An Empirical Analysis of Alcohol Addiction

by

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Abstract

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This study is an empirical application of the rational addiction theory to the consumption of alcohol and heavy drinking. The model, developed by Becker and Murphy, emphasizes the interdependency of past, current and future consumption of an addictive good. This is different than myopic addiction models where the current consumption is dependent on past consumption but not on future consumption. The data employed is the Monitoring the Future Survey, a panel representative of young adults between seventeen and twenty seven years old, over a period of fourteen years from 1976 to 1989. Since alcohol abuse is most prevalent in this age group with significant adverse effects, this sample may be a more relevant choice than a representative sample of all ages.

Because of the endogenous nature of the past and future consumption, two stage least squares method is used to estimate alcohol demand function. I find that the consumption of alcohol is addictive in the sense that increases in past or future consumption cause the current consumption to rise. Since the coefficient on the future consumption is positive and significant, the rational addiction model is more appropriate than the myopic addiction model. The long-run elasticity of consumption with respect to price of beer is larger than the short-run elasticity, which is expected in the context of the rational addiction theory.

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Table of Contents

List of Tables

I. Introduction

In their 1988 paper, Becker and Murphy develop a model of addictive behavior where individuals behave rationally. Like the other addictive behavior models, their model assumes that an increase in past consumption of an addictive good increases the current consumption. The contribution of Becker-Murphy model to the addiction literature is that addicts are rational in the sense that they act according to the expected future consequences of their current actions. This is quite different from the myopic type of addiction models where the individual optimizes his/her utility without considering the effects of current consumption on the future utility.

With the assumption of rational behavior, current, past and future consumption of an addictive good becomes interdependent. Therefore, an increase in the past consumption, as well as an increase in the future consumption will cause the current consumption to rise. Since the consumption of a good is negatively related to its price, a price reduction in future (perhaps because of an expected tax break) will increase future consumption, which in turn will increase current marginal utility of that good (hence its consumption). Note that by symmetry, the effect of a change in the past price will be in the same direction as the one resulting from a change in the future price.

Another prediction of the rational addiction is a larger long-run own price elasticity than the short-run own price elasticity. The long-run, in this context, means that the past consumption is allowed to vary while short-run elasticity is calculated by keeping the past consumption fixed. This prediction of the model has important policy implications. If one computes a price elasticity based only on the current consumption of an addictive good then the future consumption predictions of this good will not be correct.

Alcohol and cigarette consumption are good candidates for addictive behavior. They are also important policy variables both in terms of health consequences and tax revenue purposes. If, for example, the addicts are rational, a tax hike on these goods will decrease the future consumption more than what would be predicted when the calculation is based on the short-run elasticity. Consequently, governments may not achieve certain policy goals (e.g., financing of health care reform or funding of rehabilitation programs for addicts through 'sin taxes', etc.) because of overstated additional tax revenues over a period of time.

II. Literature Survey

II.A. Myopic Models of Addiction

Interest in addictive behavior by economists dates to Alfred Marshall. Writing in 1920, he noted: "Whether a commodity conforms to the law of diminishing or increasing return, the increase in consumption arising from a fall in price is gradual; and, further, habits which have once grown up around the use of a commodity while its price is low are not quickly abandoned when its price rises again" (Marshall 1920, p. 807). Most economists who have studied this behavior since Marshall have assumed myopia or imperfectly rational behavior. There are two types of models that can be classified under this topic: One type of model deals with consumers who ignore the effects of current consumption on future utility when they determine the optimal quantity of an addictive good in the current period. In these models, past consumption affects current consumption through an accumulated stock of habits (for example, Houthakker and Taylor 1970; Pollak 1970, 1976; von Weizsäcker 1971; El-Safty 1976; Hammond 1976). In the second class of models, consumers have stable but inconsistent short-run and long-run preferences (for example, Schelling 1978, 1984*a*, 1984*b*; Elster 1979; Winston 1980; Thaler and Shefrin 1981).

Excellent reviews of the literature on myopic models of addiction are contained in Deaton and Muellbauer (1980), Phlips (1983), Iannaccone (1984), and Chaloupka (1988) provide extensive reviews of myopic addiction models. Instead of the models, their empirical applications are reviewed here.

Houthakker and Taylor (1970) argue that if a commodity is non-durable, its stock should have a positive impact on its current consumption in the presence of habit formation. If it is durable, a negative stock effect is possible due to inventory adjustment (there is negative effect if there is no addiction). Houthakker and Taylor fit dynamic time-series demand functions for the United States and several countries in Western Europe using non-additive and additive specifications and find considerable support for habit formation. Structural stock coefficients, which are retrieved from coefficients of lagged consumption and other lagged variables, are positive for almost all non-durable goods. In the U.S., among the coefficients of 81 goods for the period 1929-1964, the stock coefficient of alcoholic beverages ranks eight with a value of 1.1 and the stock coefficient of cigarettes is tenth with a coefficient of 0.9. Phlips (1972, 1978), uses a somewhat refined version of the Houthakker-Taylor model, and reports that U.S. time-series data is dominated by habit formation.[1]

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1 In his study alcohol and cigarettes are not treated as separate consumption items.

Other researchers have applied variants of the Houthakker-Taylor model to the demand for alcohol and cigarettes in the United Kingdom and Australia. Kennedy *et al.* (1973) and Thom (1984) find evidence of habit formation in their estimates of the demand for beer, wine, and distilled spirits in Ireland. Duffy (1980), however, finds no support of the Houthakker-Taylor habit formation hypothesis in beer, wine, and spirits demand equations for the United Kingdom as a whole. Tsolakis *et al.* (1983) report that the model is compatible with Australian wine consumption but not beer consumption. Jones (1989) reports that a habit model outperforms a non-habit model in the case of beer for the U.K but not in the case of spirits, wine, and cigarettes.

Studies by Grabowski (1976), Johnson and Oksanen (1977), and Baltagi and Levin (1986) are somewhat more flexible and their data requirements are less demanding than the specifications required to fit the Houthakker-Taylor model. They use lagged alcohol and cigarette consumption effects in estimating the demand functions. Grabowski (1976) obtains demand functions for fifteen goods including alcoholic beverages but excluding cigarettes using 1956-1972 data for the United States. In various alternative specifications, he finds that the past alcohol consumption coefficient is always positive and statistically significant. His coefficient estimates range between 0.5 and 0.7 and typically is the second or third largest lagged effect. Johnson and Oksanen (1977) fit demand functions for

beer, wine, and spirits in Canada. They use time-series data of province cross sections for the period of 1956-1970. They too report positive past consumption coefficients for each beverage, statistically significant for spirits and wine. The coefficient on wine is approximately 0.5, the spirits coefficient is 0.3, and the beer coefficient is 0.1. Baltagi and Levin (1986) report a lagged consumption coefficient of 0.9 for cigarette demand functions. Their data set consist of a time-series of state cross sections for the period 1964-1980 in United States.

All of the studies described so far treat lagged consumption or the stock as predetermined, because they all assume myopic behavior on the part of the consumer. Even if this exogenous treatment of the past consumption is appropriate, the coefficient of the lagged dependent variable is biased and inconsistent in the presence of serial correlation. Some of the studies attempt to correct for serial correlation, but there may still be a bias if there is misspecification in the process. The alcohol demand studies by Thom (1984) and Jones (1989) had to deal with very complex empirical specifications as a result of combining Deaton and Muellbauer's (1980) Almost Ideal Demand System and the Houthakker-Taylor model. Moreover, the functional forms and estimation methods used by Houthakker and Taylor (1970) and by Phlips (1972, 1978) are more complicated than the procedures used by Becker *et al.* (1994).

A final criticism of myopic studies of addiction is related to the role of advertising in the demand function. Berndt (1991) discusses several econometric problems in estimating the effects of advertisement on demand functions. As indicated by Saffer (1993), if advertising is treated as a stock, then a series of lagged advertising variables will affect current consumption. When these effects are modeled as a Koyck process, then the coefficient of past consumption will reflect both the effect of habit formation and the effect of advertising.

Empirical studies discussed so far focus on the impact of past consumption on current consumption. Myopic studies by Young and by Pekuurinen have a different emphasis. Young (1983) studies the demand for cigarettes in the United States and Pekuurinen (1989) in Finland, attempting to implement Scitovsky's (1976) notion that consumers should respond more to price decreases than to price increases in the case of addictive goods. They present empirical evidence in support of this proposition, nevertheless, there is no formal model that contains a proof of it. Moreover, both studies neglect any effects of past consumption on current consumption. In addition, their observations may be the result of intertemporal interactions of past, current and future prices on the demand for addictive goods which is the topic of this paper. Becker and Murphy's (1988) treatment of unstable steady states does not preclude asymmetric price responses

in aggregate data, although the response to a price reduction is not necessarily larger than the response to a price increase.

II.B. Rational Models of Addiction

Addictive behaviors, the most obvious examples of which are cigarette smoking, consumption of illegal drugs and excessive alcohol use, have been the subject of numerous research and many economic models in the past and continues to be so. Grossman (1993, p. 91) takes the view that since "lifestyles play a more important role in health outcomes than medical care... policy-makers would be interested in empirical evidence of behaviors with regard to their sensitivity to price – a policy-manipulable variable in light of excise taxes – and other Government regulations such as the minimum legal drinking age for the purchase and consumption of alcoholic beverages."

His first studies deal with the effects of cigarette prices on smoking and the effects of alcohol prices on alcohol use in micro data. Gary Becker, Michael Grossman and Kevin Murphy tested empirically the theory of rational addiction in the well-known paper (Becker *et al.* 1991*a*, 1994)[2] which pertains to cigarette addiction in time series of state cross sections in the United States. This paper

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2 Becker *et al.* 1991*a* is the earlier version of 1994 paper.

was followed by a second paper containing some theoretical extensions of the rational addiction model (Becker *et al.* 1991*b*) and a third project dealing with alcohol, addiction, and price (Grossman *et al.* 1995). Finally, he estimates demand functions for cocaine consumption by young adults (Grossman *et al.* 1996).

The empirical research using a rational addiction framework is new compared to the empirical research using a myopic addiction framework. In order to determine the optimal quantity of an addictive good, the consumers of the rational models of addiction consider the future effects of the current consumption. However, the consumers of the myopic models ignore the effects of current consumption on future utility.

Important theoretical contributions to the rational models of addiction have been made by Ryder and Heal (1973), Boyer (1978, 1983) and Kydland and Prescott (1982). All of these authors deal with optimal path of consumption over time when the utility function is not additively separable.[3] Using these models as the starting point, Becker and Murphy (1988) developed a specific model of rational addiction that contains the first explicit derivation of long-run and short-run demand functions for addictive goods in the case of farsighted consumers. The

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[3] See Iannaccone (1984) and Chaloupka (1988) for in depth review of these models.

main contribution of their model of rational addiction is to indicate that it is incorrect to assume that addictive goods are not sensitive to price.

Becker and Murphy (1988) assume that consumers maximize a lifetime utility function which is separable over time and the quantity demanded of the addictive good is inversely related to the current, past and future prices of the good. Past prices affect past consumption of the addictive goods and an increase in past consumption raises current consumption. On the other hand, a decrease in future prices lowers the shadow price of current consumption, raising the current consumption. In other words, increases in past or future consumption cause current consumption to rise. Along the same lines, a long-run response to the price change of an addictive good is larger — in absolute value — than the short-run response. Since this model constitutes the theoretical framework of this study, I leave the detailed explanation to Section III.

In their 1991*b* paper, Becker *et al.* develop some theoretical extensions to the rational addiction model. They note that the total cost of an addictive good equals the sum of good's price and the money value of its future adverse effects. The negative effects of excessive alcohol consumption on earnings is an example to future adverse effects. They also note that the future costs tend to be less important to poorer, less educated and younger consumers because they generally place a smaller monetary value on health and other harmful future

effects than richer, more educated and adult consumers who have higher wage rates. Finally, the poor, youths and less educated are more likely to have lower time-discount factors (they value present substantially more than the future) compared to rich, adults, and the more educated. Therefore poor, young and less educated are more sensitive to changes in money prices of addictive goods then the upper or middle income class, adults and more educated who are more sensitive to perceived or actual harmful consequences that they expect to occur in the future.

An important contribution of Becker and Murphy (1988) pertains to their treatment of rational addiction in the context of unstable steady states. In an unstable state, a price change causes people to start or stop using an addictive good or to change their consumption of the addictive good drastically. They show that unstable steady states are possible in their rational addiction model. Decisions to start or stop the consumption of an addictive good can be studied within this framework. Besides prices, stressful life events like divorce affect such a decision. Becker-Murphy model also implies that the probability of consuming an addictive good in the current period and the current consumption quantity will rise if a change in status from married to divorced or unemployed to employed is anticipated in the near future.

Other contributions to the literature on the theory of rational addiction are by Barthold and Hochman (1988) and Michaels (1988). Barthold and Hochman predict that free inpatient treatment programs would be more successful than outpatient treatment. Michaels proposes that anti-drinking campaigns that promote the productivity of activities other than alcohol abuse would be more successful than campaigns that stresses only on the negative effects of alcohol abuse.

II.B.1. Empirical Applications of Rational Addiction Models: Demand for Cigarettes, Gambling and Leisure Time

Becker *et al.* (1994) fit models of rational addiction to cigarettes in a U.S. time series of state cross sections for the period 1955-1985. They focus on the simple model in which the rate of depreciation on the addictive stock equals one (see equation [4]), which is also the focus of this study.[4] They fit structural demand functions using two-stage least squares method where past and future consumption are treated as endogenous variables and past and future cigarette prices as instruments.[5] They also use current, past, and future state cigarette

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4 In an earlier version of the paper (Becker *et al.* 1991*a*), they also estimate the general model where the depreciation rate is less than one (see footnote 12 and 15).

5 Grossman (1993) explains that they treat the cigarette price as exogenous even though the cigarette industry is highly concentrated in the United States. He justifies this based on the work of Sumner (1981, p. 1017), who

excise tax rates as instruments in some specifications, because consumers may have more information about taxes, especially future taxes, than about future prices.

They find that, the two-stage least squares estimates of current price, and past and future consumption coefficients are all statistically significant. Furthermore, as their model predicts (see Section III, page 28), price coefficient is negative, while the coefficients on lead and lagged consumption variables are positive, indicating that cigarette smoking is addictive and that consumers are rational rather than myopic. They calculate that the long-run price elasticity of demand is between -0.73 and -0.79, which is about twice as large as the short-run price elasticity which is between -0.36 and -0.41. Again, as predicted, there appears to be intertemporal complementarity between cigarette consumption at various points in time: cigarette consumption in any year is lower when both future prices and past prices are higher.

One problem they note about the coefficient estimates is that the point estimates of the discount factor β are very low — the ratio of the coefficient of future

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concludes that "the effect of monopoly power as a source of price variation in the [cigarette] industry is small compared with tax rate differences and other cost differences over time and space." Also, Porter (1986) does not find much difference between cigarette market demand functions that treat price as exogenous and demand functions that treat price as endogenous.

consumption to the coefficient of past consumption. They range from 0.31 to 0.64 which correspond to interest rates ranging from 56.3 percent to 222.6 percent. They attribute these high interest rates to uncertainty about the future prices on the part of consumer: Since they can not fully anticipate the future prices, estimates based on the assumption of perfect foresight may overstate the variability of expected future prices. Due to an errors-in-variables bias, this may lead to an understatement of the effect of future prices on current consumption.

In an alternative specification, they exclude the future price and taxes from the instrument set to explore the preceding issue. Under this specification, they obtain substantially different coefficient estimates from the ones that include these variables as instruments. While these estimates still have the correct signs to support the rational addiction model the results reject the hypothesis that future prices and taxes are inappropriate instruments.

As mentioned above, Becker *et al.* (1994) obtain very low discount rates which they attribute to the aggregate nature of their data set.[6] Therefore they specify new models where six alternative discount factors ranging from 0.70 to 0.95 (interest rates ranging from 5.3 percent to 42.9 percent) are imposed on the

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6 Other studies too indicate considerable variation in the estimates of consumer discount factors (Hansen and Singleton 1983, Mankiw *et al.* 1985, Hotz *et al.* 1988, Bover 1991, Epstein and Zin 1991).

coefficient of the future consumption. They obtain long-run and short-run price elasticities that are very similar to the ones obtained without such constraints regardless of the discount factor imposed. The imposed discount factors are statistically significant in most specifications where the future prices and taxes are used as instruments whereas they are not significant in specifications where the instruments do not include lead prices and taxes. This provides further support to their original specification.

Further evidence in support of the rational model of cigarette addiction is obtained by Chaloupka (1991). Using cigarette consumption measures in three adjacent periods from the second National Health and Nutrition Examination Survey, which is a micro data set, he estimates cigarette demand functions similar to those in Becker *et al.* (1994). His estimates of future and past consumption coefficients are positive and significant. He reports a short-run price elasticity (-0.20) that is less than one-half of the long-run price elasticity of -0.45. He also finds that the less educated is more sensitive to changes in cigarette prices than the more educated, a prediction made by Becker *et al.* (1991*b*). A similar result was obtained by Townsend (1987) with British data. Lewit *et al.* (1981) and Lewit and Coate (1982) report that youths respond more to cigarette prices than adults. Using U.S. data, Farrell and Fuchs (1982) find that increasing awareness of the long-run harmful effects of smoking since 1960's,

had greater effect on smoking by rich and more educated than by poor and less educated. Townsend (1987) replicates these results for Britain. Note that Wasserman *et al.* (1991) fail to replicate the interaction between age and price in the demand for cigarettes using various National Health Interview Surveys in the 1970's and 1980's.

Keeler *et al.* (1993) regress cigarette consumption on the current price, three lags of the price, and three leads of the price in a monthly time-series study of the demand for cigarettes in California during the period 1980-1990. Their results too confirm the rational addiction model. However, their estimates are not based on the structural form used by Becker *et al.* (1994). As explained in Section III, future and past prices have direct effects on future and past consumption, and they only indirectly affect current consumption when the current price is held fixed. In this context, future and past prices will negatively affect the current consumption of rational addicts. Keeler *et al.* report, however, positive and insignificant past and future price coefficients. This result may be due to the fact that there are too many leads and lags included in the regression equations and to multicollinearity among monthly time-series of prices for a single state.

Mobilia (1990) applies the rational addiction framework to the demand for gambling at horse racing tracks. Her data consist of a U.S. time series of horse track cross sections for the period from 1950 through 1986 (tracks over time are

the units of observation). She measures consumption by the real amount bet per attendant (handle per attendant) and price by the takeout rate (the fraction of the total amount bet that is retained by the track). Her findings are similar to those in the rational addictive studies of cigarettes by Becker *et al.* (1994), and Chaloupka (1991). The long-run price elasticity of demand for gambling at horse tracks equals -0.7 and is more than twice as large as the short-run elasticity of -0.3. Moreover, an increase in the current takeout rate lowers handle per attendant in past and future years.

In an alternative specification, Mobilia considers attendance per capita as a dependent variable. This specification does not support the rational addiction model. Since her data indicate that eighty percent of all bets are placed by only twenty percent of the attendees, it is clear that gambling is addictive only for a smaller portion of attendees, the rest of them attend for entertainment purposes. Therefore, handle per attendant is a much better measure of addiction to gambling than attendance per capita.

Using Panel Study of Income Dynamics of the University of Michigan, Hotz *et al.*(1988) and Bover (1991) apply variants of rational addiction models to the demand for leisure time or the supply of hours of work over the life cycle. Both report evidence of rational addiction in the sense that current hours of work are positively related to past and future hours of work.

Research on the supply side of the market for addictive goods is limited. Becker *et al.* (1994) briefly consider the optimal pricing policy of a rational monopolistic producer of an addictive good. They show that the monopolist will set current price such that marginal revenue is less than marginal cost since future profits are higher when current consumption is larger (current price is smaller) because greater current consumption raises future consumption. They also show that current price and current profits can rise in the face of a drop in demand due, for example, to an increase in information about the harmful effects of cigarette smoking. Similarly, expecting a future price increase in the form of Federal excise tax on cigarettes[7] monopolistic cigarette producer will increase the current price and profits. Current price rises because a decline in future demand reduces the gains from lowering price now. In turn, current profits rise because the monopolist previously was pricing below the current period profit-maximizing point. These trends in demand, price, and profits have characterized the cigarette industry since 1981.

Showalter (1991) develops a more elaborate model of the optimal pricing policy of a monopolistic producer of an addictive good where he also considers the behavior of consumers of the good. He studies four different combination:

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7 A higher Federal excise tax on cigarettes was expected to go into effect at the beginning of 1983. Cigarette prices increased sharply not only in 1983 but also prior to the tax increase during 1982.

myopic monopolist-myopic consumer, rational monopolist-myopic consumer, myopic monopolist-rational consumer, and rational monopolist-rational consumer. Using the same data set employed by Becker *et al.* (1994), Showalter finds that the rational monopolist-rational consumer model provides the best fit, although he treats past and future consumption as exogenous in estimating the demand function.

II.B.2. Empirical Applications of Rational Addiction Models: Demand for Alcohol and Cocaine Consumption

Forming a rational addiction model of demand for alcohol is more difficult when compared to the rational addiction models for demand of cigarettes due to some characteristics of alcohol consumption. One is that alcohol is not as addictive as cigarette because many people consume small quantities of alcohol but not cigarettes. In other words, alcohol consumption exhibits a more continuous distribution compared to cigarette consumption which has more bimodal distribution described by Becker and Murphy (1988).

Another distinction of alcohol consumption is that applications of rational addiction to alcohol consumption must pay attention to the heavy drinkers. These are people who drink heavily from time to time but are not alcoholics, distinguished by the fact that they consume a smaller annual amount of alcohol compared to alcoholics. It is generally believed that the number of heavy

drinking occasions and consumption by heavy drinkers and by alcoholics are not sensitive to price changes. If this belief were correct, the application of rational addiction model to alcohol consumption would not be justifiable. However, there are several studies that suggest otherwise.

One of the earlier pieces of the literature that oppose the conventional wisdom about the heavy drinking occasions of the non-alcoholics and consumption by heavy drinkers being not sensitive to price is by Bigelow and Liebson (1972) They made a clinical experiment using two male, skid row, chronic alcoholic volunteers residing in Baltimore to show that alcohol-dependent people reduce their alcohol consumption as a function of beverage costs. In another experimental study of price reductions, Babor *et al.* (1978), used twenty adult male volunteers with prior history of casual drinking and fourteen adult male volunteers with prior history of heavy drinking. They studied the effects of price reductions during afternoon happy hours in Boston on alcohol consumption. Half of the subjects were given price reductions for three hours in the afternoons and the other half purchased alcohol under a single price. Their results showed that the afternoon price reductions significantly increased alcohol consumption by both casual and heavy drinkers. When the standard purchase price was reinstated consumption by both groups decreased.

Another study in this area is by Kendell *et al.* (1983) which examines the alcohol consumption by heavy and moderate drinkers before and after Scotland increased the excise tax for alcoholic beverages. They used a sample of 463 residents of the Lothian region. Their results showed that alcohol consumption fell proportionately more among heavy drinkers than among other drinkers.

All of these studies point to the same direction. However, generalizing the results of these studies would be misleading due to the limited and non-representative nature of the samples. Nevertheless they indicate that this topic is a good candidate for further research and refined estimates of demand functions for alcohol consumption are needed.

In their well known study, Cook and Tauchen (1982) examine the variations in death rates from cirrhosis of the liver and the variations in per capita consumption of distilled spirits in a time series of license State cross sections for 1962-1977. They find that the State excise tax rate on distilled spirits has a negative and statistically significant effect on the death rate from cirrhosis. Their results show that a $1 increase in the State excise tax rate lowers the death by between 5.4 and 10.8 percent and lowers the per capita consumption by 7.2 percent. Clearly, their results show that consumption of distilled spirits is intensely sensitive to price.

Grossman *et al.* (1987) use the first National Health and Nutrition Survey, which is conducted between 1971 and 1975 and Coate and Grossman (1988) use the second National Health and Nutrition Survey (1976-1980). These studies derive the alcohol demand functions for youths of ages sixteen through twenty-one. They find that the use of alcohol by youths is inversely related to the prices of alcoholic beverages in both data sets. The results indicate that when the price rises, not only the fraction of infrequent drinkers decline but the fraction of frequent drinkers decline even more in absolute or percentage terms. Similarly the fraction of heavy drinkers decline more than the fraction of light drinkers as a result of a price increase.[8] Kenkel (1993), using 1985 National Health Interview Survey data, reports that among youths and adults, the number of days on which a person consumed five or more drinks during the past year is inversely related to price. Manning *et al.* (1995) report similar results using 1983 National Health Interview Survey.

The above studies are conducted in the context of a standard consumer behavior model. Unlike the rational addiction models, they do not try to estimate structural demand functions where the current consumption depends on past

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8 According to their definitions, frequent drinkers drink four to seven times a week, fairly frequent drinkers have one to three drinks per week. Heavy drinkers have six or more cans of beer on a typical drinking day, fairly heavy drinkers drink three to five cans.

and future consumption. Grossman *et al.* (1995) provide strong evidence of rational addictive behavior for alcohol consumption in the context of Becker-Murphy model, which will be presented in later parts of this study. Waters and Sloan (1995) use the Alcohol Supplement of the 1983 Health Interview Survey to estimate alcohol demand functions assuming rationally addictive consumers. Their findings support the rational addiction models. However, their result must be used carefully: The time lag used in the study is four years[9] and only the current consumption value is actually known. The past consumption is constructed from the respondent's past drinking history. The future consumption is estimated based on coefficients obtained from the regression of the ratio of 1983 (actual) to 1979 (constructed) consumption on age, drinking history, race, gender, marital status, smoking variables and liquor price differences during the period 1979-1983. They also assumed that the respondents lived in the same standard metropolitan statistical area which is not very realistic.

Finally, Grossman *et al.* (1995) test the rational addiction model using micro data from the Monitoring the Future Survey and price information from the System to

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9 Current values are from 1983, past values from 1979 and future values are from 1987.

Retrieve Information from Drug Evidence (STRIDE).[10] They apply the Becker-Murphy model described in the next section and find evidence in support of rational addictive behavior in cocaine consumption: The coefficients on past and future frequency of cocaine consumption as well as coefficients on past and future cocaine participation variables are positive and significant, and the price effect is significantly negative.[11] They also report a larger long-run price elasticity compared to the short-run elasticity, which is predicted by Becker *et al.* (1991*b*).

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[10] For prior studies on demand functions of illicit drugs that do not apply rational addiction model see their paper.

[11] They estimate two functions. One uses cocaine participation as the dependent variable, the other uses frequency of cocaine use given positive participation.

III. Analytical Framework

Following Becker, Grossman, and Murphy (1994), I assume that consumers have a dynamic utility function in the sense that the current utility depends not only on the current consumption level but also past and future consumption. The utility function is then

$$U(Y_t, C_t, C_{t-1}, e_t) \tag{1}$$

which is assumed to be concave to satisfy the requirements of a standard utility function.[12] Here, C is alcohol consumption, Y is the consumption of a composite good and e is the effect of unmeasured variables on the utility (assumed to be independent from C). The subscripts indicate the period of observation. The individuals are assumed to live forever and maximize the sum of their lifetime utility discounted at the rate of r. If we further assume that the individual's rate

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12 This utility function is actually a special case of the more general form, $U(Y_t, C_t, S_t, e_t)$, where S_t is the stock of the addictive good. A simple process that determines the stock at time t is $S_t = (1-\delta)S_{t-1} + C_{t-1}$, where δ is the rate of depreciation on the stock. The utility function given in the text assumes that $\delta = 1$, *i.e.* the stock completely depreciates, and the term S_t is replaced by C_{t-1}.

of time preference is equal to the interest rate and treat Y as numeraire, the consumer's problem becomes[13]

$$\max \sum_{t=1}^{\infty} \beta^{t-1} U(C_t, C_{t-1}, Y_t, e_t) \tag{2}$$

subject to

$$\sum_{t=1}^{\infty} \beta^{t-1} (Y_t + P_t C_t) = A$$

where $\beta = 1/(1+r)$. A is the present value of lifetime wealth and the effect of consumption of the addictive good is ignored on the earnings (hence $\partial A / \partial C_i = 0, \ \forall i$) and on the length of consumer's life. The level of consumption in the period prior to that under consideration C_0 is known. Setting up the lagrangean and solving for the first order conditions gives us

$$\frac{\partial \mathcal{L}}{\partial Y_t} = U_y(C_t, C_{t-1}, Y_t, e_t) - \lambda = 0 \tag{3a}$$

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13 This equation assumes that the addictive stock depreciates fully from one period to the next so that the stock is totally replaced by the past value of the consumption. In other words the depreciation rate of the addictive stock is equal to one.

$$\frac{\partial \mathcal{L}}{\partial C_t} = U_{1C_t}(C_t, C_{t-1}, Y_t, e_t) + \beta U_{2C_t}(C_{t+1}, C_t, Y_{t+1}, e_{t+1}) - \lambda P_t = 0 \qquad (3b)$$

Equation (3a) indicates that the marginal utility of the non-addictive composite good is equal to the marginal utility of wealth ($U_y = \lambda$). Equation (3b), $U_{1C_t} + \beta U_{2C_t} = \lambda P_t$ implies that this period's marginal utility derived from the current consumption plus the next period's utility resulting from the current consumption, discounted at the rate of β equals the current price times the marginal utility of wealth. The nature of the addictive good will determine the sign of the partial derivatives of the utility function: If it is a harmful one, U_2 is negative and if beneficial U_2 is positive. On the other hand, an increase in the past consumption must have a positive effect on the marginal utility of C_t for the current consumption to increase, regardless of the nature of the addictive good.

Considering a quadratic utility function, the solution to the equation system given in (3) will give us the following structural demand function:[14,15]

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14 Intercept not shown.

15 Becker *et al.* (1991*a*) show that, using the more general version of the model (see footnote 12), the demand for the addictive good, omitting the intercept term, becomes
$C_t = \theta C_{t-1} + \beta\theta C_{t+1} + \theta_1[1+(1-\delta)^2\beta]P_t - \theta_1(1-\delta)P_{t-1} - \beta\theta_1(1-\delta)P_{t+1} + \theta_2 e_t + \theta_3 e_{t+1}$.

$$C_t = \theta C_{t-1} + \beta\theta C_{t+1} + \theta_1 P_1 + \theta_2 e_t + \theta_3 e_{t+1} \tag{4}$$

where

$$\theta_1 = \frac{u_{yy}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \tag{5}$$

$$\theta_2 = \frac{-(u_{yy}u_{1e} - u_{1y}u_{ey})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \tag{6}$$

$$\theta_3 = \frac{-\beta(u_{yy}u_{2e} - u_{2y}u_{2e})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \tag{7}$$

where the lowercase letters are the coefficients of the quadratic utility function. Since U is concave, θ_1 is negative which implies that current price and current consumption of the addictive good are inversely related, all other variables being held constant. θ in equation (4) determines the effect of past and future consumption of the addictive good on current consumption: When it is positive, greater past and future consumption will result in greater current consumption; when it is negative, increases in past and future consumption will decrease the level of current consumption.

$$\theta = \frac{-(u_{12}u_{yy} - u_{1y}u_{2y})}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)} \tag{8}$$

When the consumption of a good is addictive, it is expected that the past consumption to reinforce the current consumption. In our context, the good will be considered addictive if and only if an increase in past consumption leads to an increase in current consumption, holding P_t , λ, e_t and e_{t+1} constant. In other words, if θ is positive then the good is addictive. In addition, the magnitude of θ will measure the degree of addiction: the more addictive a good, the greater is the reinforcement from the past consumption, hence larger θ.

Equation (4) provides us with a basis of empirical analysis: The consumption in current period is expressed in terms of past and future consumption, current price and the unobservables. Applying ordinary least squares estimation to this equation though will result in biased parameter estimates. The unobserved errors, e_t, that effect the utility are likely to be serially correlated. Even if these variables are not correlated, C_{t-1} depends on e_t and C_{t+1} depends on e_{t+1} through the optimizing behavior implied by equation (4). Thus, even if the true value of θ is zero, ordinary lest squares estimation might incorrectly indicate that past and future consumption affect current consumption.

Note that in equation (4), the right hand side variables does not include only the past and future prices of the addictive good, *i.e.* P_{t-1} and P_{t+1} affect the current consumption through their effects on C_{t-1} and C_{t+1}. This provides us with a mechanism to solve the endogeneity problem of past and future consumption. Provided that the unobservables are uncorrelated with prices in these periods, past and future prices are logical instruments for C_{t-1} and C_{t+1} , since past prices directly affect past consumption, and future prices directly affect future consumption.

The empirical analysis described above can be refined further by including certain life cycle variables such as the marital status, employment, religious participation, education etc., that affect the utility and therefore determine e_t . If $\frac{\partial^2 U}{\partial e_{t+1} \partial C_t} = 0$ and $\frac{\partial^2 U}{\partial e_t \partial C_t} \neq 0$ then C_t depends on e_t but not on e_{t+1} in equation (4). Then a current demographic or socioeconomic variable can be used as regressor in the structural demand function given by equation (4), and past and future values of the same variable will be instruments for past and future consumption.

In the empirical analysis presented here, the coefficient of the future consumption will provide a direct test of a rational model of addiction as opposed to the alternative of myopic addiction. In the latter case, the consumer does not consider the effect of the current consumption on future utility and

future consumption. Specifically, a myopic individual has a first-order condition for the utility maximization problem that does not contain the term βU_2 as in the equation (3b). Therefore, the solution to the myopic first-order condition for C_t — the myopic equivalent of equation (4) — does not contain the terms C_{t+1} and e_{t+1} on the right hand side. The consumer is completely backward-looking: Current consumption depends only on current price, past consumption, the marginal utility of wealth — through θ_1 in equation (5) — and current events. Hence, the myopic behavior implies that the coefficient on the future consumption should be zero, while the rational model implies that it should have the same sign as the coefficient on past consumption. Note also that the magnitude of the coefficient on the future consumption is determined by the coefficient on the past consumption and the discount factor.

Equation (4) implies that there is intertemporal complementarity or negative cross price elasticities between alcohol consumption at various points in time. Holding the prices in all other periods constant, a price increase in period t-1 will decrease the consumption in that period. The negative effect of this price change will be then seen on the current consumption through the term θC_{t-1} , since θ is positive even though the price in current period is kept constant. Similarly, if P_{t+1} increases with prices in all other periods held constant, C_{t+1} will decrease and through the term $\beta\theta$, C_t will decrease.

This analysis can be easily extended to a permanent increase in price. Since the price will be higher in all future periods, consumption will be lower in all future periods. In addition, the individual will consume even less because at any period she or he faces a lower consumption for the next period. This suggests that under rational addiction assumption, the short-run demand elasticity for the addictive good will be substantially different than the long-run elasticity. The short-run effect is the response to a price change in period t and all future periods that is not anticipated until period t. The long-run price effect pertains to price change in all periods. Since C_{t-1} remains the same if the price change is unanticipated until period t, the short-run effect must be smaller than the long-run effect.

In order to see these results in mathematical terms, one can solve the second-order difference equation in (4), which will give the current consumption in terms of prices and life-cycle variables in all periods.[16] Given the following roots of the different equation, and with $4\theta^2\beta < 1$, $\phi_1 < 1$, and $\phi_2 > 1$ for a stable system,

[16] For the derivation of the solutions see Becker *et al.* (1994).

$$\left.\begin{aligned}\phi_1 &= \frac{1-\sqrt{1-4\theta^2\beta}}{2\theta}\\ \phi_2 &= \frac{1+\sqrt{1-4\theta^2\beta}}{2\theta}\end{aligned}\right\} \tag{9}$$

the following current, past and future temporary effects are obtained:

$$\frac{\partial C_t}{\partial P_t} = \frac{\theta_1}{\theta\phi_2} \tag{10}$$

$$\frac{\partial C_t}{\partial P_{t-1}} = \frac{\theta_1}{\theta\phi_2^2} \tag{11}$$

$$\frac{\partial C_t}{\partial P_{t+1}} = \frac{\theta_1\phi_1}{\theta\phi_2} \tag{12}$$

Since $\theta_1 < 0$, all these temporary effects are negative. The short-run effect is

$$\frac{dC_t}{dP} = \frac{\theta_1}{\theta(1-\phi_1)\phi_2} \tag{13}$$

and the long-run effect is

$$\frac{\partial C}{\partial P} = \frac{\theta_1}{\theta(1-\phi_1)(\phi_2-1)} = \frac{\theta_1}{(1-\theta-\beta\theta)} \tag{14}$$

As mentioned in the previous paragraph, this long-run effect must be greater than the short-run effect, because the ratio of equation (14) to equation (13) is $\phi_2/(\phi_2 - 1)$, and $\phi_2 > 1$ as stated above.

IV. Data

IV.A. Monitoring the Future Survey

Institute for Social Research of the University of Michigan started surveying high school seniors in 1975 as part of the Monitoring the Future research program[17]. Each year, a nationally representative sample of 15,000 to 19,000 students are surveyed between March 15 and April 30 and they are asked several questions on consumption of cigarettes, alcohol and illegal drugs among others. Starting with the class of 1976, approximately 2,400 of these seniors are chosen to be followed up. In this sample, respondents reporting daily marijuana use or use of any other illegal drug are over-represented by a factor of three[18]. This selected sample of 1976 seniors are followed up every two years. Starting with 1977, the seniors selected to be followed-up are divided into two groups of 1,200 each; one group is surveyed on even-numbered years, and the other on odd-numbered years after the baseline year. This means that for any baseline sample (except the 1976 baseline) half of the respondents are followed up the first time only one year after they graduate, and the other half are followed up two years from their

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17 These surveys are described in detail by Johnston *et al.* (1993).

18 In this sample, approximately 15% accounts for these observations, meaning that in the nationally representative sample around 5% met this criterion.

graduation. Thereafter, all respondents were sent survey questionnaires at two year intervals.

The data used for this study consist of the panels created using the samples chosen to be followed up. There are thirteen baseline samples that gives us twenty-four panels: First panel is formed of the 1976 class and has seven waves of data (one for the baseline and six for the follow-ups). The baseline for second and third panels is 1977 and each has six follow-up waves. Fourth panel starts with 1978 baseline and has again a total of seven waves. Since the last data is only available until 1989, the next four panels have a total of six waves of data. The panels nine through twelve has five waves, thirteen through sixteen four waves and panels seventeen through twenty has three waves. The baseline for panel twenty is 1986. The Michigan data set contains four more panels but they have only two waves. Since the empirical analysis for the rational addiction model requires the past, current and future values of consumption and price, as well as socioeconomic and demographic variables, only the first twenty panels can be used in this study. In order to have more consistent interval only the odd numbered panels where all the observations are two years apart will be used in this analysis.

Each person in this data set will have between one and five records. The baseline observation will be used for the past values of the variables from the first follow-

up, which will be the first record of each person. The future values of the variables in the first record will be taken from the second follow-up. This first record exists for all the respondents, because we have at least three waves of data for the first twenty panels. The current values for the second record comes from the second follow-up, the past values from the first follow-up and the future values from the third follow-up. The second record exists only for those in panels one through sixteen. The other records for each respondent are created using the same procedure where only respondents in the first four panels have five records[19]. Note that since only the odd numbered panels are considered for the regression analysis, the past value of the variables refer to second annual lag and the future values to the second annual lead.

As the description of the sample suggests I am applying the rational addiction model to the demand for alcohol by teenagers and young adults. The majority of the respondents are seventeen years old at the baseline, nineteen at the first follow-up, twenty-one at the second, twenty-three at the third, twenty-five at the fourth and twenty-seven at the fifth follow-up. Note that practically all of the sample were illegal drinkers at the baseline because every state has had a

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[19] See Table 1 for the panel structure.

minimum legal age for purchasing and drinking alcoholic beverages of at least eighteen since 1930s.[20]

Becker an Murphy (1988) indicate that the consumption of addictive goods are more likely to be characterized by a bimodal distribution. As opposed to the cigarette consumption, alcohol consumption is more continuous in the general consumption. It is more likely for a person to have a few occasional drinks than to smoke a few cigarette now and then. It is therefore more difficult to apply the rational addiction model to alcohol consumption. However, the sample to be analyzed in this paper does not represent the general population. The particular age group in question is more sensitive to price. Rachal *et al.* (1980) indicate that many youths begin to drink alcohol well before the age of eighteen. Since this group usually do not have regular income, they will be very sensitive to price changes. As indicated before, the follow-up samples include three times the actual proportion of illegal drug users, and these individuals consume more alcohol than who do not use illegal drugs (Yamaguchi and Kandel 1984).

Another reason why the Michigan panel data is suitable for rational addiction analysis is that the alcohol dependence and abuse is most prevalent among

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[20] Since the legal minimum drinking age was raised to twenty-one in several states between 1976 and 1987, in later panels, even some of the respondents in the first follow-up and second follow-up were illegal drinkers.

persons aged eighteen through twenty-nine (Grant *et al.* 1991). This range is very close to the range of our sample. Based on data from 1988 National Health Interview Survey, Grant *et al.* (1991) report that the prevalence rate of alcohol abuse and dependence fell from seventeen percent for persons aged eighteen through twenty-nine to less than two percent for persons aged sixty-five and over. Moreover, the prevalence rate in the youngest category was almost double the rate of persons aged thirty through forty-four.

The preceding arguments suggest that the coefficient of past consumption — θ in equation (4) — is likely to be larger in the Monitoring the Future panel sample than in a representative panel of persons of all ages. From equation (14), we know that larger values of θ lead to larger long-run price effect, which will provide the basis for predicting the sensitivity of the panel to the price changes. Another variable that indicates the same prediction is the discount factor of youths and the young adults: They are likely to have lower time discount factors[21] (β) than older adults. Becker *et al.* (1991) show that a reduction in the discount factor increases the long-run price effect. Another reason for greater price sensitivity by teenagers and young adults is the peer pressure. This group individuals are more likely to drink if their peers also engage in this behavior. In this case, a fall in price of alcohol causes each consumer to increase his or her

[21] Their time preference for the present is higher.

demand for this addictive good. Then through the peer effect this increase in demand is reinforced. When we combine this peer effect with the reinforcement effect of the addictive nature alcohol consumption, we would expect a greater price sensitivity in our sample.

IV.B. Prices and Cost of Living Indices

Monitoring the Future data described above include the county level FIPS codes. Therefore, it was possible to add alcoholic beverage prices to the each respondent's observation. This information is available from the *Inter-City Cost of Living Index,* published quarterly by the American Chamber of Commerce Researchers Association (ACCRA) at the city level for between 250 and 300 cities since the first quarter of 1968. The ACCRA collects data for several consumer goods, including beer, wine and distilled spirits. In addition to price information, a cost of living index for each of the cities is computed which is normalized to one in a given quarter.[22]

As previously mentioned, the baseline survey is conducted between March 15 and April 30, when the respondent is still a senior. The follow-up surveys are mailed to their home addresses during the first half of April. It is therefore

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[22] This will give the cost of living in one city relative to the national average — as defined by the cities included in the sample — in a given quarter and year.

assumed that the annual alcohol consumption measure described in the next section will reflect the consumption in the first two quarters of the survey year and the last two quarters of the previous year. Consequently, the annual alcohol price is calculated as a simple average of these quarters. The future price, which is two years after the current observation, is calculated as the simple average of the last two quarters one year after the survey is mailed and the first two quarters of the year after. In other words, the year in our sample is defined from July 1st of the previous year through June 30th of the current year.[23]

Since the alcoholic beverage prices are collected at the city level and we only know the county of residence of the respondents, the nearest city's price is assigned to the county where the respondent lived. Note that the prices are never matched to counties from cities in a neighboring state because much of the variation in alcoholic beverage prices is due to the differences in state excise taxes. Furthermore, if a respondents's county of residence is different from one observation to the next, then a simple average of prices from these two counties are used starting the third quarter of the current year, through the fourth quarter of the next year. This will effect the future price calculation which is the average

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[23] For example, year 1980 in our sample refers to the period 07/01/79 to 06/30/80. Then, the future value for prices for this year is the simple average of quarterly prices from 3rd and 4th quarters of 1981 and 1st and 2nd quarters of 1982.

of the first two quarters two years after the current one and the last two quarters — which are now averages themselves — one year after the current year.

The Monitoring the Future survey has five questionnaires each addressing one of the sections in more detail. Four of these questionnaires did not ask the specific alcoholic beverage consumption. Since the most heavily consumed alcoholic beverage is beer and since it is preferred among teenagers and young adults, beer prices are used as the measure of alcoholic beverage in the regression analyses. The ACCRA started collecting the beer prices only in 1982. Since the past value of price in the first record of a respondent from the first panel must come from 1976, it was necessary to use regression analysis to estimate the beer prices as far back as that year. To complete the series, the nominal ACCRA beer price is regressed on the sum of the state and federal excise tax, quarterly U.S. beer price index (1982-84=1),[24] ACCRA city-specific cost of living index times quarterly CPI for the U.S. (1982-1984=1),[25] and dichotomous indicator variables for the first three quarters of a given year. Then, using the regression coefficients, the beer prices for quarters prior to 1982 are estimated. This

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24 Consumer Price Index, U.S. Bureau of Labor Statistics.

25 As noted in footnote 22, ACCRA gives the cost of living in a city relative to the average of all cities in that year. By multiplying this index by the U.S. Consumer Price Index, which gives the cost of living relative to the average of 1982-1984 for the U.S. in general, the effects of price changes in time, as well as price differences among cities are captured.

quarterly nominal beer price series is then converted to real terms by dividing them by the year- and city-specific cost of living index described in footnote 25. The annual prices are obtained by averaging this real price measure over the four relevant quarters described previously.

IV.C. Measurement of Variables

The data set consists of 7,945 respondents yielding 21,420 person-years (see page 36 for data set structure). There are no missing values for the following variables: the number of alcoholic drinks in the past year; past, current and future real beer price; current real annual earnings; age, male, black, and other race/ethnicity. Missing values for the other variables are replaced by panel- and strata-specific means.[26] The means and standard deviations of these variables are given in Table 2. Note that these figures are weighted to correct for oversampling of persons in the illegal drug stratum. Thus, the means and standard deviations in the table are representative of those in the population.

The number of drinks of alcohol consumed in the past year is the dependent variable in all regressions in the next section. This variable is given by the

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[26] Note that there are two strata for each panel: Persons who used marijuana daily at baseline or used another illegal drug during the past month at baseline, and persons who did not exhibit these illegal drug use patterns at baseline.

product of the number of drinking occasions during the last 12 months and the number of drinks consumed on a typical drinking occasion. Both components are measured with error. The number of drinking occasions is an ordered categorical variable with 7 outcomes: 0 occasions, 1-2 occasions, 3-5 occasions, 6-9 occasions, 10-19 occasions, 20-39 occasions, and 40 or more occasions. It is converted into a continuous variable by assigning midpoints to the closed intervals and a value of 50 to the open-ended interval.

The number of drinks on a typical drinking occasion is inferred from the response to the question: "On the occasions that you drink alcoholic beverages, how often do you drink enough to feel pretty high?" The response categories are none of the occasions, few of the occasions, half of the occasions, most of the occasions, and nearly all of the occasions.[27] I assume that the second response category corresponds to 25 percent of all occasions, that fourth corresponds to 75 percent of all occasions, and that the fifth corresponds to 100 percent of all occasions. I also assume that 4 drinks must be consumed to feel pretty high.

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[27] Four-fifths of the sample are asked the above question. The other one-fifth is asked: "When you drink alcoholic beverages, how high do you usually get?" The responses are not at all high, a little high, moderately high, and very high. The responses to these two questions are made compatible by treating persons who usually get very high as persons who drink enough to feel pretty high on nearly all drinking occasions, persons who usually get moderately high as persons who get pretty high on half of all drinking occasions, and persons who get a little high as persons who get pretty high on few of all drinking occasions.

Persons in the first response category are assumed to consume 1.5 drinks on a typical drinking occasion (I assume that respondents will not feel pretty high if they drink one or two drinks). To calculate the number of drinks per occasion for the categories in between, I multiply these two extremes by the percentage associated with each: Persons in the second category are assumed to consume $0.25 \times 4 + 0.75 \times 1.5 = 2.125$ drinks on a typical occasion. Persons in third category are assigned $0.50 \times 4 + 0.50 \times 1.5 = 2.75$ drinks per occasion and persons in the fourth category are assigned a value of $0.75 \times 4 + 0.25 \times 1.5 = 3.375$.[28]

Like the current annual price of beer, the legal drinking age variable is calculated as the annual average of the first two quarters of the survey year and last two quarters of the year prior to the survey. Since it determines how difficult it is to obtain beer, this variable is a partial determinant of the full price of alcohol, especially for underage youths.[29] This variable is multiplied by a dichotomous variable that is equal to one for those respondents that are of age twenty-one or

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[28] In an alternative specification, the number of drinks per occasion is calculated differently for females, with not much effect on the results. This suggests that although the number of drinks in a typical drinking occasion is calculated subjectively, the results obtained are fairly accurate.

[29] This variable represents the minimum legal drinking age for the purchase and consumption of low alcohol beer and accounts for the grandfather clauses many states adopted when raising their legal ages for all alcoholic beverages to 21 years to comply with the Federal Uniform Drinking Age Act of 1984. For more details on the construction of the legal drinking age measure, see Chaloupka *et al.* (1993).

younger and zero otherwise. This will allow to capture the effect of variation in minimum drinking age laws on the relevant portion of the sample,. In other words, since no state has ever had a legal drinking age greater than twenty-one, the value of the variable used in regressions will be equal to zero for respondents older than twenty-one years old, restricting the effect of such laws. Note that since the birth date of the respondent is not known, it is not known when she or he become a legal drinker. Therefore, the dichotomous variable indicating that the age is less than or equal to twenty-one is actually based on the follow-up number: As explained in section IV.A the majority of the sample were nineteen years old in the first follow-up and twenty-one in the second follow-up. Along the same lines, the four age variables in Table 2 are actually dichotomous indicators for the first, second, third, and fourth follow-ups, respectively.

It will be easier — hence less costly — to obtain alcoholic beverage for those underage youth who reside close to a state with a lower legal drinking age. In order to capture this potential of border crossing, in addition to the own-state minimum legal drinking age described above, a dichotomous indicator for lower border drinking age is created. This variable will be equal to one if a respondent lives in a county within 25 miles of a state with a lower legal drinking age and zero otherwise. For the same reasons as with the legal drinking age variable, it is interacted with the dichotomous indicator for persons whose age is less than or

equal to twenty-one. Holding the own-state legal drinking age constant, the coefficient of the border age variable in the demand function should be positive.[30]

A variety of independent variables were constructed from the demographic and socioeconomic information collected in the surveys. These include sex, race (black or other, omitted category is whites), age (see above), real annual earnings, years of formal schooling completed, college student status (full-time, half-time, or less than half-time, omitted category is not-in-college), work status (full-time, part-time, or unemployed, omitted category is not-in-labor force)[31], religious participation (infrequent or frequent, omitted category is no participation), marital status (married, engaged, or separated or divorced, omitted category is singles), and the respondent's number of children. Finally, all models include dichotomous variables for nine of the ten cohorts (the high school senior classes of 1976 through 1984). The time-varying variables serve as proxies for life-cycle variables that affect the marginal utility of current consumption.

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30 For a detailed discussion of legal drinking age effects, see Grossman *et al.* (1987), Coate and Grossman (1988), Laixuthai and Chaloupka (1993).

31 Full-time work status and full-time college student status are not mutually exclusive categories in theory or in the follow-up questionnaires.

At the first follow-up, past values of socioeconomic variables pertain to baseline data. Since they were seniors at the baseline, the past value of years of formal schooling completed at the first follow-up equals eleven for all respondents, and the past values of college student status indicators (see above) are all equal to zero. The past work status is taken from a baseline question on average hours of work per week during the school year.[32] High school seniors who do not work at all during the school year are assumed to be not in the labor force rather than unemployed. The lag of earnings as of the first follow-up equals the sum of income from work during the school year and other sources such as allowances and summer jobs.[33]

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32 Full-time workers at baseline are students who work more than 20 hours per week during the school year.

33 For the follow-up surveys, respondents are only asked about own earnings.

V. Empirical Estimation

As mentioned in section IV.A, only the odd numbered panels are used in the regression analysis. This means that the all the observations are two years apart. Therefore all the references to past values are for two years earlier and all references to future values are two years later than the current year. In section III, it is explained that the past and future consumption are endogenous to the model. Therefore, the equation (4) is fitted by two-stage least squares (TSLS). The instruments consist of the exogenous variables in the model, the past annual real beer price, the future annual real beer price, the past values of the two measures pertaining to the legal drinking age (legal drinking age*age≤21 and lower border drinking age indicator*age≤21)[34], and the past and future values of all time-varying socioeconomic variables. These socioeconomic variables include real annual earnings, years of formal schooling completed, college student status, work status, religious participation, marital status, and number of children.

The past and future values of all time-varying socioeconomic variables are valid instruments for reasons given in Section III. Moreover, the second lead and lag of the real beer price and the second lag of the drinking age do not provide enough explanatory power to obtain reliable parameter estimates. Probably this

[34] The future values of variables pertaining to the legal drinking age are not used as instruments because they are equal to zero except at the first follow-up.

is because in a given year, the real beer price and the drinking age measures vary only among counties, while past and future consumption vary among persons.

A problem with the use of leads and lags of the socioeconomic variables as instruments is that these variables may not be exogenous. While plausible arguments can be made for the endogeneity of all of them, the real issue is which ones are most likely to be caused by alcohol consumption or correlated with the disturbance term in the structural alcohol demand function given by equation (4). I assume that, religious participation, marital status, and number of children are more likely to be correlated with alcohol consumption.[35] Therefore, demand functions are obtained with and without these variables.

Note that because of the way the alcohol consumption variable is constructed (see page 43), it is subject to measurement error and the results in Section VI.A must be interpreted accordingly: Almost 38 percent of — unweighted — cases fall into the open-ended frequency category of 40 or more drinking occasions in the past 12 months. Clearly, the magnitudes of price elasticities will be affected by the number of drinking occasions assigned — 50 in this study — to this category. Thus, it is more important to focus on the relative magnitudes of the

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[35] For evidence that marriage causes reductions in alcohol consumption, see Miller-Tutzauer *et al.* (1991). For evidence that heavy drinking lowers the probability of marriage, see Kenkel and Ribar (1994).

elasticities (the long-run elasticity relative to the short-run elasticity or relative to the elasticity that ignores addiction) than on the absolute magnitudes of the elasticities. On the other hand, the drinking frequency measure is a more objective measure compared to the measure of the number of drinks on a typical drinking day. Therefore, the probability of frequent drinking is treated as a separate outcome in Section VI.B.

Note also that the real price of beer, as described in Section IV.B, contains measurement error for several reasons: First, the price prior to the first quarter of 1982 was obtained by regression analysis. Second, the price that the respondent faces may be different than the one used in estimating the demand functions because there is no guarantee that nearest ACCRA survey city to the respondent's county of residence is actually the city or town in which the respondent actually resides. Finally, the cost of living index reflects expenditure patterns of middle-income households which may well be different from those of teenagers and young adults. Since random measurement error in an independent variable will bias its coefficient and t-ratio toward zero, the price coefficients and associated t-ratios in Section VI are conservative lower-bound estimates.[36]

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[36] There is an additional source of error in the calculation of future price: It is assumed that respondents fully anticipate that they will move and that they

The regressions in the next section are obtained using the whole sample without weighting for the illegal drug use stratum. Maddala (1983 pp. 170-171) shows that this is the appropriate procedure in the case of exogenous stratification (oversampling on the basis of an exogenous variable in a regression model). The reason is that in regression analysis weighting is employed to produce efficient estimates rather than to produce consistent estimates. There is no reason why the drawing of non-equiproportionate samples from different strata should introduce heteroscedasticity such that the variance of residual is dependent on the sampling fraction.

Maddala also shows that in the case of endogenous stratification it is appropriate to weight by the square root of the inverse of the sampling fraction.[37] However in the regression specifications used in this study, the drug strata is not used as either dependent nor independent variable. Furthermore, Maddala's model assumes that the slope coefficients are the same in the two strata. The coefficients resulting from the regressions are then essentially averages for the

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are aware of the future prices in their new neighborhood. A detailed discussion of the effects of measurement error in future price on rational addiction estimates of cigarette demand functions can be found in Becker *et al.* (1994). Moulton (1990) argues that t-ratios of coefficients of aggregate variables in micro regressions are biased downward if the disturbances in the regression are correlated among persons who live in the same area. This assumes, however, that the aggregate variable is measured without error.

37 See Maddala (1983), pp. 171-173.

two strata, with more weight given to the illegal drug stratum than would be the case in a random sample. In fact, experimentation with weighted regressions did not result in coefficients that are much different from the ones presented in Section VI. Another argument about this analysis is the question of participation in alcohol consumption *vs.* consumption given participation. This distinction is not made in the empirical analysis because of the very low percentage of respondents who did not have any drink during the past year – only eight percent reported that they did not drink during the previous 12 months.

VI. Results

VI.A. Alcohol Demand functions

Table 3 contains standard alcohol demand functions that ignore addictive behavior, *i.e.* past and future consumption are excluded from these estimates. The regression in column 1 omits religious participation, marital status, and number of children, while the regression in column 2 includes these variables.

The most important findings in these regressions are the negative and significant price and legal drinking age effects and the positive and significant border age effect. The magnitude, but not the significance, of the price coefficient is sensitive to the inclusion of religious participation, marital status, and number of children. In particular, the price coefficient is cut in half when these variables are added to the set of regressors. At the weighted sample means of price and consumption, the price elasticity of demand equals -0.38 in the first regression and -0.20 in the second regression.[38] The first estimate may be influenced by omitted variables bias, while the second may be influenced by simultaneous equations bias. Therefore, we regard the average of these two figures of -0.29 as

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38 All elasticities in this section and the next one are computed at the weighted sample means of price and consumption. Elasticities computed at the unweighted sample means are similar.

the benchmark price elasticity that emerges from a demand function for the number of drinks of alcohol in the past year that ignores addictive behavior.

Table 4 tests the rational addiction model directly by estimating the structural demand function given by equation (4). The first two columns contain two-stage least squares (TSLS) regressions in which past consumption and future consumption (as they are defined in previous sections) are endogenous. Religious participation, marital status, and number of children are excluded from the first regression and included in the second. The instruments for past and future consumption are all the exogenous variables in the model, the past and the future beer price, the past values of the legal drinking age and lower border age dummy, interacted with the dichotomous variable for those respondents who are 21 years old or younger, and the past and future time-varying socioeconomic variables. The last two columns contain the corresponding ordinary least squares (OLS) regressions. The table also contains F-ratios resulting from Wu's (1973) test of the hypothesis that OLS estimates are consistent.

In the model with religious participation, marital status, and number of children, the consistency of OLS is rejected. In the model without these variables, the Wu test is inconclusive. The F-ratio of 3.18 is significant at the 5 percent level but not at the 1 percent level. Given these results and the potential endogeneity of

religious participation, marital status, and number of children, it is useful to consider the OLS regressions as well as the TSLS regressions in evaluating the findings.

The estimated effects of past and future consumption on current consumption are significantly positive in the four regressions in Table 4, and the estimated price and legal drinking age effects are significantly negative in all cases. The positive and significant past consumption coefficient is consistent with the hypothesis that alcohol consumption is an addictive behavior. The positive and significant future consumption coefficient is consistent with the hypothesis of rational addiction and inconsistent with the hypothesis of myopic addiction. The sum of the past and future consumption coefficients is always smaller than one which means that the long-run, short-run, and temporary price effects are all negative.

Clearly, the estimates indicate that alcohol consumption is addictive in the sense that past and future changes significantly impact current consumption. This evidence is inconsistent with the hypothesis that alcohol consumers are myopic. Still, the estimates are not fully consistent with rational addiction because the estimates of the discount factor (β) — given by the ratio of the coefficient of future consumption to the coefficient of past consumption — are implausibly high. The implied discount factor is 2.58 in the first regression, 1.26 in the second

regression, 1.37 in the third regression, and 1.34 in the fourth regression. These discount factors correspond to negative interest rates of -61 percent, -20 percent, -27 percent, and -26 percent, respectively.

The standard errors of the four estimates of the discount factor are 0.76, 0.23, 0.04, and 0.04, respectively.[39] The estimates of 2.58, 1.37, and 1.34 are significantly greater than one (*t*-ratios equal 2.08, 9.25, and 8.50, respectively). Not only the estimate of 1.26 is not significantly greater than one (*t*-ratio equals 1.13), but, it is also not significantly greater than 0.95 (*t*-ratio equals 1.35). A discount factor of 0.95 corresponds to a quite reasonable interest rate of 5 percent. When this discount factor is imposed *a priori*, the price and legal drinking age coefficients — presented in Table 5 — are very close to the corresponding coefficients in Table 4. These results, combined with the detailed analysis in Becker *et al.* (1994), suggest that data on alcohol consumption or cigarette smoking are not rich enough to pin down the discount factor with precision even if the rational addiction model is accepted.

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39 If a is the coefficient of past consumption, b is the coefficient of future consumption, v_a is the variance of a, v_b is the variance of b, and c_{ab} be the covariance between a and b. Then the variance of ratio b/a is given by

$$a^{-2}v + b^2a^{-4}v_a - 2b^{-3}c_{ab}.$$

39 For a derivation, see Kmenta (1986, p. 486).

Table 6 explores the effects of more leads and lags of the beer price as an instrument. In these regressions first and third annual lag and lead of beer price are added to the list of instruments. The results are very similar to the ones in Table 4 and reinforces the validity of rational addictive behavior in this sample.

Table 7 is an attempt to estimate the equation explained in footnote 15, the more general model where the stock variable does not depreciate fully. The depreciation rate is assumed to be 80 percent. The regression specification is similar to the one in Table 4, but the stock variable replaces the past consumption variable. The future consumption and the stock variable are endogenous, and the instruments are the same as in Table 4. Results from regression analysis of other depreciation rates (0.4 through 0.9 in increments of 0.1) were similar to those in Table 4, but δ=0.8 had the highest determination coefficient. As in Table 4, Wu test rejects the hypothesis that OLS is consistent when religious participation, marital status, and number of children are included in the model. But the test fails to reject this hypothesis when the restricted set of variables is used (column 1). The coefficient estimates obtained from this model is consistent with rational addiction assumptions, but the future price coefficients are never significant. This can be attributed to the high degree of correlation (0.75) between current and future price.

Table 8 uses the estimates from Table 4 to compute the elasticity of the annual number of drinks of alcohol with respect to the various price changes defined by equations starting on page 33 at the weighted sample means of price and consumption. The long-run elasticity ranges from -0.26 to -1.26 (average equals -0.65). The short-run elasticity ranges from -0.18 to -0.86 (average equals -0.41). The ratio of the long-run elasticity to the corresponding short-run elasticity is more stable. It varies from 1.44 to 1.77 (average equals 1.60). This ratio should be compared to a ratio of approximately 2.00 in the case of rational addiction demand functions for cigarettes (Chaloupka 1991; Becker *et al.* 1994). Becker *et al.* (1991*b*) show that the ratio of the long-run price elasticity to the short-run price elasticity rises as the degree of addiction, measured by the coefficient of past consumption, rises. Thus, the results presented here suggest that alcohol consumption is somewhat less addictive than cigarette smoking. Nevertheless, the long-run elasticity of demand for the number of drinks of alcohol in the past year is substantially larger than the short-run elasticity. Hence, the long-run reduction in consumption caused by a permanent price increase due, for example to an increase in the federal excise tax rate on beer, would be considerably larger than the reduction in consumption after one year.

The average long-run price elasticity of -0.65 also is more than twice as large as the benchmark price elasticity of -0.29 that emerge from the demand functions in

Table 3 that ignore addiction. Indeed, the average short-run elasticity is almost 40 percent larger than the benchmark elasticity. Consequently, forecasts of increases in tax revenue due to excise tax hikes would be considerably overstated and forecasts of reductions in consumption would be considerably understated if they were based on the benchmark elasticity.

With regard to the temporary price elasticities, a 10 percent reduction in the current price causes consumption to rise by between 1 and 1.5 percent. A 10 percent reduction in current price also leads to an increase of between 0.3 percent and 0.7 percent in next period's consumption and to a 0.4 to 1.2 percent increase in the previous period's consumption. These negative cross price effects are inconsistent with non-addictive behavior, and the negative future price effect is inconsistent with myopic behavior. The future price elasticity exceeds the past price elasticity because the estimate of the discount factor always is larger than one.

In Table 9, I examine the robustness of the price and consumption effects by estimating a two-stage least squares fixed-effects model. Using this technique, all time-varying variables are transformed into deviations from person-specific means and delete time-invariant variables from the regressions. This approach is equivalent to including a dummy variable for each person in an untransformed specification. It controls for unobserved heterogeneity, which may be correlated

with religious participation, marital status, and the number of children. Thus the fixed-effects specification is an alternative way to control for the forces captured by these variables and they are omitted. Since the Wu test strongly rejects the consistency of OLS (F-ratio equals 9.22), only the TSLS coefficients are presented in the table.[40]

The results in Table 9 strongly confirm those in Table 4. The past and future consumption coefficients are positive and significant, while the current price coefficient is negative and significant. The long-run price elasticity of -0.54 is substantial. As previously mentioned (section V, page 51), the real price of beer contains random measurement error for a variety of reasons. The downward bias in the price coefficient and its *t*-ratio due to this factor are exacerbated in the fixed-effects model (Griliches 1979; Griliches and Hausman 1986). Thus, the estimates in Table 9 are not necessarily superior to those in Table 4. Taken together, however, the two tables underscore the stability and validity of the findings in this study.

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40 Although the model in Table 9 contains the same time-varying regressors as the first model in Table 4, it is not surprising that the Wu test decisively rejects OLS in the former table but not the latter. Nickell (1981) shows that fixed-effects OLS estimation produces a negative bias and inconsistency in the coefficient of the lagged dependent variable in the absence of serial correlation. Using his techniques, one can demonstrate that the coefficients of past and future consumption are understated in the OLS fixed-effects

Moore and Cook (1995) provide further evidence in support of a rational model of alcohol addiction in the National Longitudinal Survey of Youth. The members of that survey are approximately the same age as the members of Monitoring the Future. Moore and Cook report positive effects of past and future consumption on current consumption and a negative effect of the state beer tax on consumption. Their study differs from this one for a number of reasons. First, they have only two observations on current consumption. Second, they do not measure the cost of alcohol by the city-specific beer price. Third, because the beer tax coefficient is estimated somewhat imprecisely. Finally, the long-run beer tax effect is not always negative. Moreover, their main focus is on habit formation via the effects of past variables rather than on rational addiction.

VI.B. Participation in Frequent Drinking

In this section, I examine the determinants of participation in frequent drinking. Frequent drinkers are those who report forty or more drinking occasions in the past year. Recall that this is the upper open-ended interval in the drinking frequency item on the questionnaire. Thirty-three percent of all cases (weighted) fall into this category, It is particularly important to focus on the frequent drinking outcome because it was assigned a value of 50 occasions in the past year

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model. Indeed, when this procedure is used, past and future consumption coefficients become negative.

in computing the annual number of drinks. Clearly, the elasticities reported in the last section would be affected if a different value had been used.

Linear probability models are obtained. In principle, standard errors of regression coefficients should be corrected based on White's (1980) algorithm. In fact, the correction had almost no impact on the standard errors in preliminary calculations, which is not surprising given the large sample size. Thus, *t*-ratios are based on uncorrected standard errors. The two-stage least squares estimates correspond to Heckman and MaCurdy's (1985) simultaneous equations linear probability model.

I begin with regressions of the probability of forty or more annual drinking occasions that ignore addictive behavior by excluding past and future consumption. The results (shown in Table 10) mirror those in Table 3. In particular, the price and legal drinking age effects are negative and significant, while the border age effect is positive and significant. The magnitude, but not the significance, of the price coefficient is sensitive to the inclusion of religious participation, marital status, and number of children. At the weighted sample means of price and participation in frequent drinking, the price elasticity of demand equals -0.44 in the regression without these variables and -0.22 in the regression with them. The average of these two figures of -0.33 may be regarded

as the benchmark elasticity for participation in frequent drinking that emerges from a demand function that ignores addiction.

Table 11 and Table 12 contain structural rational addiction demand functions for the probability of frequent drinking. This probability is directly related to past and future consumption. Two approaches are taken to measure past and future consumption. The variables in Table 11 (past percentage high and future percentage high) are based on the response to the question: "On the occasions that you drink alcoholic beverages, how often do you drink enough to feel pretty high?" The response categories are none of the occasions, few of the occasions, half of the occasions, most of the occasions, and nearly all of the occasions. Previously, we used these categories to estimate the number of drinks on a typical drinking occasion by assuming that 4 drinks must be consumed to feel pretty high. Here we simply scale them as 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent. This is a more flexible indicator than our estimate of the number of drinks consumed on a typical drinking occasion because it makes no assumption about the number of drinks required to feel pretty high. Moreover, it is reported and measured independently of drinking frequency. Past percentage high (the second lag of the scaled variable just defined) has a weighted mean of 32 percent and future percentage high (the second lead) has a weighted mean of 28 percent.

The disadvantage of the estimates in Table 11 is that they cannot be used to compute long-run participation price elasticities – elasticities which can be compared to those that ignore addiction. Therefore, in Table 12 we use the past and future probabilities of frequent drinking (or dichotomous indicators in the OLS models) as measures of past and future consumption. Taken together, the estimates in Table 11 and Table 12 can be viewed as first-order approximations to structural demand functions for participation in an addictive behavior. Past and future consumption are endogenous in the TSLS regressions. The instruments are the same as in that section.

Regardless of whether the demand functions are obtained by TSLS or by OLS, the estimated effects of past and future percentage high on the probability of current participation in frequent drinking are significantly positive in Table 11, and the price and legal drinking age effects are significantly negative. Similar results emerge from Table 12, except that the price coefficient is significant at the 10 percent level on a one-tailed test but not at the 5 percent level in columns 2 and 4. The long-run price elasticity of participation in frequent drinking is -1.18 in the first regression in Table 12, -0.27 in the second regression, -0.63 in the third, and -0.32 in the fourth. The average elasticity of -0.60 is approximately twice as large as the elasticity that ignores addiction of -0.33. These findings provide

rather strong support for the rational addiction approach to participation in frequent drinking.

VI.C. Starting and Quitting Frequent and Heavy Drinking Behavior

In this section the determinants of starting and quitting frequent and heavy drinking behaviors are examined. Frequent drinking is defined as having had forty or more drinking occasions during the past 12 months and heavy drinking is defined as drinking enough to feel pretty high on at least half of all drinking occasions. The start sample consist of only those respondents who never engaged in the behaviors described at the baseline and quit sample consist of those who were engaged in such behavior at the baseline or started the behavior in one of the follow-ups. I am focusing on first-time starts or quits. Hence, once the behavior starts the respondent's following records are dropped from the data set. Similarly once a person quits the behavior at issue, his or her later observations are deleted. The regression equations are in the form of discrete-time hazard functions (for example, Allison 1982) in which the hazard (the conditional probability of starting or quitting in period t) is specified as a linear probability equation.

Note that the above data sets are smaller than the ones used in previous sections and this makes it more difficult to find the significant relationships in this section's regressions. Allison (1984) and Heckman and Singer (1984) explain that the duration effects are biased in the presence of unobserved heterogeneity. In the data set, the duration is highly correlated with age and I do not attempt to find out the separate impacts of age, duration and heterogeneity. Therefore, a measure of duration is omitted from the hazard function.

Table 13 and Table 14 present the reduced form regressions of the probabilities of starting frequent and heavy drinking, respectively. Table 15 and Table 16 are for the structural demand functions in the context of rational addiction for these two behaviors. Future consumption in Table 15 is measured by the percentage of times the respondent got high, and the number of drinking occasions in Table 16. Since the past the start decision does not depend on past consumption, past variables are not used in the first stage of the TSLS regressions for these models. The mean start probability is 0.16 for frequent drinking, and 0.14 for heavy drinking.

The last four tables pertain to the probability of stopping frequent or heavy drinking behavior. As with the starting behavior regressions, the first two present the reduced form functions and the last two contain the structural rational addiction demand functions. In this case, the past variables as well as

the future variables will affect quitting probability. The past and future consumption variables are the percentage high for Table 19 and number of drinking occasions for Table 20. The mean quit probability is 0.29 for frequent drinkers and 0.41 for heavy drinkers.

As predicted by the rational addiction model, the start probabilities are positively related to the future consumption. In seven of eight cases these effects are significant at one percent level. The rational addiction model predicts that the future consumption will have a negative effect on the quit probability. This is the result of the regressions in the last two tables, and five of the eight coefficients are significant. The past consumption effect is not strong (five coefficients have the correct, negative sign, of which only three are statistically significant).

Fourteen of the sixteen current price coefficients have the correct negative sign in the starting probability regressions, and fifteen of the sixteen price coefficients are correctly positive in quit regressions. But only a few of them are statistically significant. Although none of them statistically significant, the future price coefficients in the start regressions have the correct negative sign, and three of the four future price coefficients in quit regressions are correctly positive. Two of the four past price coefficients have the correct positive sign but they are not significant.

Since the key coefficients have the correct signs and the future consumption coefficients are significant, these results support the rational addiction model. But this support is not very strong. But as mentioned in the first paragraph of this section, this may be attributed to the smaller size of the samples employed, and the measurement error in the price variable.

VII. Appendix

Table 1
Monitoring the Future
Baseline and Follow-up Survey Years

Panel Number	Baseline Year	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up	5th Follow-up	6th Follow-up
1	1976	1978	1980	1982	1984	1986	1988
2	1977	1978	1980	1982	1984	1986	1988
3	1977	1979	1981	1983	1985	1987	1989
4	1978	1979	1981	1983	1985	1987	1989
5	1978	1980	1982	1984	1986	1988	
6	1979	1980	1982	1984	1986	1988	
7	1979	1981	1983	1985	1987	1989	
8	1980	1981	1983	1985	1987	1989	
9	1980	1982	1984	1986	1988		
10	1981	1982	1984	1986	1988		
11	1981	1983	1985	1987	1989		
12	1982	1983	1985	1987	1989		
13	1982	1984	1986	1988			
14	1983	1984	1986	1988			
15	1983	1985	1987	1989			
16	1984	1985	1987	1989			
17	1984	1986	1988				
18	1985	1986	1988				
19	1985	1987	1989				
20	1986	1987	1989				
21	1986	1988					
22	1987	1988					
23	1987	1989					
24	1988	1989					

Table 2

Variable Descriptions, Weighted Means and Standard Deviations

(n = 21,420)

Variable	Mean	Standard Deviation	Description
Annual number of drinks	60.630	49.210	Number of alcoholic drinks in the past year[41]
Price	2.789	0.282	Real annual beer price[42]
Legal drinking age*age≤21	11.992	8.405	Minimum legal age for purchase and consumption of alcohol, multiplied by dichotomous variable to indicate that age ≤21[41]
Lower border drinking age*age≤21	0.096	0.257	Dichotomous variable that is equal to one if the respondent is less than 21 years of age and resides within 25 miles of a state with lower legal drinking age[41]
Male	0.449	0.433	Dichotomous variable for gender
Black	0.094	0.254	Dichotomous variable for African-Americans
Other race/ethnicity	0.070	0.223	Dichotomous variable for race/ethnicity other than African-Americans and whites
Real earnings	8417.570	6194.360	Real earnings (money earnings divided by cost of living index described in footnote 25)
Years of schooling	13.504	1.372	Years of schooling competed
Full-time college student	0.296	0.396	Dichotomous variables indicating the educational status of the respondent at the survey time
Half-time college student	0.038	0.165	
Less than half-time college student	0.054	0.196	

(continued)

41 See Section IV.C. for more details.

42 See Section IV.B. for more details.

Table 2 (concluded)

Variable	Mean	Standard Deviation	Description
Working full-time	0.566	0.425	Dichotomous variables for
Working part-time	0.201	0.343	employment status of the
Unemployment	0.030	0.145	respondent at the survey time
Infrequent religious participation	0.426	0.429	Dichotomous variables for religious
Frequent religious participation	0.465	0.433	participation
Married	0.292	0.396	Dichotomous variables for marital
Engaged	0.084	0.242	status
Separated/divorced	0.028	0.144	
Number of children	0.270	0.540	Respondent's number of children
Age 19	0.333	0.411	Dichotomous variables indicating
Age 21	0.276	0.390	the age of the respondent
Age 23	0.199	0.348	
Age 25	0.131	0.293	
Class of 1976	0.155	0.315	Dichotomous variables indicating
Class of 1977	0.167	0.325	the year of the baseline survey that
Class of 1978	0.141	0.303	the respondent participated
Class of 1979	0.135	0.298	
Class of 1980	0.104	0.266	
Class of 1981	0.097	0.258	
Class of 1982	0.069	0.221	
Class of 1983	0.066	0.216	
Class of 1984	0.034	0.158	
Class of 1985	0.032	0.153	

Table 3

Non-addictive Demand Functions, Dependent Variable = Annual Number of Drinks

(n = 21,420)

	(1)	(2)
Price	-8.158 (6.48)	-4.303 (3.55)
Legal drinking age*age ≤ 21	-1.106 (2.55)	-1.217 (2.92)
Lower border drinking age indicator*age ≤ 21	7.789 (5.73)	7.323 (5.61)
Age 19	39.832 (4.68)	30.987 (3.78)
Age 21	38.513 (4.47)	32.121 (3.88)
Age 23	11.985 (6.31)	6.357 (3.44)
Age 25	7.563 (3.89)	4.728 (2.52)
Male	26.624 (33.42)	21.818 (28.09)
Black	-33.299 (23.66)	-31.869 (23.14)
Other race/ethnicity	-13.818 (9.39)	-14.281 (10.12)
Real earnings	0.00027 (3.79)	0.00043 (6.38)
Years of completed schooling	1.606 (5.46)	0.850 (2.88)
Full-time college student	8.358 (6.82)	3.948 (3.31)
Half-time college student	1.982 (0.95)	-1.316 (0.66)
Less than half-time college student	0.785 (0.46)	-1.486 (0.91)

(continued)

Table 3 (concluded)

	(1)	(2)
Working full-time	6.734 (5.52)	1.525 (1.27)
Working part-time	2.103 (1.69)	-0.438 (0.37)
Unemployed	6.683 (2.81)	0.682 (0.30)
Infrequent religious participation		-1.544 (1.31)
Frequent religious participation		-23.469 (19.44)
Married		-23.379 (22.69)
Engaged		-9.582 (7.12)
Separated or divorced		6.329 (2.84)
Number of children		-3.264 (4.45)
R-squared	0.104	0.176

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 4

Structural Demand Functions, Dependent Variable = Annual Number of Drinks

(n = 18,473)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past consumption	0.254 (4.37)	0.274 (8.18)	0.346 (60.07)	0.338 (58.69)
Future consumption	0.656 (9.12)	0.345 (11.14)	0.474 (76.30)	0.454 (72.60)
Price	-2.470 (2.40)	-2.155 (2.24)	-2.663 (2.84)	-1.744 (1.87)
Legal drinking age*age ≤ 21	-1.038 (3.12)	-1.131 (3.44)	-1.015 (3.14)	-1.059 (3.30)
Lower border drinking age indicator*age ≤ 21	1.597 (1.42)	3.379 (3.24)	2.139 (2.12)	2.203 (2.21)
Age 19	23.748 (3.55)	26.317 (4.07)	26.838 (4.24)	23.548 (3.74)
Age 21	24.748 (3.70)	26.672 (4.08)	26.258 (4.09)	24.113 (3.78)
Age 23	1.738 (1.04)	2.490 (1.67)	3.256 (2.27)	1.362 (0.94)
Age 25	2.885 (1.86)	3.148 (2.10)	3.544 (2.41)	2.675 (1.83)
Male	1.495 (0.80)	7.521 (8.03)	4.384 (7.13)	3.596 (5.86)
Black	-5.205 (2.25)	-13.157 (8.66)	-7.178 (6.29)	-8.032 (6.99)
Other race/ethnicity	-2.672 (1.90)	-6.599 (5.42)	-3.965 (3.48)	-4.431 (3.92)
Real earnings	0.0001 (1.83)	0.00023 (4.09)	0.0001 (1.93)	0.00017 (3.21)
Years of completed schooling	0.590 (2.45)	0.455 (1.94)	0.680 (3.10)	0.320 (1.41)
Full-time college student	1.613 (1.36)	2.218 (2.29)	3.468 (3.81)	1.599 (1.75)
Half-time college student	-0.164 (0.10)	-0.762 (0.48)	0.418 (0.27)	-0.951 (0.62)
Less than half-time college student	-1.582 (1.21)	-1.978 (1.54)	-1.101 (0.87)	-2.088 (1.67)

(continued)

Table 4 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	2.742 (2.74)	1.334 (1.41)	3.055 (3.36)	1.040 (1.13)
Working part-time	1.390 (1.49)	0.294 (0.32)	1.420 (1.56)	0.474 (0.52)
Unemployed	0.701 (0.36)	-0.226 (0.12)	1.182 (0.65)	-0.982 (0.54)
Infrequent religious participation		-0.297 (0.32)		0.0024 (0.003)
Frequent religious participation		-9.297 (7.73)		-5.484 (5.84)
Married		-12.719 (12.77)		-9.614 (11.89)
Engaged		-5.666 (5.00)		-4.287 (4.13)
Separated or divorced		6.712 (3.68)		6.900 (3.89)
Number of children		-1.932 (3.15)		-1.538 (2.66)
R-squared	0.191	0.292	0.568	0.576
Wu F-ratio	3.417	16.945	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 5

Structural Demand Functions, Discount Factor of 0.95 Imposed, Dependent Variable = Annual Number of Drinks

(n = 18,473)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past consumption	0.436 (13.85)	0.320 (19.55)	0.416 (139.58)	0.402 (131.13)
Future consumption	0.415 (13.85)	0.304 (19.55)	0.395 (139.58)	0.382 (131.13)
Price	-2.293 (2.27)	-2.034 (2.12)	-2.529 (2.68)	-1.599 (1.71)
Legal drinking age*age ≤ 21	-0.972 (2.98)	-1.110 (3.38)	-0.988 (3.04)	-1.034 (3.21)
Lower border drinking age indicator*age ≤ 21	1.854 (1.67)	3.312 (3.17)	2.141 (2.11)	2.210 (2.20)
Age 19	26.709 (4.09)	26.657 (4.12)	27.605 (4.33)	24.319 (3.84)
Age 21	25.410 (3.86)	26.564 (4.06)	26.237 (4.07)	24.185 (3.78)
Age 23	3.199 (2.01)	2.695 (1.81)	3.636 (2.52)	1.777 (1.22)
Age 25	3.474 (2.29)	3.242 (2.17)	3.686 (2.50)	2.860 (1.95)
Male	3.851 (2.23)	7.551 (8.05)	4.892 (7.93)	4.003 (6.50)
Black	-5.694 (2.51)	-12.831 (8.50)	-6.962 (6.07)	-8.010 (6.94)
Other race/ethnicity	-3.722 (2.75)	-6.619 (5.43)	-4.190 (3.66)	-4.661 (4.11)
Real earnings	0.000086 (1.55)	0.00022 (3.99)	0.000094 (1.76)	0.00017 (3.14)
Years of completed schooling	0.619 (2.61)	0.450 (1.92)	0.674 (3.05)	0.326 (1.42)
Full-time college student	4.057 (4.19)	2.592 (2.76)	4.263 (4.67)	2.222 (2.42)
Half-time college student	0.487 (0.31)	-0.696 (0.44)	0.609 (0.39)	-0.834 (0.54)
Less than half-time college student	-0.998 (0.78)	-1.911 (1.49)	-0.920 (0.73)	-1.976 (1.57)

(continued)

Table 5 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	2.756 (2.80)	1.291 (1.36)	2.989 (3.27)	1.003 (1.08)
Working part-time	1.371 (1.49)	0.306 (0.33)	1.403 (1.53)	0.477 (0.52)
Unemployed	0.711 (0.37)	-0.346 (0.19)	1.074 (0.59)	-1.094 (0.60)
Infrequent religious participation		-0.171 (0.18)		0.166 (0.18)
Frequent religious participation		-9.023 (7.56)		-5.421 (5.74)
Married		-13.010 (13.30)		-10.341 (12.76)
Engaged		-6.215 (5.77)		-5.246 (5.05)
Separated or divorced		7.029 (3.87)		7.364 (4.14)
Number of children		-1.714 (2.86)		-1.245 (2.15)
R-squared	0.196	0.291	0.563	0.572
Wu F-ratio	0.420	26.996	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 6

Structural Demand Functions, Depreciation Rate = 1, Dependent Variable = Annual Number of Drinks, Additional Leads and Lags of Price Employed as Instruments

(n = 17,667)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past consumption	0.245 (4.19)	0.265 (7.58)	0.347 (58.75)	0.338 (57.41)
Future consumption	0.633 (9.27)	0.345 (10.84)	0.472 (74.10)	0.453 (70.58)
Price	-2.912 (2.84)	-2.379 (2.44)	-2.910 (3.05)	-2.025 (2.14)
Legal drinking age*age ≤ 21	-0.944 (2.79)	-0.986 (2.92)	-0.916 (2.76)	-0.956 (2.90)
Lower border drinking age indicator*age ≤ 21	1.640 (1.42)	3.224 (2.96)	2.000 (1.90)	2.025 (1.94)
Age 19	22.664 (3.36)	23.584 (3.55)	25.068 (3.85)	21.662 (3.35)
Age 21	23.306 (3.44)	23.763 (3.54)	24.252 (3.68)	22.017 (3.36)
Age 23	2.047 (1.24)	2.413 (1.59)	3.173 (2.17)	1.348 (0.92)
Age 25	3.166 (2.03)	3.255 (2.14)	3.673 (2.46)	2.812 (1.90)
Male	2.198 (1.22)	7.665 (7.93)	4.300 (6.83)	3.546 (5.64)
Black	-5.817 (2.55)	-13.052 (8.35)	-6.845 (5.88)	-7.643 (6.52)
Other race/ethnicity	-3.257 (2.35)	-6.744 (5.43)	-4.082 (3.51)	-4.564 (3.96)
Real earnings	0.00011 (1.97)	0.00023 (4.12)	0.00011 (2.00)	0.00017 (3.22)
Years of completed schooling	0.615 (2.50)	0.431 (1.80)	0.665 (2.96)	0.283 (1.22)
Full-time college student	2.145 (1.81)	2.586 (2.60)	3.806 (4.09)	1.929 (2.06)
Half-time college student	0.416 (0.25)	-0.368 (0.23)	0.909 (0.57)	-0.509 (0.32)
Less than half-time college student	-1.324 (0.99)	-1.836 (1.39)	-0.923 (0.71)	-1.944 (1.51)

(continued)

Table 6 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	3.174 (3.10)	1.617 (1.66)	3.347 (3.59)	1.246 (1.32)
Working part-time	1.648 (1.73)	0.500 (0.53)	1.675 (1.80)	0.678 (0.73)
Unemployed	1.460 (0.73)	0.277 (0.14)	1.569 (0.84)	-0.656 (0.35)
Infrequent religious participation		-0.527 (0.55)		-0.218 (0.23)
Frequent religious participation		-9.443 (7.66)		-5.490 (5.71)
Married		-12.713 (12.47)		-9.535 (11.55)
Engaged		-5.121 (4.42)		-3.786 (3.57)
Separated or divorced		7.108 (3.80)		7.444 (4.10)
Number of children		-2.150 (3.42)		-1.679 (2.85)
R-squared	0.194	0.291	0.568	0.576
Wu F-ratio	3.086	17.340	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 7

Structural Demand Functions, Depreciation Rate = 0.8, Dependent Variable = Annual Number of Drinks

(n = 17,053)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Stock	0.255 (4.85)	0.250 (8.00)	0.328 (59.65)	0.321 (58.31)
Future consumption	0.588 (8.53)	0.339 (10.81)	0.464 (71.53)	0.445 (68.03)
Price	-3.546 (2.45)	-2.614 (1.80)	-3.271 (2.30)	-2.746 (1.95)
Future price	1.266 (0.88)	0.967 (0.69)	1.009 (0.74)	1.588 (1.17)
Legal drinking age*age ≤ 21	-1.065 (3.22)	-1.176 (3.54)	-1.042 (3.20)	-1.089 (3.37)
Lower border drinking age indicator*age ≤ 21	1.773 (1.57)	3.363 (3.19)	2.036 (2.01)	2.085 (2.08)
Age 19	28.924 (4.31)	29.995 (4.55)	32.021 (4.99)	28.577 (4.47)
Age 21	26.541 (3.97)	27.888 (4.20)	27.678 (4.26)	25.527 (3.95)
Age 23	1.721 (0.95)	1.802 (1.07)	2.784 (1.73)	0.794 (0.49)
Age 25	2.212 (1.27)	2.442 (1.43)	2.761 (1.66)	1.913 (1.16)
Male	2.473 (1.31)	7.354 (7.64)	4.025 (6.33)	3.187 (5.02)
Black	-6.461 (2.63)	-13.696 (8.41)	-7.152 (5.79)	-8.017 (6.46)
Other race/ethnicity	-3.166 (2.15)	-6.754 (5.21)	-3.845 (3.18)	-4.320 (3.61)
Real earnings	0.000093 (1.58)	0.0002 (3.44)	0.00008 (1.42)	0.00015 (2.60)
Years of completed schooling	0.614 (2.50)	0.362 (1.46)	0.646 (2.77)	0.276 (1.14)
Full-time college student	2.555 (2.15)	2.525 (2.53)	3.831 (4.10)	1.861 (1.98)
Half-time college student	0.363 (0.22)	-0.215 (0.13)	0.784 (0.49)	-0.594 (0.37)
Less than half-time college student	-0.774 (0.58)	-1.676 (1.24)	-0.496 (0.38)	-1.613 (1.23)

(continued)

Table 7 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	2.783 (2.70)	1.129 (1.14)	2.832 (3.00)	0.826 (0.86)
Working part-time	1.305 (1.39)	0.049 (0.052)	1.260 (1.36)	0.310 (0.33)
Unemployed	1.704 (0.83)	0.525 (0.27)	1.797 (0.94)	-0.494 (0.26)
Infrequent religious participation		-0.142 (0.15)		0.209 (0.22)
Frequent religious participation		-9.009 (7.20)		-4.865 (5.00)
Married		-13.037 (12.56)		-9.836 (11.63)
Engaged		-6.250 (5.31)		-4.950 (4.64)
Separated or divorced		7.195 (3.66)		7.293 (3.83)
Number of children		-2.277 (3.30)		-1.672 (2.62)
R-squared	0.191	0.289	0.572	0.580
Wu F-ratio	1.845	18.306	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 8

Price Elasticities of Demand

Based on Table 4				
	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Long run	-1.265	-0.260	-0.681	-0.386
Short run	-0.857	-0.181	-0.384	-0.225
Temporary current	-0.144	-0.111	-0.154	-0.099
Temporary past	-0.046	-0.034	-0.067	-0.041
Temporary future	-0.120	-0.043	-0.092	-0.056

Table 9
Price and Consumption Coefficients, Two-Stage Least Squares Fixed-Effects Model

(n = 17,237)

	Two-Stage Least Squares
Past consumption	0.203 (2.01)
Future consumption	0.343 (1.81)
Price	-5.337 (2.54)
R-squared	0.013
Wu F-ratio	10.118
Long-run price elasticity	-0.54

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts, religious participation, marital status, and number of children are not shown.

Table 10

Reduced Form Demand Functions,
Dependent Variable = Probability of Forty or More Annual Drinking Occasions

(n = 21,462)

	(1)	(2)
Price	-0.052 (4.96)	-0.026 (2.58)
Legal drinking age*age ≤ 21	-0.011 (2.96)	-0.012 (3.27)
Lower border drinking age indicator*age ≤ 21	0.036 (3.22)	0.033 (3.02)
Age 19	0.304 (4.28)	0.240 (3.46)
Age 21	0.313 (4.36)	0.267 (3.82)
Age 23	0.076 (4.83)	0.036 (2.30)
Age 25	0.046 (2.83)	0.026 (1.62)
Male	0.217 (32.79)	0.185 (28.23)
Black	-0.220 (18.78)	-0.211 (18.10)
Other race/ethnicity	-0.089 (7.26)	-0.092 (7.70)
Real earnings	0.000003 (5.07)	0.0000041 (7.12)
Years of completed schooling	0.018 (7.25)	0.012 (4.75)
Full-time college student	0.042 (4.08)	0.011 (1.07)
Half-time college student	0.0033 (0.19)	-0.020 (1.16)
Less than half-time college student	0.016 (1.13)	0.00064 (0.046)

(continued)

Table 10 (concluded)

	(1)	(2)
Working full-time	0.052 (5.09)	0.015 (1.48)
Working part-time	0.015 (1.46)	-0.0029 (0.29)
Unemployed	0.059 (2.98)	0.017 (0.89)
Infrequent religious participation		-0.014 (1.42)
Frequent religious participation		-0.155 (15.17)
Married		-0.159 (18.29)
Engaged		-0.053 (4.66)
Separated or divorced		0.032 (1.71)
Number of children		-0.025 (4.08)
R-squared	0.0917	0.1381

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 11

Structural Demand Functions, Dependent Variable = Probability of Forty or More Annual Drinking Occasions

(n = 19,145)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past percentage high	0.0042 (2.17)	0.0042 (4.27)	0.0039 (31.52)	0.0037 (29.82)
Future percentage high	0.012 (3.98)	0.0048 (4.81)	0.0037 (26.15)	0.0033 (23.45)
Price	-0.025 (1.99)	-0.023 (2.28)	-0.038 (3.72)	-0.024 (2.36)
Legal drinking age*age ≤ 21	-0.013 (3.19)	-0.014 (3.87)	-0.013 (3.72)	-0.014 (3.90)
Lower border drinking age indicator*age ≤ 21	-0.00062 (0.043)	0.015 (1.31)	0.020 (1.82)	0.019 (1.78)
Age 19	0.209 (2.54)	0.219 (3.15)	0.290 (4.18)	0.232 (3.38)
Age 21	0.258 (3.17)	0.270 (3.84)	0.319 (4.54)	0.278 (4.01)
Age 23	0.0053 (0.24)	0.0093 (0.57)	0.049 (3.08)	0.016 (1.02)
Age 25	0.0091 (0.47)	0.013 (0.82)	0.032 (1.97)	0.016 (1.02)
Male	0.065 (2.35)	0.115 (12.14)	0.145 (21.84)	0.130 (19.53)
Black	-0.042 (1.20)	-0.115 (7.16)	-0.133 (10.88)	-0.136 (11.12)
Other race/ethnicity	-0.014 (0.68)	-0.052 (3.95)	-0.058 (4.68)	-0.062 (5.08)
Real earnings	0.0000047 (6.72)	0.0000047 (8.09)	0.0000039 (6.72)	0.0000046 (7.98)
Years of completed schooling	0.030 (8.48)	0.017 (6.73)	0.023 (9.54)	0.016 (6.46)
Full-time college student	0.031 (2.62)	0.013 (1.29)	0.040 (4.03)	0.013 (1.30)
Half-time college student	-0.0074 (0.38)	-0.018 (1.06)	0.0029 (0.17)	-0.017 (1.01)
Less than half-time college student	0.016 (1.01)	0.0022 (0.16)	0.014 (1.03)	0.0011 (0.077)

(continued)

Table 11 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	0.044 (3.66)	0.015 (1.46)	0.045 (4.53)	0.015 (1.46)
Working part-time	0.025 (2.17)	0.0053 (0.53)	0.018 (1.78)	0.0033 (0.34)
Unemployed	0.00049 (0.02)	-0.009 (0.45)	0.027 (1.35)	-0.0039 (0.20)
Infrequent religious participation		-0.0047 (0.47)		-0.0072 (0.73)
Frequent religious participation		-0.060 (4.22)		-0.080 (7.74)
Married		-0.111 (10.95)		-0.122 (13.90)
Engaged		-0.037 (3.06)		-0.043 (3.83)
Separated or divorced		0.042 (2.14)		0.043 (2.22)
Number of children		-0.030 (4.76)		-0.029 (4.65)
R-squared	0.086	0.153	0.215	0.236
Wu F-ratio	5.887	2.685	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 12

Structural Demand Functions,
Dependent Variable = Probability of Forty or More Annual Drinking Occasions,
Past and Future Probabilities Included

(n = 18,579)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past probability	0.199 (2.21)	0.252 (5.18)	0.326 (49.93)	0.317 (48.45)
Future probability	0.651 (6.59)	0.348 (8.34)	0.402 (62.57)	0.387 (59.93)
Price	-0.021 (2.06)	-0.013 (1.46)	-0.020 (2.24)	-0.011 (1.26)
Legal drinking age*age ≤ 21	-0.010 (3.13)	-0.011 (3.56)	-0.010 (3.19)	-0.010 (3.38)
Lower border drinking age indicator*age ≤ 21	0.0044 (0.42)	0.014 (1.43)	0.010 (1.06)	0.010 (1.06)
Age 19	0.224 (3.47)	0.236 (3.87)	0.252 (4.17)	0.226 (3.74)
Age 21	0.240 (3.66)	0.247 (4.01)	0.250 (4.07)	0.233 (3.82)
Age 23	0.020 (1.30)	0.016 (1.18)	0.031 (2.24)	0.014 (0.99)
Age 25	0.019 (1.29)	0.015 (1.09)	0.021 (1.52)	0.013 (0.96)
Male	0.023 (1.18)	0.069 (7.00)	0.059 (10.08)	0.051 (8.65)
Black	-0.048 (2.35)	-0.095 (6.82)	-0.070 (6.48)	-0.075 (6.82)
Other race/ethnicity	-0.027 (2.03)	-0.051 (4.50)	-0.041 (3.73)	-0.044 (4.05)
Real earnings	0.0000013 (2.19)	0.0000021 (3.96)	0.0000012 (2.34)	0.0000018 (3.48)
Years of completed schooling	0.0057 (2.24)	0.0065 (2.91)	0.0085 (4.06)	0.0058 (2.65)
Full-time college student	-0.0069 (0.62)	-0.0049 (0.54)	0.0093 (1.07)	-0.0058 (0.67)
Half-time college student	-0.0087 (0.56)	-0.014 (0.94)	-0.003 (0.20)	-0.014 (0.97)
Less than half-time college student	-0.0037 (0.29)	-0.005 (0.42)	0.0023 (0.19)	-0.0055 (0.46)

(continued)

Table 12 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	0.018 (1.82)	0.009 (1.01)	0.024 (2.77)	0.0079 (0.89)
Working part-time	0.0019 (0.20)	-0.0022 (0.25)	0.005 (0.58)	-0.0023 (0.26)
Unemployed	0.023 (1.21)	0.015 (0.85)	0.031 (1.76)	0.013 (0.72)
Infrequent religious participation		-0.010 (1.10)		-0.0079 (0.91)
Frequent religious participation		-0.072 (6.55)		-0.057 (6.39)
Married		-0.090 (9.52)		-0.079 (10.23)
Engaged		-0.034 (3.11)		-0.032 (3.18)
Separated or divorced		0.041 (2.37)		0.042 (2.49)
Number of children		-0.014 (2.37)		-0.011 (1.97)
R-squared	0.128	0.197	0.425	0.433
Wu F-ratio	3.468	2.809	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 13

Reduced Form Demand Functions,
Dependent Variable = Probability of Starting Forty or More Annual Drinking Occasions

(n = 10,669)

	(1)	(2)	(3)	(4)
Price	-0.020 (1.67)	-0.0044 (0.37)	-0.0078 (0.45)	-0.00072 (0.042)
Future price			-0.016 (0.98)	-0.0048 (0.29)
Legal drinking age*age ≤ 21	-0.012 (3.14)	-0.013 (3.47)	-0.011 (3.08)	-0.013 (3.46)
Lower border drinking age indicator*age ≤ 21	0.014 (1.19)	0.015 (1.26)	0.014 (1.23)	0.015 (1.27)
Age 19	0.444 (5.95)	0.422 (5.68)	0.441 (5.90)	0.421 (5.67)
Age 21	0.363 (4.81)	0.353 (4.71)	0.360 (4.76)	0.352 (4.70)
Age 23	0.081 (3.50)	0.062 (2.68)	0.082 (3.54)	0.062 (2.69)
Age 25	0.045 (1.86)	0.037 (1.53)	0.046 (1.89)	0.037 (1.54)
Male	0.094 (12.17)	0.076 (9.83)	0.094 (12.17)	0.077 (9.83)
Black	-0.115 (9.55)	-0.122 (10.02)	-0.115 (9.56)	-0.122 (10.03)
Other race/ethnicity	-0.066 (4.80)	-0.072 (5.27)	-0.067 (4.84)	-0.072 (5.28)
Real earnings	0.000001 (1.33)	0.0000017 (2.25)	0.000001 (1.30)	0.0000017 (2.24)
Years of completed schooling	0.0089 (2.86)	0.0072 (2.21)	0.0089 (2.83)	0.0072 (2.21)
Full-time college student	0.038 (3.40)	0.018 (1.61)	0.037 (3.38)	0.018 (1.60)
Half-time college student	0.0075 (0.38)	-0.0038 (0.19)	0.0071 (0.36)	-0.0039 (0.20)
Less than half-time college student	0.0018 (0.11)	-0.010 (0.62)	0.0015 (0.089)	-0.010 (0.62)

(continued)

Table 13 (concluded)

	(1)	(2)	(3)	(4)
Working full-time	0.019 (1.72)	0.0045 (0.40)	0.019 (1.71)	0.0045 (0.40)
Working part-time	-0.0015 (0.14)	-0.0094 (0.88)	-0.0016 (0.15)	-0.0094 (0.88)
Unemployed	0.036 (1.61)	0.018 (0.81)	0.037 (1.62)	0.018 (0.81)
Infrequent religious participation		-0.00043 (0.034)		-0.00037 (0.029)
Frequent religious participation		-0.076 (6.06)		-0.075 (6.05)
Married		-0.108 (10.40)		-0.108 (10.39)
Engaged		-0.047 (3.59)		-0.047 (3.59)
Separated or divorced		0.009 (0.37)		0.009 (0.37)
Number of children		0.0091 (1.19)		0.0092 (1.19)
R-squared	0.0596	0.0817	0.0597	0.0817

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 14

Reduced Form Demand Functions,
Dependent Variable = Probability of Starting to Get High on at Least Half of all Annual Drinking Occasions

(n = 8,404)

	(1)	(2)	(3)	(4)
Price	-0.018 (1.41)	-0.0046 (0.36)	-0.0082 (0.45)	-0.001 (0.058)
Future price			-0.013 (0.74)	-0.0048 (0.28)
Legal drinking age*age ≤ 21	0.0012 (0.30)	0.00045 (0.11)	0.0014 (0.34)	0.0005 (0.13)
Lower border drinking age indicator*age ≤ 21	0.020 (1.57)	0.020 (1.53)	0.021 (1.60)	0.020 (1.54)
Age 19	0.158 (2.00)	0.153 (1.93)	0.155 (1.96)	0.152 (1.92)
Age 21	0.062 (0.77)	0.063 (0.79)	0.059 (0.73)	0.062 (0.77)
Age 23	0.038 (1.69)	0.032 (1.41)	0.039 (1.73)	0.032 (1.42)
Age 25	0.021 (0.88)	0.018 (0.79)	0.021 (0.91)	0.019 (0.80)
Male	0.047 (5.72)	0.034 (4.15)	0.047 (5.73)	0.034 (4.15)
Black	-0.080 (6.72)	-0.082 (6.71)	-0.081 (6.74)	-0.082 (6.72)
Other race/ethnicity	-0.053 (3.73)	-0.057 (4.09)	-0.053 (3.76)	-0.058 (4.10)
Real earnings	-0.0000013 (1.74)	-0.000001 (1.33)	-0.0000013 (1.77)	-0.000001 (1.34)
Years of completed schooling	-0.00074 (0.24)	-0.0011 (0.32)	-0.00081 (0.26)	-0.0011 (0.33)
Full-time college student	0.022 (1.85)	0.015 (1.23)	0.021 (1.83)	0.015 (1.22)
Half-time college student	-0.012 (0.59)	-0.018 (0.89)	-0.013 (0.60)	-0.019 (0.89)
Less than half-time college student	-0.0027 (0.16)	-0.0061 (0.36)	-0.003 (0.18)	-0.0063 (0.36)

(continued)

Table 14 (concluded)

	(1)	(2)	(3)	(4)
Working full-time	0.012 (0.98)	0.0043 (0.35)	0.012 (0.98)	0.0043 (0.35)
Working part-time	0.0061 (0.53)	0.00077 (0.067)	0.0059 (0.51)	0.00072 (0.062)
Unemployed	0.042 (1.72)	0.028 (1.15)	0.043 (1.73)	0.028 (1.15)
Infrequent religious participation		0.012 (0.85)		0.012 (0.86)
Frequent religious participation		-0.059 (4.19)		-0.058 (4.17)
Married		-0.059 (5.44)		-0.059 (5.43)
Engaged		-0.049 (3.58)		-0.049 (3.58)
Separated or divorced		-0.0061 (0.24)		-0.0061 (0.24)
Number of children		0.0077 (0.96)		0.0077 (0.97)
R-squared	0.0542	0.0683	0.0543	0.0683

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 15

Structural Demand Functions, Dependent Variable = Probability of Starting Forty or More Annual Drinking Occasions

(n = 10,164)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Future percentage high	0.0092 (2.50)	0.0052 (5.29)	0.0041 (26.48)	0.0038 (24.14)
Price	-0.0046 (0.32)	-0.0026 (0.21)	-0.014 (1.17)	-0.0035 (0.29)
Legal drinking age*age ≤ 21	-0.013 (3.36)	-0.013 (3.56)	-0.013 (3.34)	-0.013 (3.54)
Lower border drinking age indicator*age ≤ 21	-0.0063 (0.43)	0.0033 (0.27)	0.0051 (0.44)	0.0065 (0.56)
Age 19	0.357 (4.06)	0.370 (4.85)	0.409 (5.44)	0.385 (5.12)
Age 21	0.325 (3.92)	0.332 (4.34)	0.354 (4.65)	0.341 (4.49)
Age 23	0.029 (0.87)	0.038 (1.55)	0.061 (2.60)	0.045 (1.93)
Age 25	0.013 (0.43)	0.022 (0.87)	0.032 (1.31)	0.026 (1.08)
Male	0.043 (1.81)	0.055 (6.00)	0.075 (9.43)	0.062 (7.81)
Black	-0.038 (1.13)	-0.078 (5.17)	-0.080 (6.33)	-0.090 (7.03)
Other race/ethnicity	-0.029 (1.42)	-0.047 (3.21)	-0.048 (3.41)	-0.054 (3.79)
Real earnings	0.0000023 (2.39)	0.0000022 (2.88)	0.0000016 (2.05)	0.0000021 (2.75)
Years of completed schooling	0.017 (3.79)	0.011 (3.17)	0.013 (4.03)	0.010 (2.97)
Full-time college student	0.029 (2.38)	0.015 (1.29)	0.033 (2.94)	0.015 (1.33)
Half-time college student	0.005 (0.24)	-0.0042 (0.21)	0.0064 (0.32)	-0.0039 (0.20)
Less than half-time college student	0.012 (0.67)	-0.0031 (0.18)	0.0061 (0.36)	-0.0056 (0.33)

(continued)

Table 15 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	0.019 (1.60)	0.0058 (0.50)	0.020 (1.74)	0.0054 (0.47)
Working part-time	0.0035 (0.30)	-0.0053 (0.49)	0.00089 (0.083)	-0.0064 (0.59)
Unemployed	0.018 (0.70)	0.012 (0.54)	0.031 (1.33)	0.015 (0.65)
Infrequent religious participation		0.0031 (0.24)		0.0032 (0.25)
Frequent religious participation		-0.034 (2.29)		-0.045 (3.58)
Married		-0.087 (7.41)		-0.093 (8.76)
Engaged		-0.027 (1.97)		-0.033 (2.50)
Separated or divorced		0.0055 (0.22)		0.0087 (0.34)
Number of children		0.0021 (0.26)		0.0039 (0.49)
R-squared	0.057	0.087	0.119	0.131
Wu F-ratio	2.131	2.096	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 16

Structural Demand Functions, Dependent Variable = Probability of Starting to Get High on at Least Half of all Annual Drinking Occasions

(n = 7,859)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Future frequency of drinking occasions	0.003 (1.39)	0.0043 (3.67)	0.0048 (22.02)	0.0045 (20.28)
Price	-0.010 (0.68)	0.0038 (0.28)	-0.0041 (0.32)	0.0041 (0.32)
Legal drinking age*age ≤ 21	0.0026 (0.64)	0.0023 (0.56)	0.003 (0.72)	0.0023 (0.57)
Lower border drinking age indicator*age ≤ 21	0.018 (1.35)	0.016 (1.21)	0.016 (1.20)	0.016 (1.20)
Age 19	0.104 (1.18)	0.086 (1.03)	0.077 (0.94)	0.083 (1.02)
Age 21	0.023 (0.26)	0.014 (0.16)	0.003 (0.037)	0.012 (0.14)
Age 23	0.026 (0.98)	0.015 (0.64)	0.015 (0.66)	0.015 (0.62)
Age 25	0.015 (0.59)	0.0092 (0.38)	0.010 (0.40)	0.0088 (0.36)
Male	0.034 (2.16)	0.016 (1.56)	0.022 (2.62)	0.015 (1.78)
Black	-0.053 (2.37)	-0.042 (2.56)	-0.037 (2.87)	-0.041 (3.08)
Other race/ethnicity	-0.041 (2.45)	-0.039 (2.53)	-0.034 (2.32)	-0.039 (2.61)
Real earnings	-0.0000021 (2.38)	-0.0000021 (2.55)	-0.0000024 (3.07)	-0.0000021 (2.72)
Years of completed schooling	-0.0041 (1.01)	-0.0052 (1.45)	-0.0062 (1.88)	-0.0054 (1.57)
Full-time college student	0.005 (0.31)	-0.0039 (0.30)	-0.0041 (0.34)	-0.0046 (0.37)
Half-time college student	-0.020 (0.89)	-0.024 (1.13)	-0.023 (1.08)	-0.025 (1.14)
Less than half-time college student	-0.0077 (0.42)	-0.011 (0.61)	-0.010 (0.58)	-0.011 (0.62)

(continued)

Table 16 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	0.0069 (0.53)	0.0023 (0.18)	0.003 (0.25)	0.0022 (0.17)
Working part-time	0.0046 (0.38)	0.002 (0.17)	0.0039 (0.33)	0.002 (0.17)
Unemployed	0.053 (2.05)	0.045 (1.75)	0.053 (2.05)	0.046 (1.77)
Infrequent religious participation		0.006 (0.40)		0.0057 (0.38)
Frequent religious participation		-0.048 (3.17)		-0.047 (3.24)
Married		-0.036 (2.68)		-0.035 (3.05)
Engaged		-0.040 (2.73)		-0.039 (2.76)
Separated or divorced		-0.027 (1.01)		-0.028 (1.06)
Number of children		0.011 (1.28)		0.011 (1.31)
R-squared	0.056	0.073	0.108	0.115
Wu F-ratio	0.769	0.027	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 17

Reduced Form Demand Functions,
Dependent Variable = Probability of Quitting Forty or More Annual Drinking Occasions

(n = 5,355)

	(1)	(2)	(3)	(4)
Past price			0.035 (1.13)	0.032 (1.06)
Price	0.022 (1.10)	0.010 (0.54)	0.015 (0.45)	0.011 (0.34)
Future price			-0.024 (0.88)	-0.032 (1.17)
Legal drinking age*age ≤ 21	0.0044 (0.63)	0.0051 (0.73)	0.0056 (0.79)	0.0064 (0.91)
Lower border drinking age indicator*age ≤ 21	-0.044 (2.11)	-0.040 (1.94)	-0.043 (2.04)	-0.039 (1.88)
Age 19	-0.018 (0.13)	0.024 (0.17)	-0.052 (0.37)	-0.010 (0.076)
Age 21	-0.067 (0.48)	-0.035 (0.26)	-0.098 (0.69)	-0.067 (0.48)
Age 23	0.0014 (0.042)	0.036 (1.11)	-0.0024 (0.072)	0.034 (1.02)
Age 25	0.0029 (0.086)	0.021 (0.62)	0.003 (0.088)	0.021 (0.64)
Male	-0.160 (12.86)	-0.145 (11.64)	-0.160 (12.86)	-0.145 (11.63)
Black	0.096 (2.43)	0.097 (2.48)	0.094 (2.40)	0.096 (2.44)
Other race/ethnicity	0.083 (3.08)	0.082 (3.07)	0.083 (3.10)	0.082 (3.08)
Real earnings	-0.000000015 (0.015)	-0.0000013 (1.28)	-0.000000075 (0.071)	-0.0000014 (1.35)
Years of completed schooling	-0.015 (3.29)	-0.010 (2.19)	-0.015 (3.33)	-0.010 (2.24)
Full-time college student	-0.053 (2.64)	-0.036 (1.79)	-0.053 (2.64)	-0.036 (1.79)
Half-time college student	-0.033 (1.05)	-0.015 (0.49)	-0.034 (1.06)	-0.016 (0.50)
Less than half-time college student	-0.040 (1.54)	-0.030 (1.18)	-0.039 (1.53)	-0.030 (1.17)

(continued)

Table 17 (concluded)

	(1)	(2)	(3)	(4)
Working full-time	-0.047 (2.28)	-0.032 (1.54)	-0.047 (2.28)	-0.032 (1.55)
Working part-time	-0.019 (0.94)	-0.013 (0.63)	-0.019 (0.94)	-0.013 (0.63)
Unemployed	-0.026 (0.64)	-0.0041 (0.10)	-0.025 (0.62)	-0.0032 (0.079)
Infrequent religious participation		0.012 (0.69)		0.012 (0.73)
Frequent religious participation		0.079 (4.25)		0.080 (4.27)
Married		0.135 (7.88)		0.136 (7.90)
Engaged		0.106 (5.16)		0.106 (5.17)
Separated or divorced		-0.044 (1.07)		-0.042 (1.04)
Number of children		0.036 (2.37)		0.036 (2.37)
R-squared	0.0499	0.0765	0.0503	0.0769

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 18

Reduced Form Demand Functions,
Dependent Variable = Probability of Quitting Getting High on at Least Half of all Annual Drinking Occasions

(n = 6,775)

	(1)	(2)	(3)	(4)
Past price			-0.044 (1.43)	-0.052 (1.70)
Price	0.023 (1.17)	0.0084 (0.43)	0.049 (1.45)	0.044 (1.31)
Future price			0.0056 (0.20)	-0.00038 (0.014)
Legal drinking age*age ≤ 21	0.008 (1.30)	0.0075 (1.25)	0.0072 (1.16)	0.0067 (1.10)
Lower border drinking age indicator*age ≤ 21	-0.050 (2.78)	-0.047 (2.60)	-0.052 (2.86)	-0.048 (2.68)
Age 19	-0.057 (0.46)	-0.0053 (0.043)	-0.027 (0.21)	0.029 (0.23)
Age 21	-0.092 (0.74)	-0.048 (0.39)	-0.065 (0.51)	-0.018 (0.14)
Age 23	0.0058 (0.13)	0.038 (0.88)	0.012 (0.28)	0.046 (1.05)
Age 25	-0.045 (0.98)	-0.024 (0.54)	-0.045 (0.97)	-0.023 (0.52)
Male	-0.127 (10.45)	-0.106 (8.70)	-0.127 (10.44)	-0.105 (8.69)
Black	0.092 (2.98)	0.089 (2.90)	0.093 (3.02)	0.090 (2.93)
Other race/ethnicity	0.047 (1.89)	0.041 (1.67)	0.046 (1.83)	0.039 (1.59)
Real earnings	0.0000021 (1.69)	0.000001 (0.83)	0.0000021 (1.72)	0.000001 (0.85)
Years of completed schooling	0.011 (2.14)	0.014 (2.78)	0.011 (2.15)	0.014 (2.79)
Full-time college student	-0.070 (3.72)	-0.043 (2.30)	-0.070 (3.74)	-0.043 (2.31)
Half-time college student	-0.040 (1.29)	-0.022 (0.70)	-0.041 (1.30)	-0.022 (0.71)
Less than half-time college student	0.034 (1.27)	0.047 (1.76)	0.033 (1.25)	0.046 (1.74)

(continued)

Table 18 (concluded)

	(1)	(2)	(3)	(4)
Working full-time	0.020 (1.04)	0.039 (2.01)	0.020 (1.05)	0.040 (2.02)
Working part-time	-0.0029 (0.16)	0.006 (0.33)	-0.0032 (0.17)	0.0056 (0.31)
Unemployed	-0.021 (0.59)	-0.0021 (0.06)	-0.022 (0.60)	-0.0026 (0.072)
Infrequent religious participation		-0.0037 (0.21)		-0.0036 (0.21)
Frequent religious participation		0.078 (4.21)		0.078 (4.24)
Married		0.147 (8.22)		0.147 (8.22)
Engaged		0.101 (4.98)		0.102 (4.99)
Separated or divorced		-0.078 (1.78)		-0.078 (1.77)
Number of children		0.020 (1.28)		0.021 (1.32)
R-squared	0.0302	0.054	0.0305	0.0544

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 19

Structural Demand Functions, Dependent Variable = Probability of Quitting Forty or More Annual Drinking Occasions

(n = 5,233)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past percentage high	0.005 (1.54)	0.0073 (2.95)	-0.00044 (1.69)	-0.0003 (1.18)
Future percentage high	-0.0027 (0.82)	-0.002 (1.17)	-0.0029 (10.58)	-0.0026 (9.53)
Price	0.015 (0.69)	-0.0044 (0.20)	0.025 (1.25)	0.015 (0.74)
Legal drinking age*age ≤ 21	0.0026 (0.35)	0.0026 (0.34)	0.0043 (0.61)	0.0049 (0.71)
Lower border drinking age indicator*age ≤ 21	-0.054 (2.21)	-0.059 (2.43)	-0.035 (1.70)	-0.033 (1.57)
Age 19	-0.052 (0.35)	-0.024 (0.16)	-0.0042 (0.03)	0.033 (0.25)
Age 21	-0.056 (0.38)	-0.019 (0.12)	-0.055 (0.39)	-0.026 (0.19)
Age 23	-0.0077 (0.20)	0.024 (0.63)	0.014 (0.41)	0.046 (1.37)
Age 25	-0.00057 (0.015)	0.018 (0.49)	0.007 (0.21)	0.024 (0.71)
Male	-0.167 (6.57)	-0.165 (8.57)	-0.138 (10.93)	-0.128 (10.11)
Black	0.104 (2.35)	0.108 (2.42)	0.101 (2.50)	0.103 (2.56)
Other race/ethnicity	0.073 (2.41)	0.074 (2.46)	0.075 (2.77)	0.075 (2.79)
Real earnings	0.000001 (0.73)	0.00000023 (0.17)	-0.00000053 (0.50)	-0.0000016 (1.52)
Years of completed schooling	-0.016 (2.73)	-0.0087 (1.58)	-0.019 (4.21)	-0.014 (3.01)
Full-time college student	-0.054 (2.56)	-0.036 (1.64)	-0.054 (2.68)	-0.037 (1.83)
Half-time college student	-0.030 (0.87)	-0.011 (0.30)	-0.029 (0.89)	-0.012 (0.37)
Less than half-time college student	-0.044 (1.64)	-0.035 (1.24)	-0.044 (1.70)	-0.034 (1.35)

(continued)

Table 19 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	-0.056 (2.34)	-0.036 (1.53)	-0.059 (2.83)	-0.043 (2.06)
Working part-time	-0.019 (0.84)	-0.0064 (0.28)	-0.028 (1.40)	-0.021 (1.04)
Unemployed	-0.046 (1.02)	-0.030 (0.65)	-0.027 (0.65)	-0.0069 (0.17)
Infrequent religious participation		0.021 (1.10)		0.010 (0.55)
Frequent religious participation		0.103 (4.11)		0.061 (3.24)
Married		0.160 (6.93)		0.121 (6.95)
Engaged		0.115 (4.71)		0.092 (4.47)
Separated or divorced		-0.0045 (0.10)		-0.051 (1.23)
Number of children		0.034 (2.01)		0.036 (2.35)
R-squared	0.047	0.066	0.075	0.095
Wu F-ratio	1.972	6.422	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

Table 20

Structural Demand Functions, Dependent Variable = Probability of Quitting Getting High on at Least Half of all Annual Drinking Occasions

(n = 6,150)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Past frequency of drinking occasions	-0.0036 (0.89)	0.0035 (1.41)	-0.0015 (4.02)	-0.0014 (3.67)
Future frequency of drinking occasions	-0.002 (0.70)	-0.0071 (4.22)	-0.0055 (15.29)	-0.005 (13.66)
Price	0.015 (0.73)	0.004 (0.20)	0.012 (0.59)	0.0026 (0.13)
Legal drinking age*age ≤ 21	0.0057 (0.89)	0.0075 (1.20)	0.0057 (0.94)	0.0057 (0.95)
Lower border drinking age indicator*age ≤ 21	-0.042 (2.11)	-0.042 (2.22)	-0.038 (2.12)	-0.038 (2.11)
Age 19	-0.038 (0.29)	0.014 (0.12)	-0.015 (0.13)	0.012 (0.094)
Age 21	-0.053 (0.40)	-0.041 (0.32)	-0.043 (0.34)	-0.021 (0.17)
Age 23	0.012 (0.27)	0.045 (1.00)	0.020 (0.45)	0.039 (0.89)
Age 25	-0.036 (0.75)	-0.018 (0.37)	-0.031 (0.67)	-0.019 (0.41)
Male	-0.092 (2.98)	-0.075 (3.92)	-0.075 (6.03)	-0.066 (5.27)
Black	0.046 (0.90)	0.079 (1.98)	0.044 (1.36)	0.048 (1.48)
Other race/ethnicity	0.039 (1.36)	0.027 (1.04)	0.029 (1.14)	0.027 (1.08)
Real earnings	0.0000031 (2.24)	0.0000017 (1.28)	0.000003 (2.47)	0.0000022 (1.79)
Years of completed schooling	0.014 (2.33)	0.017 (3.12)	0.016 (3.07)	0.017 (3.33)
Full-time college student	-0.052 (2.29)	-0.014 (0.69)	-0.037 (1.99)	-0.022 (1.18)
Half-time college student	-0.030 (0.92)	-0.019 (0.61)	-0.028 (0.89)	-0.016 (0.53)
Less than half-time college student	0.047 (1.69)	0.063 (2.31)	0.054 (2.02)	0.061 (2.30)

(continued)

Table 20 (concluded)

	Two-Stage Least Squares		Ordinary Least Squares	
	(1)	(2)	(3)	(4)
Working full-time	0.027 (1.35)	0.048 (2.41)	0.031 (1.58)	0.043 (2.20)
Working part-time	-0.0021 (0.11)	0.0081 (0.44)	-0.000081 (0.004)	0.0061 (0.33)
Unemployed	-0.016 (0.44)	0.019 (0.51)	-0.0046 (0.13)	0.0072 (0.20)
Infrequent religious participation		0.0019 (0.11)		0.00018 (0.01)
Frequent religious participation		0.064 (3.13)		0.057 (3.08)
Married		0.099 (4.41)		0.101 (5.56)
Engaged		0.056 (2.43)		0.070 (3.39)
Separated or divorced		-0.090 (1.90)		-0.097 (2.12)
Number of children		0.029 (1.61)		0.014 (0.86)
R-squared	0.031	0.056	0.079	0.091
Wu F-ratio	0.770	2.332	–	–

Note: Absolute value of the asymptotic *t*-statistic is in parentheses, and intercepts are not shown. Regressors include dichotomous variables for nine of the ten cohorts (the senior classes of 1976 through 1984).

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