

**ECONOMIC MODELS OF ADDICTION  
AND APPLICATIONS TO CIGARETTE SMOKING  
AND OTHER SUBSTANCE ABUSE**

Frank J. Chaloupka

Professor of Economics, University of Illinois at Chicago  
Research Associate, National Bureau of Economic Research  
Director, ImpacTeen, UIC Health Research and Policy Centers

and

John Tauras, University of Michigan and NBER  
Michael Grossman, CUNY and NBER

## **Economists and Addiction: Brief History**

- Alfred Marshall (1920): "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 when its price is low are not quickly abandoned when its price rises again"
- Anticipates the differences between the short-run and long-run price responses that play an important role in economic models of addiction
- Milton Friedman (1962): "Economic theory proceeds largely to take wants as fixed. This is primarily a case of division of labor. The economist has little to say about the formation of wants; that is the province of the psychologist. The economist's task is to trace the consequences of any given set of wants. The legitimacy and justification for this abstraction must rest ultimately, in this case as with any other abstraction, on the light that is shed and the power to predict that is yielded by the abstraction."

## **Economists and Addiction: Brief History (continued)**

- Many characterized addictive consumption as imperfectly rational behavior not conducive to standard economic analysis:
  - Thomas Schelling (1978) describing a smoker who wants to kick the habit: "Everybody behaves like two people, one who wants clean lungs and long life and another who adores tobacco.... The two are in a continual contest for control; the 'straight' one often in command most of the time, but the wayward one needing only to get occasional control to spoil the other's best laid plan."
- Others, however, argued that tools of economics could be appropriately applied to addictive behaviors:
  - George Stigler and Gary Becker (1977): "We assert that this traditional approach of the economist offers guidance in tackling these problems - and that no other approach of remotely comparable generality and power is available."

## **Insights from Psychology**

- Experimental studies of addiction have found reinforcement, acquired tolerance and withdrawal
  - Reinforcement implies a learned response to past consumption; that is, greater past consumption raises the marginal utility of current consumption
  - Acquired Tolerance: a given level of current consumption is less satisfying when past consumption is higher
  - Withdrawal: a negative physical reaction and other reductions in satisfaction as current consumption is terminated

## Alternative Approaches to Economic Modeling of the Demand for Addictive Substances

- Conventional Approach:
  - Standard, constrained, lifetime utility-maximizing framework of economics:

$$U(t) = f[ C(t), X(t) ]$$

$C(t)$  - consumption of addictive substance at time  $t$

$X(t)$  - consumption of composite good at time  $t$

- maximize utility function subject to income constraint
- Produces demand function of the type:

$$C(t) = g[ P(t), Y(t), \mathbf{Z}(t) ]$$

$P(t)$  - current price of addictive substance

$Y(t)$  - income

$\mathbf{Z}(t)$  - vector of variables reflecting tastes

## **Alternative Approaches to Economic Modeling of the Demand for Addictive Substances (continued)**

- Comments on Conventional Approach:
  - Current consumption of addictive substance depends only on current factors
  - Increase in current price will reduce current consumption (price defined broadly to include monetary price, time costs, expected legal costs, and anticipated health consequences)
  - Increase in past price and/or anticipated increase in future price will have no impact on current consumption
  - Does not reflect the dependence of current consumption decisions on past behavior that characterizes the use of an addictive substance

## **Alternative Approaches to Economic Modeling of the Demand for Addictive Substances (continued)**

- Myopic Models of Addictive Demand (Gorman, Pollak, Houthakker and Taylor, Hammond, Mullahy, and others)
  - Standard, constrained, lifetime utility-maximizing framework of economics:

$$U(t) = f[ C(t), C(t-1), X(t) ]$$

C(t-1) - consumption of addictive substance  
in previous period

- maximize lifetime utility function subject to appropriate income constraint
- Produces demand function of the type:

$$C(t) = g[ P(t), C(t-1), Y(t), \mathbf{Z}(t) ]$$

## **Alternative Approaches to Economic Modeling of the Demand for Addictive Substances (continued)**

- Comments on Myopic Approach:
  - Current consumption of addictive substance depends on current and past factors
  - Good is defined as addictive if increase in past consumption raises current consumption
  - Increase in current price will reduce current consumption
  - Increase in past price, by reducing past consumption, will also reduce current consumption
  - Anticipated increase in future price will not change current consumption
  - Long-run effect of a permanent price change will exceed short-run effect
  - Does reflect the dependence of current consumption decisions on past behavior that characterizes the use of an addictive substance
  - Ignores the future implications of addictive consumption when making current consumption decisions

## **Alternative Approaches to Economic Modeling of the Demand for Addictive Substances (continued)**

- Rational Models of Addictive Demand
  - Standard, constrained, lifetime utility-maximizing framework of economics:

$$U(t) = f[ C(t), C(t-1), X(t) ]$$

- maximize lifetime utility function subject to appropriate income constraint
  - Produces demand function of the type:

$$C(t) = g[ P(t), C(t-1), C(t+1), Y(t), Z(t) ]$$

$C(t+1)$  - future consumption of addictive substance

## **Alternative Approaches to Economic Modeling of the Demand for Addictive Substances (concluded)**

- Comments on Rational Approach:
  - Current consumption of addictive substance depends on current, past, and future factors
  - Good is defined as addictive if increase in past consumption raises current consumption
  - Increase in current, past, or future price will reduce current consumption
  - Long-run effect of a permanent price change will exceed short-run effect
  - Reflects the dependence of current consumption decisions on past behavior that characterizes the use of an addictive substance
  - Implies that the future implications of addictive consumption are considered when making current consumption decisions

## **Additional Comments on Price Effects**

- Long-run effects of permanent price changes are larger than effects of temporary price changes
- Effects of anticipated changes in price are larger than effects of unanticipated price changes
- Ratio of long-run to short-run price effect is greater the greater the degree of addiction
- Long-run price effect greater the larger the rate of time preference for the present

## Interactions Between Price and Personal Characteristics

- Hypotheses:
  - Individuals with greater preference for the present (younger, lower income, less educated) will be relatively more sensitive to changes in the monetary price of addictive goods
  - Individuals with greater preference for the future (adults, higher income, more educated) will be relatively more responsive to changes in the perceived future consequences of addictive consumption

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Conventional Studies:
  - Large number of diverse studies of cigarette demand using variety of aggregate and individual-level data from US and other countries
  - Consensus estimate for overall price elasticity of demand in the range from -0.3 to -0.5
  - Prevalence elasticity ranges from -0.1 to -0.2

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Studies focusing on youth:
  - Economic theory suggests youth will be more sensitive to price (relatively low income, importance of peer influences); similarly, addictive models imply youth will be more price sensitive (more present-oriented, less addicted)
  - Earliest studies by Lewit and his colleagues concluded youth smoking was about three times more sensitive to price than adult smoking
  - Similarly, Lewit, et al., find young adults more sensitive to price than older adults, but not as responsive as youth; conclude that price sensitivity is inversely related to age
  - Subsequent work by Wasserman and his colleagues concluded that price elasticity among youths was not significantly different from that for adults

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Results from recent research by my colleagues and I on price sensitivity of youth and young adult smoking:
  - Teens (Chaloupka and Grossman, 1996):
    - Prevalence elasticity: -0.675
    - Conditional demand elasticity: -0.638
    - Unconditional elasticity: -1.313
  - Also find negative impact of smokeless tobacco taxes on both the probability and frequency of smokeless tobacco use among young males (Chaloupka, Tauras, and Grossman, 1997)
  - Find differences in price elasticity by gender (young males more responsive to price than young females) and race (young blacks more sensitive to price than young whites) (Chaloupka and Pacula, 1998)
- Young Adults (Chaloupka and Wechsler, 1997):
  - Prevalence elasticity: -0.53
  - Conditional demand elasticity: -0.58
  - Unconditional elasticity: -1.11

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Selected Review of Myopic Demand Studies:
  - Earliest work by Houthakker and Taylor (1966, 1970) using aggregate data for US concludes that tobacco (and alcohol) show strong evidence of addiction (stock of past consumption has significant positive impact on current consumption)
  - Later models based on early work by Farrell (1952) and others estimating "irreversible" demand functions; these imply asymmetric responses to changes in price due to addictive nature of consumption
    - Farrell (1952) finds evidence of addiction for tobacco use based on UK data for 1870-1938
    - Young (1983) uses US data for 1929-1973; finds demand is more responsive to price decreases (elasticity of -0.61) than to price increases (elasticity of -0.30)
    - Similar result found for Finland (Pekurinen, 1989)
  - Mullahy (1985) uses "addictive stock" approach, data from 1979 National Health Interview Survey; obtains strong evidence supporting hypothesis that smoking is addictive; estimated price elasticity of -0.47

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Selected Review of Rational Demand Studies:
  - First empirical applications of Becker and Murphy (1988) model of rational addiction by Chaloupka (1988, 1990, 1991, 1992) using data from Second National Health and Nutrition Examination Survey
    - Strong evidence that cigarette smoking is an addictive behavior (significant positive effect of past consumption on current consumption)
    - Strong evidence of rational behavior (significant impact of future consumption on current consumption)
    - Long-run price elasticity about double short run price elasticity
    - Younger adults behave more myopically than older adults; less educated more myopic than more educated
    - Less educated more responsive to price than more educated (Townsend reaches similar conclusion with respect to difference by income in UK data; more recently, Farrelly, et al. find similar evidence based on US data)
    - Men behave more myopically and are more responsive to price (long-run elasticity centered on -0.6) than women (insignificant price effects)

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Tauras and Chaloupka (1999):
  - Data on cigarette smoking taken from panels formed from the annual Monitoring the Future Surveys of high school seniors conducted from 1976 through 1993 (about 2,400 persons in each panel; surveyed every two years)
    - unconditional cigarette demand, smoking prevalence, and conditional cigarette consumption
    - Positive and significant effects of past smoking on current cigarette consumption (addiction)
    - Positive and significant effects of future consumption on current smoking (non-myopic behavior)
    - Long-run price elasticity more than double the short-run estimates

## **Econometric Studies of Addictive Demand: Cigarette Smoking**

- Selected Review of Rational Demand Studies (continued):
  - Becker, Grossman, and Murphy (1994) use time-series of annual state cross-sections for period from 1955 through 1985
    - Positive and significant past and future consumption effects consistent with rational addiction
    - Long-run price elasticity of -0.75 nearly double the short-run elasticity of -0.40
  - Keeler, et al. (1993); Sung, et al. (1994), using data on California and western US produce findings generally comparable with other studies of US
  - Douglas (1998) uses retrospective data on smoking initiation and cessation from 1987 NHIS; finds strong evidence of rational addiction; estimates that a 10 percent increase in cigarette prices reduces the duration of cigarette addiction by 10 percent
  - Mixed evidence from other countries:
    - generally consistent evidence from Finland (Pekurinen, 1991) and Australia (Bardsley and Olekalns, 1998)
    - little support from UK (Duffy, 1996), Greece (Cameron, 1997), and Ireland (Conniffe, 1995)
    - Generally based on very limited annual time-series data

## **Econometric Studies of Addictive Demand: Alcohol Use and Abuse**

- Conventional Studies:
  - Large economics literature examining the impact of alcohol prices using a variety of aggregated and individual-level data on numerous measures of alcohol use and abuse; concludes that price has a significant negative impact on:
    - prevalence of drinking
    - frequency of drinking
    - alcohol consumption
    - prevalence/frequency of binge drinking
    - drinking and driving (self-reported drinking and driving, involvement in non-fatal automobile accidents, motor vehicle accident fatality rates)
    - other accidents (non-fatal and fatal)
    - heavy drinking (liver cirrhosis and other alcohol related death rates)
    - violence (self-reported measures, homicides, suicides, other violent crime rates)
  - As with cigarette smoking, evidence suggests that youth and young adults will be more responsive to price than adults

## **Econometric Studies of Addictive Demand: Alcohol Use and Abuse**

- Rational Addiction Studies of Alcohol Demand:
  - Chaloupka, et al. (1992), (using liver cirrhosis death rates); long-run price elasticity of -1.3; somewhat larger than short-run estimates; strong evidence of addiction and non-myopic behavior
  - Grossman, Chaloupka, Sirtalan (1998):
    - Data on alcohol use taken from panels formed from the annual Monitoring the Future Surveys of high school seniors conducted from 1976 through 1985
      - number of drinks of alcohol consumed in past year; also examined prevalence of heavy drinking and other related measures
      - Price elasticity of demand from models ignoring addiction: -0.29
      - Positive and significant effects of past drinking on current alcohol consumption (addiction)
      - Positive and significant effects of future consumption on current drinking (non-myopic behavior)
      - Short-run price elasticity: -0.41
      - Long-run price elasticity: -0.65
      - Ratio of long-run to short run elasticities suggests that alcohol use is not as addictive as smoking
    - Moore and Cook (1995) and Waters and Sloan (1995) provide additional empirical evidence in support of the rational addiction model

## **Econometric Studies of Addictive Demand: Illicit Drug Use**

- Conventional Demand Studies:
  - Relatively small literature in economics due to limited availability of reliable data on illicit drug use and prices
  - Early studies by Nisbet and Vakil (1972), and Silverman and colleagues (Silverman and Spruill, 1977; Brown and Silverman, 1974) produced estimates of relatively inelastic demands for marijuana and heroin
  - More recent studies by Saffer and Chaloupka (1999a, 1999b) provide similar evidence that marijuana, cocaine, and heroin use are inversely related to price; also find complementarity among substances
  - Chaloupka, Grossman, and Tauras (1999) find that youth cocaine and marijuana use is more sensitive to price than adult use
- Myopic demand studies of drug use:
  - van Ours (1995) estimates demand functions for opium in Dutch East Indies (now Indonesia) in time-series of 22 regions for 1922-1938
    - finds strong evidence of addiction, with past opium consumption having positive and significant impact on current consumption
    - Substantial long-run price elasticity of -1.00, about 40 percent larger than short-run elasticity
    - Elasticity of number of opium users with respect to price in range from -0.30 to -0.40

## **Econometric Studies of Addictive Demand: Illicit Drug Use**

- Rational demand studies of drug use:
  - Grossman and Chaloupka (1998) use data from panels formed from 1976 through 1985 MTF surveys of high school seniors (same sample as used for alcohol demand study) to examine cocaine demand among young adults
  - Positive and significant effects of past participation on current participation; same findings for frequency of use implying that cocaine use is addictive
  - Positive and significant effects of future participation and frequency on current measures; implies that individuals are behaving non-myopically
  - Negative and significant effects of price in all models
  - Findings consistent across alternative outcomes, specifications, and estimation methods
  - Long-run price elasticity of -1.35; approximately 60 percent larger than short-run price elasticity; suggests that cocaine use is more addictive than alcohol use, but less addictive than smoking

## Recent Extensions of Economic Theories of Addiction

- "Rational Addiction" model often criticized because of its implicit assumption that addicts are "rational" or farsighted:
  - Winton (1980): "The addict looks strange because he sits down at period  $j=0$ , surveys future income, production technologies, investment/addiction functions, and consumption preferences over his lifetime to period  $T$ , maximizes the discounted value of his expected utility, and decides to be an alcohol. That's the way he will get the greatest satisfaction out of life. Alcoholics are alcoholics because they want to be alcoholics, *ex ante*, with full knowledge of its consequences."
- Recent, yet to be empirically tested, extensions to the model attempt to deal with this criticism:
  - Orphanides and Zervos (1995): introduce uncertainty by assuming that inexperienced users are not fully aware of the potential harm, including addiction, from consuming an addictive substance; knowledge comes from observing others and from own experimentation
    - can lead addicts to regret their addiction
  - Suranovic, et al. (1999): emphasize the role of "quitting costs" associated with cessation and shift from model based on fully rational behavior to one assuming "bounded rationality" that focuses on current utility maximization rather than lifetime utility maximization

## **Econometric Studies of Addictive Demand: Summary**

- Demands for licit and illicit addictive substances are not exceptions to the law of the downward sloping demand curve
  - Significant increases in monetary prices will lead to significant reductions in tobacco, alcohol, and other drug use
- Price responsiveness inversely related to age; that is, youth and young adults are more responsive to changes in price than older adults
  - Given that most substance use is initiated in teenage years, large, sustained increases in price may be the most effective means of achieving substantial long-run reductions in substance use in all segments of the population

## **Econometric Studies of Addictive Demand: Summary**

- Ignoring the addictive nature of demands for tobacco, alcohol, and other drugs will lead to biased estimates of the long-run impact of price on demand
- Because of their addictive nature, long-run reductions in demand resulting from a permanent price increase for tobacco, alcohol, and other drugs will be substantially larger than short-run reductions
- Conversely, because of their addictive nature, temporary price changes will have very little impact on demand
- Demands for addictive substances reflect non-myopic behavior
- Increases in the future price of these substances (i.e. new information on the future health consequences of substance use) will lead to significant reductions in current use

## **Econometric Studies of Addictive Demand: Summary**

- More myopic individuals will be more price sensitive than will more farsighted individuals
- Younger, less educated, and lower income persons will be more responsive to permanent changes in the monetary prices of addictive substances than will older, more educated and higher income persons
- More farsighted individuals will be more responsive to changes in the perceived future consequences of substance use and abuse
- Increases in other aspects of the full price of substance use and abuse will also lead to reductions in current and future use of tobacco, alcohol, and illicit drugs
  - Reductions in availability (i.e. minimum legal purchase ages, limits on youth access)
  - Increases in the expected legal costs of substance use and abuse
  - New information on the short and long term health consequences of substance use and abuse