Substance Abuse and the Demand for Cigarettes

by

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Abstract

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Substance abuse population consists of a special segment of the addiction group who overindulges in the use of drugs and alcohol. Concurrent use of cigarettes and drug or cigarettes and alcohol is especially high among this population. This study examines the impact of lifetime substance abuse diagnosis on cigarette smoking. Using two waves of individual records from the National Comorbidity Survey (NCS), the paper examines their smoking behavioral pattern from two perceptive: whether they respond differently to cigarette price changes from non-abusers and whether they are likely to substitute for drug or alcohol use upon quitting smoking. Results indicate that substance abusers and non-abusers may differ in how they respond to price and cost. Differential price elasticity estimates show that substance abusers do respond negatively to cigarette price changes, and in this study has a higher price elasticity than the non-abuse group (-0.55 versus -0.26). By adding quitting in the regression analysis, I obtain a significant and negative effect of quitting on drug and alcohol use for the substance abusers. As a result quitting is not likely to have a causal effect on possible substitution for the old 'habit' substance use for this vulnerable group. Higher cigarette excise taxes can still be an effective public policy tool for reducing smoking among individuals who have abused other substances and are also more likely to be heavy smokers. Concerns for the side effects of such policy such as substitution for other substance use upon quitting are alleviated.

Acknowledgements

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Chapter One: Introduction ---- Cigarette Smoking among the Substance Abuse Population

Cigarettes have been the target of top preventable health killer ever since the release of the First Surgeon's General report in 1964.[1] The First Surgeon General's report established the causal link between smoking and lung cancer, putting cigarettes smoking on the spotlight for public health. With the release of 28 subsequent reports covering wider ranges of health issues related to smoking, cigarettes have gradually reduced its glow of independence and individualistic rebellion posed by the mass media in 1960's. On the contrary, cigarette smoking is being associated with all kinds of fatal diseases such as lung cancer, shortened labor time and premature death. An estimated 400,000 deaths is lost to smoking each year, causing total annual damage to be around 167 billion.[2] Among these costs are direct medical bills for detention, treatment and rehabilitation, and indirect cost of lost productivity due to illness caused by smoking.

The nature of substance risky behavior causes externality which is not counted for in the individual's analysis of cost and benefit. Secondhand smoking and prenatal smoking causes as much damage to non-smokers as the smokers themselves. Thus relevant government interventions have been called in, such as regulation on the tobacco industry, dissemination of health knowledge among the public, and

[1] The First Surgeon General's report was released on January 11, 1964. On the basis of more than 7,000 articles relating smoking and disease in the biomedical literature at that time, the Surgeon General's Advisory Committee reached the conclusion that cigarette smoking is a cause of lung cancer and laryngeal cancer in men and the most important cause of chronic bronchitis. The release of the report was the first in a series of steps taken to diminish the impact of tobacco use on the health of the American society. All the reports that have been released since can be found on the official website. http://www.surgeongeneral.gov

[2] See "Fact sheet (updated September, 2006)" published by Centers for Disease Control and Prevention. http://www.cdc.gov/tobacco/data_statistics/Factsheets

establishment of health centers for addiction treatment. Policy can also indirectly influence people's smoking behavior by raising prices. Full cigarette price not only includes retail cigarette price but also implicit cost of consumption, such as the time spent to obtain the cigarettes. One important aspect of government policy is to reduce smoking prevalence by raising cigarette price through exercise tax and indoor smoking bans.

Like other normal consumption goods, cigarettes are subject to the law of demand. When the price of cigarettes goes up consumption goes down. Economic research has contributed to the understanding of this downward sloping curve by measuring the sensitivity of change in consumption in response to change in price. Numerous studies have tried to measure the elasticity of smoking participation and cigarette consumption. Yet the results of these studies are in wide range from -0.1 to -1.2. The elasticity of smoking participation can be anywhere between -0.1 and -0.6. The elasticity of consumption, which is less precisely measured, is in even bigger variation. The degree of sensitivity varies with type of data used and model specification. Yet several behavioral patterns concerning smoking have emerged. Smoking has strong correlation with demographic characteristics. Cigarette consumption declines with age, education and income. White are more likely to smoke than any other ethnicities. Male smoking rate is higher than female. Youth are more price sensitive than adults.

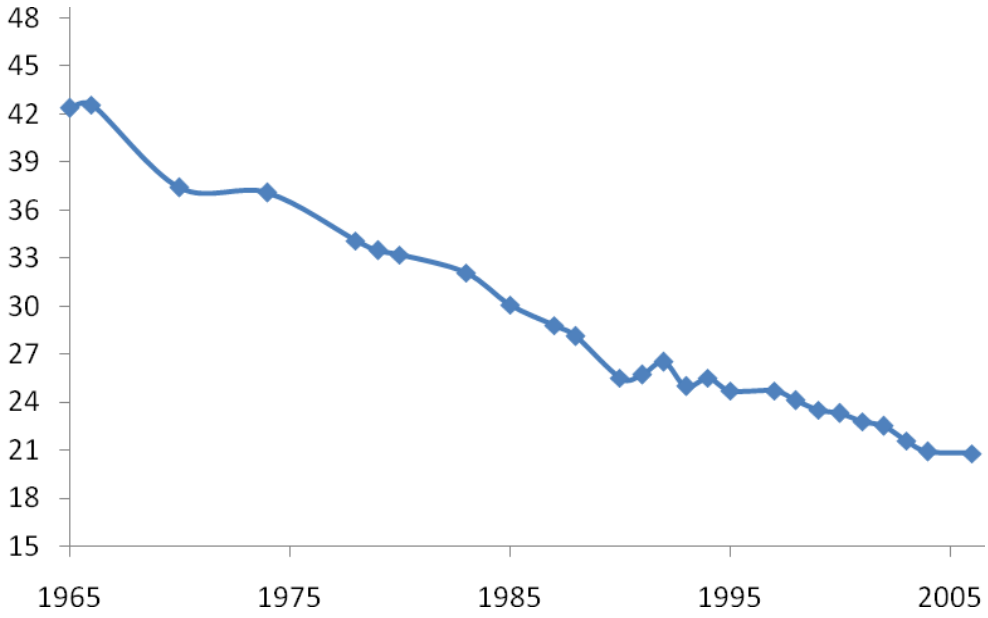
While much of the literature has focused on smoking prevalence in the general population, the interaction between cigarette and other substance use has been generally understudied. However the concurrent use of more than one substance is well documented. That "smokers drink and drinkers smoke" is a popular observation. NESARC (National Epidemiological Survey on Alcohol and Related Conditions), a

survey conducted by the National Institute on Alcohol Abuse and Alcoholism between 2001 and 2002, estimates approximately 46 million adults used both alcohol and tobacco during the past year and 6.2 million reported dependence on both alcohol and nicotine. The heaviest alcohol drinkers are also likely to be the heaviest consumers of cigarettes. Correlation between alcohol and cigarettes are strong at occurrence as well as use. One explanation for such strong correlation between the two substance uses is the similar mechanism in the brain that they work on. Both alcohol and cigarettes may act on the mesolimbic dopamine system, a part of the brain that is involved in reward, emotion, memory and cognition. Consuming alcohol and tobacco together is likely to augment the pleasure users experience from either use alone.

Cigarette smoking and illicit drug use also appear to go hand in hand. Several empirical studies find evidence for a sequencing pattern in consumption of addictive substance. Initiation of cigarette smoking or alcohol consumption is typically followed by marijuana use and later on other hard drugs among adolescents. This has led to the hypothesis of gateway effect where cigarettes and alcohol serve as the "gate" to other stronger substances. However this correlation hasn't proven to be causal. There might be common outside factors rooted in the biopsychological perspective that cause the use of both substances. Common liability theory suggests that cigarette itself is not the cause for progression to hard drugs, but rather propensity for drug use, which is the result of a combination of genetic, familial and environmental factors. Smoking can be a possible identifier of an individual at risk for progression to other illicit drugs.

Figure 1

Percentage of Smoking Prevalence Among U.S. Adults, 18 Years of Age and Older (1965-2005)



Source: Center for Disease Control and Prevention, Morbidity and Mortality Weekly Report [series online]

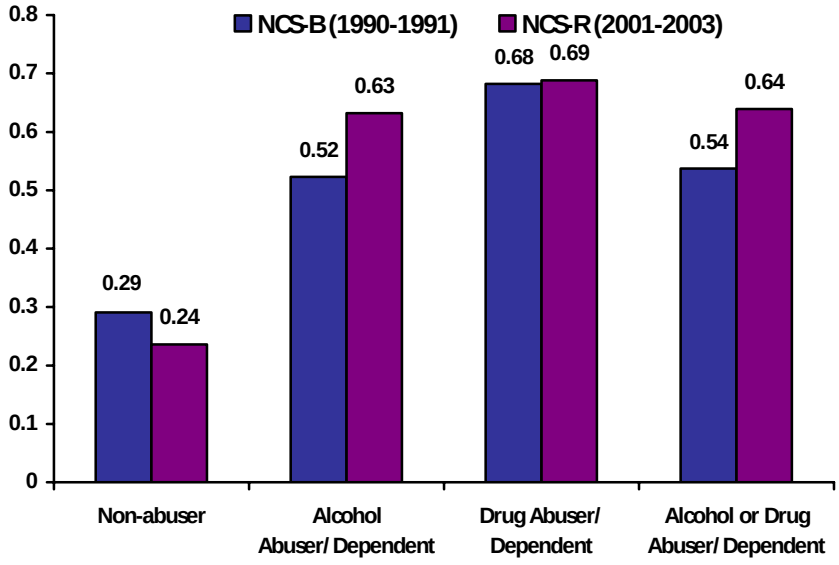
The focus of smoking behavior among the substance abuse population comes from the shifting pattern between the two groups across time. There is also concern about possible substitution between three major kinds of substance use. Smoking prevalence in the US has been declining since the early 70's. Following the ban on advertising on tobacco products and the legal settlement with the tobacco companies in 1998, smoking rate dropped from 42% in 1965 to 20.9% in 2004.[3] The drop is due to the decrease in initiation rate and the increase in quitting rate. Youth smoking rate has decrease as well, which could also contribute to the decrease of subsequent adult

[3] See Figure 1.

smoking population. On the other hand, the smoking rate among the substance abuse population has been quite steady if not increasing. According to National Comorbidity Survey which was conducted in two waves in 1990-1991 and 2001-2003, smoking rate among the substance abusers increases from 53.7% to 63.9% in ten years.[4] The increase comes mostly from the alcohol abusers and dependents, with an increase from 52.3% in 1991 to 63.2% in 2002. Smoking rate among the drug abuse population remains quite the same at 68%.

Figure 2

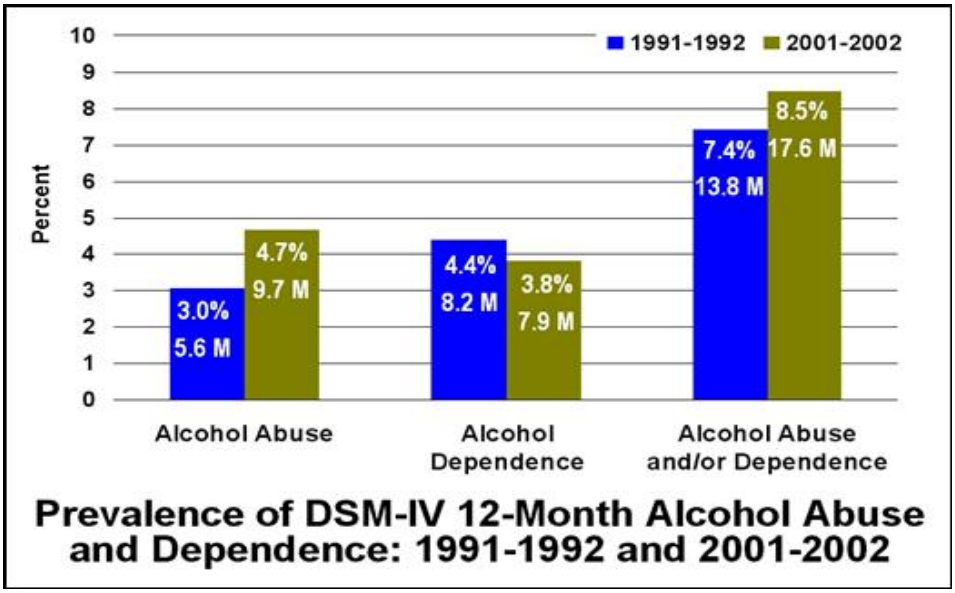
Smoking Prevalence by Lifetime Substance Disorder groups



Source: National Comorbidity Survey-Baseline (NCS-B); National Comorbidity Survey- Replicate (NCS-R)

[4] See Figure 2.

Figure 3



Source: Alcohol Abuse Increases, Dependence Declines Across Decade: Young Adult Minorities Emerge As High-Risk Subgroups, June 2004 National Institute on Alcohol Abuse and Alcoholism

Adding to the fact is the steady increase of alcohol and drug abuse population in recent years. National Institute Alcohol Abuse and Alcoholism reported an increase of alcohol abuse and dependence from 7.4% in 1991 to 8.5% in 2002.[5] Similar upward trend is detected in illicit drug abuse, where according to DAWN (Drug Abuse Warning Network),[6] ER emergency visits of all three categories of drug use (cocaine, heroine and marijuana) increase at least 34% from 1995 to 2002. Marijuana has the most obvious upward trend among the three.[7] With the pool of substance abuse population growing compared with the rest of the population, we would expect a shifting pattern of smoking prevalence away from the non-abusers to the substance abusers. People who choose to smoke are thus more likely to have strong addiction.

[5] See Figure 3.

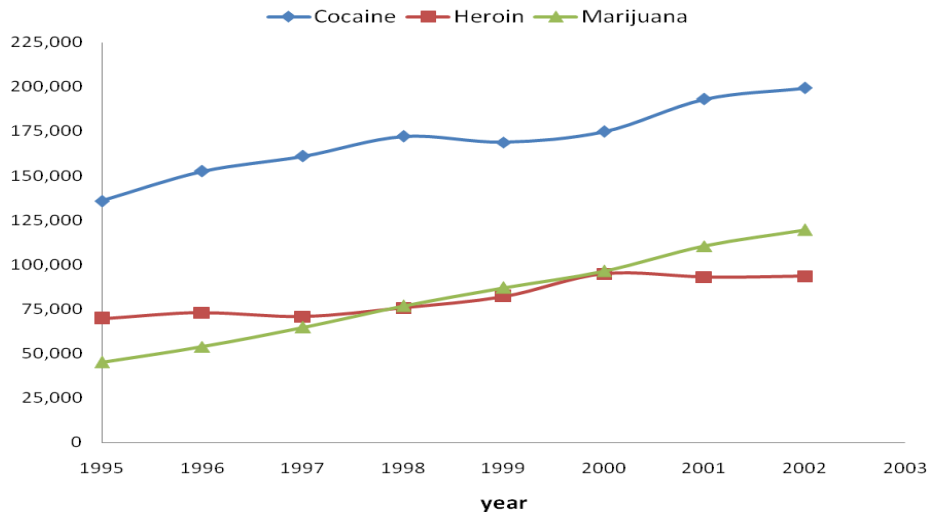
[6] Drug Abuse Warning Network is a public health surveillence system that monintors drug-related visitns to hospital emergency departments and drug-related deaths investigated by medical examiners and coroners.

[7] See Figure 4.

To further reduce smoking prevalence to the target of Health 2010 would require additional inspection into this specific sub population.

Figure 4

DAWN Total ER Mentions (1995-2002)



Source: Drug Abuse Warning Network ([*http://dawninfo.samhsa.gov*](http://dawninfo.samhsa.gov)*)*

Cigarette smoking has been consistently established as highly comorbid with a range of other substance use and mental health problems. The diagram above shows that smoking rate is twice as much for the substance abuse group as for the non-abuse group. Is this correlation simply due to the fact that cigarettes, drugs and alcohol deliver the same kind of pleasure and excitement through the nerve system? Or some unknown endogeneity such as risky personality or psychiatric disorder that attract a specific group to the same addictive pattern? The relationship between cigarettes, drugs and alcohol has been tested to either compliments or substitutes. Cigarettes and drugs are close to each other in usage, for both are inhalants that work in a similar mechanism. The relationship between cigarettes and alcohol is ambiguous. Some studies show that increase in cigarette tax would reduce the consumption of cigarettes

as well as alcohol, while others test to the opposite. So if policy is primarily targeted at the consumption of cigarettes, it might have side effects on another depending on the complimentary or substitute correlation. But if this correlation is due to psychiatric disorder or personal characteristic, addiction can be treated as a whole rather than specific form no matter which form the policy is aimed at.

Substance use disorder is one classification of mental illness in *Diagnostic and Statistical Manual of Mental Disorders* (DSM). It refers to disorders related to the taking of drugs including alcohol, the side effect of a medication, and the toxin exposure. There are two categories of disorders which put different emphasis on the degree of the addiction. Substance abuse is the repeated and compulsive use of drugs despite the adverse social, legal and health consequences such as reduced productivity at work, neglect of households, and social interpersonal problems. Substance dependence includes the symptoms of substance abuse, but also adds the physical dependence on the drugs, which would result in tolerance and withdraw. A diagnosis of substance abuse is preempted by the diagnosis of substance dependence if the individual's pattern meets the criteria of dependence. The detailed diagnosis criteria for both substance abuse and substance dependence in DSM can be found in the Appendix one. For the simplicity of this article, the term "substance abuser" is used to indicate an individual who is diagnosed with either substance abuse or substance dependence.

The large discrepancy in smoking prevalence between substance abusers and non-abusers could be subject to the influence of many factors such as socioeconomic disparities and differential personal preferences. Substance abusers tend to earn less income, have less education and be younger in age in the NCS sample. Psychology literature also finds the concentration of certain personality traits such as novelty

seeking, extraversion and impulsivity among substance abusers. To answer the question of whether substance abusers are of a distinctive group, an economic examination fully or partially controlling for these factors would greatly help to decompose the differences. So the first econometric examination would be to control for the differences in income, age, education, ethnicity and other demographic factors between the groups and confirm the correlation between substance use disorder and smoking.

Secondly the paper is to compare the price elasticity of the substance abuse group with that of the non-abuse group using stressful events and family substance abuse history as instrumental variables. Rational addiction model predicts that people with strong addictions, reflected by higher discount rates for future are likely to be more responsive to price changes. If the model is somewhat reflective of the case of substance abusers, they might be more responsive to price changes than non-abusers.

One concern for tobacco control policy targeted at the general population is that those who consume multiple forms of substances might switch from cigarette to drug or alcohol when cigarette smoking is restricted. Past research shows that smokers are likely to take on excessive eating after they quit smoking. Being overweight has no harmful health consequence. Thus the substitution of smoking with eating would not cause concerns for the tobacco control policy. But the same is not true with substance use. In fact current or prior substance abusers are heavy and regular users of alcohol or illicit drug. Reversing the substance abuse population back to the use of such substance might cause more damage than the gain from stopping smoking. In the last part the paper will explore if there is such substitution existing between cigarette smoking and other substance use, especially among the substance abuse population.

Chapter Two: Literature Review ---- Elasticity and Cross Price Elasticity

2.1 Price and the demand for cigarettes

The role of price plays an important part in the research of cigarette smoking. Like other conventional consumptions, cigarettes respond to price change according to the rule of downward sloping curve. When price goes up, participation rate and daily cigarette use go down. The price not only includes retail price and federal and state taxes, but also the monetary cost of the time to obtain and smoke a cigarette. In such cases, not only would we see a drop in cigarette consumption with the increase of federal and state taxes, but also with the passage of laws that ban indoor smoking, media advertising on cigarettes, and cross state cigarette smuggling.

Early research on price responsiveness is based on simple cross sectional aggregate consumption data. Lyon and Simon (1968) is among the early attempts to catch the elasticity of cigarette consumption. They use state retail price and per capita consumption in the year before and after the tax change published by the *Tobacco Tax Council* to obtain elasticity for each state each year when there is a tax change. The average of all state in all years is -0.511. Baltagi and Goel (1987) improved on Lyon and Simon (1968) by correcting for bootlegging effect and expanding the sample year to 1983. They obtained a much lower elasticity around -0.260. Baltgai and Goel (1987)'s estimation involves no assumption of demand function or any regression techniques. They take the difference in cigarette consumption between experiment group and control group after cigarette tax change. Control group is no tax change states, and experiment group is tax change states. According to their finding, bootlegging accounts for half of the elasticity calculated from the previous studies.

One important breakthrough for the estimation of price elasticity is the article by Becker and Murphy (1988). They propose the theory of rational addiction, which

states that smokers are rational foreseers who respond not only current price changes but also past and future price changes. Smokers maximize their utility across their life time. Past consumption of addictive behavior reinforces current consumption by entering the function of marginal utility of current consumption. Past and future price influences current consumption through past and future consumption. Thus when there is a current price change, it has short run effect as well as long run effect which include the effect on future consumption. The model distinguishes between long run price effect versus short run effect, temporary price effect versus life cycle events.

Based on the rational addiction model specification, Becker, Grossman and Murphy (1994) carries out the empirical experiment using a time series of state per capita cigarette consumption from 1955 to 1985. They used current consumption as the dependent variable, current price, personal income, index correcting for possible bootlegging effect as the independent variables. Past and future consumption can not enter the demand function directly because they are inevitably correlated with the error terms and would bias the estimation of the coefficient. Thus 2SLS is used. The estimation results confirmed the addictive nature of smoking by obtaining a positive coefficient on past consumption, and the rational nature of smoking through also a positive coefficient on future consumption. As predicted in the model, the price elasticity differed one from another depending on the definition. Long run price effect (-0.73) which includes the effect on future consumption is almost twice as much as short run (-0.40). Anticipated own price effect (-0.373) which could inversely change current consumption is larger than unanticipated effect (-0.349). Rational addiction model provides a possible explanation between the gaps of the estimation of price elasticities.

The use of macro data for empirical estimation creates collinearity problem when price changes can also be affected by state specific characteristics such as anti smoking sentiment. The ignorance of such endogeneity could produce biased and inconsistent estimators. Micro individual data can provide a gateway to such problem. Individual behavior is less likely to correlate with aggregate price change. A good example of use of such empirical analysis is by Chaloupka (1991). He estimated the rational addiction model by Becker and Murphy (1988) using the second National Health and Nutrition Examination Survey. The survey follows individual smoking habits from 1976 to 1980, which provided a panel study to test for the validity of the model. The estimation structure follows Becker and Murphy (1988), which produced similar results as measured in Becker, Grossman and Murphy (1994). Current consumption is dependent on current, past and future price, as well as past and future consumption. Past and future consumptions are instrumented with lags and leads of price and cigarette taxes to correct for endogeneity. The results confirm the addictive and rational nature of the substance use behavior with positive coefficients on both past and future consumption. Long run price elasticity ranges from -0.36 to -0.27, which is much lower that those obtained from Becker, Grossman and Murphy (1994).

Chaloupka(1991) also tested the degrees of addiction by different sub groups. Rational addiction model states that the shadow price of cigarette consumption for the less educated would be higher than that for the well educated. The same relationship is true between the young and elderly. Thus the former group would be more responsive to price change if the demand curve has constant slope. The results confirm part of the prediction with the less educated group, but young and older group turn out to be both less responsive than the mid age group.

Lewit and Coate (1982) is another example of using micro level data set. They estimate price elasticity of demand for cigarettes using individual smoking behavior from 1976 Health Interview Survey. They found price effect mainly through the decision to smoke among young males rather than adjustment in the quantity of cigarettes. The estimated elasticity is around -0.42.

2.2 Teen smoking

Smoking is a habitual forming behavior that starts at an early age. In fact the age onset is inversely related with the degree of addiction later on in the life. Thus the focus on teen smoking and youth smoking becomes an important subject that influences not only current smoking participation but also future participation. Lewit, Coate and Grossman (1981) is one of the few early papers that put the focus on teen smoking. They use teenage samples aged from 12 to 17 from Cycle III of Health Examination Survey to test the impact of Fairness Doctrine and anti-smoking messages on TV on teenage smoking. Their tests found most of the impact on teenage smoking participation rather than the quantity smoked. Teenage smoking participation elasticity exceeds one in all model specifications. It is estimateted from -1.2 to -1.4, which is more than twice that of the adults. The paper also found negative and significant impact of Fairness Doctrine and anti-smoking messages. The effect is found mostly on the first year of the doctrine and is diminishing for the years afterwards. The same is true with anti-smoking messages. The effect is minor in magnitude, but has marginally significant negative sign. Chaloupka and Wechsler (1997) focused on an older population who are college students aged from 18 to 22. But the same pattern is found among college students as well: they are much more responsive than the adults. Overall elasticity, which is the combination of elasticity

for smoking participation and elasticity for conditional cigarettes demand, ranges from -0.906 to -1.309. Restrictive laws on smoking such as smoking bans in restaurants, retail stores, schools, working places have their limited effect on college smoking. Only bans in restaurants and schools have significant and negative impact on college smoking. Although not all studies agree empirically on the results of the younger group, they more or less confirm that youth smoking is at least as responsive as the adults, if not more.

2.3 Smoking and other substance use

Polydrug use and the interaction between different kinds of substance abuse is a relatively unexplored area. Evidence in biomedical literature shows that the use of illicit drugs may heighten the effects of alcohol, just as drinking alcohol can heighten the effects of illicit drugs. The two drug uses reinforce each other, so that polydrug use is not an uncommon phenomenon.

DiNardo and Lemieux (2001) use data from Monitoring the Future to test the effect of minimum drinking age and decriminalization of marijuana on the demand of the two goods. They find that the increase of minimum drinking age from 18 to 21 has slightly increased the participation of marijuana among high school seniors as the unwanted side effect of the policy. But this substitute effect is not symmetrical because no significant influence is found by the decriminalization of marijuana on alcohol participation. Similar results are also found in Pacula et al (2000) indicating that alcohol and marijuana are substitutes, but the results were reversed in Pacula (1998). The estimation results are sensitive to the model specification such as the inclusion of state and year effect, and quadratic time trend, and further experimentations are needed to confirm the relationship in the polydrug use.

Some literature also explored the relationship between smoking and other substance use such as alcohol and drug. Dee (1999) found complimentary relationship between teen smoking and drinking using pooled cross-sectional data from MTF (Monitoring the Future). His results are based on the cross price effect from increased drinking age on smoking participation and higher cigarette taxes on drinking. Both cross price effects show that the increase of full price of one commodity would reduce the consumption of the other.

Beenstock and Rahav (2002) use individual consumption data from Israel to test the gateway theory. Gateway theory states that the sequence of consumption of addictive goods usually follows from alcohol and cigarettes, and then to cannabis, and finally to hard drugs such as cocaine, heroin and LSD. Thus according to this theory, cigarettes smokers or drinkers are more likely to engage in cannabis and hard drugs subsequently than non smokers and non drinkers. Their empirical evidence supports the chain from cigarettes to cannabis, but that from cannabis to hard drugs is weak. The dataset combines three waves of epidemiological survey carried out by the Israel Anti-Drug Authority. There is no cross section variation in cigarette price in Israel, but real cigarette price varies extensively across time. They use this time variation as instruments to identify changes in smoking participation. Changes in cigarette price are unlikely to be related directly to changes in cannabis use. The link between smoking participation and cannabis participation is strong under both 2SL and recursive bivariate model. Cigarette price turned out to be a strong identification instrument for smoking. But since the price of cannabis is unavailable in the paper, they use domino effect from the change in cigarette price on cigarette smoking and then on cannabis use in the first stage of hard drug use. The instrument proved to be weak and the link between cannabis and hard drug use is also weak as a result.

2.4 Exploration in the medical literature

Factors associated with cigarette smoking have been widely examined in pharmacologic, epidemiologic, behavior genetic, psychologic and psychiatric perspectives. Nicotine stimulates the brain's reward system and produces dependence resulting in physical and neurobiologic withdrawal symptoms on abrupt cessation. Addiction to nicotine causes smokers increase smoking intensity, smoking rate or inhalation to maintain levels of nicotine in the brain.

Genetic epidemiologic studies have used the twin study design to separate the effects of genetic and environmental risk factors on current smoking status. They estimate that the majority of the liability to become and remain a smoker is explained by addictive genetic factors. Specific environmental effects are related, but there is no consistent, statistically significant evidence for a shared or common environment effect. Personality and behavioral studies try to suggest why some people are more likely to smoke and what smokers perceive that they derive from smoking tobacco. Factors that might have become motives for smoking are constructed from psychosocial models such as smoking to relax, smoking to modify affect, or food substitution. Smokers experience self-reported increases in arousal and decreases in stress after smoking cigarettes, which might help to identify one of the motives for smoking cigarettes. Novelty seeking, extraversion, impulsivity, and neuroticism have been identified as the personality factors found at higher levels among smokers than nonsmokers. But it doesn't help to explain the difference in addiction level among smokers.

Significant associations have been found between smoking and depression, anxiety, and alcohol dependence. Ever smoking was found to be statistically

significantly more prevalent in those with major depression and with DSM-III alcohol dependence than in those with no DSM-III diagnoses. Modeling of genetic and environmental factors indicate a statistically significant genetic correlation between the liabilities to smoking and major depression, with specific environmental factors affecting the liabilities independently and a common environmental factor influencing the liability to smoking only. They suggest that common genetic factors may contribute to both daily smoking and major depression.

The relationship between tobacco and alcohol use and abuse has been the subject of comprehensive reviews. Smoking and alcoholism are statistically significantly associated in population samples. The study by Sher and Gotham (1996) supported reciprocal influence and common vulnerability models, where tobacco and alcohol influence each other with each predicting the other over time. Although a previous diagnosis of tobacco dependence or alcohol dependence increases the likelihood of being diagnosed with another disorder at a later time, comorbid tobacco and alcohol dependence does not increase the chance of recovery from either side. Studies show substantially the same genetic factors are operating in the same manner to influence both alcohol and tobacco use. Most of the genetic effect on tobacco consumption was found in the common genetic pathway, while most of the genetic effects on alcohol consumption were found in substance-specific pathways. This may reflect independent regulation of the multiple pharmacologic effects of nicotine and the paired substance.

Prevalence surveys indicate that some demographic variables are consistently associated with cigarette smoking. Specifically, male, younger age, and lower SES[8]

[8] SES (social economic status) reflects an individual's position within a hierarchal social structure. It depends on a combination of occupation, education, income, wealth, place of residence and such.

and lower educational attainment are positively associated with current smoking prevalence. The relationship between SES and smoking can be complex, which involves a number of related factors. Low SES is often associated with disadvantaged neighborhoods that have reduced levels of educational attainment, reduced level of parental monitoring, and a history of psychiatric disorder in mothers. These traits are statistically significantly associated with increased risk of smoking initiation. Whether low SES should be listed as an individual social factor that influence smoking prevalence should be handled with caution.

A string of clinical studies focus on the change of smoking behavior before and after the treatment of alcoholic and drug use disorders among substance abuse patients. Most substance abuse treatment facilities do not routinely treat cigarette smoking, while many literatures suggest complimentary cigarette smoking treatment would not interfere with the main theme, but on the contrary would enhance the treatment result. Joseph (1993) compared intervention group for alcoholism and drug addiction where smoking is totally banned during hospitalization with control group where smoking is allowed in certain designated areas. The result shows that there is no significant difference in treatment outcome, be it alcohol use or drug use. Patkar (2006) reported no significant change in number of cigarettes smoked per day from baseline to the end of the treatment for a group of 168 crack cocaine dependent patients. Many studies find that cessation of smoking during treatment helps to prevent relapse into alcohol and drug addictive behavior. But the degree of cigarette reduction varies with past history of alcohol and drug addiction. Wiseman(1998) reported patients with longer clinic enrollments report more increases and fewer reductions in the number of cigarettes smoked per day after the treatment of cocaine use. Sullivan (2002)

confirmed that tobacco abstinence does not increase alcohol relapse. But continued smoking adversely affects treatment for marijuana dependence. Kohn (2003) concluded that, based on a relatively bigger trial of 649 patients, those who quit smoking were less likely to be diagnosed as alcohol dependent compared to those that remained smokers. Those who started or resumed smoking were more likely to be diagnosed as both alcohol and drug dependent at treatment entry compared to all other groups. These clinical studies see no distinction between alcohol addiction and drug addiction when they compare the results. But intervention of smoking addiction during treatment of the other substance use would not interfere with the results.

Chapter Three: Models ---- Augmented Cigarette Demand Model with Two Addictive Goods

The addiction models in the literature incorporate two features that are specific to addictive consumption. The first feature reflects the effect of past consumption of the good on current consumption. If the good is addictive, increased past consumption increases current consumption because it raises marginal utility of current consumption. Past consumption accumulates in health capital stock, which enters the utility function of current consumption directly. This is interpreted as reinforcement effect in medicine. On the other hand, increased past consumption can also lowers current utility because of the harmful nature of the consumption good. When a person becomes addicted to the good, the increase in the utility by reinforcement effect must exceed the decrease caused by the harm.

The second feature reflects the effect of future consumption on current consumption. Although it resembles a symmetric relationship to the effect of past consumption on current consumption, the second feature requires the perfect foresight of future price. Thus future consumption could also enter the utility function of current period in the same manner as past consumption if price information is fully anticipated. The availability of the second feature distinguishes rational addiction model from myopic model. Myopic model acknowledges the addictive nature of the good but ignores the perfect foresight of price information. Thus in a myopic model there is no effect of future consumption on current consumption. In this paper a myopic model approach would be adopted to develop a theoretical backup for empirical estimation since the data set is only comprised of two years of variation. Richer information of price would be required if rational addiction model is to be tested.

The question starts with a typical consumption bundle that a representative individual faces. It can be expressed by a utility maximization on two goods: one composite good Y and another addictive good X. Since the focus of this paper is on the interaction between two addictive goods, X is further decomposed of two goods: C and S.

$$V=U(C_i, S_i, Y_i) \quad (1)$$

V is the instantaneous utility at any time t. It depends on three consumption goods: C, S and Y. C_i stands for consumption of cigarettes for individual i. S_i stands for the consumption of other substance use for the same individual. In this case S could be the diagnosis of either alcohol or drug. Y_i stands for the consumption of a bundle of non addictive goods. The utility function exhibits the property of concavity and negative second derivatives with respect to all three inputs. Then the following conditions are true:

$$U_y > 0 \; U_{yy} < 0;$$
$$U_c > 0 \; U_{cc} < 0;$$
$$U_s > 0 \; U_{ss} < 0; \quad (2)$$

The individual derives the feeling of pleasure and excitement from the consumption of cigarettes and other substance use. The marginal utility of cigarettes and substance use is positive. Cigarettes, alcohol and drug are harmful substances, which could imply their negative effect on health capital stock. Health capital stock enters the consumption of cigarette function. But this paper would temporarily ignore the question of health stock, and focus on the relationship between cigarette smoking and other substance use.

The consumption of Y is isolated from the rest of the two, meaning having no interaction with marginal utility of cigarette and other substance use.

$$U_{yc}=U_{ys}=0$$

However the use of cigarettes and other substances are related. The consumption of S increases the marginal utility of cigarettes, which means $U_{cs}>0$. Both alcohol and drug augment the excitement and pleasure of smoking cigarettes. Thus there is reason to believe that cross marginal utility is symmetric and positive.

The individual also faces resource constrains.

$$W_i=I_i = Y_i+P^cC_i+P^sS_i \quad (3)$$

The total recourse available is personal income I earned at any instantaneous time t. P^c and P^s are prices for cigarettes and other substances respectively. Assume the price of the composite good Y is normalized to 1.

Assume a simple quadratic utility function in the consumption of addictive goods.

$$U_i= \alpha_1C_i- (1/2)\alpha_2C_i^2+ \alpha_3S_i + \alpha_4Y_i \quad (4)$$

The marginal utilities can be expressed as:

$$U_c=\alpha_1- \alpha_2C_i$$
$$U_{cc} =- \alpha_2$$
$$U_s = \alpha_3$$
$$U_y= \alpha_4 \quad (5)$$

Following the above mentioned property of the utility function, it would be reasonable to assume that all α are positive.

To reflect the enhancement of cigarette effect when consumed together with alcohol and/or drug, assume α_2 is a function of S_i.

$$\alpha_2 = \beta_1 + \beta_2 S_i \quad (4)\text{ -1}$$

Then

$$U_{CS} = -\beta_2 C_i \quad (5)\text{ - 1}$$

Based on the assumption that simultaneous consumption of substance abuse and cigarettes increases the marginal utility of smoking cigarettes only, $U_{cs}>0$ and $\beta_2<0$.

Solve for the constrained utility maximization problem and obtain the first order condition for C_i. I have:

$$C_i = \frac{\alpha_1}{\alpha_2} - \frac{\lambda}{\alpha_2} P^C$$
$$\lambda = \alpha_4 = \frac{\alpha_3}{P^S} \qquad (6)$$
$$I = P^C C_i + P^S S_i + Y_i$$

λ is the marginal utility of income. The second equation states the equality of the monetary value of marginal utility across all goods. Substitute λ and α_2 in the first equation.

$$C_i = \frac{\alpha_1}{\beta_1 + \beta_2 S_i} - \frac{\alpha_3}{\beta_1 + \beta_2 S_i} \frac{P^C}{P^S} \qquad (7)$$

With previous assumptions of $\alpha_1>0$ and $\beta_2<0$, a substance abuser is likely to smoke more cigarettes or more likely to participate in smoking than a non-abuser. The first term in the equation reflects the effect of substance use on marginal utility of cigarettes. The presence of substance abuse increases the consumption of cigarettes. The second term in the equation reflects the effect of substance use on the price responsiveness of cigarettes. Holding everything else constant, the presence of substance abuse increases the magnitude of the coefficients and therefore the price responsiveness.[9] In all if substance abusers do obtain more pleasure from smoking cigarettes than non substance abusers, they would have a higher demand for cigarettes and respond more the price changes according to the model.[10]

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[9] S_t is a dichotomous variable varying between 0 and 1. When S_t equals one, the denominator of the second term is smaller since β_2 is negative. Therefore the whole term is bigger, implying a bigger response.

[10] The specification and derivation of the model benefits from Saffer and Dave (2005) where they examine the effect of mental illness on illicit drug use, alcohol use and cigarette smoking.

Solve the equation system (6) and obtain the demand equation for cigarettes, substance abuse and the composite non addictive good.

$$\begin{aligned} S_i &= S(P^S, P^c, I_i) \\ C_i &= C(P^C, P^S, I_i) \\ Y_i &= Y(P^C, P^s, I_i) \end{aligned} \tag{8}$$

So each demand function depends on the price of its own good, the price of other goods, and aggregate income.

Equation (7) supports the theoretical framework to examine the role of substance abuse on smoking. Accounting for other factors that might influence cigarette smoking, the following empirical equation will be estimated.

$$C_i = \chi_1 + \chi_2 P_i^C + \chi_3 S_i P_i^C + \chi_4 S_i + \chi_5 I_i + X + \varepsilon_i \tag{9}$$

The left hand side variable will include two measures of cigarette smoking: participation and consumption. The right hand side includes cigarette price, substance abuse, the interaction between substance abuse and cigarette price, income and other demographic characteristics represented by X. ε_i is the error term and contains all the other immeasurable information that influences cigarette smoking. Cigarette participation and substance abuse are both dichotomous variables. If χ_3 is positive substance abuse is likely to increase the elasticity on cigarette price. If it turns out to be negative the opposite conclusion will be drawn.

One problem of direct estimation of Equation (9) is the endogeneity of substance abuse. ε_i could be correlated with substance abuse. The correlation could be due to the common liability factors that influence cigarette smoking and substance abuse at the same time. Examples of such common liability factors are well illustrated in the medical literature. Individuals with high risk preference, novelty seeking personality or impulsive behavior are more likely to take on substance use. These factors are hard

to control in this data set and therefore the estimation without control for endogeneity is going to be biased. Endogeneity can be corrected with the use of instruments. Equation (9) can be estimated using the predicted value of substance abuse from instruments. Or the following structure is proposed for estimation.

$$\begin{aligned} C_i \mid_{s_i = 1} &= \beta_0 + \beta_1 P^C + \beta_2 X_i + \varepsilon_{1i} \\ C_i \mid_{s_i = 0} &= \alpha_0 + \alpha_1 P^C + \alpha_2 X_i + \varepsilon_{2i} \\ S_i &= \kappa_1 + \kappa_2 P^S + \kappa_3 I_i + \kappa_5 X_i + \varepsilon_{3i} \end{aligned} \tag{10}$$

The right hand side variables are cigarette smoking and substance use respectively. The demand for cigarettes is stratified into two groups based on the diagnosis of substance abuse. The left hand side variables are similar to equation (9), except the exclusion of cross price effect. The effect of substance abuse will be reflected on the difference of the coefficients on cigarette price. If β_1 is bigger in magnitude than α_1 it confirms that substance abusers are more price responsive than non-abusers. The error terms in the cigarette demand function are very likely to be correlated with the selection criteria on substance abuse for the same reason in Equation (9). Again correction for endogeneity requires the replacement of the actual value substance abuse with the predicted value from substance abuse demand function. The problem of endogeneity and use of instruments will be discussed more the chapter 5.

To test possible cross substitution between the use of three drugs, demand functions from Equation (8) is extended with the inclusion of demographic variables and error terms.

$$S_i = \gamma_0 + \gamma_1 P^S + \gamma_2 P^C + \gamma_3 X_i + \varepsilon_{3i} \tag{11}$$

The cross price effect is reflected by the coefficient γ_2. If γ_2 is positive, cigarettes and the other substance use are substitutes. If γ_2 is negative, cigarettes and the other substance use are complements.

Chapter Four: Data Set ---- National Comorbidity Survey (1990-2002)

National Comorbidity Survey (NCS) is a national representative survey on mental health in the US. It has fully structured diagnosed mental disorders, including alcohol dependence and abuse, and drug dependence and abuse. The first wave of the survey (NCS-Baseline) was carried out between the fall of 1990 to the spring of 1992 with a total of 8098 respondents. The focus of the survey is emotional and behavioral problems, drug and alcohol use that lead to diagnosis of psychiatric disorders according to the definitions of DSM-III-R.

DSM stands for Diagnostic and Statistical Menu of Mental Disorders. It is published by American Psychiatric Association that lists the various categories and criteria for diagnosis of mental disorder. It has gone through five main revisions since its first publication since 1952. DSM-III-R was published in 1987 as a revision of DSM-III. The diagnostic interview used to generate these diagnoses in NCS is a modified version of CIDI (Composite International Diagnostic Interview). CIDI is a comprehensive and full-structured interview designed to be used for assessment of mental disorders according to the criteria of DSM. CIDI is maintained by the World Health Organization. Both the interview questions and the final diagnoses are available in the dataset. NCS has two time dimensions of diagnoses of substance use disorders. Twelve-month diagnoses are made within the subsample of the respondents who qualify for lifetime diagnoses and who also reported at least one DSM symptom during the 12 month period before the interview. Analysis has been carried out on both twelve-month substance abusers and lifetime abusers.

The first wave also contains one tobacco supplement that questions half of the sample about their tobacco use. The total number of this sub sample size is 4411

observations. The questions include standard tobacco survey questions such as daily usage, onset age, quitting attempts, and physical and emotional changes related to quitting. These measurements will be combined with basic social and personal background information such as family, religion, marriage, employment and ethnic and racial background in the survey to examine the impact of substance use on smoking.

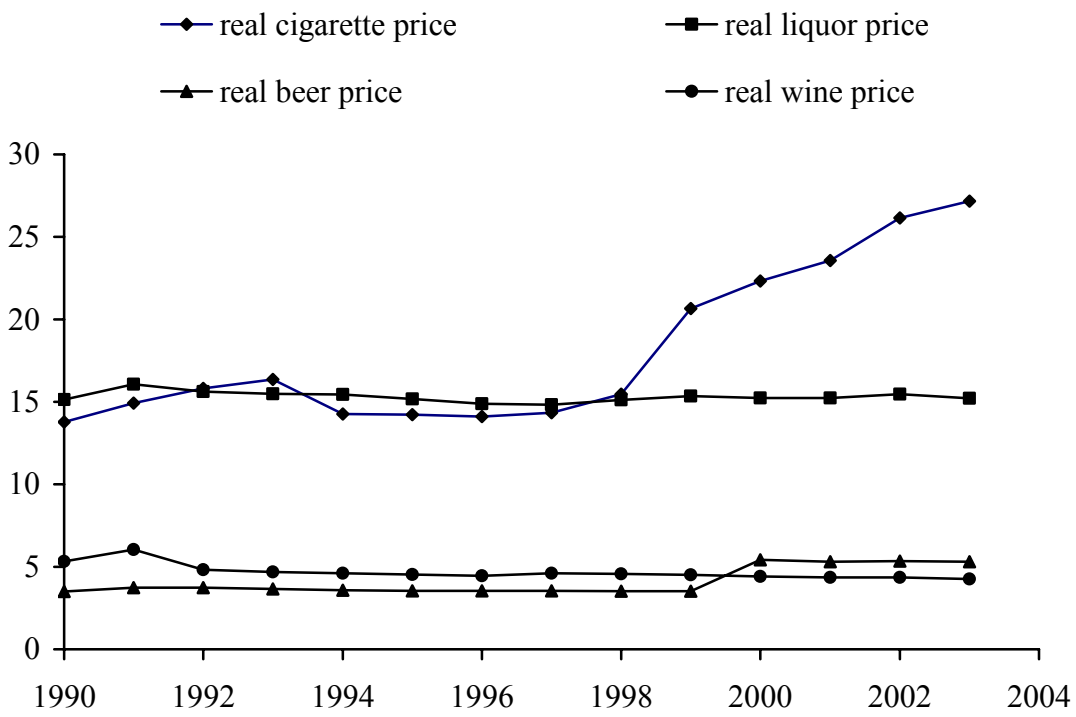
The second wave was fielded between February 2001 and April 2003, which produced two more surveys on the prediction and trend on the course of mental illness: NCS-2 and NCS-R (NCS-Replication). NCS-2 followes the same sample as NCS-Baseline, while NCS-R draws on a new national sample of 10,000 respondents. NCS-2 is currently unavailable for public use. The structure of NCS-R is the same as NCS-B with diagnosed mental disorders and tobacco use. The diagnosis criterion for psychiatric disorder is from DSM-IV. The survey results in a total of 9282 observations.

Combining NCS-B and NCS-R gives the advantage of exploiting both cross sectional and cross year variations in tobacco policy, alcohol price, and drug price. Tobacco policy takes a dramatic change after the issuance of the General Surgeon's report. Government regulations tighten the use of tobacco in public by raising taxes, imposing media bans on advertising, and most recently bans on indoor smoking. Figure 5 shows the upward trend in real cigarette price from 1991 to 2003. Federal cigarette tax increases from 20 cents per pack in 1991 to 39 cents in 2003. State cigarette tax also increases with variations among the states. On average it increases from 23.98 cents per pack in 1991 to 66.07 cents in 2003, an increase by 175.5%. Two level of cigarette tax hikes result in 119% increase in cigarette price including all taxations. Cross sectional cigarette price variation mainly comes from difference in

state level of tax. In 2003 the lowest level of state tax is Virginia, merely 2.5 cents a pack. The highest is Massachusetts of 151 cents a pack. Most actions in indoor smoking bans and advertising bans occur before 1991. So much of the exploration of the difference in tobacco policy will come from the monetary price of cigarettes.

Figure 5

Trend of Real Cigarette and Alcohol Price from 1990 to 2003



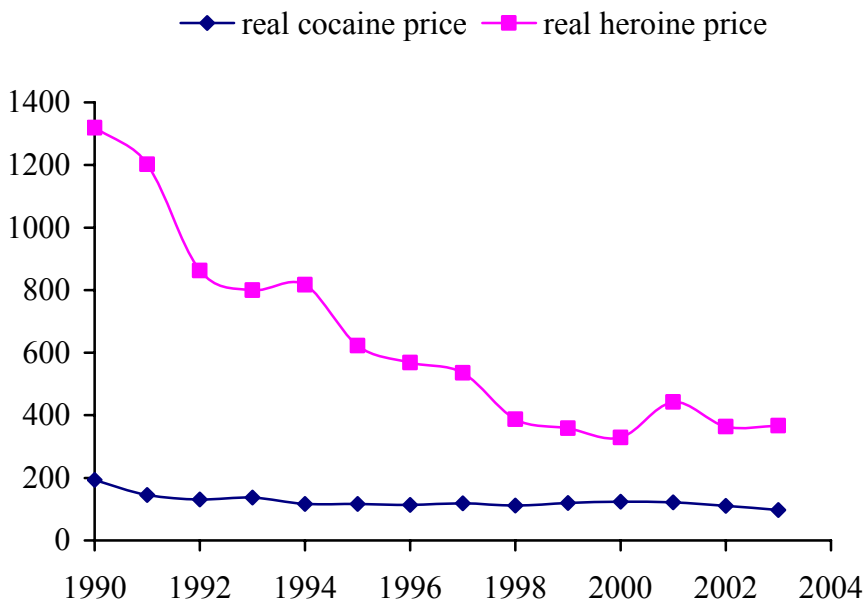
Source: ACCRA Cost of Living Index

The trend in real alcohol price and drug price would help to identify possible instruments for alcohol and drug use disorders. Real alcohol price is declining steadily due to the stability of federal tax since 1991. Real beer price declines by 9 percent, real wine price by 13 percent, and real spirits price by 8 percent. The same declining

trend is also detected in drug price, where marijuana exhibits the biggest fluctuation[11]. Figure 6 shows the real price of cocaine and heroine from 1990 to 2003. Both prices fall throughout the years. Heroine price is almost a third of its price ten years ago, and cocaine price is half of what it costs ten years ago. The pattern of marijuana price change is slightly different from cocaine and heroine, as shown in Figure 7. Price is on the upward ride till the 1993, and then starts to decline till 1996. A sharp increase occurred from 1996 to 1997. From then on, the price is on the steady decrease. Real marijuana price is about 70% in 2001 of the price in 1990. The drug prices are from STRIDE (System to Retrieve Information from Drug Evidence), maintained by the Drug Enforcement Administration of U.S. Department of Justice. [12]

Figure 6

Trend of Real Cocaine and Heroine Price from 1990 to 2003

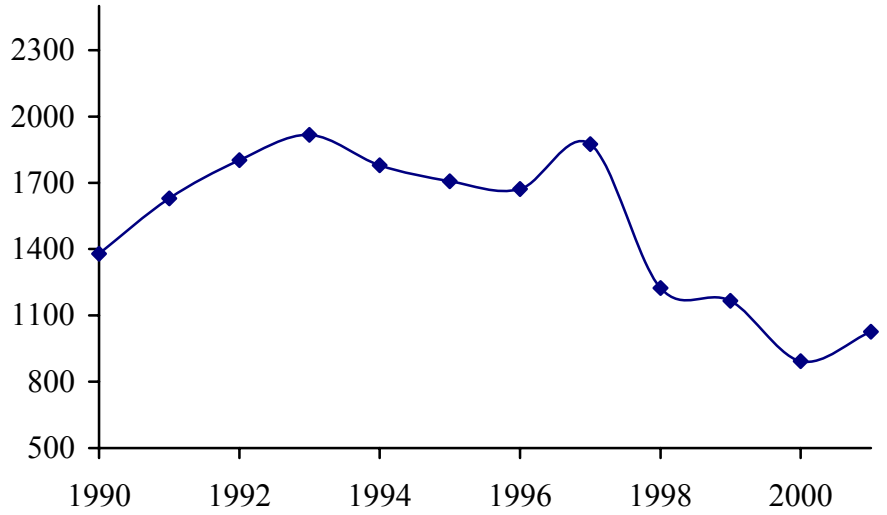


[11] See Grossman (2005).

[12] The drug price used here is a derived price reflecting the price of a pure gram of the drug itself. The initial drug price information is collected from the street. Regression analysis correcting for geographic difference, population and sample errors is carried out to derive a full set of drug price based on MSA. See Dave (2004).

Figure 7

Trend of Real Marijuana Price from 1990 to 2001



The combined data set has the typical characteristic of a national sample with 27% mean rate of smoking participation. Table 1 summarizes the definition of the key variables used in the dataset. Following are the descriptive statistics of the two surveys. Means are weighted to adjust for sample selection for each survey.

Table 1

Definition of the Variables

Variables	Definition
Lifetime substance abuse	Dichotomous variable indicating diagnosis of either lifetime alcohol or lifetime drug abuse/dependence
Lifetime alcohol abuse	Dichotomous variable indicating diagnosis of lifetime alcohol abuse/dependence
Lifetime drug abuse	Dichotomous variable indicating diagnosis of lifetime drug abuse/dependence
Tobacco participation past year	Dichotomous variable indicates whether having smoked past year
Tobacco participation lifetime	Dichotomous variable indicates having ever smoked during lifetime
Num. of cigs (smoking the most) [13]	Number of cigarettes smoked per day when smoking the most
Num. of cigs (past year) [14]	Number of cigarettes smoked per day past year
Days of smoking (past year)[14]	Number of days at least one cigarette was smoked past year
Quit smoking past year[13]	Dichotomous variable when 1 indicates having quitted smoking past year
Cocaine participation past year	Dichotomous variable when 1 indicates having used cocaine past year
Alcohol participation past year	Dichotomous variable when 1 indicates having used alcohol past year
Drinking frequency past year	Number of times alcohol was used past year
Age	Age of the respondent
Male	Gender of the respondent, 1 indicating a male
Education	Number of years of schooling
Married	Dichotomous variable when 1 indicates having married
White	Race of the respondent, 1 indicating white
Black	Race of the respondent, 1 indicating black

[13] The survey question is only available in NCS-Baseline.

[14] The survey question is only available in NCS-Replication.

Table 1 continued …

Other race	Race of the respondent, 1 indicating race other than white and black
Household Income	Dollar value of overall household income
Religious[15]	Dichotomous variable when 1 indicates being religious
Midwest	Residence of the respondent, 1 indicating Midwest
Northeast	Residence of the respondent, 1 indicating Northeast
South	Residence of the respondent, 1 indicating South
West	Residence of the respondent, 1 indicating West
Lifetime combat	Dichotomous variable indicating whether having had combat experience in a war
Lifetime kidnapped	Dichotomous variable indicating whether having been threatened with a weapon, or held captive or kidnapped
Lifetime accident	Dichotomous variable indicating whether having involved in life threatening automobile accidents
Lifetime ever raped	Dichotomous variable indicating whether having been raped
Lifetime other event	Dichotomous variable indicating whether having had other traumatic events
Lifetime molested	Dichotomous variable indicating whether having been sexually molested
Lifetime saw kill/injured	Dichotomous variable indicating whether having witnessed someone badly injured or killed
Lifetime suicide thoughts	Dichotomous variable indicating whether having seriously thought committing suicide
Lifetime death of relatives	Dichotomous variable indicating whether having experienced death of relatives
Lifetime crisis	Dichotomous variable indicating whether having had traumatic events to loved ones
Mother substance abuse problem	Dichotomous variable indicating mother's alcohol or drug use disorder
Father substance abuse problem	Dichotomous variable indicating father's alcohol or drug use disorder

[15] "Religious" indicates having religious preference versus none. In NCS-baseline, being Protestant, Catholic or other categories are considered as religious. In NCS-replication, religious categories are more detailed. So being Protestant, Baptist, Lutheran, Methodist, Pentecostal, Presbyterian, Catholic or others are considered as religious. "Non-religious group" are those coded as no religion preference or atheist.

Table 2

Descriptive Statistics of NCS-B

	Full Sample		Past Year Substance Abuser		Lifetime Abusers	
	1	2	3	4	5	6
Variable	Obs.	Mean	Obs.	Mean	Obs.	Mean
Age	5877	33.17	937	29.77***[16]	2217	32.62***
Male	5877	0.50	937	0.70***	2217	0.65***
Education	5877	12.81	937	12.44*	2217	12.77***
Married	5877	0.60	937	0.49***	2217	0.62***
Hispanic	5877	0.09	937	0.09	2217	0.08***
Black	5877	0.12	937	0.07***	2217	0.06***
Other Race	5877	0.03	937	0.02***	2217	0.02***
Household Income	5877	40414.24	937	35014.89***	2217	38874.92
Religious	5877	0.91	937	0.86***	2217	0.87***
Metro[17]	5877	0.46	937	0.45	2217	0.45
Midwest	5877	0.24	937	0.25	2217	0.24
Northeast	5877	0.21	937	0.22	2217	0.21
South	5877	0.35	937	0.32	2217	0.31
West	5877	0.20	937	0.21	2217	0.24
Past year Cocaine Participation	5862	0.02	933	0.13***	2208	0.06***
Past year cocaine use	182	41.55	131	54.38	158	50.06
Past year marijuana participation	5848	0.10	926	0.41***	2199	0.25***
Past year marijuana use	750	78.43	361	105.99***	539	90.21*
Past year alc. participation	5876	0.63	936	0.95***	2216	0.84***
Past year drnk freqency	3913	88.56	891	195.16***	1876	135.02***
Past year tobacco part.	4408	0.32	479	0.55***	1138	0.48***

[16] *** indicates significance test for the difference between substance abusers group and non substance abusers group. The performed test is t-test. *** indicates significance at 1% level; ** at 5% level; * at 10% level.

[17] "Metro" area refers to large, core metropolitan counties; greater SMSA's of 1,000,000 or more population; core counties of metropolitan areas of 1,000,000 or more population.

Table 2 continued …

Lifetime tobacco part.	4411	0.47	480	0.65***	1139	0.66***
Num of cigarette when smkng most	2070	22.80	478	16.75***	1137	17.18***
Past year quitting smoking	1400	0.11	257	0.08*	546	0.11
Past year alcohol disorder[18]	5877	0.10	937	0.86	2217	0.36
Lifetime alcohol disorder	5877	0.24	937	0.93	2217	0.89
Past year drug disorder	5877	0.04	937	0.32	2217	0.14
Lifetime drug disorder	5877	0.12	937	0.47	2217	0.45

[18] Alcohol or Drug disorder includes diagnoses for both abuse and dependence.

Table 3

Descriptive Statistics of NCS-R

	Full Sample		Past Year Substance Abuser		Lifetime Abusers	
	1	2	3	4	5	6
Variable	Obs	Mean	Obs	Mean	Obs	Mean
Age	5692	45.01	283	30.70***	1144	40.12***
Male	5692	0.47	283	0.69***	1144	0.68***
Education	5692	13.08	283	12.65***	1144	12.82***
Married	5692	0.56	283	0.30***	1144	0.48***
Hispanic	5692	0.11	283	0.17***	1144	0.12
Black	5692	0.12	283	0.07**	1144	0.09***
Other Race	5692	0.04	283	0.04	1144	0.05*
Household Income	5692	59276.14	283	55187.88	1144	53566.76***
Religious	5671	0.86	281	0.68***	1138	0.73***
Metro	5692	0.40	283	0.45*	1144	0.41
Midwest	5692	0.24	283	0.26	1144	0.24
Northeast	5692	0.19	283	0.19	1144	0.18
South	5692	0.36	283	0.26	1144	0.28
West	5692	0.22	283	0.29	1144	0.30
Past year Cocaine Participation	1116	0.10	178	0.30***	608	0.16***
Past year cocaine use	118	28.11	57	27.47	87	31.95
Past year marijuana participation	2824	0.22	262	0.58***	965	0.32***
Past year marijuana use	640	99.65	151	139.50***	308	138.12***
Past year alc. participation	4427	0.84	277	0.99***	1121	0.80***
Past year drnk frenq	3756	87.43	274	171.91***	888	135.06***
Past year tobacco part.	5692	0.25	283	0.64***	1144	0.52***
Lifetime tobacco part.	5692	0.50	283	0.83***	1144	0.81***

Table 3 continued ….

Past year cigarette use	1923	14.19	210	14.58	697	16.65***
Past year num of days smoking	3053	178.48	237	280.12***	942	229.79***
Past year alcohol disorder	5692	0.03	283	0.81	1144	0.21
Lifetime alcohol disorder	5692	0.13	283	0.92	1144	0.90
Past year drug disorder	5692	0.01	283	0.36	1144	0.09
Lifetime drug disorder	5692	0.08	283	0.67	1144	0.54

Table 2 shows the comparison between full sample and substance abuse sample for NCS-Baseline. A maximum of 5877 observations are included in the table. The first two columns show the number of observations and means of the full sample. The mean age is 33 years old with half males. White is the majority, around 75%. The average household income is 40414 dollars in 1990 -1991 currency. The ratio for being religious is 91%. About half of the sample population lives in metropolitan area. Tobacco participation is 32%, which is higher than the national rate of 25% at that time. For those who smoke, they smoke an average of 22.8 cigarettes per days when smoking the most. Only 11% quitted smoking during the past year. Drug use includes two categories because heroine participation is zero in NCS-R. The majority of the drug use is with marijuana, with participation rate of 10%. Cocaine participation is 2%. Alcohol participation is 63%, with an average of 88.6 times of drinking during the past year. Of the whole sample, 24% have lifetime alcohol abuse/dependence disorder, and 12% have lifetime drug abuse/dependence disorder.

Column 4 shows the means only for the past year alcohol and drug abusers. The significance test shows that this group has very different characteristics from the general population. They tend to be younger, slightly less educated, less religious, having a high percentage of white and male, and lower income. Their tobacco use is stronger than the whole sample. Smoking participation is higher and quitting rate is lower. So they tend to be more persistent smokers. Column 5-6 refers to lifetime alcohol and drug abusers. Similarly they are in the lower class of SES: less educated and lower income. But the difference in income is not significant. This group also has higher rates of cigarette use. But the quitting rate is not significantly different from the whole sample.

Table 3 is the summary statistics of NCS-R. It is also divided into three panels: full sample, past year alcohol/drug abusers, and lifetime alcohol/drug abusers. NCS-R sampling population is about 10 years older than NCS-B, mimicking the aging process of the sampling population from NCS-B in 1990-2001.[19] However education level is higher; marriage rate is lower; and smaller percentage is religious. The trend in drug and alcohol consumption reflects the same pattern as the national sample. Comparing with NCS-B, cocaine participation is five times higher reaching 10%; marijuana participation is two times higher reaching 22%. Alcohol participation is higher by 33%. However the percentage of people with alcohol/drug use disorder is lower. 13% has lifetime alcohol abuse/dependence; 8% has lifetime drug abuse/dependence. Tobacco use is lower compared with ten years ago, which is comparable with the national trend. Smoking participation is 25%, with an average of

[19] The purpose of NCS-R is to draw a comparison study with NCS-2. NCS-2 follows the same individuals as in NCS-B, and therefore ten years later the same sample would age by 10 years. However the characteristics of the sample show that NCS-R might be a different group than NCS-B.

14 cigarettes per day during the past year. No quitting measurement is available in NCS-R.

Table 4

Combined NCS Descriptive Statistics

	Full Sample		Lifetime Substance Abuser	
Variables	Obs	Mean	Obs	Mean[20]
Age	13689	41.27	2289	36.36***
Male	13689	0.48	2289	0.66***
Education	13689	13.12	2289	12.95
Married	13689	0.55	2289	0.50*
White	13689	0.73	2289	0.78
Black	13689	0.12	2289	0.08***
Other race	13689	0.04	2289	0.04
Household Income	10100	49,841.84	2282	44,957.66**
Religious	11017	0.87	2277	0.80***
Midwest	13689	0.24	2289	0.25
Northeast	13689	0.19	2289	0.19
South	13689	0.35	2289	0.28***
West	13689	0.21	2289	0.28***
Lifetime substance abuse	13689	0.16	2289	1.00
Lifetime alcohol abuse	13689	0.14	2289	0.90
Lifetime drug abuse	13689	0.08	2289	0.52
Tobacco participation past year	13689	0.27	2289	0.51***
Tobacco participation lifetime	13686	0.48	2288	0.74***
Num. of cigs (smoking the most)[21]	4405	10.63	1137	17.18***
Num. of cigs (past year)[22]	1937	15.16	698	17.03***
Days of smoking (past year)[22]	3083	189.44	943	228.59***
Quit smoking past year[21]	1400	0.11	546	0.11
Cocaine participation past year	5510	0.03	1741	0.09***

[20] Sample weights are different for two waves of the survey, so the significance test is carried out separately. The asterisks show the less significant of the two. For example, Household Income is significant at 5% level in NCS-B, and 1% level in NCS-R. Only two stars are given in the table. White and Other race are significant at 1% in NCS-B, but insignificant in NCS-R. Education and Lifetime death of relatives are significant at 1% in NCS-R, but insignificant in NCS-B.

[21] The survey question is only available in NCS-Baseline.

[22] The survey question is only available in NCS-Replication.

Table 4 continued …

Alcohol participation past year	8834	0.73	2259	0.82***
Drinking frequency past year	6569	87.70	1853	139.43***
Lifetime combat	8797	0.04	2258	0.06**
Lifetime kidnapped	8268	0.06	2135	0.12***
Lifetime accident	8800	0.19	2260	0.30***
Lifetime ever raped	8770	0.07	2257	0.12***
Lifetime other event	8051	0.10	2193	0.13*
Lifetime molested	7086	0.14	2068	0.16*
Lifetime saw kill/injured	7998	0.32	2187	0.43***
Lifetime suicide thoughts	7855	0.15	2070	0.29***
Lifetime death of relatives	7711	0.42	2156	0.41
Lifetime crisis	7840	0.17	2167	0.24**
Mother substance abuse problem	8638	0.07	2200	0.14***
Father substance abuse problem	8056	0.22	2022	0.37***

Table 4 combines the two surveys and compares the means between non-abusers and substance abusers only for those who are available for tobacco use measurement. Out of 17380 survey respondents from the two waves, 13689 are available for the tobacco participation question. For comparison, variable means and number of observations are presented for the whole sample and life time substance abusers only. The left panel is for the full sample. A representative person from the sample would be 40 years old with high school education, white and religious. Weighted average tobacco participation for past year is 27%, slightly higher than the national rate of 24%.[23] For those who smoke, they smoke an average of 10 cigarettes per day when smoking the most. Past year cigarette consumption is only available in NCS-R. An average of 15 cigarettes was consumed during the past year among smokers. NCS-R also has days of smoking. The average days that at least one cigarette is smoked

[23] Tobacco participation rate for year 1990 is 25.5%, and 22.5% for year 2002. The simple average of the two years is 24%.

during the past 365 days is 189. Quitting is only available in NCS-B. 10% quit smoking during the past year.

16% of the whole sample is diagnosed or has been diagnosed with either form of substance abuse/dependence during their lifetime. The majority of the diagnoses are alcohol use disorders, which occupies 14% of the sample. Lifetime drug abusers/dependents are about 8%. So 6% of the sample is diagnosed with both alcohol abuse/dependence and drug abuse/dependence.

The right panel shows the means for lifetime substance abusers only. 2289 substance abusers are available for tobacco questions. Again the significance test shows that the substance abuse group has very different characteristics from the non-abuse group. They tend to be younger, slightly less educated, less religious, and have lower income. Smoking participation is significantly higher. The prevalence in NCS-B is 48% and in NCS-R 52%, yielding a weighted average of 51%.[24] Other measures of tobacco use are also stronger for substance abuse group. They smoke an average of 17.2 cigarettes when smoking the most in comparison with 10 .6 for the whole sample. And daily cigarette consumption is 17 cigarettes during the past year in comparison with 15.2 for the whole. Both numbers are significantly higher than the non-abuse group. At the bottom of the table lists variables for parental substance use disorder and stressful events. These variables reflect the propensity to use drugs for control of common liability factors. So it is possible that substance use disorder itself is correlated with cigarette smoking through a third factor. In both categories, the substance abuse group has a high percentage of parental substance use problem and experience of post traumatic events.

[24] I use sample size as the weight.

The data set is augmented with cigarette price, alcohol price and drug price and policy. Cigarette price is taken from Tax Burden on Tobacco published by *Orzechowski and Walker*. The price is matched with state fips code and year, using average cigarette price including federal and state taxes. Tax changes take place at different points of the year. To reflect the true cigarette price, it is weighted by the proportion of the year that tax rate was changed. Alcohol price is from the ACCRA Cost of Living index aggregated at the state level. The price reflects a 0.75l bottle of J&B scotch. Drug price is from STRIDE (System to Retrieve Information on Drug Evidence), reflecting one gram of pure cocaine at MSA level. The prices are adjusted for inflation using annual CPI. Drug arresting information is also added to the data set to reflect the implicit price for drug use. Drug related arrests ratio is defined as the total number of drug related arrests, such as sale, possession of drugs and drug related violent crimes to the total number of arrests for all kinds.

Chapter Five: Empirical Strategy ---- The Use of Instruments

Following the derivation from the theoretical model, the demand of cigarettes is augmented with S for substance use disorder as follows:

$C_i = F(P^C, S_i, X_i, \varepsilon_i)$ [25]

Cigarette demand is a function of full price of cigarettes P^C, substance use disorder S_i, individual demographic characteristics X_i and unobservable characteristics ε_i. X_i includes individual household income, education, age, gender, race, religion and marital status.

To test the effect of substance use disorder on smoking, the above equation encounters endogeneity problem. Two possible sources of endogeneity exist in this context. One comes from an uncontrollable correlation between cigarette smoking and substance use disorder. Such examples would be risk preference or personality traits, which are either not available in the dataset or immeasurable. In other words, if ε_i is correlated with both S_i and C_i, it would cause upward bias on the estimates. To eliminate this endogeneity, bivariate probit model will be used.

The second source of endogeneity comes from reverse causality in the substance abuse demand function. The demand for substance use disorder, in this case alcohol and illicit drugs, is specified in a similar fashion as the demand for cigarettes. It depends on the price of alcohol and drugs, cigarette smoking, observable individual characteristics such as income, education and age, and unobservable characteristics. Whether the direction of causality goes from substance abuse to smoking or the other way around is still subject to test. The Gateway effect suggests that smokers are more likely to consume cannabis than non-smokers and then move on to hard drugs later. But since there is no time series available in the data, no control for the Gateway

[25] Refer back to Equation (9).

effect can be added. The bivariate probit model will control bias arising from both sources of endogeneity with the use of instruments.

Equation (10) tries to capture the difference in price respondence between substance abusers and non-abuser. The test requires stratification of the whole sample into two: substance abuse group and non-abuse group. However this stratification is non-random. The selection criterion is endogenous to the cigarette demand function, which would again cause bias for estimation.

Referring back to Equation (10), The endogeneity comes from the correlation between ε_{1i} , ε_{2i} in the cigarette demand function with the error term ε_{3i} in substance abuse demand function. When the data is divided, only S_i =1 or S_i =0 are observed. Thus in the case of the substance abuse group,

$$E(C_i \mid s_i = 1) = \beta_1 P^C + \beta_2 X_i + E(\varepsilon_{1i} \mid X_i, S_i = 1)$$

or

$$E(C_i \mid s_i = 1) = \beta_1 P^C + \beta_2 X_i + E(\varepsilon_{1i} \mid X_i, \varepsilon_{3i})$$

So if ε_{1i} and ε_{3i} are not correlated, there is no worry for estimation bias. If ε_{1i} is not correlated with X_i, there would be no selection bias either. But unobservable characteristics are likely to be correlated with demographic variables such as income, education and age. Saffer and Dave (2005) showed that mental illness and family history are significantly correlated with both smoking and alcohol and drug abuse. Selection bias is hard to ignore. To eliminate the endogeneity arising from selection bias, Heckman selection model is used.

However both the bivariate probit model and Heckman selection model require the identification of instruments for substance abuse. The instruments should be correlated with the endogenous variable but uncorrelated with the outcome variable. There are two crucial criteria for the selection of the instruments. One is the exclusion

restriction which states that at least one of the independent variables in the selection equation is excluded from the structural equation. The excluded variables are the identifying instruments for the endogenous variables. They should be strongly correlated to the endogenous variable, but uncorrelated with error terms of the structural equation. The second assumption states that the power of the identification depends on the correlation between the excluded variable and the latent selection criteria. Weak correlation between the two can cause biased estimates in the structural equation. Because of the finite sample size bias, weak correlation between the instruments and the endogenous variables would exaggerate the bias. Before the use of the instruments, the above two criteria must be examined to justify the validity of the instruments.

Test for weak correlation can be found in Bound, Jaeger, and Baker (1995). They use F-statistics for the test on the joint significance on the excluded instruments and partial R-square of the excluded instruments on the first stage of IV specification. To count for the variability of nonlinear probability in this paper, a likelihood ratio test on the joint significance of the instruments is used. The likelihood ratio test is going to be based the substance abuse selection function using both the excluded variables and the instruments. Partial R-square measures the contribution of the excluded variables while controlling for other exogenous variables. High R-square value indicates a strong correlation between the instruments and the endogenous variable, while low R-square infers a spurious correlation in the original setting. Partial R-square is obtained under 2SLS specification.

Test for exclusion restriction is proposed by a Hansen-Sargan test. The joint null hypothesis is that the instruments are valid, and that the excluded instruments are correctly excluded from the estimated equation. So rejection of the null hypothesis

would cast doubt on the instruments. The test takes the residuals from the IV instrumental regression and regresses them against all the exogenous variables, which include the instruments and control variables in the second stage. With 2SLS specification, S-statistics are reported. S is defined as N*R, and is distributed as χ^2. N is the total number of observations and R is the R-square of the second stage regression. With GMM specification, J-statistic is reported. J is m* F. and also distributed as χ^2. m is the number of instruments and F is the F statistics on the joint significance of the instruments.

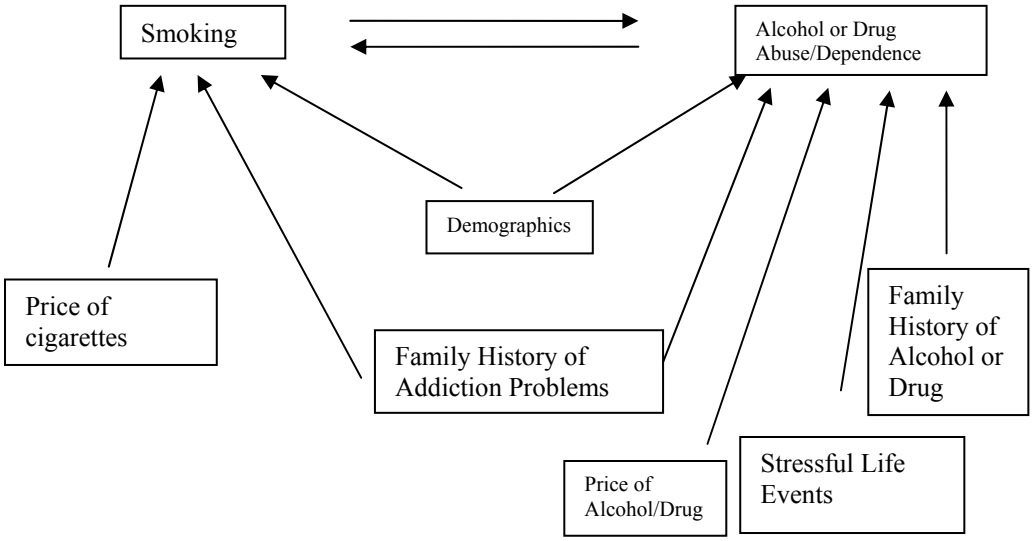
The instruments used in this paper are in reference to Saffer and Dave (2005). Their paper focuses on the population with mental illness excluding alcohol or drug abuse/dependence. They compare price elasticities for alcohol, drug and tobacco of people with mental illness with that of people with no mental illness. The instruments for mental illness are stressful events and family history of mental illness. The link between post traumatic stress disorder and substance abuse has been well documented in psychiatry.[26] Women substance abusers show high prevalence of post traumatic stress disorder mainly deriving from a history of childhood physical and/or sexual assault, and for men from combat or crime trauma. Kendler, Davis, Kessler (1997) examined the family studies of five psychiatric disorders in the first wave of the National Comorbidity Survey. They found significant familiar aggregations for all five disorders including alcohol abuse/dependence and drug abuse/dependence. Past literature have also used alcohol and drug policies as the instruments, such as minimum drinking age, marijuana decriminalization status and fines for marijuana possession. Such instruments are not absolutely pure of endogeneity problems. But

[26] See Najavits, Weiss and Shaw (1997), McFall, Mackay, and Donovan(1992).

this paper focuses on lifetime substance abusers. Price and policy information at a fixed point in time would have little effect on lifetime decision.

Figure 8

Hypothesized Causal Relationships for Substance Abuse[27]



In this paper I test three strings of instruments: family history of substance abuse, lifetime traumatic events, and alcohol and drug prices. Both genetic and environmental factors point to the link between parents' substance abuse problem with that of their children. Genetic and cross substance abuse connection is rare. That is to say, that parents' drinking problem is likely to have a strong correlation with children's drinking problem, but to have a weak correlation with their children's smoking obsession. Family substance abuse should provide a good instrumental channel. Post traumatic events can trigger the abuse of alcohol and drug for relief of

[27] Figure is in reference to Henry Saffer and Dhaval Dave (2005): Mental Illness and The Demand for Aclohol, Cocaine, and Cigaretts, Economic Inquiry Vol. 43, No. 2, April 2005, 229-246

emotional stress and burden. Price here not only includes monetary price, but also policy measurements that increase the time value of the consumption. For example raising the minimum drinking age from 18 to 21 makes it harder for adolescents to obtain alcohol at a younger age. Extra effort is needed such as obtaining a fake ID or asking older kids to get it for them. The implicit price of alcohol consumption for those under 21 is increased. However most drunk driving laws are enacted before the 1990s. There would be little variation across the states in this dataset, so only alcohol price would be tested as the instrument. But drug law enforcement varies across the state. Besides street drug price, the ratio of drug related arrests to total number of arrests is also tested as the instrument of drug abuse/dependence.

Chapter Six: Results ---- Substance Abusers Might Be Different

6.1 The effect of substance abuse on smoking

The first set of estimations follows the structural Equation (9). According to the prediction of the model, substance abusers should have a higher chance of being a smoker and respond more to price changes. But Equation (9) might overlook serious endogeneity problems. The error term ε_i is very likely to be correlated with S_i. After all cigarettes smoking together with alcohol and drug dependence/abuse belong to the same group of substance addiction. The same factors such as stressful events, the inability to cope with stressful events and incompetent social and interpersonal communication skills could trigger the abuse of any of the three forms. On the other hand, there might be inherent factors that distinguish substance abusers from non substance abusers such as personality traits. Substance abusers exhibit different scales on three measures of impulsivity that is related to substance uses: impulse control, novelty seeking and time orientation. Zuckerman and Kuhlman (2000) show the strong correlation between risk taking behavior and impulsive sensation taking, and substance abusers have higher demand for impulsive sensation activities. So the question of whether substance abusers respond differently to cigarette price can be further traced down to where the difference comes from. If controls for physiological, cognitive and behavioral factors still result in significant difference in price response, we would have reason to believe that substance abuser are a separate group.

Tables 9-13 in the appendix summarize the results from the estimation using interaction terms of substance abuse and price. Tables 9 and 10 show estimation alcohol and drug abuse/dependence separately. Both tables try to control for three sets of geographic dummies to test the sensitivity to model specification. Adding more

dummies for regional control reduce the coefficient on price and also the p-value on price coefficient. Using state dummies always seem to reduce price significance to below critical value, while the same pattern is not observed on the interaction between substance use and cigarette price. Alcohol and Drug seem to have different channels of influence for past year definition. In the panel for alcohol abuse/dependence, alcohol use disorder reduces the price responsiveness of the individual although it raises the possibility of being a smoker. The interaction between alcohol use disorder and price is always significant and positive while the coefficient on price itself is only significant in 4 regions control. The net effect of the interaction term and price coefficient gives the elasticity for alcohol abuse/dependence group, which would be positive in this case.

Using lifetime definition instead of past year increase the sample size of substance abuse group compared with non-abuse group. Thus bigger variation should give a more appropriate measurement as a result of the sample size. Price coefficient is more significant than past year definition, significant in two sets of regional controls. Both the interaction term and alcohol abuse/dependence are significant. The interaction term reduces the price response for this group, while the alcohol abuse/dependence term indicates a bigger chance of being a smoker. This seems to indicate that alcohol abusers/dependents are more likely to become a smoker, but not likely to respond more to price changes. The combined coefficient on price for the group is between – 0.00230 and -0.00230. Calculated at the mean value of participation and price, the price elasticity for alcohol abused group should fall in the range between -0.133[28] and -0.136, compared with -0.42 for the non abused group.

[28] These elasticities are all calculated at the mean of the whole sample. Smoking prevalence is at 27.4%; real cigarette price is 15.889 deflated with cost of living index

Drug abusers on the other hand are more responsive to price according the past year definition but the effect is not significant. The coefficient on drug abuse/dependence is always significant and positive. The effect of drug on cigarette seems to go through participation without price. Being a drug abuser/dependent would raise the chance of being a smoker by 23% to 30%. But once they start to smoke, they don't react differently to price changes from non drug abusers. But past year drug abusers/dependents only comprise of 363 observations out of a regression sample of 9245. The effectiveness of such regression would be dealt with caution.

Lifetime definition for drug abusers/dependents yield results closer that from alcohol abusers/dependents. Although not significant, the interaction term is positive, meaning that drug abused group is less elastic with respect to price. The drug abuse/dependent term is significant and positive. Drug abusers/dependents are twice more likely to become a smoker compared with alcohol abusers/dependents. Calculated at the mean value of participation and price, drug abusing/dependent group has price elasticity around 0.31.

Tables 11 and 12 combine alcohol and drug use together. Comparing with the previous table, the effect of alcohol abuse/dependence dominates the regression. Drug abuse population is about one third of the alcohol abuse population. As a result, the coefficients are comparable with that from the lifetime alcohol abuse/dependence. The effect of price interaction term is positive and significant, and has the opposite sign of the price coefficient. Since both alcohol and drug use disorder increases the chance of smoking, the combined substance abuse term is positive and significant.

In Table 12 the estimates also try to control for endogeneity by putting three sets of covariates directly into the cigarette demand equation. The first set includes all the

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and CPI. For non addictive group, I simply take the price coefficient on the price term, since the interaction is zero for this group.

possible stressful events that might trigger the start of substance abuse. The second set includes parent's substance abuse problem, diagnosis of post traumatic, depressive, panic attack and anti-social disorder. The last set includes parent's substance abuse problem and past year mental illness. If the unobservable characteristics in the error term can be captured by the added covariates, bias might be reduced. Here I also try to control for three levels of geographic dummies. But again state dummies yield insignificant price coefficients and 4 region dummies don't seem to control enough for the difference among states. The table only shows the results from 9 region controls.

Extra controls for possible endogeneity don't change the results much. Control for stressful events yields unstable coefficients on price. The interaction term becomes insignificant. The next two sets of control yield similar results as that with no controls. The interaction between price and substance abuse reduce the price responsiveness of the group, yet being a substance abuser increases the chances of being a smoker. The magnitude of the interaction effect is larger than that without controls, but also the coefficient on price alone is slightly larger. So the price elasticity calculated from the significant results is similar to what is obtained above. Taken as a whole group, alcohol or drug abusers/dependents are less sensitive to price changes, which is around -0.15 according to the above regression sets.

Table 5

Past year tobacco participation

lifetime substance abuse	1.237*** (10.62)
cigarette price[29]	-0.229*** (-1.94)
age	0.035*** (3.99)
age squared	-0.0005*** (-4.76)
male	-0.140*** (-3.68)
education	-0.649*** (-11.58)
married	-0.039 (-0.95)
black	-0.040 (-0.69)
hispanic	-0.257*** (-3.13)
household income	-0.512*** (-4.53)
religious	-0.086 (-1.11)
Rho	-0.429*** (24.73)[30]
price elasticity	-0.414
Test for weak correlation[31]	293.65***
Test for exclusion restriction[32]	10.454
Observations	5492

[29] Table 5 didn't use real cigarette price as what is used in Table 9-12. The cigarette price used here is only deflated with CPI, but not Cost of Living Index.

[30] The Wald test statistics on Rho=0 is shown here.

[31] Likelihood ratio test on the joint significance of the instrument is reported here. Under the 2SLS specification, joint F-statistics and Partial R-square are also obtained. F-statistics=36.08, significant at 1%. Partial R-square=0.056.

[32] Sargan Test is reported here. J-statistics is also obtained. J-statistics=9.578, not significant at any level.

Interaction equation yields results that are not consistent with prediction of the model. One would suspect how big endogeneity plays a role in the estimation. Table 5 above presents the results using bivariate model. Lifetime alcohol or drug abuse/dependence is the endogenous variable. The instruments used are parents' substance abuse problem and a series of post traumatic events. The details about the instruments and the validity of the instruments will be laid out in the following section. Heckman selection model uses the same set of instruments as the bivariate model. Thus the test statistics are the same for the two estimations. Past year alcohol and drug price have also been tested as possible instruments for substance abuse, but they turn out to be insignificant and having little influence on the endogenous variable. So price and policy instruments are dropped in the subsequent IV analysis.

After adjusting for substance use disorder, price elasticity for past year tobacco participation for the whole sample is -0.414. It falls within the proximity of what is obtained in the previous literature. The presence of substance use disorder has a strong positive and significant effect on cigarette smoking. A substance abuser is 9.22% more likely to be a smoker than a non-abuser. Referring back to Figure 2 in the article, lifetime substance abusers are 180% more likely to be smokers than non-abusers in NCS-B and 170% in NCS-R in raw data. The estimation result confirms the existence of such effect, but the marjority of the difference could be due to the disparities in income, education and other demographic chararteristics. Rho is negative, indicating the correlation of the error terms between the cigarette demand function and substance use demand function. The likelihood ratio test shows that Rho is significantly different from zero.

6.2 Separate demand equation

The next step of the estimation is to divide the sample into substance abused group and non-abuse group by lifetime and past year diagnosis. The interaction estimation equation allows for the adjustment of substance abuse only on the price coefficient. But the substance abusers might be a totally different group so that separate regression is needed. Such justification can be later examined by comparing the coefficients on the two groups. If significant differences exist, there is reason to believe that substance abusers should be treated separately from non abusers. But straight cut of the sample raises the question of selection endogeniety. Heckman (1979) points out that selection bias arises when "missing" data results from nonrandom selection. Nonrandom selection results in correlation between the selection criteria and the error terms. However this bias can be addressed by the Heckman selection model.

Division of the data set is straight-forward. Non substance abusers only refer to those with no substance abuse problems at all throughout their lifetime. Substance abusers are defined by past year definition and lifetime definition. Past year substance abusers are included in the lifetime abusers, but not the other way around. There are big variations in the sample size between the divided groups. Non substance abusers occupy 80% of the sample survey with 13979 observations. Lifetime alcohol abusers/dependents have 3027 observations; lifetime drug abusers/dependents 1669 observations. Past year alcohol abusers/dependents have 1057 observations and drug dependents/abusers 405 observations. Considering the small sample size for past year drug abusers/dependents, the regression on this group would be focused on the lifetime diagnosis.

In the first step, I test the basic model for each group with demographic control, year dummies, and three sets of regional control. The results are in Table 13 and 14. In past year definition I combine alcohol abuse and drug abuse to overcome sample size problem for drug abuse group. However in life time definition, drug abuse group is large enough to justify its own results.

Table 13 shows the inefficiency of such simple regression for the substance abused group. I try to control for three levels of geographic dummies again to test the sensitivity of the model. For non substance abused group, the results are quite standard. Price coefficient is negative and significant in two sets of regional controls. It is not significant with state dummies. At the mean value of tobacco participation and real cigarette price, it is equivalent to a price elasticity of -0.406. Other major demographic variables are significant and having the expected sign. Males are more likely to participate in smoking, while education, marriage, being Hispanic or black, being religious reduces the chance of being a smoker. The likelihood also decreases with the increase of real income.

However price is generally insignificant for substance abused group. Past year substance abused group, which combines alcohol abusers with drug abusers, has very small sample size, with only 676 observations. Only three out of twelve major variables are significant, although pseudo R2 is not low compared with non-abuse group.

Table 14 presents the results for lifetime substance abusers for the same setting. Lifetime substance abusers increase to 2124 observations, less than triple the size of past year diagnosis. Price is still negative but insignificant. The significance of the model increases. The major variables have the right sign and significance. However

the results are subject to endogeneity, which tend to give downward bias on the coefficients.

Selection bias problem is comparable to "omitted" variable problem if the omitted variables also have a big influence on the dependent variable. Adding those variables in the regression might possibly alleviate the bias. So in the next step I test with probit model under three sets of controls for endogeneity in the same way as in the interaction specification. The three sets include stressful events, the ability to cope with stressful events and incompetent interpersonal and social skills, and parents' substance use history. They cannot control for every possible source of endogeneity, but can offer benchmark of comparisons across models. All specifications control for time and region specific effects.

Table 15 in the appendix summarizes the coefficients on real cigarette price. Adding extra controls doesn't change the result much. Price is still not significant, and negative sign cannot be expected in all regressions. The last column of the table gives the most stable results across different set of regional controls. Adding lifetime stressful events yield price coefficient similar in magnitude to non-abuse group, and adding social communicative problems, parents' substance use history and past year mental illness reduce the price responsiveness. Table 15 doesn't give detailed information on the regression results. But the performance of the added extra control variables would give valuable information as to how the error term in the structural equation is related to the "omitted" variables. Parents' substance abuse history and past year mental illness show the strongest correlation with cigarette smoking. Some of the stressful events and diagnosis of social communicative disorder are significant and positively related to smoking, such as having experienced fire and seen killing. Post traumatic stress disorder and panic attack also have significant and positive effect

on cigarette smoking. But overall the extra control events are loosely connected to the demand of cigarettes.

The above result is basically in line with what is obtained in the interaction model if endogeneity problem and significance are temporarily ignored. Substance abuse group has a higher percentage of smokers, but they are less responsive to price changes. But both the interaction specification and above separate demand function are not pure of endogeneity. The third step of estimation is to use Heckman selection model to filter endogeneity and see how the results change.

Heckman selection requires the identification of legitimate instruments. As proposed in Chapter 5, relevant test on weak correlation and exclusive restriction are carried out first before the implementation of Heckman selection model. Table 16 summarizes the F-statistics and partial R-square from first stage linear equation, and Wald test of the joint significance of the instruments under the probit specification. Family substance abuse history is constructed broadly as either mother's or father's alcohol use disorder or drug use disorder. Price instrument for alcohol abuse/dependence is just the converted alcohol price per liter of pure ethanol. Price for drug abuse/dependence consists of both monetary value of drug purchase and an index for the severity of punishment for drug related crime. The index is calculated as the ratio of drug related arrests to the total arrests by states and year. Drug related arrests include drug abuse violence; drug, opium, marijuana, synthetic and other drugs sales and manufacturing; and drug possession. The index should fairly reflect the legal environment for illicit drug use.

Judging from chi2 statistics and joint F statistics, the instruments have significant correlation with the instrumented substance abuse at the 1% level. Past year diagnosis is too small a sample itself and therefore lifetime substance abuse diagnosis is used.

Alcohol abuse/dependence has stronger correlation with the instruments than drug abuse/dependence. But also alcohol abusers significantly outnumber drug abusers as well. Partial R-square is low for all four sets of endogenous variables. Parents' substance history carries a significant amount of weight in the set of the instruments. First stage regression shows that alcohol price is not significant in predicting alcohol abuse/dependence, and nor does drug price. Drug arrest index however is significant. So genetic link is the most important instrument for the selection.

Table 17 summarizes the results from the tests for exclusion restriction. The Hansen-Sargan tests show exclusion restriction is valid for alcohol abuse/dependence. Both S-statistic and J-statistic are not significant. However for drug abuse/dependence, the test statistics are significant when both price and parents' substance abuse problem are used as instruments. The validity of the instruments is questioned as a result of the above tests. Since drug and cigarettes show similar channels of addiction, I structure another panel of exclusion test with drug price as the only instrument. And the test results are shown as the last panel of Table 17. Correlation between drug price and the error terms for diminishes to insignificant level. Tests on parents' substance abuse problem as the only instrument cannot be performed because Hansen-Sargan test requires more than one instrument to form the Chi2 distribution. But comparison of the two panels with and without parents' substance abuse problem shows that drug price alone might serve as a better instrument for drug abuse/dependence than drug price and parents' substance abuse problem combined. In a short summary of the instruments, alcohol abuse/dependence has higher correlation with the endogenous variable, and lower correlation with the error terms.

Table 6

Past year tobacco participation

	Lifetime substance abuser	Non-abuser	Lifetime Substance abuse probit selection
cigarette price[33]	-0.453*** (-3.34)	-0.149* (-1.73)	0.111 (1.14)
age	0.012 (0.67)	0.035*** (4.46)	0.043*** (5.03)
age squared	-0.00019 (-0.87)	-0.00045*** (-5.14)	-0.00058*** (-5.40)
male	-0.205* (-1.72)	-0.192*** (-3.94)	0.004*** (17.31)
education	-0.540*** (-6.27)	-0.648*** (-10.73)	-0.167*** (-3.60)
married	-0.082 (-1.22)	0.007 (0.16)	-0.084** (-2.04)
black	0.304** (2.49)	-0.084 (-1.23)	-0.421*** (-7.12)
hispanic	-0.298*** (-2.89)	-0.221*** (-2.66)	-0.132* (-1.96)
household income	-0.439*** (-2.96)	-0.468*** (-4.43)	-0.367*** (-2.98)
religious	-0.022 (-0.20)	-0.060 (-0.91)	-0.186*** (-3.79)
mother substance abuse			0.363*** (5.30)
father substance abuse			0.302*** (7.45)
combat			-0.089 (-0.66)
kidnap			0.152*** (3.22)
accident			0.090*** (2.88)
ever raped			0.381*** (5.49)
Saw killing/injured			0.216*** (5.75)
death of relatives			0.053 (1.19)
lifetime suicidal thoughts			0.313*** (6.28)

[33] Cigarette price is deflated with CPI only, but not with Cost of Living Index.

Table 6 continued …

Rho	-0.444** (4.19)30	0.749*** (32.19)	
price elasticity	-0.553	-0.255	
Test for weak correlation[34]			293.65***
Test for exclusion restriction[35]			10.454
Observations	1587	3905	5492

Table 6 shows the results from Heckman selection probit model. The sample is estimated with one substance abuse demand equation on the whole sample and two cigarette demand euqations for the partitioned groups (one for lifetime substance abuse populatin and another for non-abuse population). Rho reflects the correlation between the disturbance term in each cigarette demand equation and the disturbance in the substance abuse demand equaiton. Both groups have significant and negative price responses. Price elasticities for the substance abuse group are -0.55, and -0.26 for the non-abuse group. So in Heckman selection model the substance abuse group turns out to be more price responsive than the non-abuse group. Rho is the correlation between the two error terms of structural equation and selection equation. Rho is negative and significant, indicating a negative correlation between the unobservable characteristics from substance abuse demand function and cigarette demand function.[36] But since the majority of the substance abusers in the sample are alcohol

[34] Likelihood ratio test on the joint significance of the instrument is reported here. Under the 2SLS specification, joint F-statistics and Partial R-square are also obtained. F-statistics=36.08, significant at 1%. Partial R-square=0.056.

[35] Sargan Test is reported here. J-statistics is also obtained. J-statistics=9.578, not significant at any level.

[36] This is somehow again intuition. One would expect the same characters that lead someone to take on alcohol or drug abuse would also increase the probability of being

abusers/dependents, the correlation reflects more of that between the demand for alcohol use disorder and the demand for cigarettes.

The legitimacy tests for the instruments can be found at the bottom of the table. Instead of using parents' substance abuse history alone, I also add a series of stressful events to the instruments. The likelihood ratio test for the joint significance of the instruments is significant at 1%, indicating that the instruments have significant predicting power on the endogenous variable. The same conclusion can be drawn from the partial R2 under 2SLS. Partial R2 is 0.057, about 35% of the adjusted R2 obtained from the IV model. Both S test and J test on exclusion restriction are not significant, indicating that the instruments should be excluded from the cigarette demand equation. The far right column shows the results from substance abuse selection equation. The dependent variable is lifetime diagnosis of substance use disorder, including either alcohol abuse/dependence or drug abuse/dependence. The instruments are significant and positive in predicting the substance abuse. Most have the expected sign on substance abuse. Parents' substance abuse problem has a positive and significant effect on children's substance abuse. Genetics link proves to be an important factor in explaining substance abuse problem. It is also expected that post traumatic events are likely to trigger the use of substance abuse for relief of depression and anxiety. Most of the lifetime stressful events are significant and positive in the regression. Except for combat experience and death of relatives or friends, stressful events are significant at 1% level.

Comparing results from Heckman selection model with that from basic probit function, selection bias is strong. Failure to control for endogeneity would significantly bias the estimates. However one might also suspect whether the

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a smoker. But the negative might signal a possible substitute relationship between alcohol and cigarette since alcohol abuse dominates the results for both.

increased significance on price coefficient is due to the elimination of endogeneity or simple the lack of deflation on the cigarette price itself.

6.3 What is the cross price effect?

The sign of the cross price effect tells a substitute or complementary relationship between cigarette smoking and the other substance use. Previous literature has suggested substitute relationship between smoking and alcohol consumption and gateway effect between smoking and drug use. The implication of such relationship renders reference for important tobacco control policy question. Policy targeted at one substance use might affect the consumption of another. If higher cigarette tax pushes smokers with current or prior substance use disorder towards heavier drug use or drinking, the net effect of such policy might lean towards the contrary to its original intention.

The first set of regressions look at the role of cigarette price in alcohol consumption and drug use in the whole sample. The dependent variables are alcohol participation, frequency of alcohol use, drug participation. The independent variables are cigarette price, alcohol and drug price, drug related crime rates, and a set of demographic variables. All regressions have state and year dummy controls. Table 18 in the appendix presents the results. Cigarette price is insignificant in all four demand functions. It is positive in alcohol participation function. The coefficient indicates that one percentage increase in cigarette price would increase alcohol participation by 0.48 percent, a negligible small amount. The opposite sign is obtained in alcohol use function. Cigarette price is positive cocaine and marijuana participation.

Table 7

Past Year Alcohol Consumption[37]

	Alcohol Participation		Drinking frequency	
	Lifetime Substance abuser	Non-abuser	Lifetime Substance abuser	Non-abuser
alcohol price	-0.0046 (-1.57)	-0.0135*** (-2.73)	-0.0313* (-1.91)	-0.0141* (-1.87)
control states	0.0230 (1.13)	0.0265 (1.06)	0.0484 (0.44)	0.0092 (0.18)
quit[38]	-0.0657*** (-4.11)	0.0409** (2.56)	-0.1380 (-1.42)	0.0910* (1.71)
age	-0.0188*** (-5.68)	0.0088*** (4.12)	-0.0186 (-1.24)	-0.0023 (-0.33)
age square	0.0001*** (3.40)	-.00013*** (-5.65)	0.0002 (0.88)	0.00009 (1.21)
male	0.0085 (0.62)	0.0896*** (6.92)	0.5768*** (5.97)	0.5700*** (14.57)
education	0.0062* (1.78)	0.0275*** (9.49)	-0.0429** (-2.13)	0.0213* (1.78)
married	-0.0208 (-1.37)	-0.0191 (-1.65)	-0.3816*** (-4.45)	-0.2579*** (-5.07)
black	0.0242 (1.36)	-0.0806*** (-2.62)	0.4826*** (3.32)	-0.02835 (-0.36)
household income	0.0011*** (4.53)	0.0008*** (4.16)	0.0019** (2.65)	0.0010 (1.65)
religious	-0.0029 (-0.13)	-0.0494** (-2.28)	-0.3180*** (-3.11)	-0.3551*** (-6.53)
year 2002	0.0190 (0.72)	0.3657*** (10.76)	0.2057** (2.00)	0.3708*** (6.53)
price elasticity	-0.102	-0.34	-0.56	-0.26
observations	2168	6251	1774	4491
Adjusted R-squared	0.11	0.17	0.07	0.07

[37] Alcohol consumption is measured as the log of number of times alcohol was used during the past year. All estimates are from OLS procedure. Heckman selection yields similar results as OLS and Rho=0 cannot be rejected by Wald test. Therefore selection bias is temporarily ignored here.

[38] A quitter is defined as lifetime smoker but not current smoker. The quitting behavior happens sometime during the past.

Table 8

Past Year Cocaine and Marijuana Participation

	Cocaine participation		Marijuana participation	
	Lifetime Substance abuser	Non-abuser	Lifetime Substance abuser	Non-abuser
cocaine price	-0.00040** (-2.33)	-6.4e-06 (-0.28)	---	---
drug arrest ratio	0.0176 (0.55)	0.0023 (0.30)	0.1553* (1.66)	0.0651*** (3.43)
marijuana decriminalization	---	---	-0.0064 (-0.33)	0.0052 (0.62)
quit[38]	-0.0345** (-2.48)	-0.0024 (-1.04)	-0.0637*** (-2.75)	-0.0041 (-0.42)
age	-0.0068** (-1.97)	0.00020 (0.35)	-0.0182*** (-3.32)	-0.0027* (-1.69)
age square	0.000046 (0.85)	-8.01e-06 (-0.97)	0.00007 (0.94)	-2.51e-06 (-0.08)
male	0.0217 (1.31)	0.0021 (1.03)	0.0780*** (3.26)	0.0346*** (7.56)
education	-0.0047** (-2.11)	0.0006 (1.64)	-0.0012 (-0.29)	0.0032* (1.88)
married	-0.0459*** (-4.29)	-0.0047* (-1.36)	-0.0950*** (-4.81)	-0.0390*** (-6.59)
black	0.1339*** (7.00)	0.0044 (1.25)	0.0859*** (2.68)	0.0032 (0.40)
household income	-0.000039 (-0.20)	0.000017 (0.84)	-0.0001 (-0.80)	6.07e-06 (0.07)
religious	-0.0104 (-0.72)	-0.0077*** (-2.79)	-0.0813*** (-3.43)	-0.0279*** (-3.11)
year 2002	0.0720*** (4.06)	0.0418*** (5.82)	0.1009*** (4.49)	0.1259*** (9.86)
price elasticity	0.57	---	---	---
observations	1618	3493	2010	4945
Pseudo R-squared	.0.11	0.18	0.12	0.17

Since current cigarette price has no significant effect on current use of alcohol and drug, I replace cigarette price with quitting smoking in the demand functions. A

quitter is a former smoker who quits anytime during the past. The exact year of the occurrence is unknown.

While substance abusers exhibit higher price elasticities in smoking participation than non-abusers in the Heckman selection model, the same pattern is not found consistently in alcohol consumption and cocaine consumption. Table 7 summarizes the results for alcohol participation and consumption. Alcohol participation is one if the respondent reported having taken at least one drink during the past year, otherwise zero. Alcohol consumption is the number of times at least one drink was consumed during the past year. The regression on alcohol consumption takes the logarithm of the drinking frequency, and therefore is a conditional consumption function based on the drinkers only.

Past literature on alcohol price elasticity focuses on the elasticity measured by the number of drinks rather than participation since moderate alcohol consumption is quite common among the society and has no evident detrimental effect on health. The typical short-run and long-run elasticities for alcohol are -0.41 and -0.65.[39] In this study alcohol participation elasticity is also examined because it might capture the risk of relapse among prior substance abusers.[40] As the regression results show, substance abusers have non significant price response and the magnitude of the resulting price elasticity is smaller than non-abusers for alcohol participation. Non abuser group yields significant and negative price elasticity and it is around -0.34. For conditional alcohol consumption, both substance abusers and non-abusers have significant and negative price effects. The substance abuse group has a higher price

[39] See Michael Grossman (2005).

[40] Research on the correlation between the urge to drink and relapse after treatment among alcohol abusers is few. Some studies find that alcohol consumption does not necessarily lead to loss of control over drinking among recovering alcoholics. Others find a moderate correlation exist between the urge and the actual alcohol consumption.

elasticity of -0.56, than non-abuse group of -0.26. In this instance, substance abusers are more responsive to price changes as in the same case of smoking participation. The weighted average of the above substance abuse elasticity and non-abuse elasticity is -0.34. It is comparative with typical short-run elasticity for alcohol drinking frequency obtained in other literature.

Table 8 summarizes the results for cocaine participation and marijuana participation. Drug users consist of a relatively small proportion of the whole sample compared with alcohol users. Past year marijuana participation, which is the most popular form of drug use, is 26% among lifetime substance abusers and 8% among non-abusers. The demand function for cocaine participation uses cocaine price and drug related arrest ratio to capture the full price of cocaine consumption, while for marijuana unit monetary price is replaced by the status of decriminalization for each state. So price elasticity is only calculated for cocaine participation. Substance abusers have a significant and negative price elasticity of -0.57, lower than the typical elasticity of -0.70 in the cocaine participation literature. [4] Non-abuse group on the other hand has non significant price coefficient, which renders it impossible to calculate the corresponding elasticity. Non-abusers have a much smaller participation ratio of only 1%, which might contribute to the reason why price is not significant. If most of the participation variation in the general literature comes from the hard-core drug takers, comparing the elasticity from substance abuse group with non-abuse group is not important.

The quitting variable captures substitution from cigarettes to alcohol or illicit drug. The effect of quitting on both alcohol use and drug use is quite consistent for the substance abuse group. Table 7 shows that quitting has significant and negative effect on alcohol participation and non significant and negative effect on alcohol

consumption. Similar pattern is revealed from cocaine and marijuana participation in Table 8. Quitting has significant and negative effect on participation of both drugs. As a result, the concern for the side effect of cigarette control measurement is not legitimate for this hard core substance use group. On the contrary, a substance abuser who quits smoking during the past is more likely to stay abstinent and sober compared with an abuser who is still a smoker. For the non-abuse group, quitting is only significant in Table 7 and the opposite is found. Quitting has a significant and positive effect on past year alcohol use. Thus for a non-abuser, quitting is likely to cause an increase in alcohol participation and consumption. Cigarettes and alcohol are acting as substitutes. In general the demand for drug use for the non-abuse group lacks significance in major variables. This raises the question whether the analysis for drug use in the general literature should put more focus on the hard-core users who generates most of the variation.

In suspect of selection bias for the same reason in smoking participation estimation, Heckman selection model is also used both in the demand for alcohol and for cocaine and marijuana. But the null hypothesis for Rho=0 can not be rejected. The results are similar to that of simple OLS and probit model. So selection bias is temporarily ignored in this estimation.

The significant and negative effect of quitting for the substance abuse group brings supporting evidence for nicotine treatment in alcohol and drug addiction literature. Most substance abuse treatment facilities do not routinely treat nicotine addiction together with alcohol or drug dependence and abuse. Yet some studies suggest that complimentary cigarette smoking treatment would not interfere with the mainstream treatment of alcohol and drug addiction. And in some cases improved results for the treatment have been observed. Cessation of smoking during treatment

helps to prevent relapse into alcohol and drug addictive behavior. A quitter of former or current substance abuse is not likely to go back to abusive drinking and drug use once treated.

Chapter 7 Implication and Conclusion

This paper empirically examines the role of substance use disorder on the demand of cigarettes and possible substitution between cigarettes and other substance use among lifetime substance abuse population. Substance abusers are significantly more likely (9.22%) to become smokers than non-abusers after controlling for common demographic variables and endogeneity using IV instruments. Substance abusers are responsive to cigarette price changes, and in this analysis turns out to be more price responsive than non-abusers. The model controls for selection bias using Heckman selection probit model. So policy aimed to discourage smoking in the general public should be effective on the substance abuse population.

Substitution between cigarettes and alcohol is found in the non-abuse group. A quitter who stopped smoking anytime during the past is likely to drink more at present. Increase in current cigarette price will also push smokers away from cigarettes and towards alcohol. No significant effect is found on cocaine consumption. For the substance abuse group, quitting has no effect on current alcohol consumption, and a negative and significant effect on cocaine participation. So a substance abuser who quits smoking sometime in the past is not likely to drink more, or start using cocaine at present. Policy concerns on possible substitution between cigarettes and other substance use among prior or current substance abusers is not justified.

The above results for the substance abuse group needs further confirmation from other empirical analyses. The use of lifetime substance abusers as a broad and distinguished group might overlook the possible effect of other factors, such as the effect of treatment of addiction on cigarette smoking. It would be interesting to separate past year substance abusers from prior substance abusers who were treated

and recovered, and see if results change. Also there might be a possibility that alcohol abusers respond differently to drug abusers.

Becker and Murphy's rational addition model states that people with a higher preference for the present and thus a higher rate of discount for the future respond more to current price changes. In psychology literature, substance abusers are associated with novelty seeking, extraversion and risk-taking personalities. So their preference for immediate reward and risk should be higher than the non-abuse group. Further tests on the differential price responses would also shed some light on whether substance abusers are after all an "impatient" group.

Appendix One: A Note on DSM-IV Criteria for Substance Dependence and Substance Abuse

Substance Dependence

A maladaptive pattern of substance use, leading to clinically significant impairment or distress, as manifested by three (or more) of the following, occurring at any time in the same 12-month period:

(1) Tolerance, as defined by either of the following:
   (a) A need for markedly increased amounts of the substance to achieve intoxication or desired effect
   (b) Markedly diminished effect with continued use of the same amount of the substance
(2) Withdrawal, as manifested by either of the following:
   (a) The characteristic withdrawal syndrome for the substance (refer to Criteria A and B of the criteria sets for Withdrawal from the specific substances)
   (b) The same (or a closely related) substance is taken to relieve or avoid withdrawal symptoms
(3) The substance is often taken in larger amounts or over a longer period than was intended
(4) There is persistent desire or unsuccessful efforts to cut down or control substance use
(5) A great deal of time is spent in activities necessary to obtain the substance (e.g. visiting multiple doctors or driving long distances), use the substance (e.g. chain-smoking), or recover from its effects
(6) Important social, occupational, or recreational activities are given up or reduced because of substance use
(7) The substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the substance (e.g. current cocaine use despite recognition of the cocaine-induced depression, or continued drinking despite recognition that an ulcer was made worse by alcohol consumption)

Substance Abuse

A. A maladaptive pattern of substance use leading to clinically significant impairment or distress, as manifested by one (or more) of the following, occurring within a 12-month period:
   (1) Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home (e.g. repeated absences or poor work performance related to substance use; substance-related absences, suspensions, or expulsions from school; neglect of children or household)
   (2) Recurrent substance use in situations in which it is physically hazardous (e.g. driving an automobile or operating a machine when impaired by substance use)
   (3) Recurrent substance-related legal problems (e.g., arrests for substance-related disorderly conduct)
   (4) Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance (e.g. arguments with spouse about consequences of intoxication, physical fights)
B. The symptoms have never met the criteria for substance dependence for this class of substance.

Appendix Two: Tables and Figures

Table 9[41]

Past year tobacco participation

	Past year alcohol use disorder		
	(1)	(2)	(3)
Real cigarette price	-0.00586* (-1.65)	-0.00602 (-1.50)	-0.00569 (-1.06)
Interaction between past year alcohol abuse and cigarette price	0.00893** (2.05)	0.00893** (2.05)	0.00917** (2.10)
Past year alcohol abuse	0.0788 (1.16)	0.0800 (1.17)	0.0765 (1.12)
Age	0.0185***	0.0186***	0.0188***
	(9.86)	(9.89)	(9.99)
Age squared	-0.000245***	-0.000245***	-0.000247***
	(-11.7)	(-11.7)	(-11.8)
Male	0.0414***	0.0416***	0.0416***
	(4.14)	(4.15)	(4.14)
Education	-0.0463***	-0.0462***	-0.0464***
	(-20.2)	(-20.1)	(-20.0)
Married	-0.0424***	-0.0425***	-0.0413***
	(-3.91)	(-3.92)	(-3.80)
Hispanic	-0.116***	-0.116***	-0.114***
	(-6.96)	(-6.80)	(-6.56)
Black	-0.0490***	-0.0472***	-0.0459***
	(-3.27)	(-3.13)	(-2.98)
Other Race	0.0429*	0.0460*	0.0465*
	(1.76)	(1.88)	(1.85)
Real household income	-0.0184***	-0.0185***	-0.0182***
	(-7.01)	(-7.02)	(-6.90)
Religious	-0.0691***	-0.0704***	-0.0679***
	(-4.66)	(-4.75)	(-4.56)
Metro	0.00160	0.00411	0.0196
	(0.14)	(0.36)	(1.26)
Observations	9246	9246	9245
Pseudo R2	0.0937	0.0942	0.0958

[41] In each of the panel, column one controls for 4 regions; column two controls for 9 regions; and the last column controls for state dummies. All regressions control for year fixed effect.

Table 9 continued …

	Past year drug use disorder		
	(4)	(5)	(6)
Real cigarette price	-0.00514 (-1.45)	-0.00527 (-1.32)	-0.00486 (-1.20)
Interaction between past year drug abuse and cigarette price	-0.000576 (-0.083)	-0.000435 (-0.063)	-0.000149 (-0.021)
Past year drug abuse	0.313*** (2.62)	0.312*** (2.61)	0.306** (2.56)
Age	0.0184***	0.0184***	0.0187***
	(9.80)	(9.82)	(9.92)
Age square	-0.000245***	-0.000246***	-0.000248***
	(-11.7)	(-11.7)	(-11.8)
Male	0.0474***	0.0476***	0.0476***
	(4.76)	(4.78)	(4.77)
Education	-0.0467***	-0.0466***	-0.0469***
	(-20.4)	(-20.3)	(-20.2)
Married	-0.0491***	-0.0492***	-0.0480***
	(-4.54)	(-4.55)	(-4.43)
Hispanic	-0.116***	-0.115***	-0.115***
	(-6.96)	(-6.80)	(-6.61)
Black	-0.0551***	-0.0534***	-0.0525***
	(-3.69)	(-3.56)	(-3.43)
Other Race	0.0423*	0.0452*	0.0458*
	(1.74)	(1.85)	(1.83)
Real household income	-0.0179***	-0.0179***	-0.0177***
	(-6.83)	(-6.84)	(-6.72)
Religious	-0.0698***	-0.0710***	-0.0685***
	(-4.72)	(-4.79)	(-4.61)
Metro	0.00209	0.00438	0.0160
	(0.19)	(0.38)	(1.04)
Observations	9246	9246	9245
Pseudo R2	0.0906	0.0911	0.0925

Table 10

Past year tobacco participation

	Lifetime alcohol use disorder		
	(1)	(2)	(3)
Real cigarette price	-0.00725**	-0.00719*	-0.00674
	(-2.01)	(-1.76)	(-1.25)
Interaction between lifetime alcohol abuse and cigarette price	0.00490*	0.00489*	0.00500**
	(1.93)	(1.92)	(1.96)
Lifetime alcohol abuse	0.128***	0.129***	0.127***
	(2.93)	(2.95)	(2.91)
Age	0.0158***	0.0159***	0.0161***
	(8.42)	(8.45)	(8.54)
Age square	-0.000215***	-0.000215***	-0.000217***
	(-10.2)	(-10.3)	(-10.3)
Male	0.0167	0.0168*	0.0167
	(1.64)	(1.65)	(1.63)
Education	-0.0457***	-0.0456***	-0.0458***
	(-19.9)	(-19.8)	(-19.7)
Married	-0.0446***	-0.0449***	-0.0438***
	(-4.12)	(-4.14)	(-4.03)
Hispanic	-0.109***	-0.108***	-0.106***
	(-6.47)	(-6.28)	(-6.07)
Black	-0.0394***	-0.0377**	-0.0364**
	(-2.60)	(-2.47)	(-2.34)
Other Race	0.0457*	0.0489**	0.0487*
	(1.86)	(1.98)	(1.92)
Real household income	-0.0159***	-0.0159***	-0.0155***
	(-6.04)	(-6.05)	(-5.88)
Religious	-0.0605***	-0.0617***	-0.0590***
	(-4.07)	(-4.15)	(-3.95)
Metro	0.00360	0.00509	0.0196
	(0.32)	(0.44)	(1.26)
Observations	9246	9246	9245
Pseudo R2	0.108	0.109	0.110

Table 10 continued …

	Lifetime drug use disorder		
	(4)	(5)	(6)
Real cigarette price	-0.00642*	-0.00650	-0.00613
	(-1.78)	(-1.60)	(-1.13)
Interaction between lifetime drug abuse and cigarette price	0.00106	0.00112	0.00130
	(0.34)	(0.35)	(0.41)
Liftime drug abuse	0.215***	0.216***	0.213***
	(3.76)	(3.77)	(3.72)
Age	0.0163***	0.0163***	0.0166***
	(8.72)	(8.74)	(8.85)
Age square	-0.000217***	-0.000217***	-0.000219***
	(-10.4)	(-10.4)	(-10.5)
Male	0.0334***	0.0335***	0.0335***
	(3.32)	(3.33)	(3.33)
Education	-0.0462***	-0.0460***	-0.0463***
	(-20.1)	(-20.0)	(-19.9)
Married	-0.0469***	-0.0471***	-0.0462***
	(-4.33)	(-4.35)	(-4.25)
Hispanic	-0.112***	-0.111***	-0.111***
	(-6.67)	(-6.51)	(-6.35)
Black	-0.0490***	-0.0474***	-0.0463***
	(-3.26)	(-3.14)	(-3.00)
Other Race	0.0475*	0.0509**	0.0504**
	(1.93)	(2.06)	(1.99)
Real household income	-0.0170***	-0.0170***	-0.0167***
	(-6.46)	(-6.46)	(-6.30)
Religious	-0.0636***	-0.0650***	-0.0627***
	(-4.28)	(-4.37)	(-4.20)
Metro	-0.000115	0.00137	0.0127
	(-0.010)	(0.12)	(0.82)
Observations	9246	9246	9245
Pseudo R2	0.102	0.103	0.104

Table 11

Past Year Tobacco Participation

	Past year substance abuse		
	(1)	(2)	(3)
Real cigarette price	-0.00608* (-1.71)	-0.00614 (-1.53)	-0.00573 (-1.07)
Interaction between past year substance abuse and cigarette price	0.00788* (1.96)	0.00788* (1.96)	0.00821** (2.03)
Past year substance abuse	0.108* (1.67)	0.109* (1.69)	0.104 (1.61)
Age	0.0189***	0.0189***	0.0192***
	(10.0)	(10.1)	(10.2)
Age squared	-0.000247***	-0.000247***	-0.000249***
	(-11.8)	(-11.8)	(-11.9)
Male	0.0387***	0.0388***	0.0389***
	(3.86)	(3.87)	(3.87)
Education	-0.0460***	-0.0459***	-0.0461***
	(-20.1)	(-20.0)	(-19.9)
Married	-0.0414***	-0.0414***	-0.0403***
	(-3.81)	(-3.82)	(-3.70)
Hispanic	-0.115***	-0.115***	-0.113***
	(-6.91)	(-6.74)	(-6.49)
Black	-0.0480***	-0.0461***	-0.0449***
	(-3.19)	(-3.05)	(-2.91)
Other Race	0.0443*	0.0474*	0.0478*
	(1.81)	(1.93)	(1.90)
Real household income	-0.0183***	-0.0183***	-0.0181***
	(-6.96)	(-6.97)	(-6.85)
Religious	-0.0679***	-0.0693***	-0.0668***
	(-4.58)	(-4.66)	(-4.48)
Metro	0.00170	0.00439	0.0188
	(0.15)	(0.38)	(1.21)
Observations	9246	9246	9245
PseudoR2	0.0964	0.0970	0.0985

Table 11 continued …

	Lifetime substance abuse		
	(4)	(5)	(6)
Real cigarette price	-0.00746**	-0.00744*	-0.00700
	(-2.06)	(-1.82)	(-1.29)
Interaction between lifetime substance abuse and cigarette price	0.00433*	0.00432*	0.00438*
	(1.76)	(1.76)	(1.78)
Lifetime substance abuse	0.146***	0.147***	0.147***
	(3.47)	(3.49)	(3.47)
Age	0.0155***	0.0156***	0.0158***
	(8.27)	(8.30)	(8.40)
Age squared	-0.000210***	-0.000211***	-0.000212***
	(-10.0)	(-10.0)	(-10.1)
Male	0.0134	0.0135	0.0134
	(1.32)	(1.32)	(1.31)
Education	-0.0457***	-0.0455***	-0.0457***
	(-19.8)	(-19.7)	(-19.6)
Married	-0.0425***	-0.0427***	-0.0416***
	(-3.92)	(-3.94)	(-3.83)
Hispanic	-0.108***	-0.107***	-0.106***
	(-6.41)	(-6.23)	(-6.02)
Black	-0.0385**	-0.0368**	-0.0353**
	(-2.54)	(-2.41)	(-2.27)
Other Race	0.0493**	0.0526**	0.0519**
	(2.00)	(2.12)	(2.04)
Real household income	-0.0154***	-0.0154***	-0.0151***
	(-5.85)	(-5.85)	(-5.69)
Religious	-0.0589***	-0.0601***	-0.0574***
	(-3.96)	(-4.03)	(-3.84)
Metro	0.00220	0.00373	0.0167
	(0.20)	(0.33)	(1.07)
Observations	9246	9246	9245
PseudoR2	0.112	0.113	0.114

Table 12[42]

Past year tobacco participation

Lifetime Substance Abuse			
	Control Set 1	Control Set 2	Control Set 3
Real Cigarette price	-0.0101* (-1.76)	-0.00832* (-1.88)	-0.00845* (-1.91)
Interaction between lifetime substance abuse and cigarette price	0.00456 (1.36)	0.00568** (2.15)	0.00544** (2.06)
Lifetime substance abuse	0.124**	0.103**	0.106**
	(2.37)	(2.25)	(2.31)
Combat	0.0126		
	(0.24)		
Accident	-0.00325		
	(-0.14)		
Fire	0.0315*		
	(1.71)		
Saw killing or injury	0.0896***		
	(5.71)		
Ever raped	0.0567**		
	(2.46)		
Ever kidnapped	0.0600**		
	(2.21)		
Parents substance abuse problem		0.0298**	0.0288**
		(2.44)	(2.37)
Post traumatic disorder		0.0400*	
		(1.71)	
Panic attack		0.0729***	
		(4.25)	
Depressive disorder		0.0438**	
		(2.57)	
Anti-social disorder		-0.0395**	
		(-2.35)	
Past year mental illness			0.0464***
			(4.11)
Observations	5214	7909	7909
PseudoR2	0.128	0.125	0.123

[42] All regressions control for 9 regional differences and year fixed effects.

Table 13[41]

Past Year Tobacco Participation

	Non-abuser		
	(1)	(2)	(3)
Real Cigarette Price	-0.007* (-1.84)	-0.007* (-1.72)	-0.007 (-1.23)
Age	0.015***	0.015***	0.015***
	(7.75)	(7.77)	(7.89)
Age squared	-0.000***	-0.000***	-0.000***
	(-9.39)	(-9.40)	(-9.48)
Male	0.020*	0.020*	0.020*
	(1.87)	(1.88)	(1.88)
Education	-0.041***	-0.041***	-0.041***
	(-17.3)	(-17.2)	(-17.2)
Married	-0.024**	-0.024**	-0.023**
	(-2.11)	(-2.12)	(-2.00)
Hispanic	-0.099***	-0.099***	-0.099***
	(-5.72)	(-5.60)	(-5.46)
Black	-0.046***	-0.045***	-0.042***
	(-3.06)	(-2.96)	(-2.74)
Other Race	0.024	0.027	0.026
	(0.96)	(1.05)	(1.01)
Real household income	-0.1329***	-0.1327***	-0.1306***
	(-4.88)	(-4.87)	(-4.78)
Religious	-0.052***	-0.053***	-0.051***
	(-3.16)	(-3.20)	(-3.08)
Metro	-0.001	0.002	0.024
	(-0.052)	(0.20)	(1.42)
Observations	7122	7122	7121
Pseudo R2	0.0760	0.0765	0.0790

Table 13 continued …

	Past Year Substance Abuser		
	(4)	(5)	(6)
Real Cigarette Price	0.007 (0.45)	-0.007 (-0.42)	-0.022 (-1.03)
Age	-0.017	-0.015	-0.019
	(-1.15)	(-0.98)	(-1.18)
Age squared	0.000	0.000	0.000
	(1.13)	(0.98)	(1.23)
Male	-0.009	-0.002	-0.004
	(-0.22)	(-0.044)	(-0.088)
Education	-0.057***	-0.057***	-0.057***
	(-5.68)	(-5.54)	(-5.32)
Married	-0.014	-0.021	-0.009
	(-0.32)	(-0.47)	(-0.19)
Hispanic	-0.171***	-0.179***	-0.166**
	(-2.58)	(-2.59)	(-2.32)
Black	0.171**	0.182**	0.179**
	(2.15)	(2.27)	(2.16)
Other Race	0.107	0.114	0.123
	(0.99)	(1.05)	(1.04)
Real household income	-0. 1771*	-0.1706	-0.1780
	(-1.69)	(-1.62)	(-1.61)
Religious	-0.053	-0.058	-0.055
	(-1.05)	(-1.15)	(-1.05)
Metro	0.024	0.004	0.004
	(0.56)	(0.089)	(0.062)
Observations	676	676	670
Pseudo R2	0.0828	0.0937	0.106

Table 14[41]

Past Year Tobacco Participation

	Lifetime Substance Abuser		
	(1)	(2)	(3)
Real Cigarette Price	-0.003 (-0.43)	-0.002 (-0.24)	-0.001 (-0.12)
Age	0.013***	0.014***	0.013**
	(2.59)	(2.73)	(2.55)
Age squared	-0.000***	-0.000***	-0.000***
	(-3.22)	(-3.37)	(-3.18)
Male	-0.010	-0.010	-0.011
	(-0.43)	(-0.44)	(-0.44)
Education	-0.053***	-0.053***	-0.052***
	(-9.60)	(-9.57)	(-9.34)
Married	-0.097***	-0.098***	-0.096***
	(-4.00)	(-4.02)	(-3.92)
Hispanic	-0.118***	-0.115***	-0.114***
	(-2.97)	(-2.84)	(-2.76)
Black	0.043	0.043	0.038
	(1.03)	(1.02)	(0.87)
Other Race	0.139**	0.146**	0.134**
	(2.42)	(2.53)	(2.25)
Real household income	-0.2151*** (-3.49)	-0.2169*** (-3.51)	-0.2165*** (-3.45)
Religious	-0.073**	-0.075**	-0.073**
	(-2.48)	(-2.54)	(-2.46)
Metro	0.014	0.011	0.001
	(0.56)	(0.44)	(0.043)
Observations	2124	2124	2124
Pseudo R2	0.0738	0.0758	0.0831

Table 15

Summary of coefficients on cigarette price with combination of region controls and endogeneity controls

	Past year substance abuser	Lifetime alcohol abuser
Control for Lifetime Stressful events		
4 regions	0.018	-0.008
	(0.99)	(-0.79)
9 regions	0.004	-0.004
	(0.20)	(-0.44)
state	-0.004	-0.0072
	(-0.14)	(-0.49)
Control for Family History and Diagnosis of social ability		
4 regions	0.002	-0.005
	(0.14)	(-0.56)
9 regions	-0.012	-0.009
	(--0.66)	(-0.72)
state	-.030	-0.005
	(-1.33)	(-0.41)
Controls for Family History and Diagnosis of past year mental illness		
4 regions	0.002	-0.005
	(0.13)	(-0.62)
9 regions	-0.012	-0.005
	(-0.67)	(-0.49)
state	-0.029	-0.005
	(-1.29)	(-0.43)
Num. of observations	655	1846
	Lifetime drug abuser	Lifetime substance abuser
Control for Lifetime Stressful events		
4 regions	0.0002	-0.008
	(0.01)	(-0.78)
9 regions	-0.009	-0.010
	(-0.52)	(-0.85)
state	-0.014	-0.008
	(-0.69)	(-0.58)
Control for Family History and Diagnosis of social ability		
4 regions	0.001	-0.004
	(0.09)	(-0.52)
9 regions	0.0001	-0.003
	(0.01)	(-0.36)
state	-0.011	-0.005
	(-0.67)	(-0.38)
Controls for Family History and Diagnosis of past year mental illness		
4 regions	-.00008	-0.005
	(-0.01)	(-0.60)
9 regions	-0.0009	-0.004
	(-0.07)	(-0.45)
state	-0.011	-0.005
	(-0.64)	(-0.42)
Num. of observations	1042	2124

Table 16

Test for weak correlation on the instruments

	Non-linear		Linear	
	Lifetime alcohol abuse	Lifetime drug abuse	Lifetime alcohol abuse	Lifetime drug abuse
Real alcohol price	yes	**---**	yes	---
Real drug price + Drug related arrests	**---**	yes	---	yes
Parents' substance abuse problem	yes	yes	yes	yes
Chi2 (Wald test)	110.82***	70.15***	---	---
Joint F-stats	**---**	**---**	33.62***	14.23***
Partial R-square	**---**	**---**	0.0131	0.0087

Table 17

Test for Exclusive Restriction on the instruments

	Lifetime Alcohol Abuse	Lifetime Drug Abuse	Lifetime Drug Abuse
Real alcohol price	yes	**---**	**---**
Real drug price + Drug related arrests	**---**	yes	yes
Parents' substance abuse problem	yes	yes	---
S-stats[43]	0.341	4.929*	0.001
J-stats[44]	0.310	8.102**	0.001

[43] S-stats assumes homoskedasticity.
[44] J- stats corrects heteroskedasticity by using robust option.

Table 18[45]

Past Year Drug Use and Alcohol Use

	Past year cocaine part.	Past year marijuana part.	Past year drinking freq	Past year alcohol part.
Drug price	-0.0000250 (-0.48)	0.0000165 (0.15)		
Drug arrest ratio	-0.0258* (-1.80)	-0.0417 (-1.32)		
Alcohol price			-4.886 (-0.28)	-0.166*** (-2.80)
Cigarette price	0.0000212 (0.19)	0.000238 (1.10)	-0.0707 (-0.82)	0.000482 (1.57)
Age	-0.00120	-0.00555**	-0.211	-0.00340**
	(-1.10)	(-2.54)	(-0.40)	(-2.10)
Age square	-0.00000277	-0.0000134	0.00981	-0.0000210
	(-0.18)	(-0.44)	(1.64)	(-1.16)
Male	0.0163***	0.0737***	44.64***	0.111***
	(5.36)	(11.4)	(16.8)	(13.2)
Education	-0.00165**	-0.00272*	-3.413***	0.0135***
	(-2.41)	(-1.78)	(-5.42)	(6.96)
Married	-0.0165***	-0.0579***	-18.07***	-0.0303***
	(-4.93)	(-8.24)	(-6.17)	(-3.28)
Hispanic	-0.00722	-0.0380***	-3.490	-0.0673***
	(-1.55)	(-3.53)	(-0.67)	(-3.99)
Black	0.0101**	-0.00178	2.460	-0.0886***
	(2.05)	(-0.18)	(0.53)	(-6.18)
Other Race	-0.00510	-0.0193	-11.15	-0.193***
	(-0.73)	(-1.24)	(-1.41)	(-7.86)
Household income	-0.0161**	-0.0403**	-0.0227	0.0169***
	(-2.05)	(-2.48)	(-0.34)	(7.04)
Religious	-0.00859**	-0.0428***	-27.94***	-0.0272**
	(-2.03)	(-4.60)	(-7.20)	(-2.01)
Metro	0.00305	0.0265***	0.958	0.0272**
	(0.69)	(2.66)	(0.24)	(2.11)
Observations	7775	9354	8237	11261

[45] The models are estimated upon the whole sample. Participation is estimated with probit model, and drinking frequency is estimated with OLS. All models control for state dummies and year dummies.

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