ First, many of these studies use non-representative samples such as students in a single state or adolescents admitted to a hospital. Thus, the results may not be applicable to the U.S. as a whole, as the relationship between substance use and suicide may differ across regions or states. Furthermore, most of these studies fail to control for a variety of confounding family and personal factors that are correlated with both substance use and suicidal behaviors, thus making it difficult to establish causation. Specifically, many researchers report that in addition to substance use, other psychiatric disorders have been linked to suicidal behaviors among youth. Psychological autopsy studies reveal that more than 90 percent of completed suicides in all age groups are associated with mental

or addictive disorders (Moscicki, 1995). In a study of teenagers who completed suicide, approximately 61 percent appeared to have had a clinically significant mood disorder at the time of death, and approximately 35 percent appeared to have had a substance abuse disorder.

Some research has addressed this issue and found that even after controlling for other psychiatric disorders, substance use remains a strong, independent predictor of suicidal behaviors. For example, Cutler et al. (2001) find that among respondents in the National Longitudinal Study of Adolescent Health, substance use has a statistically significant effect on suicide attempts, after controlling for depression. Wagner et al. (1996) similarly note that substance abuse increases the likelihood of a suicide attempt independent of any effects through comorbid depression and conduct disorders. While offering stronger evidence than other studies that alcohol abuse may causally impact suicide attempts, these studies are still limited by the incomplete measures of co-morbid conditions available in the data. Thus, in the end, they remain less than definitive.

Recent studies based on state-level data suggest that higher minimum legal drinking ages, by presumably affecting teenage alcohol use, reduce the number of completed suicides among youths. Jones et al. (1992), using state-level data from 1979 to 1984, find that the suicide rate among 15-24 year olds was 9.7% greater among youth living in states where they could drink legally compared to youth of the same age who lived in states where they could not drink legally. Birckmayer & Hemenway (1999) find that the suicide rate among 18-20 year olds was 8% higher in states with a minimum legal drinking age (MLDA) of 18 years old compared to youth living in states with a MLDA of

⁶ Studies based on adolescents and young adults in other countries also find a similar positive association between substance use and suicidal behaviors. See, for example,

21 years old. In contrast to these studies, Hingson et al. (1985) fail to find an association between the minimum legal drinking age in Massachusetts and suicides.

These studies are limited, however, in that none address the issue of causation directly. First, there is the ecological fallacy problem; the existence of an aggregate relationship does not necessarily imply the existence of an individual causal relationship (Greenland & Robins 1994). Second, these studies are based on reduced form models, which link state-level policies directly to state-level suicide rates. Thus, they do not test the direct relationship between alcohol abuse and suicide and they fail to assess the reasonableness of their findings in terms of the direct effect of alcohol abuse on suicide. For example, Birckmayer and Hemenway (1999) find that minimum legal drinking age laws affected suicide rates of those 18 to 21 and those 21 to 23 years of age, even though minimum drinking age laws are not applicable to persons 21 to 23 years of age.⁷ Markowitz et al. (2002) find that the state excise tax on beer negatively impacts completed suicides for males, and very weakly for females. The specifications include a very sparse set of correlates and do not inform on whether the failure to find an effect for females is because the tax elasticity of alcohol is zero or because alcohol consumption does not affect female suicides. Third, these studies cannot account for the fact that state minimum drinking age and other laws are not exogenously determined. It is not random that Louisiana was the last state in the country to raise the minimum drinking age to 21.

To summarize, there is considerable evidence that alcohol and drug abuse is associated with suicidal behaviors. However, the non-experimental nature of all of these

Rossow and Lauritzen (1999 & 2001), Norstrom (1995), and Beautrais et al. (1999).

⁷ Birckmayer and Hemenway (1999) suggest that this is a plausible effect since alcohol use of those 21 to 23 may be affected by minimum legal drinking ages, although there is relatively little evidence to support such a conclusion.

studies limits their ability to establish a causal relationship. This paper extends the literature by using a novel methodology that will significantly add to the weight of evidence on this issue.

3. Analytical Framework

The objective of this study is to assess the extent to which the relationship between substance use and suicide is causal. This task is complicated by two factors. The first is statistical endogeneity wherein an individual's suicidal behavior and substance use may depend on a common set of unobserved factors (for example, mental illness or family history). The second is structural endogeneity wherein both outcomes may directly influence each other. The channels by which substance use may affect suicide were discussed earlier. It is also likely that suicidal behaviors may motivate alcohol and drug consumption. For instance, a person with suicidal impulses may drink or use drugs to facilitate a suicide attempt.

Consider linear specifications of the structural production function for suicidal behaviors (S_i^*) and the demand function for substance use (A_i^*):⁸

$$(1) \quad S_i^* = \alpha_1 A_i^* + \alpha_2 X_i + \alpha_3 \mu_i + \varepsilon_i$$

$$(2) \quad A_i^* = \beta_1 S_i^* + \beta_2 X_i + \beta_3 \mu_i + \eta_i$$

Equation (1) is a production function for suicidal behaviors (S_i^*), which is a function of alcohol and/or illicit drug abuse (A_i^*), observable characteristics that affect suicidal behaviors such as age, gender, and race (X_i), and unobservable characteristics such as personality traits or a social environment that encourages risky behavior (μ_i). Equation (2) postulates the demand for alcohol and illicit drugs (A_i^*). The vector X_i represents observed individual characteristics that determine substance use; these characteristics are

the same as the observed determinants of suicidal behaviors (X_i). Similarly, the vector μ_i represents unobserved determinants of suicide that may also influence alcohol and drug use. The subscript i refers to the individual, and ε_i and η_i represent random disturbance terms. Intercepts are suppressed for convenience.

The parameter of interest is α_1 , the structural effect of substance use on suicidal behaviors. Ordinary least squares estimation of equation (1) may be biased because of two reasons. This is reflected in equation (3), the reduced form demand function for substance use, obtained by substitution of equation (1) into equation (2).

$$(3) \quad A_i^* = (\alpha_2\beta_1 + \beta_2 / 1 - \alpha_1\beta_1) X_i + (\alpha_3\beta_1 + \beta_3 / 1 - \alpha_1\beta_1) \mu_i + (\beta_1 / 1 - \alpha_1\beta_1) \varepsilon_i + (1 / 1 - \alpha_1\beta_1) \eta_i$$

$$A_i^* = \pi_1 X_i + \pi_2 \mu_i + \pi_3 \varepsilon_i + \pi_4 \eta_i$$

First, if there are common unmeasured factors (μ_i) that determine both suicide and substance use ($\alpha_3 \neq 0$ and $\beta_3 \neq 0$), then such unmeasured factors are likely to be correlated with substance use ($\pi_2 \neq 0$). This correlation between substance use and the error term will lead to biased and inconsistent estimates of the structural effect α_1 . A second reason that substance use may be correlated with the error term is structural endogeneity, or the possibility that suicidal behaviors are a determinant of substance use ($\beta_1 \neq 0$).

In the specifications above, S_i^* and A_i^* are interpreted as underlying latent variables measuring an individual's unobserved propensity to engage in suicidal and substance abuse behaviors respectively. This study measures suicidal behaviors and substance abuse as observed dichotomous indicators reflecting these underlying latent indices:

$$S_i = 1 \text{ if } S_i^* > 0$$

$$A_i = 1 \text{ if } A_i^* > 0$$

⁸ This model is derived from the model of violence in Markowitz and Grossman (1998).

$$S_i = 0 \text{ otherwise}$$

$$A_i = 0 \text{ otherwise .}$$

The estimation strategy proceeds in a stepwise fashion. Initially, equation (1) is estimated using a standard probit regression model with a parsimonious set of covariates and then with an expanded set of covariates. Most studies of the effects of substance use on suicide have controlled for a sparse set of demographic and socioeconomic variables at best. The National Comorbidity Survey (described in the next section) is a rich data set containing information on various diagnosed psychiatric disorders, parental history, and stressful life events. These variables, which may determine both substance use and suicidal behaviors, are usually unobserved in other studies. They may therefore proxy for or may be a subset of the unmeasured components vector μ_i . Estimating both the basic and the extended models allows an evaluation of how much of the association between substance use and suicide is driven by such omitted individual heterogeneity. If the magnitude of the marginal effect of substance use is highly sensitive to the inclusion of additional correlates, then it is reasonable to conclude that unobservable factors play an important role in this relationship.

This referred to as selection on observables and selection on unobservables (Altonji et al. 2001). These two terms are used to acknowledge that young adults are not sorted randomly into suicidal and substance use behaviors. Selection on observables refers to the existence of observed factors (such as age and race) that are correlated with suicidal behaviors and with substance use. Selection on unobservables refers to the possible existence of factors that are not available in the survey data and that also may be associated with both substance use and suicidal behaviors (such as family problems). The degree of selection on the observables can be gauged by comparing the estimated

coefficients on substance abuse that result from the parsimonious and expanded models. Unfortunately, the degree of selection on the unobserved characteristics cannot be measured directly. However, this study will attempt to bound this latter effect using an approach proposed by Altonji et al, and thereby draw inferences about the unbiased relationship between alcohol and drug use and suicidal behaviors.

The observed correlation between substance abuse and suicide ideation or attempts is likely to be influenced, at least to some degree, by the selection biases discussed above. For this reason, the estimated coefficients on substance abuse from the extended models may be considered upper bound estimates of the impact of substance abuse on suicidal behavior. Since the unobservable factors that determine suicide and substance abuse are expected to be positively correlated, further efforts to control for selection bias would only attenuate the estimated effect of substance abuse on suicide ideation and attempts.

If the simple comparison shows that selection on unobservable characteristics is strong, then standard probit estimates of equation (1) will be biased because it is likely that remaining unobserved factors are confounding the true relationship between substance use and suicide. For instance, unobserved personality traits such as risk and time preference as well as peer effects may be driving both outcomes. This problem arises often in applied social science research. In the absence of solid natural experiments, the common procedure would be to estimate equation (1) using instrumental variables or to jointly estimate the suicide and substance use equations using full information maximum likelihood strategies, such as the bivariate probit.

Instrumental variables estimation replaces the true value of A , which may be correlated with ε , with a predicted value of A , which is orthogonal to ε . Practical

implementation of this procedure requires valid instruments, that is variables which predict substance use but have no direct effect on suicide. Many studies have relied on state or city level policies and prices as instruments for alcohol and drug use (Markowitz, 2001; Mullahy and Sindelar, 1996; Cook and Moore, 1993; Dee and Evans, 1997). These policies are likely to be uncorrelated with suicide beyond their effect through substance use. Following this approach, the real state excise tax on beer, the density of alcohol outlets in the state, blood alcohol concentration limits, and the real city-level cocaine price are used as instruments for alcohol and drug use. These instruments as a group are very weak and poor predictors of substance use. The NCS, being a cross-sectional survey, does not allow one to take advantage of any temporal variation in the instruments. The problems associated with weak instruments and the resulting exacerbation of bias are well documented (Nelson and Startz, 1990; Bound et al., 1995), and thus limits the application of this approach in the present study.

The bivariate probit model is a full-information maximum likelihood technique based on the assumption that the unmeasured determinants in equations (1) and (3) have a joint, bivariate normal distribution. This procedure is applicable when suicidal behaviors (S_i) and substance use (A_i) are measured as dichotomous indicators of latent index variables. Bivariate probit accounts for the correlation between the error terms in both equations due to statistical and structural endogeneity by jointly estimating equations (1) and (3).⁹ However, since the same vector of socioeconomic and demographic factors is

⁹ Alternately, the two structural equations (1) and (2) can also be jointly estimated using bivariate probit, which is equivalent to estimating (1) and (3). If the bivariate probit model is applied properly, both should yield a consistent estimate of α_1 . The only difference is that the correlation between the disturbance terms in equations (1) and (3) is greater than that between equations (1) and (2). This is because the reduced form substance use equation (3) has netted out the effect of suicide and thus its error ϵ_i now

included in both equations, identification comes purely from functional form restrictions. In practice, however, such functional form restrictions generally are difficult to defend, and the bivariate probit model performs relatively poorly (imprecise estimates).¹⁰ For this reason, similarly to instrumental variables, the bivariate probit model requires valid exclusion restrictions – variables that affect substance use but do not directly affect suicide. Identification based on substance use prices and control policies is faced with the same problem as before.

An alternative identification strategy that does not rely on exclusion restrictions has been suggested by Altonji et al. (2001).¹¹ Identification in this case is achieved by constraining the value of ρ , the correlation between the errors in the two equations. First, ρ is constrained to be 0.1 initially and then incrementally increased to 0.2, 0.3, 0.4, and 0.5. This imposes on the model increasingly greater amounts of positive selection on unobservables. This analysis allows one to examine whether the effect of substance use on suicide is robust to such changes, and the threshold at which substance use no longer has a statistically significant effect.

Altonji et al. (2001) argue that if the observable determinants of an outcome are truly just a random sub-set of the complete set of determinants, selection on observable characteristics must be equal to selection on unobservable characteristics. Thus, ρ is constrained such that the amount of selection on unobservable factors is equal to the amount of selection on observable factors. In essence, the empirical link between

also appears as part of the disturbance term in the reduced form substance use equation.

¹⁰ See Rashad and Kaestner (2003) for an analysis that illustrates the poor performance of bivariate probit models in such circumstances.

substance use and the observed variables is used as a guide to its link with unobserved variables. This procedure is described in greater detail in Appendix 4-2. This assertion of equal selection is unlikely to be true, and in fact, given the specialized nature of the NCS data, it is likely that selection on observable factors is greater than selection on unobservable factors. Thus, estimates obtained under the assumption of equal selection can be interpreted as lower bound estimates.

4. Data

The empirical work is based on the National Comorbidity Survey (NCS). The NCS was a congressionally mandated, nationally representative survey designed to study mental illness in the United States. It surveyed 8,098 individuals aged 15-54 between 1990 and 1992, with the majority of interviews being conducted in 1991. For this study, the focus is on a subsample of youths aged 15-24, resulting in a sample size of approximately 1,600 individuals.

Two dichotomous measures of suicidal behaviors are constructed. The first is an indicator of suicide ideation and equals one if the respondent had “seriously thought about” or “made a plan for committing suicide” in the past year. The second is an indicator of whether the respondent attempted suicide in the past year. Approximately 6 percent of the youths sampled engaged in suicide ideation, and 2 percent attempted suicide at least once during the past year.¹²

¹¹ See Grossman et al. (2002), which studies the relationship between adolescent alcohol use and sexual behavior using bivariate probit techniques similar to those used in the present study.

¹² NCS respondents seem to be more likely to report serious suicide attempts because (1) they were questioned by a trained interviewer collecting information about all of their mental disorders; (2) the NCS instrument is designed to capture serious mental illnesses; and (3) they were asked the questions as part of a set of very probing questions about mental illness and violence. The prevalence of any suicide attempt in

The explanatory variables of interest are alcohol use and illicit drug use. Alcohol use is measured in three ways, in order to capture differential intensities of consumption. The first is a dichotomous indicator of participation representing whether the respondent drank any alcohol in the past year. The second is a measure of whether the respondent consumed five or more drinks on any given day in the past year. This is presently referred to as binge drinking, though conventionally binge drinking is defined as consuming five or more drinks in a row. The third variable is a measure of problematic alcohol consumption. It is based on diagnoses of alcohol abuse and/or dependence included in the NCS and generated using the Composite International Diagnostic Interview. Alcohol abuse is defined as either continued use despite knowledge of its adverse effect on health and social functioning or recurrent use in situations when use may be physically hazardous. Alcohol dependence requires the presence of physiological symptoms of tolerance and withdrawal and continued use despite adverse consequences. A dichotomous indicator is constructed representing individuals who were diagnosed with either alcohol abuse or dependence in the past year. For drugs, a dichotomous indicator is created for participation measuring whether the respondent used marijuana, cocaine, or heroin in the past year. Similar to alcohol, the NCS also includes diagnoses of drug abuse and dependence disorders. An indicator is defined for individuals who are diagnosed with either of these disorders in the past year.¹³ Since marijuana is the most

the NCS, for adolescents, is much closer to the rate of medically treated suicide attempts in the Youth Behavior Risk Factor Survey.

¹³ The diagnoses of drug abuse and/or dependence in the NCS may relate to non-medical uses of prescription type drugs, sedatives, tranquilizers, stimulants, and inhalants. To capture problematic drug use related only to marijuana, cocaine, and heroin, individuals who did not report using these drugs in the past year are excluded from the drug abuse/dependence diagnosis. Approximately 15 percent of the youths

commonly used illicit drug among youths, it is also interesting to analyze whether marijuana use by itself causally affects suicidal behaviors. A dichotomous indicator that measures only marijuana participation is defined. The comparison here is between past year users of marijuana and non-users; individuals using cocaine or heroin are excluded in order not to contaminate the two subsamples.¹⁴

One of the main advantages of using the NCS is that it is the only nationally representative survey in the United States to collect detailed data on diagnosed psychiatric disorders. A systematic approach to classification and diagnosis of mental illness has been developed by the American Psychiatric Association. The definition and criteria for diagnosis of specific mental illnesses are contained in the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R) (American Psychiatric Association, 1987). The component of the NCS that was used to collect data on mental illness is called the Composite International Diagnostic Interview (CIDI). It was developed by the National Institute of Health, the World Health Organization, and the University of Michigan and is a non-clinician administered instrument, which generates psychiatric diagnoses. The CIDI has undergone extensive testing for reliability and validity. Controlling for mental illness is crucial in this study, because mental illness has been shown to be a significant predictor of both substance use and suicidal behaviors (Saffer and Dave, 2002; Crumley, 1990; Moscicki, 1995). A series of 11 non-substance related psychiatric disorders are defined in the data set. Two dichotomous indicators of mental illness are constructed. First, an indicator is defined for past year occurrence of any of

diagnosed with drug abuse or dependence in the past year did not report using marijuana, cocaine, or heroin in the past year. The results are insensitive to this change.
¹⁴ Approximate 3 percent of the youths reported cocaine or heroin use in the past year.

the 11 psychiatric disorders.¹⁵ Second, an indicator is defined for distant mental illness that is equal to one if the respondent is diagnosed with any of the disorders during his or her lifetime but not in the past year. These disorder groups are listed and described in Appendix 4-3.

A series of socioeconomic and demographic variables are also defined, including the respondent's age, gender, race, family income, and indicators of religion. Since most of the respondents in the sample have not completed their schooling, indicators of whether the respondent has dropped out of high school and college are included. These variables are preferred over years of schooling since years of schooling would otherwise be highly collinear with age. An indicator of poor physical health is also defined. In addition, indicators of 8 census regions are included in all models.¹⁶

The NCS also includes rich set of information on family background and life events. Previous studies document that in addition to psychiatric disorders and substance use, suicidal behaviors also are correlated with family conflict, parental psychiatric disorder, interpersonal difficulties, being a victim of physical or sexual abuse, and other adverse childhood experiences (Brent et al. 2002; Johnson et al. 2002; Glowinski et al. 2001; Dube et al. 2001; Hagedorn & Omar 2002; Simon et al., 2002; Beitchman et al. 1992). These factors are likely to confound the relationship between substance use and suicide (Rossow and Lauritzen, 2001; Cutler et al., 1999). To capture some of these risk

¹⁵ Major depressive disorder is excluded from the mental illness variables. While suicide ideation and suicide attempts are neither necessary nor sufficient for this diagnosis, they are factors listed under DSM-III-R that may satisfy some of the criteria for major depression. This disorder is therefore excluded since it may introduce spurious correlation between mental illness and the left-hand side suicide variables. Including major depression does not significantly alter the results.

factors, indicators are included for whether either of the respondent's parents was depressed for at least two weeks, had a problem with alcohol, had a problem with illegal drugs, ever attempted suicide, or ever died from suicide. Additional life event measures of whether the respondent was involved in a fire or natural disaster, abused or neglected as a child, molested, suffered through the death of someone close, or witnessed a friend or family member have a major life crisis are also defined. An individual's preference towards risky activities may also be an important determinant of substance use and suicidal behaviors. To control for this possibility, indicators of seatbelt use and condom use during the past year are included. Weighted means for all variables for the full sample of youths are presented in Appendix 4-1.

5. Results

Table 4-1 presents sample means of selected variables by alcohol and drug use, as measured by abuse or dependence in the past year. The figures indicate that suicidal behaviors are more prevalent among youths who abuse alcohol or drugs compared to those who do not. For example, 16.1 percent of young adults who abuse alcohol have engaged in suicide ideation compared to only 4.3 percent of young adults who don't have an alcohol disorder. Among young adults who abuse drugs, 22.2 percent have engaged in suicide ideation compared to 4.9 percent of young adults without a drug disorder. Similar statistically significant differences are also observed for suicide attempts between the groups. These findings are consistent with the prior literature that demonstrates a strong positive correlation between suicidal behaviors and substance use.

¹⁶ Including dummy variables for state rather than region do not alter the results. However, it does cause some of the observations from certain states to be dropped (and reduces the sample size) due to perfect collinearity in the probit models.

The figures in Table 4-1 also show that substance use is correlated with other observed and sometimes unobserved characteristics. For example, youths who have alcohol or drug disorders are more likely to have dropped out of high school compared to youths without such disorders. They also appear to have more risk preferring personalities as evidenced by the fact that individuals who abuse alcohol or drugs are about twice as likely to never wear a seatbelt or never use condoms. Substance use is also significantly associated with factors that are sometimes unmeasured in other studies. Alcohol or drug abusing youths are much more likely to have been diagnosed with a psychiatric disorder during the past year and in their lifetime. They also appear to have grown up in a more disrupted family environment; youths diagnosed with an alcohol or drug disorder are more likely to have been abused and neglected and have a parent who was depressed or had problems with alcohol and drugs. It is apparent from the data that there is “positive selection” on observed characteristics – individuals who abuse substances and engage in suicidal behaviors are not a random sample. They are more likely to engage in other risky behaviors as well, have other psychiatric disorders, and have a dysfunctional upbringing. This selection on observable factors indicates that selection on additional unobserved factors may also play an integral role. It may be the case that the relation between suicide and substance use is not truly causal but rather is being driven by this positive selection. The multivariate models, presented next, address this possibility.

Univariate probit estimates of the effect of alcohol participation on suicide ideation and attempts are presented in Table 4-2. Columns 1 and 3 present models with a parsimonious set of commonly observed correlates. Consistent with prior research, the

magnitudes of the marginal effects of alcohol use are positive and statistically significant. For example, youths who drink have a probability of engaging in suicide ideation during the past year that is 2.9 percentage points higher than youths who do not drink. The corresponding marginal effect of alcohol use on suicide attempts is 0.9 percentage point. Given that about 6 percent and 2 percent of the overall sample engage in these behaviors respectively, these marginal effects are relatively large. The other independent variables are similar to prior empirical studies. Results from the basic models show that males are less likely to engage in suicide ideation and attempts compared to females, as are high school dropouts, protestants, and individuals who are not in poor health.

Columns 2 and 4 present estimates from expanded regression models that include several additional explanatory variables. Specifically, these specifications add indicators of mental illness, other risky behaviors, parental background, and stressful life events. These additional correlates are typically treated as unobserved in other studies. As a result, comparing estimates from these expanded models with the more basic models allows us to gauge the importance of unobservable factors. The marginal effect of alcohol use on suicide ideation is only about half the size as before – 1.6 percentage points compared to 2.9 percentage points in the simple model. While the standard errors remain relatively stable, the significance level is lower. With respect to suicide attempts, the marginal effect of alcohol use decreases by 80 percent – 0.2 percentage point compared to 0.9 percentage point in the simple model. After adding the extra covariates, alcohol use no longer has a statistically significant effect on attempts. It is interesting to note in the expanded models that the negative effect of male on suicidal behaviors is greatly reduced. This is mostly due to the inclusion of the indicators for mental illness, as

females have elevated rates of mood disorders, depression, and other affective disorders. Suicide ideation is positively and significantly affected by recent mental illness. Individuals diagnosed with any psychiatric disorder during the past year have a probability of seriously thinking about or planning suicide that is 6.5 percentage points higher than those without any recent mental illness. Suicide attempts are affected by both past year and lifetime mental illness. Individuals whose mother or father died from suicide, were neglected or molested, or underwent some family crisis were also more likely to engage in suicidal behaviors.

Table 4-3 presents the effects of all six substance use measures on suicide ideation for the parsimonious and expanded model specifications. Each cell represents a separate regression model for each different measure of substance use. The effects of other explanatory variables are similar to those discussed above for Table 4-2 and are not reported. The effects of alcohol use are duplicated for convenience. The first column represents the simple specifications, and the second column includes the expanded variables set. Note that there is a dose-response effect for alcohol use – the marginal effect of alcohol abuse/dependence on suicide ideation is higher than that of binge drinking which in turn is higher than that of alcohol participation. Measures indicating higher or more problematic consumption thus have a larger effect on suicide ideation. The same pattern applies to any drug use and drug abuse/dependence. Furthermore, comparison of the two columns reveals that all marginal effects are reduced by about 40-50 percent in the expanded models. For example, alcohol and drug abuse/dependence both increase the probability of suicide ideation by a very large magnitude of 10 percentage points in the simple model. Once the additional factors are included, the

marginal effect drops to about 6 percentage points. Despite the lower coefficients and stable standard errors, the effects of all substance use measures remain statistically significant. However, the diminished magnitudes confirm the finding from the simple descriptive statistics in Table 4-1, that there is considerable selection on observable characteristics.

Table 4-4 presents the results for suicide attempts. The same pattern and conclusion emerges here as well. In both the basic and extended models, indicators of more heavy or problematic alcohol and drug use have a larger positive impact on suicide attempts. Comparison of the two specifications indicates that the marginal effect of each substance use measure is reduced by 70-80 percent after controlling for the additional covariates. For example, the marginal effects of alcohol and drug abuse/dependence fall from 4.4 and 6.0 percentage points to 1.1 and 1.8 percentage points. While alcohol participation no longer has a statistically significant impact on suicide attempts in the extended model, the other substance use measures continue to exert a significant influence.

Overall, the results in Tables 4-2, 4-3, and 4-4 are consistent with numerous prior studies and show a positive relationship between substance use and suicidal behaviors, albeit a smaller one due to the inclusion of some powerful additional covariates. The diminished magnitudes of the marginal effects once again indicates that there is a large degree of selection on observed factors and that the relation between substance use and suicide is sensitive to these additional covariates. If controlling for psychiatric disorders, risk preference, parental history, and stressful life events accounted for all or even most of the positive selection, then one could confidently conclude that the positive estimates

in Tables 4-3 and 4-4 are causal. However, this is highly unlikely. The significant selection on observable characteristics strongly suggests that there is also additional selection on unobserved characteristics. While the pseudo- R^2 more than doubles between the basic and extended models, it still remains relatively low – approximately 0.23 for suicide ideation and 0.37 for suicide attempts. It appears that a significant amount of unexplained variation in suicidal behaviors still remains. Many other factors that have not been accounted for even in the expanded models, such as time preference, sexual orientation, or peer effects, come to mind. Thus, it is likely that the estimates in column 2 of Tables 4-3 and 4-4 represent strict upper bound estimates of the effects of substance use on suicide, since any additional positive selection on unmeasured factors would only attenuate these effects.

Table 4-5 presents constrained bivariate probit estimates for suicide ideation, based on the identification strategy proposed by Altonji et al. (2001). Univariate probit estimates, equivalent to ρ equaling zero, are reproduced in column 1 for ease of comparison. The strategy is to assess the degree of selection on unobservable characteristics that is necessary to eliminate this positive association between substance use and suicide ideation. It is assumed that there is positive selection on unobservables, which is consistent with the descriptive evidence in Table 4-1, and constrain the correlation coefficient ρ to incrementally equal 0.1, 0.2, 0.3, 0.4, and 0.5. Larger values of ρ correspond to stronger correlation between unobservable determinants of substance use and suicide ideation. It is assumed that the lower bound estimates of substance use on suicide are zero since there is little theoretical reason to expect that substance use reduces suicidal behaviors.

Estimates in Table 4-5 reveal that even very modest amounts of selection on unobserved traits can eliminate the positive link between substance use and suicide ideation. For example, a correlation coefficient (ρ) between 0 and 0.1 eliminates the positive relation between alcohol participation, binge drinking, or drug abuse/dependence and suicide ideation. For any drug or marijuana participation, a correlation coefficient (ρ) between 0.1 and 0.2 is sufficient to eliminate the statistically significant positive association. For problematic drug use, a slightly larger ρ between 0.2 and 0.3 is required before the positive effect on suicide ideation disappears. Therefore, unless there is very little selection on unobserved factors, it appears unlikely that the positive association between substance use and suicidal thoughts or plans is causal.

One method of evaluating how much selection there is on unobservable variables is to assume that it is equal to the selection on observed variables. The last column of Table 4-5 presents estimates from a bivariate probit model identified by this equality between selection on the included and excluded variables. It is evident from these results that there is a significant amount of positive selection on observed factors, which is not surprising given that included variables such as mental illness and family background exert a strong influence on both substance use and suicide ideation in the same direction. Furthermore, the estimated ρ from this model is larger for more problematic measure of alcohol or drug use, implying a greater degree of positive selection at higher doses. If this amount of selection also characterizes unobserved elements, then the statistically positive association between all measures of substance use and suicide ideation is eliminated. For example, constraining the selection on unmeasured factors to equal the selection on measured factors yields a correlation coefficient of 0.47 in the case of

alcohol abuse/dependence. Yet, the positive effect of alcohol abuse/dependence disappears for ρ greater than 0.2. This implies that selection on unobservables would have to be less than half the amount of selection on observed variables for the positive association to remain. While these models have included some powerful mutual correlates of substance use and suicide, for example mental illness and parental history, one cannot definitively say how much additional selection there is. However, given that a large amount of unexplained variation remains and that relatively small values of ρ are enough to eliminate the effects, it is unlikely that substance use plays any causal role in suicide ideation.

Table 4-6 presents similar estimates for models of suicide attempts. Alcohol participation has no statistically significant effect on this measure of suicide. Here again, for binge drinking, marijuana use, and drug use, modest amounts of selection on unobservable factors erase the positive link between these measures and suicide attempts. Judging from the last column, selection on unobservables would have to be less than half of the amount of selection on observables for the effect to persist. For indicators of alcohol and drug abuse or dependence, however, the positive impact remains robust to relatively large amounts of selection. For instance, problematic alcohol use continues to have a statistically significant positive effect on suicide attempts even if ρ is as high as 0.4. Given that the equal selection rule yields a ρ of 0.21, this suggests that alcohol abuse/dependence will have a positive causal impact on attempts even if the selection on unobservables is twice as much as the selection on observables. For drug abuse or dependence, the positive effect remains significant until a ρ of 0.3. Since the equal selection constraint also yields a ρ of 0.3, it can be stated that the positive effect of

problematic drug use on suicide attempts is causal if the selection on unobserved factors does not exceed that on observed factors. Given that the NCS was specifically designed to study the prevalence and determinants of mental illness in the United States, it is likely that the observed components in the data set are more important than the unobserved components. The equal selection constraint would thus overestimate the amount of selection on unobservables, and the marginal effects that result from this constraint are likely to be lower bound estimates.

As a specification test, Table 4-5 also presents the effects of tobacco participation (for both past year and past month) on suicide ideation.¹⁷ Simple means show a significant difference in tobacco participation between individuals who contemplated suicide and those who did not. Those who reported suicide ideation in the past year had a past year smoking prevalence rate almost three times as high compared to those who did not report any suicide ideation. Past month smoking participation was 3.4 times as high. From the first column in Table 4-5, tobacco participation has a significantly positive effect on past year suicide ideation in the extended univariate probit models. The marginal effects are also of a very high magnitude. However, it is difficult to imagine that this relationship between smoking and suicide is causal; it is more likely reflecting the confounding influence of other omitted factors. In this case, the constrained bivariate probit models should properly be able to account for this problem. Indeed the subsequent

¹⁷ The tobacco questionnaire was administered to only a subsample of the NCS respondents. Tobacco participation does not have a statistically significant effect for individuals ages 15 to 24 once the mental illness, family history, and life events variables are included. In order to simulate an artificial positive effect, the sample was restricted to individuals ages 15 – 20, for which tobacco participation does have a significantly positive effect on suicide ideation. This results in a sample size of 496. The analysis could not be duplicated for suicide attempts due to the small number of attempts in this smaller sample.

columns in the table show that the positive effect of smoking on suicide ideation is not robust and is eliminated by even modest amounts of selection on unobservables.

Estimates based on the equal selection constraint show that tobacco participation does not causally impact suicide ideation. In other words, if the constrained bivariate probit procedure is valid, then the effect of smoking participation on suicide ideation should be eliminated using the same procedure. While not definitive, it is reassuring that the technique does not show a causal effect when there clearly is none.

6. Conclusions

The objective of this study was to analyze the effect of alcohol and illicit drug use on the suicidal behaviors of young adults aged 15-24. The particular concern was to examine whether the widely documented positive association between substance use and suicide represented a true causal impact or whether it was driven by unmeasured individual heterogeneity. To assess the strength and robustness of this association, the estimation strategy relied on two approaches – comparison between parsimonious versus extended specifications and constrained bivariate probit models.

Given that the magnitudes of the marginal effects of substance use were significantly diminished when indicators of mental illness, other risky behaviors, family history, and life events were added to the basic specification, there appears to be a considerable amount of selection along these dimensions. Even after the addition of these powerful predictors, there was much variation in suicidal behaviors left to be explained; the pseudo- R^2 was approximately 0.23 and 0.37 for ideation and attempts respectively. The relatively large amount of unexplained variation combined with the

high degree of sensitivity of the effects to the additional correlates suggests that selection on unobservable may also be important.

This was confirmed by evidence from the constrained bivariate probit models. For suicide ideation, relatively small amounts of selection on unobservables succeeded in eliminating the positive effect of all measures of substance use. Based on the equal selection rule of Altonji et al. (2001), the amount of selection on unobservables would have to be less than half the amount of selection on observables for there to be a statistically significant positive relationship between substance use and suicide ideation. Since there is no definitive way to assess the absolute amount of selection on unobservables, this possibility cannot be ruled out conclusively. However, it appears that the positive relation between substance use and suicide ideation reflects more the common influence of omitted factors rather than a true causal effect. Similar patterns were observed for models of suicide attempts. Alcohol use by itself has no effect on attempts since even in the extended models with no additional positive selection imposed, the marginal effect is statistically insignificant. For binge drinking, drug use, and marijuana use, selection on unobservable factors would have to be less than half the amount of selection on observable factors for these measures to exert a positive influence on attempts. Diagnosed alcohol or drug disorders do appear to have a causal impact on suicide attempts. Their positive marginal effects remain relatively robust. For example, the positive effect of alcohol abuse/dependence is not entirely wiped out even if selection on unobservables is twice that on observables. However, the marginal effects of both of these substance use measures are quite small. Under the equal selection rule, problematic alcohol use raises the probability of a suicide attempt in the past year by 0.12 percentage

point. The marginal effect of problematic drug use on suicide attempts is 0.11 percentage point.¹⁸ While these effects are far from the univariate probit estimates of 1.1 and 1.8 percentage points respectively, they are also extremely conservative since it is unlikely that the selection on unobservables is as large as that on observables in the NCS dataset. Evaluated at the sample mean, this translates to a 6 percent increase in the probability of a suicide attempt.

This study has clearly shown that there is a considerable amount of selection that confounds estimates between substance use and suicidal behavior. As a result, the magnitudes obtained in some other studies may be biased upwards. While the suicide rate among young adults has exploded in the past decades and become a pressing public health concern, it does not appear that policies aimed at reducing recreational alcohol or drug use will significantly impact suicidal behaviors. To date, there is very little evidence that any existing suicide prevention policies actually reduce the risk of suicide. Identifying and treating youth who meet clinical criteria for alcohol and drug abuse and dependence may be an effective way to reduce the risk of suicide attempts. The prevalence of alcohol and drug use disorders, among special populations of youths such as juvenile offenders, is much higher than the general youth population (Martseller et al., 1997; Teplin et al., 2002). Interventions that identify and assist these youths, such as accessible screening and treatment programs, combined with policies combating serious

¹⁸ Many studies in the health economics literature have shown that even heavy drug and alcohol users respond to full price and that teenagers and young adults are more price sensitive than the population as a whole. In addition to the other chapters of this study, see, for example Leung and Phelps (1993), Grossman et al. (1998), Grossman et al. (2001), and Caulkins (2001).

alcohol and drug disorders among youths does leave open the possibility that they will also succeed in lowering suicide attempts.

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Table 4-1
Sample Means by Past Year Alcohol / Drug Abuse or Dependence

Variable	Past Year Alcohol Abuse or Dependence	
	No	Yes
Suicide Ideation	0.0426***	0.1610
Suicide Attempt	0.0106***	0.0762
Age	19.0815***	20.2480
Age Squared	372.4665***	415.5178
Male	0.4742***	0.7093
High School Dropout	0.0760***	0.1558
College Dropout	0.2983	0.3551
Income	24.4131	23.9279
Black	0.1407***	0.0283
Hispanic	0.1400	0.1231
Catholic	0.3215	0.3526
Protestant	0.5025*	0.4300
Other Religion	0.0570	0.0504
Poor Health	0.0769	0.1164
Past Year Mental Illness	0.2412***	0.3645
Distant Mental Illness	0.1363***	0.2931
No Seatbelt	0.0890***	0.2315
No Condom	0.1676***	0.2776
Parents Depressed	0.4300**	0.5250
Parents Drink	0.2525**	0.3427
Parents Drugs	0.0563	0.0872
Parents Suicide Attempt	0.0420	0.0605
Parents Suicide Death	0.0026	0.0002
Fire	0.1183*	0.1765
Abused	0.0300*	0.0620
Neglected	0.0198	0.0340
Molested	0.0583	0.0397
Shock	0.1241	0.1592
Death of Relative	0.2232	0.2751
Crisis	0.2206	0.2607
Observations	1,444	255

Notes: Number of observations listed represents the maximum number. For some variables, the actual sample size is slightly less due to missing information. For variables with significant amount of missing information, we assigned the sample mean and created a dichotomous variable indicating missing information for these observations. Variables falling into this category are: parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death. Asterisks indicate that the difference between abusers and non-abusers is statistically significant as follows: *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 4-1 Contd.
Sample Means by Past Year Alcohol / Drug Abuse or Dependence

Variable	Past Year Drug Abuse or Dependence	
	No	Yes
Suicide Ideation	0.0488***	0.2216
Suicide Attempt	0.0130**	0.1253
Age	19.2211	19.6270
Age Squared	377.7183	391.0510
Male	0.4946***	0.7032
High School Dropout	0.0762***	0.2587
College Dropout	0.3108	0.2374
Income	24.4599	22.5631
Black	0.1312***	0.0262
Hispanic	0.1381	0.1294
Catholic	0.3278	0.2961
Protestant	0.4967	0.4231
Other Religion	0.0544	0.0824
Poor Health	0.0774*	0.1610
Past Year Mental Illness	0.2473***	0.4318
Distant Mental Illness	0.1476***	0.3250
No Seatbelt	0.1017**	0.2215
No Condom	0.1749**	0.3158
Parents Depressed	0.4373	0.5373
Parents Drink	0.2490***	0.5149
Parents Drugs	0.0535***	0.1720
Parents Suicide Attempt	0.0429	0.0715
Parents Suicide Death	0.0024	0.0003
Fire	0.1191**	0.2420
Abused	0.0281**	0.1333
Neglected	0.0183*	0.0761
Molested	0.0554	0.0611
Shock	0.1282	0.1430
Death of Relative	0.2301	0.2371
Crisis	0.2254	0.2395
Observations	1,599	100

Notes: Number of observations listed represents the maximum number. For some variables, the actual sample size is slightly less due to missing information. For variables with significant amount of missing information, we assigned the sample mean and created a dichotomous variable indicating missing information for these observations. Variables falling into this category are: parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death. Asterisks indicate that the difference between abusers and non-abusers is statistically significant as follows: *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 4-2
Effect of Alcohol Use on Suicide Ideation and Suicide Attempt in the Past Year
Univariate Probit Estimates

Variable	Suicide Ideation		Suicide Attempt	
Alcohol Participation	0.0289*** [0.3050] (0.1183)	0.0155* [0.2412] (0.1380)	0.0091* [0.3941] (0.2318)	0.0017 [0.4138] (0.3013)
Age	0.0086 (0.2595)	0.0049 (0.2827)	0.0036 (0.5455)	-0.0004 (0.5877)
Age Squared	-0.0004 (0.0065)	-0.0002 (0.0069)	-0.0001 (0.0143)	0.000001 (0.0159)
Male	-0.0352*** (0.1104)	-0.0115 (0.1198)	-0.0122** (0.2045)	-0.0020** (0.2060)
High School Dropout	0.0720** (0.2207)	0.0274 (0.2562)	0.0194* (0.3092)	0.0038 (0.3450)
College Dropout	0.0194 (0.1653)	0.0109 (0.1655)	0.0041 (0.3039)	0.0001 (0.3231)
Income	-0.0015 (0.0026)	0.0008 (0.0029)	0.00001 (0.0061)	0.00003 (0.0064)
Black	-0.0070 (0.1407)	-0.0061 (0.1660)	0.0072 (0.2545)	0.0044* (0.2992)
Hispanic	-0.0068 (0.1785)	-0.0104 (0.1815)	0.0048 (0.2619)	0.0006 (0.2733)
Catholic	-0.0249 (0.1878)	-0.2185 (0.2258)	-0.0032 (0.2647)	0.0004 (0.2839)
Protestant	-0.0250* (0.1343)	-0.0218** (0.1670)	-0.0031 (0.2856)	-0.0009 (0.2785)
Other Religion	-0.0242 (0.2115)	-0.0162 (0.2604)	-0.0002 (0.3854)	0.0010 (0.4330)
Poor Health	0.0538*** (0.1194)	0.0242** (0.1207)	0.0190** (0.2425)	0.0039* (0.2854)
Past Year Mental Illness	-	0.0645*** (0.1286)	-	0.0068*** (0.2971)
Distant Mental Illness	-	0.0103 (0.1497)	-	0.0047* (0.3097)
No Seatbelt	-	0.0212* (0.1459)	-	-0.0001 (0.2933)
No Condom	-	-0.0082 (0.1575)	-	-0.0003 (0.2211)
Parents Depressed	-	0.0129 (0.1209)	-	0.0004 (0.3397)
Parents Drink	-	0.0086 (0.1485)	-	0.0017 (0.3008)

Contd.

Table 4-2 Contd.

Parents Drugs	–	0.0101 (0.2622)	–	0.0002 (0.3201)
Parents Suicide Attempt	–	-0.0235 (0.2426)	–	-0.0006 (0.4055)
Parents Suicide Death	–	0.1013** (0.7604)	–	0.0122*** (0.7809)
Fire	–	0.0143 (0.1437)	–	0.0077*** (0.1591)
Abused	–	0.0283 (0.2796)	–	0.0003 (0.4647)
Neglected	–	0.0615* (0.3078)	–	0.0081* (0.3790)
Molested	–	0.0343 (0.2368)	–	0.0039** (0.2180)
Shock	–	0.0159 (0.1427)	–	-0.0002 (0.1615)
Death of Relative	–	0.0068 (0.1237)	–	0.0002 (0.1419)
Crisis	–	0.0223*** (0.1027)	–	0.0037*** (0.1501)
Pseudo R-Squared	0.073	0.217	0.122	0.357
Observations	1,632	1,632	1,511	1,511

Notes: Marginal effects are reported. Coefficients are in brackets. Robust standard errors, clustered by state, are in parentheses. For dichotomous variables, marginal effects were approximated using the discrete change from zero to one. All models include eight region dummies. Dummy variables for missing information (parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death) are also included in the extended model. Two-tailed test: *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 4-3
Effect of Alcohol and Drug Use on Suicide Ideation in the Past Year
Univariate Probit Estimates

Suicide Ideation		
Alcohol Participation	0.0289*** [0.3050] (0.1183) Pseudo R ² = 0.073 N = 1,632	0.0155* [0.2412] (0.1380) Pseudo R ² = 0.217 N = 1,632
Binge Drinking	0.0328*** [0.3284] (0.0953) Pseudo R ² = 0.075 N = 1,629	0.0170** [0.2530] (0.1000) Pseudo R ² = 0.216 N = 1,629
Alcohol Abuse or Dependence	0.1017*** [0.7318] (0.1183) Pseudo R ² = 0.106 N = 1,632	0.0611*** [0.6401] (0.1309) Pseudo R ² = 0.238 N = 1,632
Drug Participation	0.0594*** [0.4846] (0.1165) Pseudo R ² = 0.084 N = 1,631	0.0337*** [0.4099] (0.1390) Pseudo R ² = 0.224 N = 1,631
Drug Abuse or Dependence	0.1004*** [0.6552] (0.2399) Pseudo R ² = 0.087 N = 1,632	0.0569** [0.5532] (0.2559) Pseudo R ² = 0.222 N = 1,632
Marijuana Participation	0.0663*** [0.5214] (0.1181) Pseudo R ² = 0.085 N = 1,581	0.0369*** [0.4436] (0.1402) Pseudo R ² = 0.235 N = 1,581
Additional Covariates	Excluded	Included

Notes: Marginal effects are reported. Coefficients are in brackets. Robust standard errors, clustered by state, are in parentheses. Marginal effects were approximated using the discrete change from zero to one. Basic set of covariates included in all models are: age, age squared, male, education, income, black, hispanic, catholic, protestant, other religion, poor health, and eight region dummies. Additional covariates are: past year mental illness, distant mental illness, parents depressed, parents drink, parents drugs, parents suicide attempt, parents suicide death, dummy variables for missing information (parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death), fire, abused, neglected, molested, shock, conflict, death of relative, and crisis. *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 4-4
Effect of Alcohol and Drug Use on Suicide Attempt in the Past Year
Univariate Probit Estimates

Suicide Attempts		
Alcohol Participation	0.0091* [0.3941] (0.2318) Pseudo R ² = 0.122 N = 1,511	0.0017 [0.4138] (0.3013) Pseudo R ² = 0.357 N = 1,511
Binge Drinking	0.0119** [0.4997] (0.2354) Pseudo R ² = 0.139 N = 1,508	0.0021* [0.4746] (0.2515) Pseudo R ² = 0.361 N = 1,508
Alcohol Abuse or Dependence	0.0435*** [0.9692] (0.2131) Pseudo R ² = 0.185 N = 1,511	0.0109*** [1.3171] (0.2776) Pseudo R ² = 0.428 N = 1,511
Drug Participation	0.0193*** [0.5679] (0.2041) Pseudo R ² = 0.135 N = 1,510	0.0040** [0.6204] (0.2618) Pseudo R ² = 0.368 N = 1,510
Drug Abuse or Dependence	0.0602*** [0.9890] (0.2789) Pseudo R ² = 0.174 N = 1,511	0.0184*** [1.1690] (0.3237) Pseudo R ² = 0.401 N = 1,511
Marijuana Participation	0.0215*** [0.5866] (0.2116) Pseudo R ² = 0.0127 N = 1,461	0.0042** [0.6561] (0.2855) Pseudo R ² = 0.372 N = 1,461
Additional Covariates	Excluded	Included

Notes: Marginal effects are reported. Coefficients are in brackets. Robust standard errors, clustered by state, are in parentheses. Marginal effects were approximated using the discrete change from zero to one. Basic set of covariates included in all models are: age, age squared, male, education, income, black, hispanic, catholic, protestant, other religion, poor health, and eight region dummies. Additional covariates are: past year mental illness, distant mental illness, parents depressed, parents drink, parents drugs, parents suicide attempt, parents suicide death, dummy variables for missing information (parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death), fire, abused, neglected, molested, shock, conflict, death of relative, and crisis. *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 4-5
Effect of Alcohol and Drug Use on Suicide Ideation in the Past Year
Constrained Bivariate Probit Estimates

Suicide Ideation	Univariate Probit $\rho = 0$	Constrained Bivariate Probit $\rho = 0.1$	Constrained Bivariate Probit $\rho = 0.2$	Constrained Bivariate Probit $\rho = 0.3$	Constrained Bivariate Probit $\rho = 0.4$	Constrained Bivariate Probit $\rho = 0.5$	Constrained Bivariate Probit $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$
Alcohol Participation	0.0155* [0.2412] (0.1380)	0.0047 [0.0721] (0.1376)	-0.0068 [-0.0996] (0.1367)	-0.0201** [-0.2749] (0.1354)	-0.0365*** [-0.4546] (0.1336)	-0.0579*** [-0.6405] (0.1314)	-0.0104 [-0.1493] (0.1364) $\rho = 0.23$
Binge Drinking	0.0170** [0.2531] (0.1000)	0.0056 [0.0849] (0.0994)	-0.0056 [-0.0848] (-0.0983)	-0.0175*** [-0.2567] (0.0967)	-0.0312*** [-0.4317] (0.0946)	-0.0480*** [-0.6109] (0.0919)	-0.0065 [-0.0982] (0.0982) $\rho = 0.21$
Alcohol Abuse or Dependence	0.0611*** [0.6401] (0.1309)	0.0393*** [0.4623] (0.1298)	0.0218** [0.2844] (0.1280)	0.0074 [0.1058] (0.1254)	-0.0048 [-0.0739] (0.1220)	-0.0160** [-0.2552] (0.1176)	-0.0125 [-0.1970] (0.1191) $\rho = 0.47$
Drug Participation	0.0337*** [0.4099] (0.1390)	0.0174* [0.2346] (0.1383)	0.0041 [0.0608] (0.1367)	-0.0071 [-0.1119] (0.1344)	-0.0175** [-0.2839] (0.1312)	-0.0279*** [-0.4557] (0.1270)	-0.0110 [-0.1745] (0.1333) $\rho = 0.34$

Contd.

Table 4-5 Contd.
Effect of Alcohol and Drug Use on Suicide Ideation in the Past Year
Constrained Bivariate Probit Estimates

Suicide Ideation	Univariate Probit $\rho = 0$	Constrained Bivariate Probit $\rho = 0.1$	Constrained Bivariate Probit $\rho = 0.2$	Constrained Bivariate Probit $\rho = 0.3$	Constrained Bivariate Probit $\rho = 0.4$	Constrained Bivariate Probit $\rho = 0.5$	Constrained Bivariate Probit $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$
Drug Abuse or Dependence	0.0569** [0.5532] (0.2559)	0.0316 [0.3597] (0.2559)	0.0127 [0.1683] (0.2542)	-0.0014 [-0.0214] (0.2506)	-0.0120 [-0.2095] (0.2451)	-0.0202* [-0.3959] (0.2373)	-0.0091 [-0.1532] (0.2470) $\rho = 0.37$
Marijuana Participation	0.0369*** [0.4436] (0.1402)	0.0197* [0.2656] (0.1394)	0.0060 [0.0894] (0.1379)	-0.0053 [-0.0855] (0.1355)	-0.0153** [-0.2594] (0.1323)	-0.0250*** [-0.4327] (0.1280)	-0.0046 [-0.0738] (0.1357) $\rho = 0.29$
Tobacco Participation Past Year	0.0352*** [0.4443] (0.1621)	0.0197* [0.2731] (0.1610)	0.0068 [0.1020] (0.1592)	-0.0044 [-0.0692] (0.1564)	-0.0150 [-0.2410] (0.1525)	-0.0259*** [-0.4136] (0.1476)	-0.0135 [-0.2165] (0.1531) $\rho = 0.39$
Tobacco Participation Past Month	0.0344* [0.4197] (0.2454)	0.0181 [0.2460] (0.2429)	0.0049 [0.0728] (0.2393)	-0.0063 [-0.1003] (0.2343)	-0.0164 [-0.2733] (0.2278)	-0.0264** [-0.4464] (0.2196)	-0.0195 [-0.3281] (0.2254) $\rho = 0.43$

Notes: Marginal effects are reported. Coefficients are in brackets. Robust standard errors, clustered by state, are in parentheses. Additional covariates are: age, age squared, male, education, income, black, hispanic, catholic, protestant, other religion, poor health, past year mental illness, distant mental illness, parents depressed, parents drink, parents drugs, parents suicide attempt, parents suicide death, dummy variables for missing information (parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death), fire, abused, neglected, molested, shock, conflict, death of relative, crisis, and eight region dummies. *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

Table 4-6
Effect of Alcohol and Drug Use on Suicide Attempt in the Past Year
Constrained Bivariate Probit Estimates

Suicide Attempt	Univariate Probit $\rho = 0$	Constrained Bivariate Probit $\rho = 0.1$	Constrained Bivariate Probit $\rho = 0.2$	Constrained Bivariate Probit $\rho = 0.3$	Constrained Bivariate Probit $\rho = 0.4$	Constrained Bivariate Probit $\rho = 0.5$	Constrained Bivariate Probit $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$
Alcohol Participation	0.0017 [0.4138] (0.3013)	0.0003 [0.2434] (0.2997)	0.0001 [0.0702] (0.2978)	-0.0002 [-0.1068] (0.2948)	-0.0006 [-0.2887] (0.2905)	-0.0013* [-0.4773] (0.2852)	0.0001 [0.1099] (0.2984) $\rho = 0.18$
Binge Drinking	0.0021* [0.4746] (0.2515)	0.0003 [0.3025] (0.2487)	0.0001 [0.1292] (0.2456)	-0.0001 [-0.0465] (0.2414)	-0.0003 [-0.2256] (0.2361)	-0.0008* [-0.4096] (0.2297)	0.0002 [0.1788] (0.2466) $\rho = 0.17$
Alcohol Abuse or Dependence	0.0109*** [1.3171] (0.2776)	0.0020*** [1.1299] (0.2732)	0.0012*** [0.9405] (0.2682)	0.0008*** [0.7477] (0.2614)	0.0005** [0.5503] (0.2527)	0.0003 [0.3467] (0.2419)	0.0012*** [0.9274] (0.2678) $\rho = 0.21$
Drug Participation	0.0040** [0.6204] (0.2618)	0.0006* [0.4455] (0.2592)	0.0003 [0.2714] (0.2558)	0.0001 [0.0969] (0.2509)	-0.0001 [-0.0789] (0.2441)	-0.0003 [-0.2574] (0.2354)	0.0002 [0.1930] (0.2538) $\rho = 0.24$

Contd.

Table 4-6 Contd.
Effect of Alcohol and Drug Use on Suicide Attempt in the Past Year
Constrained Bivariate Probit Estimates

Suicide Attempt	Univariate Probit $\rho = 0$	Constrained Bivariate Probit $\rho = 0.1$	Constrained Bivariate Probit $\rho = 0.2$	Constrained Bivariate Probit $\rho = 0.3$	Constrained Bivariate Probit $\rho = 0.4$	Constrained Bivariate Probit $\rho = 0.5$	Constrained Bivariate Probit $\rho = \frac{Cov(X'\Pi, X'\gamma)}{Var(X'\gamma)}$
Drug Abuse or Dependence	0.0184*** [1.1690] (0.3237)	0.0031*** [0.9726] (0.3190)	0.0018** [0.7766] (0.3137)	0.0010* [0.5800] (0.3067)	0.0005 [0.3819] (0.2976)	0.0002 [0.1809] (0.2860)	0.0011** [0.6052] (0.3077) $\rho = 0.29$
Marijuana Participation	0.0042** [0.6561] (0.2855)	0.0006* [0.4785] (0.2829)	0.0003 [0.3021] (0.2796)	0.0001 [0.1259] (0.2744)	-0.00005 [-0.0512] (0.2673)	-0.0002 [-0.2305] (0.2580)	0.0003 [0.2861] (0.2792) $\rho = 0.21$

Notes: Marginal effects are reported. Coefficients are in brackets. Robust standard errors, clustered by state, are in parentheses. Additional covariates are: age, age squared, male, education, income, black, hispanic, catholic, protestant, other religion, poor health, past year mental illness, distant mental illness, parents depressed, parents drink, parents drugs, parents suicide attempt, parents suicide death, dummy variables for missing information (parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death), fire, abused, neglected, molested, shock, conflict, death of relative, crisis, and eight region dummies. *** significant at 0.01 level, ** significant at 0.05 level, and * significant at 0.10 level.

**Appendix 4-1
Sample Means**

Variable	Definition	Mean
Suicide Ideation	A dichotomous indicator equal to one if the respondent seriously thought about or made a plan for committing suicide in the past year	0.0593
Suicide Attempts	A dichotomous indicator equal to one if the respondent attempted suicide in the past year	0.0199
Alcohol Participation	A dichotomous indicator equal to one if the respondent drank alcohol in the past year	0.5122
Binge Drinking	A dichotomous indicator equal to one if the respondent had five or more drinks on any given day in the past year	0.3941
Alcohol Abuse or Dependence	A dichotomous indicator equal to one if the respondent is diagnosed with alcohol abuse or dependence in the past year	0.1408
Drug Participation	A dichotomous indicator equal to one if the respondent used marijuana, cocaine, or heroin in the past year	0.1680
Drug Abuse or Dependence	A dichotomous indicator equal to one if the respondent is diagnosed with drug abuse or dependence in the past year	0.0607
Marijuana Participation	A dichotomous indicator equal to one if the respondent used only marijuana in the past year	0.1455
Past Year Tobacco Participation	A dichotomous indicator equal to one if the respondent used cigarettes in the past year	0.1877
Past Month Tobacco Participation	A dichotomous indicator equal to one if the respondent used cigarettes in the past month	0.1493
Age	Age of respondent	19.2457
Age Squared	Square of Age	378.5274
Male	A dichotomous indicator for males	0.5073
High School Dropout	A dichotomous indicator if the respondent has completed less than 12 years of education and is no longer a student	0.0873
College Dropout	A dichotomous indicator if the respondent has completed less than 16 years of education and is no longer a student	0.3063
Income	Family income, adjusted for differences in the ACCRA inter-city cost of living index and the national CPI, measured in thousands of dollars	24.3448
Black	A dichotomous indicator for blacks	0.1248
Hispanic	A dichotomous indicator for hispanics	0.1376
Catholic	A dichotomous indicator for catholics	0.3259

Appendix 4-1 Contd.
Sample Means

Variable	Definition	Mean
Protestant	A dichotomous indicator for protestants	0.4923
Other Religion	A dichotomous indicator for any other religion	0.0561
Poor Health	A dichotomous indicator for poor or fair health	0.0825
Past Year Mental Illness	A dichotomous indicator equal to one if the respondent is diagnosed with any of 12 psychiatric disorders, in the past year	0.2585
Distant Mental Illness	A dichotomous indicator equal to one if the respondent is diagnosed with any of 12 psychiatric disorders, in their lifetime but not in the past year	0.1584
No Seatbelt	A dichotomous indicator equal to one if the respondent never wore a seatbelt in a car or truck during the past year.	0.1089
No Condom	A dichotomous indicator equal to one if the respondent never used a condom during sex in the past year.	0.1833
Parents Depressed	A dichotomous indicator equal to one if the respondent reported either parent being depressed for at least two weeks	0.4434
Parents Drink	A dichotomous indicator equal to one if the respondent reported either parent had a problem with drinking	0.2652
Parents Drugs	A dichotomous indicator equal to one if the respondent reported either parent had a problem with illegal drugs	0.0607
Parents Suicide Attempt	A dichotomous indicator equal to one if the respondent reported either parent attempted suicide	0.0446
Parents Suicide Death	A dichotomous indicator equal to one if the respondent reported either parent died from suicide	0.0023
Fire	A dichotomous indicator equal to one if the respondent was involved in a fire, flood, or natural disaster	0.1265
Abused	A dichotomous indicator equal to one if the respondent was physically abused as a child	0.0345
Neglected	A dichotomous indicator equal to one if the respondent was seriously neglected as a child	0.0218
Molested	A dichotomous indicator equal to one if the respondent was molested	0.0557

Appendix 4-1 Contd.
Sample Means

Variable	Definition	Mean
Shock	A dichotomous indicator equal to one if the respondent suffered a great shock because someone close to them experienced a traumatic event	0.1291
Death of Relative	A dichotomous indicator equal to one if any close friend or relative of the respondent died in the past year	0.2305
Crisis	A dichotomous indicator equal to one if anyone close to the respondent had a major life crisis in the past year	0.2263
New England	A dichotomous indicator for respondents residing in the New England states	0.0474
Middle Atlantic	A dichotomous indicator for respondents residing in the Middle Atlantic states	0.1146
East	A dichotomous indicator for respondents residing in Eastern states	0.1878
West	A dichotomous indicator for respondents residing in the Western states	0.0765
South Atlantic	A dichotomous indicator for respondents residing in the South Atlantic states	0.2155
East South Central	A dichotomous indicator for respondents residing in the East South Central states	0.0485
West South Central	A dichotomous indicator for respondents residing in the West South Central states	0.1091
Mountain	A dichotomous indicator for respondents residing in the Mountain states	0.0513
Pacific	A dichotomous indicator for respondents residing in the Pacific states	0.1493
Number of Observations		1,699

Notes: Number of observations listed represents the maximum number. For some variables, the actual sample size is slightly less due to missing information. For variables with significant amount of missing information, we assigned the sample mean and created a dichotomous variable indicating missing information for these observations. Variables falling into this category are: parents depressed, parents drink, parents drugs, parents suicide attempt, and parents suicide death.

Appendix 4-2 Equal Selection Constraint

The intuition behind the strategy proposed by Altonji et al. (2001) can be illustrated as follows. Rewrite equations (1) and (3) in matrix form:

$$(4) \quad S = \alpha A + W'\Gamma$$

$$(5) \quad A = X'\Pi + v$$

Note that equation (4) represents the fully specified model and as such, includes no error term. The non-substance use determinants of suicidal behavior ($W'\Gamma$) can be divided into two parts: the observed and unobserved determinants.

$$(6) \quad S = \alpha A + X'\gamma + \varepsilon,$$

where $X'\gamma$ is the observed component of suicidal behavior and ε is the unobserved component. The identification problem is that substance use A is likely correlated with the unmeasured component ε , but substance use is also likely correlated with the measured component. These correlations can be expressed in terms of the linear projection of substance use on the observable and unobservable determinants of suicide:

$$(7) \quad \text{Proj}(A \mid X'\gamma, \varepsilon) = \text{Proj}(A \mid W'\Gamma) = \delta_c W'\Gamma = \delta_c X'\gamma + \delta_c \varepsilon.$$

Equation (7) assumes that the correlation between substance use and the measured component of suicidal behavior is equal to the correlation between substance use and the unmeasured component of suicidal behavior.¹⁹ This is the equal selection rule, and it is justified for example, if the measured variables were a random subset of a larger set of possible determinants, which is a reasonable assumption given that most secondary data sets used for economic analyses were not devised for the specific research question under study (Altonji et al., 2001).

Altonji et al. (2001) show that under certain condition, the correlations in equation (7) amount to the following:²⁰

$$(8) \quad \delta_c = \frac{\text{Cov}(A, X'\gamma)}{\text{Var}(X'\gamma)} = \frac{\text{Cov}(X'\Pi + v, X'\gamma)}{\text{Var}(X'\gamma)} = \frac{\text{Cov}(X'\Pi, X'\gamma)}{\text{Var}(X'\gamma)}$$

and

$$\delta_c = \frac{\text{Cov}(A, \varepsilon)}{\text{Var}(\varepsilon)} = \frac{\text{Cov}(X'\Pi + v, \varepsilon)}{\text{Var}(\varepsilon)} = \frac{\text{Cov}(v, \varepsilon)}{\text{Var}(\varepsilon)}.$$

Therefore,

$$\frac{\text{Cov}(X'\Pi, X'\gamma)}{\text{Var}(X'\gamma)} = \frac{\text{Cov}(v, \varepsilon)}{\text{Var}(\varepsilon)}.$$

The important point is that the left-hand side of the equality above can be estimated using observed data. This equality can be used to identify the model, since it provides an estimate of ρ – the correlation between the errors in the bivariate probit model. Actual estimation proceeds in steps. Initially, we assume that ρ is zero and obtain estimates of $\text{Cov}(X'\Pi, X'\gamma)/\text{Var}(X'\gamma)$ to use as an estimate of ρ . We then re-estimate the model to obtain a new estimate of $\text{Cov}(X'\Pi, X'\gamma)/\text{Var}(X'\gamma)$ and ρ . This process is continued until the estimate of ρ converges.

¹⁹ Because of strong selection on exogenous variables such as age, gender, and race, we exclude these variables when imposing the equal selection constraint.

²⁰ The necessary conditions are: random selection of observed variables, large number of determinants (i.e., large W) of suicidal behavior, and independence of observed and unobserved variables.

Appendix 4-3 Psychiatric Disorders from the National Comorbidity Survey

The following disorders are defined in the NCS data set. The mental illness variables used in this study are dichotomous indicators defined as equal to one if any of these disorders are present in the past year and during the respondent's lifetime but not in the past year:

- 1) Generalized anxiety disorder is defined by a protracted period of anxiety and worry, accompanied by multiple associated symptoms. These symptoms include muscle tension, easily fatigued, poor concentration, insomnia, and irritability.
- 2) Social Phobia describes people with marked and persistent anxiety in social situations, including performances and public speaking. The critical element of the fearfulness is the possibility of embarrassment or ridicule.
- 3) Simple Phobia include common conditions which are characterized by marked fear of specific objects or situations. Exposure to either the object of the phobia, either in real life or via imagination or video, invariably elicits intense anxiety, which may include a panic attack
- 4) Panic Attack is a discrete period of intense fear or discomfort that is associated with numerous somatic and cognitive symptoms. These symptoms include palpitations, sweating, trembling, shortness of breath, sensations of choking or smothering, chest pains, nausea or gastrointestinal distress, dizziness or lightheadedness, tingling sensations, and chills or blushing and hot flashes. The experience generally provokes a strong urge to flee or escape from the place where the attack began.
- 5) Panic Disorder is diagnosed when a person has experienced at least two unexpected panic attacks and develops persistent concern or worry about having further attacks or changes his or her behavior to avoid or minimize such attacks.
- 6) Agoraphobia comes from the ancient Greek meaning a fear of an open marketplace. Agoraphobia today describes severe and pervasive anxiety about being in situations from which escape might be difficult or avoidance of situations such as being alone outside of home, traveling in a car, bus or airplane, or being in a crowded area.
- 7) Post traumatic stress disorder refers to the anxiety and behavioral disturbances and functional impairment which develop after exposure to an extreme trauma, such as rape, other severe physical assault, near death experience, witness to murder and combat, and which persist for more than a month.
- 8) Dysthymia is a chronic form of depression. Its early onset and unrelenting, smoldering course are among the features that distinguish it from major depressive disorder. It is sometimes associated with passive, avoidant and dependent traits. There are less

symptoms required than there are for major depressive disorder, but the duration is at least two years.

9) Bipolar disorder is a recurrent mood disorder featuring one or more episodes of mania or mixed episodes of mania and depression. Bipolar is different from major depressive by virtue of a history of manic episodes. It has a higher familial prevalence than major depressive disorder.

10) Mania is a mood disturbance which ranges from euphoria to irritability. It may include inflated self-esteem, decreased need for sleep, being more talkative, racing thought process, distractibility, increased goal directed behavior and increased activities which are risky.

11) Non-Affective Psychosis is a summary category made up of schizophrenia, schizophreniform disorder, schizoaffective disorder, delusional disorder and atypical psychosis. It is characterized by profound disruption in cognition and emotion affecting the most fundamental human attributes such as language and thought. It can include hallucinations and delusions.

Additional disorders also defined for lifetime are:

12) Antisocial Personality Disorder requires a pattern of irresponsible and antisocial behavior beginning in childhood or early adolescence and continuing into adulthood.

13) Adult Antisocial Behavior is defined as a persistent pattern of criminal or other aggressive or antisocial behavior. This diagnosis pertains to those who do not meet the full criteria for Antisocial Personality Disorder and whose antisocial behavior cannot be attributed to any other mental disorder.

14) Conduct Disorder is a persistent pattern of behavior where the basic rights of others and major age-appropriate societal norms or rules are violated. Thi

Chapter V

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