An Econometric Analysis of the Role of Information in Cigarette Addiction

by

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A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2000

STATEMENT BY AUTHOR

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ACKNOWLEDGEMENTS

The research for this study was a journey in itself. I want to thank Dr. Satheesh Aradhyula for seeing me through that journey – with great patience – from beginning to end. I want to thank Ms. Amy Lohman for her incredible inspiration and encouragement: her support allowed me to walk *steadily* through the painstaking process of dotting the i's and crossing the t's. I offer special thanks to Ms. Jan Black. Our conversations about this paper became a four-year chautauqua. The Hawley House Men's Organization also contributed greatly to the insights that informed this study – thank you Mr. Robin Hill O.T., Mr. Joe Rapoza M.S.W., and Mr. Sheldon Ross. Finally, I want to thank my mother, Sara Carruthers, without whom perhaps none of this would have been possible.

DEDICATION

This work is dedicated to all those who bear messages of hope and healing to the addicts that are still suffering the pains of their addiction. May the messenger and the addict both be granted serenity in all their affairs.

"Every form of addiction is bad, no matter whether the narcotic be alcohol or morphine or idealism."

Carl Jung , *Memories, Dreams, Reflections*

"One wonders if any contemporary researchers have ever borne the despair of Sisyphus that distinguishes life under a strong addiction. The only consistent lifetime plan that the addict makes is the one he breaks each night anew."

Anonymous

"The believing we do something when we do nothing is the first illusion of tobacco."

Ralph Waldo Emerson , *Journals*

TABLE OF CONTENTS

1 INTRODUCTION 10
1.1 Problem Statement 10
1.2 Background and Justification 12
1.2.1 Public Health and Cigarettes 12
1.2.2 Contemporary Economic Treatments of Addictions 14
1.3 Research and Objectives 15
1.4 Thesis Organization 16

2 THE CONSUMPTION OF CIGARETTES 18
2.1 Public Health and Regulation 18
2.1.1 The Social Costs of Cigarette Use 18
2.1.2 Regulation and Tobacco Control 20
2.1.3 Initiation and Cessation 27
2.2 Models of Cigarette Consumption 31
2.2.1 Models from Psychology 31
2.2.1.1 Bateson's Theory of Alcoholism 32
2.2.1.2 Contemporary Psychoanalytic Theories of Addiction 36
2.2.2 Models from Economics 39
2.2.2.1 The 'Rational Addictions' Model 39
2.2.2.2 Other Economic Theories of Addiction 42
2.2.3 The Estimation of Models of Cigarette Demand 47
2.2.3.1 A Review of the Literature 47
2.2.3.2 Relevant Empirical Models 49

3 METHODOLOGY 54
3.1 An Illustrative Model of Addiction 54
3.1.1 The Anxiety Model by Schechter 55
3.1.2 The Addiction Model 57
3.1.3 The Impact of the Unconscious 64
3.2 The Empirical Model of Cigarette Demand 67
3.2.1 The Likelihood Function for the Empirical Model 68
3.2.2 Application and Estimation of the Poisson Distribution 72
3.2.3 Application and Estimation of the Ordered Logistic Distribution 75

4 DATA, EMPIRICAL ANALYSIS, AND RESULTS 80
4.1 Data Sources 80
4.1.1 The National Household Survey on Drug Abuse 80
4.1.2 The Tobacco Institute Cigarette Price Data 85
4.1.3 Bureau of Labor Statistics Price Deflators 87
4.1.4 Data Preparation 88
4.1.5 Descriptive Statistics 92
4.2 Estimation 97
4.2.1 Dependent and Independent Variables 97
4.2.1.1 Approach for Estimation 97
4.2.1.2 Participation 102
4.2.1.3 Consumption 104
4.2.1.4 Methods 106
4.3 Results 108
4.3.1 Participation Regressions 108
4.3.2 Consumption 118

5 CONCLUSIONS 125
5.1 Summary 125

APPENDICES 130
APPENDIX A. Derivations for the Model in Section 3.1 131
Total Differential of the Addiction Model: Unconscious Choice 131
The Policy Effect of Increasing Signals 134
APPENDIX B. Derivation of the Likelihood Equations 140
The Participation Equation Derivatives 140
The Consumption Equation Derivatives 141
APPENDIX C. Data Dictionary 147
APPENDIX D. Association between Signal and Use Variables 154

REFERENCES 158

LIST OF TABLES

Table 2.1-1 Regulations in Select States and Local Regions....22
Table 2.1-2 Federal Milestones in Tobacco Regulation....24
Table 2.2-1 Some Milestones in the Economics Literature on Addictions....40
Table 4.1-1 Records Available to Study....83
Table 4.1-2 Records Excluded by MSA and Year....84
Table 4.1-3 A Price Comparison for 1992....90
Table 4.1-4 Demographic Profile of the Sample....92
Table 4.1-5 Cigarette Use Characteristics....94
Table 4.1-6 Indicators of Dependence....95
Table 4.1-7 Cigarette Use Prevalence....96
Table 4.2-1 Psychological State and Signal Regressors....98
Table 4.2-2 Association Between PASTMNTH and HALFPACK and the Signals....99
Table 4.2-3 Survey Question Used for Dependent Variables....103
Table 4.2-4 Distribution of Respondents by Consumption....104
Table 4.3-1 Participation Regressions*....112
Table 4.3-2 Consumption Regressions*....121
Table 5.1-1 Association of Problems and Consumption....126
Table D-2 Association with PASTMNTH Controlling for TRY_QUIT, All Obs.....155
Table D-3 Association with PASTMNTH Controlling for QUIT_ANY, All Obs.....155
Table D-4 Association with PASTMNTH Controlling for TRY_QUIT, Ever Used....156
Table D-5 Association with HALFPACK Controlling for TRY_QUIT....156
Table D-6 Association with HALFPACK Controlling for QUIT_ANY....157

LIST OF ILLUSTRATIONS

Figure 1.2-1 Annual Consumption of Cigarettes During the Past Century * 12
Figure 2.2-1 Symmetry, Complementarity and Consumption 33
Figure 3.2-1 The Structure of the Model of Choice 67
Figure 4.1-1 Total State and Federal Taxes Per Pack 86
Figure 4.1-2 Average Per Pack Prices 86
Figure 4.1-3 Price Levels By MSA 87
Figure 4.1-4 Preparation of Data for Analysis 89
Figure 4.2-1 Prevalence of Cigarette Use 107
Figure 4.3-1 Distribution of Participation in Estimation Sample 109
Figure 4.3-2 Income and the Risk of Smoking 114
Figure 4.3-3 Tax Rates and Risk of Smoking 115
Figure 4.3-4 Histogram of Consumption 119

ABSTRACT

The 1964 Surgeon General's Report provoked increased research activity on the topic of cigarette consumption. Recent economic research has viewed cigarette addiction as resulting from conscious, fully informed choices. In the current study, we incorporate findings from the psychology literature. We develop an analytical model of addictive consumption that exhibits results consistent with a theory of alcoholism by Gregory Bateson. We show that unconscious determinants can cause inconsistent consumption decisions and lead to higher than desired consumption. We then develop an empirical model of consumption. In the empirical model, consumption choice is formulated as a hurdle model with an ordered logit participation equation and a censored Poisson consumption equation. We estimate the model using data from the National Household Survey on Drug Abuse (NHSDA) from the years 1991 to 1993. Our empirical results show certain classes of consumers may increase consumption in response to increased information about the hazards of smoking.

1 INTRODUCTION

1.1 Problem Statement

One goal of the current study is to introduce into the neoclassical consumer choice problem, in a specific and quantitative manner, insights about addictive behavior gleaned from the psychology literature on addictions. A seminal paper by Gregory Bateson (1987) provides a theory of alcoholic behavior. The insights in the paper lay the foundation for much of research done to date in the disciplines of family therapy and addictions counseling. Further, a paper from economics literature by Schechter (1988) examines the role of anxiety in economic decisions. The two papers provide the basis for the theoretical and empirical work done in this study.

The current study applies Bateson's theory of alcoholism to the case of cigarette consumption. An insight drawn from Bateson is that there is a "converse matching between [...] sobriety and [...] intoxication, such that the latter may be seen as inappropriate and subjective correction to the former." Specifically, and up to a threshold, the addict may attempt abstention, whereupon, that threshold having been reached, the addict "has a drink" as a correction to the discomforts of sobriety. That threshold is conceptualized as a latent variable in the choice problem faced by the addict.

A second goal of the current study is to identify the effects that signals from the addict's environment have on consumption decisions. We are interested specifically in

those signals that contain information about the hazards of smoking. To undertake this goal, the choice problem facing the addict is examined in the literature. An illustrative example is considered, and then the problem is studied empirically through an econometric analysis. Survey data from the 1991, 1992, and 1993 National Household Survey on Drug Abuse (NHSDA) is used in the analysis along with information on cigarette prices from The Tobacco Institute. Estimates of the significance of the determinants in the demand for cigarettes are developed. Other variables are incorporated into the analyses to control for demographic differences, and multiple substance use indicators, and income and prices.

The estimated choice problem is formulated as follows. Utility is maximized as a function of the consumption of cigarettes given the state of the addict's knowledge about the health effects of cigarettes. Knowledge about the health effects is acquired through the signals received from family, relatives and other social institutions. The consumption choice is modeled as a two-stage process. The individual first chooses whether to smoke. Conditional upon smoking, the consumer chooses a level of consumption.

The described choice process is referred to as a hurdle model. The first stage is the participation choice and the second stage, the consumption choice. Other authors (Jones (1989), Chaloupka (1991), Labeaga (1999)) have estimated cigarette demand with a hurdle model. In the current study, the participation choice is estimated as an ordered logit model. The second stage, the consumption decision, is estimated as a censored Poisson model given that the NHSDA consumption data is reported in half pack increments. To the our knowledge, the present study is the first to address, through an

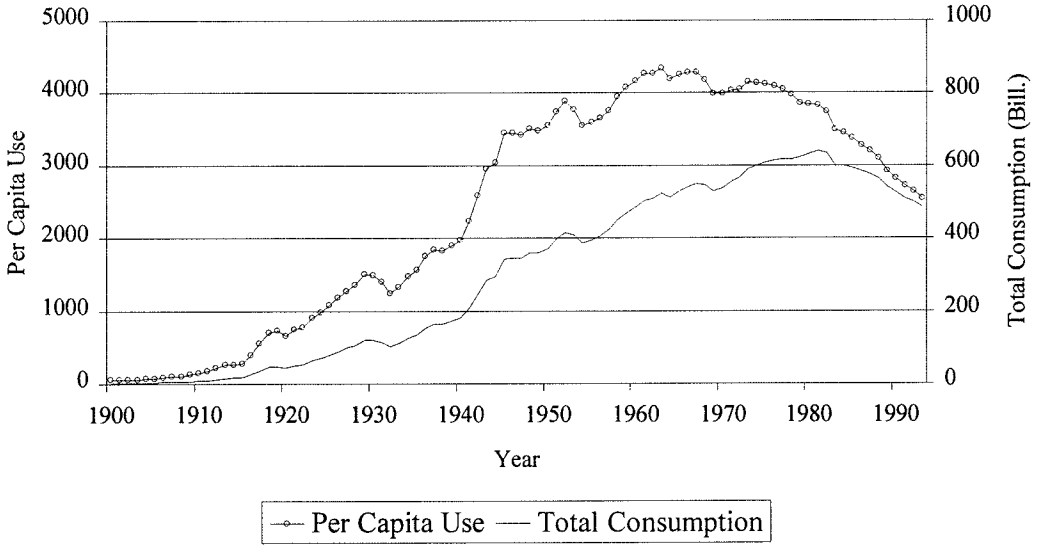
ordered logit-Poisson estimation, the discrete and censored nature of consumption data as reported in most survey data.

1.2 Background and Justification

1.2.1 Public Health and Cigarettes

Consumers in the United States consume billions of cigarettes per year (Giovino et al., 1994). Although the per capita rate of consumption has declined noticeably in recent decades, cigarette use still causes millions of dollars of additional unnecessary health expenditures annually. Moreover, the increased preventable morbidity and mortality attributable to cigarette use lessens the overall quality of life for our society.

Figure 1.2-1 Annual Consumption of Cigarettes During the Past Century *



* Source: Giovino et al., 1994.

Fishman et al. (1998), reporting for the Centers for Disease Control (CDC), a branch of the U.S. Department of Health and Human Services, summarized the current state of knowledge about tobacco use and risk in a recent report:

> *"Since the release of the first Surgeon General's report on tobacco in 1964, scientific knowledge about the health consequences of tobacco use has increased substantially [...]. As knowledge about the health consequences of tobacco use and exposure to environmental tobacco smoke (ETS) has increased, knowledge about effective interventions to prevent and reduce tobacco use and exposure to ETS has also increased. Extensive study during the preceding 30 years has documented that reductions in tobacco use decreases the incidence of several diseases and disorders as well as decreases mortality [...]. However, one fourth of all adults in the United States still smoke [...], and tobacco use continues to cause >430,000 deaths each year ... [p. 21]"*

Barendregt et al. (1997) cite the Surgeon General when they note that the lifetime medical costs of smokers exceed those of non-smokers by an average of $6000. Bartlett et al. (1994) found that for each package sold in 1993 about two dollars was spent on smoking-attributable medical costs. Of the two dollars, nearly half was paid through public sources.

Smoking was the cause of more than 400,000 deaths in 1990 (Nelson et al., 1994). The authors note that smoking is single most preventable cause of death in the United States and as much as 20% of all deaths in the United States can be attributed to smoking. The authors also estimate years of potential life lost – measure of premature nature of the

mortality. They find that in 1990 over 4,000,000 years of life were lost to smoking-attributable deaths.

1.2.2 Contemporary Economic Treatments of Addictions

The largest portion of existing economic research on addictions has been the work of Gary Becker and his colleagues. The resulting research has typically borrowed concepts from other branches of economics in the effort explain addictions. For example, a seminal paper by Stigler and Becker (1977) re-envisioned the household as a productive unit along the lines of the firm. In this model, households used commodities as inputs and transformed them into household output for final consumption. Their model seems to borrow conceptually, if not analytically, from production theory.

In a recent article, Shira Lewin (1996) notes that, historically, modern economics has tended to minimize interdisciplinary research with allied social sciences. Lewin suggests that this self-imposed isolation has adversely effected the productivity of economic research. Relevant to this study, Lewin questions whether economics can be independent of psychology particularly in the areas of consumer choice and preference theory.

The modest incorporation of psychological findings into economic research efforts is as evident in the addictions-related literature as it is in other areas of the economics literature. This is noteable when one considers two items. First, the existing body of literature on addictions from psychology is tremendous. As of 1979, Austin, Macari and Letteiri had identified over 1300 major research studies in their review of the

literature. Second, addiction-related issues are more and more frequently the topic of contemporary public debate.

The present study addresses the need to have more informed research into the economics of addictive behavior. Specifically, there is a need for an economic theory of addictive behavior that is consistent with the existing psychological knowledge about addictions. That need is addressed here in part. In this study, the model developed is based on the research of Gregory Bateson. His writings were seminal to the development of modern family therapy. We also considered the theories of several modern psychoanalysts. A further discussion of these contributions is given in Chapter 2.

1.3 Research and Objectives

The present study is based partly on a paper by Gregory Bateson (1987). In the paper, Bateson developed a systemic model of addictive behavior. His paper provides only a thought model so additional work was required to transform his model into one which could be used for empirical purposes. Specifically, his arguments needed to be conceptualized as mathematical relations. Moreover, the mathematical form needed to be sufficiently parsimonious so as to allow for estimation or calibration of a quantitative model. The results from Schechter (1988), Viscusi (1979) and others provided a model structure that could be used to explore Bateson's ideas.

We propose that, counter to conventional intuition, common tobacco control policy prescriptions (e.g., health information campaigns, taxes, etc.) can actually increase consumption of the individual smoker. This proposition is offered in light of Bateson's

observation that "under certain circumstances, the [addict's] discomfort activates a positive feedback loop to increase the behavior that preceded the discomfort (1987, p.327)." In order to test the proposition, the research objectives for this study were as follows:

i) to pose Bateson's observations within the context of economic choice motivated by the model by Schechter;

ii) to describe a plausible microeconomic choice model that exhibited his result;

iii) to contruct an appropriate econometric model of demand;

iv) to identify data that would support empirical application of the model

v) to estimate the demand function while incorporating variables that reflected Bateson's counter-intuitive observations.

The intent of this study is to provide insight into the economic behavior of addicts. It is hoped that the current research will provide the beginnings of a framework for developing correct policy prescriptions in the future.

1.4 Thesis Organization

The current study is organized in the following manner. The next chapter discusses the regulatory environment with respect to tobacco, the costs associated with cigarette addiction, and patterns in smoking initiation, use and cessation. The chapter also reviews existing models of addiction with a focus on tobacco use. We review both

psychological models and economic models of the behavior; a specific model, Bateson's model is examined in detail. In Chapter 2, we also review past empirical studies of cigarette demand. Several papers are considered in detail including the work of Jones (1989), Becker, Grossman and Murphy (1994), and Mullahy (1997a, 1997b).

In Chapter 3, we consider an economic model of consumption that illustrates aspects of Bateson's model. The model is incorporates ideas from Schechter and Viscusi who investigated the role of risk and anxiety in choice. In Chapter 3, we consider also the empirical form of the model for estimation. The estimation of ordered logit and Poisson regressions is discussed. Chapter 4 discusses data sources, the analysis and results. In Chapter 5, we summarize our findings and outline topics for further research.

2 THE CONSUMPTION OF CIGARETTES

2.1 Public Health and Regulation

In the sections below, we discuss the magnitude of the costs born by individuals and society from cigarette consumption. We find that after several decades of research and public policy action there are still sizable costs due to smoking. We then examine the recent regulatory experience in tobacco control. We follow with a discussion of patterns of initiation and cessation. The review of initiation and cessation behaviors provides a basis from which to compare the empirical results discussed later in this study.

2.1.1 The Social Costs of Cigarette Use

The 1964 Report of the Surgeon General contained the first significant public warning about the dangers of cigarette smoking. In the recent decades a number of studies have been undertaken to quantify the public and private costs attributable to tobacco use. This data provides a means to measure the relative risk and also the potential (and realized) costs of tobacco control.

Luce and Schweitzer (1977) estimated the cost due to smoking-related diseases. They estimate these costs at $26 billion annually. They also estimate the indirect costs (in which they include as lost earnings, premature mortality and property damage) as valued

at $18 billion annually. They comment that the smoking disease-related costs account for approximately 11 percent of the total costs of all diseases faced by the U.S. population.

Oster et al. (1984) also measured the costs associated with smoking on an individual basis. They examined the costs by age, gender and rate of consumption. They reported that for a 40-year-old man (as an example) the costs ranged from $20,000 to $56,000 over the lifetime of the individual based on the level of cigarettes consumed daily.

In 1994, Bartlett et al. (1994) reported in the Morbidity and Mortality Weekly Report (MMWR) the medical expenditures attributable to smoking. The gross estimated value of the expenditures was given as approximately $22 billion out of a total expenditure of $308 billion on medical care. Of the $22 billion, Bartlett et al. reports that the individual paid 21 percent of the costs. Bartlett et al. also reports that out the $2.06 medical expenditure attributable to each pack of cigarettes sold, $0.89 were paid through public sources.

Nelson et al. (1994) have measured the effect of mortality due to the cigarettes. Nelson et al. report in the MMWR that the years of potential life lost (YPLL) varied from 6,720 years to 498,297 years across states. The report gives the total estimated YPLL for 1990 as approximately 4,000,000 years. The dollar cost associated with this figure will depend on expected lifetime earnings at time of death.

Warner, Hodgson and Carroll (1999) reviewed a large number of recently published papers on the costs attributable to smoking. They noted that with one

exception, all the studies found that the medical costs of smoking to U.S. as a whole were about 6-8% of total national expenditure on health care. The one exception found the costs to be substantially higher.

2.1.2 Regulation and Tobacco Control

Statistics on the consumption of cigarettes and other tobacco products are well documented. This is in part due to the legal market for the products as well as to the public effort that has been devoted in recent years to substance abuse prevention. A variety of interventions have been implemented to decrease cigarette consumption. In the current section, we examine the interventions to affect use.

The Shelton et al. (1998) note that "policies that affect the price of tobacco products are the single most effective means of decreasing tobacco use [...] price increases, usually a result of increases in the excise tax on tobacco products, encourage current tobacco users to [...] reduce their consumption of tobacco products."

In a report published in the Centers for Disease Control (CDC) periodical, the MMWR, Farrelly and Bray (1998) cite results from a pooled cross-sectional time series study of over 300,000 respondents to a survey. The authors quote a price elasticity of the choice to smoke as –0.15 and a price elasticity of the quantity consumed as –0.10. They state that these results imply a for 50% increase in price, an overall reduction in consumption would be achieved. A study published by the CDC (CDC, 1996) in the MMWR examined the effectiveness of price increases in conjunction with a media campaign. The article reviewed the anti-smoking campaign that resulted from the 1992

ballot Question 1 in Massachusetts. The article concludes that combination of the price affected through excise tax increases in combination with the media substantially reduced consumption.

A similar policy, Proposition 99, in California was reviewed in an article by Hu et al. (1995). The authors found that for a policy of increasing excise taxes by 25 cents and a $26 million expenditure on media advertisements, consumption was reduced by about 1000 million packs. The reduction was for the period from 1990 through 1993. The authors note that the excise tax increase affected the largest decrease. About 819 million less packages were sold due to the tax increase whereas approximately 232 million less packages were sold due to the media campaign. Elder et al. (1996) also independently evaluated the California Proposition 99 and found that the policy had indeed decreased consumption. The authors note that the decline in sales (a national trend) was greater in California than in the rest of the U.S. during the period between early 1990 and later 1994. The authors cite a 7.9% average quarterly decline versus the national figure of 3.2% per quarter. We consider additional literature on price policies in a section later in this chapter.

Siegel and Biener (1997) analyze both Question 1 and Proposition 99. They results concur with those reported by Hu et al. (1995), Elder (1996), and the CDC (1996). They note however, that they found no evidence of a decrease in consumption by minors. They recommend that consistency in public support and in program development of future tobacco control initiatives will help to prevent erosion of the desired program impacts.

A variety of other policies have been used to incite a decrease in consumption in the population. The National Institutes of Health (NIH) has over the past 15 years periodically documented the legislative actions taken towards tobacco control at a state and local level (NIH, 1993). In a recent monograph, the NIH and the National Cancer Institute (NCI, 2000) provided a matrix by state and local region of all the legislation nationwide that has been passed to in the effort to decrease the use of cigarettes. The Institute notes that in the late 1980s through the mid-1990s the number of smoking-related local ordinances passed per year increased rapidly. Between 1985 and 1995, the number of communities enacting local tobacco control legislation averaged between 50 and 175 per annum. This compares with an average of below twenty per year prior to 1982.

Table 2.1-1 Regulations in Select States and Local Regions

Locale		Year		WorkPlace	% With Smokefree	
		Enacted	Amended	Restriction	WorkPlace	
					Overall	Never
California		1976	1994	Total	58.40%	59.40%
	LA	1984	1993	Partial		
Florida		1985	1992	Partial	53.60%	55.80%
Illinois		1961	1995	Partial	40.00%	42.80%
	Chicago	1988	1993	Partial		
New York		1989	1994	Partial	42.70%	44.50%
	NY City	1988	1994	Partial		

The NCI classifies the regulations into four types: clean indoor air ordinances, youth access regulations, tobacco advertising laws, and tobacco product promotion

regulations. The NCI (2000) reports that as of the date of the monograph there were over 800 clean indoor air ordinances in place across the United States. California had most local ordinances in place out of all the states. California had over 280 ordinances. Massachusetts had the second largest number with over 120 clean indoor air ordinances passed.

The table above gives information from the NCI monograph about select regions that are used in the current study. The date the first clean air smoking-related ordinance was enacted was published only for states. According to the NCI, Illinois enacted legislation very early. Most regions listed here (and a majority in the U.S.) have only partial restrictions on smoking indoors. The indoor smoking restrictions typically are classified as applying to workplaces, restaurants, bars or other public buildings. Partial restrictions imply that only a portion of the building is non-smoking. In the case of restaurants and bars partial restrictions mean that the business must provided a smoke-free seating area for patrons.

We have provided information on workplace restrictions above. The information on the percent of individuals with workplace restrictions was developed by the NCI from the Current Population Survey administrated by the federal Bureau of Census. The figures are based on responses by individuals in the survey to questions about smoking restrictions in place at their workplace. Although Illinois enacted legislation well before the other states, the overall, that state shows a low rate of reported workplace restrictions.

Jacobsen, Wasserman and Anderson (1997) discuss the history of tobacco control legislation. As does the NCI, the authors note that there has been an increase in the state and local tobacco control legislation being enacted in the past fifteen to twenty years. The NCI (2000) and Jacobsen, Wasserman and Anderson (1997) both agree that local legislation typically is more stringent than state and federal legislation. However, both also note that there is a trend towards preemption by federal and state regulatory bodies in the enactment of new laws. Preemption in a state or federal limits the ability for a local agency to enact legislation that is stricter than the state (or federal) law. Preemption also sometimes prevents new legislation from being enacted. The trend toward preemption may slow the growth in local regulation in the future.

Prior to the growth in local regulation, the federal government was the major force in the tobacco control movement. The release of Surgeon General's 1964 Report initiated a series of federal regulations related to smoking.

Table 2.1-2 Federal Milestones in Tobacco Regulation

Year	Regulation	Legislative Intent
1965	Cigarette Labeling and Advertising Act	Require warning labels
1967	FCC "fairness doctrine" ruling	Require equal media time
1969	Public Health Cigarette Smoking Act	Ban on all media ads
1972	Manufacturers agree to add warnings to ads	
1984	Comprehensive Smoking Education Act	Rotate warnings
1986	Comprehensive Smokeless Tobacco Health Education Act	Warnings on smokeless tobacco
1989	Congressional ban of smoking on airline flights	
1992	Synar Amendment	Allocations of grant monies
1994	Pro Children Act	Smoking restrictions in schools
1995	Synar Amendment	In effect for all states

Table 2.1-2 above shows the timeline over some major regulations passed by the federal government. Much of the legislation promulgated by the federal government has been in response to the health risks identified in the Surgeon General's report. The intention behind many of laws is clearly to inform the consumer of the risks of smoking.

There has been some debate over whether consumers make use of the information from the various sources provided under the law. Hamermesh and Hamermesh (1983) found that cognition of the risks associated with smoking varied across ages. In a study of males only, Hamermesh and Hamermesh found that men over 40 were less likely to accurately perceive the risks associated with smoking relative to younger men. Overall, however, Hamermesh and Hamermesh found that anti-smoking information campaigns did change people's perceptions of risk. In a recent study in Australia, Borland (1997) found that health warnings on cigarette packages had an effect on the perception of risk and also on behavior. In the study smokers exposed to the warnings were almost twice as likely to attempt to abstain as the control population.

A number of recent studies of examined the effect of advertising as a source of information (positive and negative) about the health risk associated with smoking. Jacobsen, Wasserman and Anderson (1997) note that an early anti-smoking campaign resulted from the 1967 Fairness doctrine ruling. As a consequence the major broadcasting networks were required to provide airtime for anti-smoking ads equal to the time purchased by the tobacco industry. Over 1300 anti-smoking advertisements were placed within two year span under the Fairness doctrine ruling. Jacobsen, Wasserman and Anderson note that the anti-smoking advertisements were short-lived because in 1969 the

federal Public Health Cigarette Smoking Act was passed. The act preempted the ruling the ads ceased. Hamilton (1971) notes that the effect of passing the Public Health Cigarette Smoking Act may have been to inadvertently increase consumption. He measured the elasticities of response to advertising. He found that the anti-smoking ads had a greater effect as a source of information about risks than the promotional advertisements by the tobacco industry had in stimulating demand.

Davis (1987) found that the tobacco industry shifted their expenditure on advertising to other media – mainly print media. He notes that from 1974 to 1984 the real dollar increase in advertising increased by threefold. He found that when all products and services were ranked nationally by expenditure, cigarette advertising was the second highest advertising expenditure in magazines and third highest in newspapers. Pucci and Siegel (1999) studied youth exposure to print advertising of tobacco products during the period between 1980 and 1993. They found that the tobacco industry has shifted its marketing to target the youth population. They found that the proportion of promotional advertising appearing in youth magazines rose from 7% in 1980 to nearly 100% in 1987.

The tobacco control movement has responded to these shifts. Massachusetts has implemented advertising campaigns to promote health awareness. Kozlowski et al. (2000) reports on a campaign to counter-market "light" cigarettes. The authors found that the campaign was successful in helping individuals form proper beliefs about the dangers of smoking light cigarettes. In a pair of papers, Flynn et al. (1992, 1994) studied the use of mass media in the northeastern United States to inform middle school children about the hazards of smoking. The two studies found that carefully constructed media

campaigns can be successful in preventing cigarette smoking particularly in high-risk youths.

2.1.3 Initiation and Cessation

In the last section, we discussed the effectiveness of advertising and counter-advertising in changing the smoker's perceptions and behaviors. In the current section, we will review the research on smoking uptake and cessation. We will also consider the literature on the regular smokers.

We noted in the last section that the tobacco industry has shifted its focus towards promotion of its products to the youth. Unger and Chen (1999) examine the role of social networks in smoking uptake. The authors used data from over 10000 California adolescents to estimate the correlates of smoking initiation using a proportional hazards model. They found that individuals were more at risk of smoking if they had friends who smoked or if they had a favorite cigarette ad. The risk of smoking onset was greater for those that had a favorite ad than those who had a parent who smoked although the risk of onset with a parent who smoked was still higher than average. African-Americans, Asians, and Hispanics were all at lower risk of onset than whites. Females were at a lower risk than males.

Patton et al. (1998) performed a longitudinal study of students in Australia. They followed students over a period of three years. The authors found parental smoking and divorce were both found to be strongly predictive of smoking onset. Parental smoking was found to be predictive of later daily use. The authors observed high rates of short-

term abstinence in both daily smokers and occasional smokers. However, 70% of daily smokers relapsed within one year.

Similar to Unger and Chen, Patton et al. found gender differences in their study. The differences, however, were not in rates of onset but rather females found to be less likely cease and more likely to relapse than males. Parental smoking was a very strong predictor of relapse. Those individuals with a parent who smoked were almost at five times as much risk of relapse as those without a smoking parent.

In a study on the determinants of the onset of smoking, Anda et al. (1999) found that adverse experiences in childhood were strong predictors of future tobacco use. The authors cite the long-term use of nicotine as a type of self-medication. The authors consider eight types of experiences ranging from sexual abuse to divorce. A total of 9215 adults were participants in the study. The prevalence among the participants of having at least of one the eight adverse experiences was 63 percent. The individuals in the study with at least five of the experiences in their history had 3 times the odds of ever smoking when compared to those individuals reporting no adverse experiences.

Parrot (1995) directly studied the use of cigarettes as self-medication. He examined the use of the cigarettes to control stress levels throughout the day. Parrot found that smokers exhibited a decrease in feelings of anxiety and stress shortly after smoking. He notes however, that relative to the average individual, a significant class of smokers reported above average stress levels prior to smoking. For this class of individuals, post-smoking stress levels were only average rather than below average.

Lewinsohn, Rohde and Brown (1999) studied the relationship between adolescent smoking and future substance abuse. They followed a cohort of students from high school to age 24. Three interviews were held with the students: one in high school, one just following graduation and one at age 24. Information was gathered in each interview about the type and use of substances. The authors found that adolescent smoking was a predictor of future use of marijuana and other illicit drugs in adulthood. However, maintenance of cessation of smoking for over 12 months significantly reduced the risk of illicit drug use during adulthood. They note that further research needs to be done to determine the causal relationships.

In a recent article, Hughes, Cummings and Hyland (1999) reported on the ability of smokers to reduce and maintain a reduction in consumption. They hypothesized that maintenance of the reduction was a predictor of lower risk of future smoking. They note that the study of reduction in consumption – versus a choice of abstinence – is relevant given the dynamics within the U.S. population. The authors observe that the cessation rate in the population increased steadily from 1960 to 1990. From 1990 to 1995, the cessation rate leveled off which has prompted researchers in health policy to consider new alternatives in the effort to decrease overall cigarette use in the population.

Hughes, Cummings and Hyland and found that the individuals in their sample were able decrease consumption and maintain the reduction. The mean number of cigarettes reduced per day was 7.5. They note that this reduction is substantial and that the result suggests a new opportunity for health policy.

Gilpin, Cavin and Pierce (1997) studied occasional smokers. For their study, they define the occasional smoker as an individual whom does not smoke every day. They exclude even those individuals who smoke only a few cigarettes per day. They hypothesized that occasional smoking could be a stable long-term behavior. The authors found evidence to support their hypothesis. They also found that occasional smokers tend to be less likely to be concerned with the price of cigarettes than regular smokers. They also are more likely to have abstained for one year or more than other smokers.

Madden and Bickel (1999) studied the relationship between price and consumption in a controlled experiment. The experiment allowed participants (all self-reported smokers) to purchase puffs from cigarettes over the course of several 3 hours sessions. Money could be earned in the sessions to buy puffs. The money could also be saved. The participants as earnings could keep all unspent earned dollars from the experiment. The results showed that there was a significant price effect on the demand for puffs. The effect was more pronounced when the subjects were required to maintain abstinence for several hours before each session. The resulting price elasticities ranged from a low of –0.10 to high of –2.90 depending on the price and the time since abstinence.

In the current study, we incorporate the results from Gilpin, Cavin and Pierce. Our empirical model allows for three classes of individuals: non-smokers, occasional smokers and daily smokers given that occasional smoking is found to be a stable pattern of behavior. We motivate a model in our study presented on the next chapter based on the findings of Anda et al. We also incorporate the findings of Lewisohn, Rohde and Brown

in our selection of data on the use other substances including marijuana. Unfortunately, we did not have information on parental smoking behaviors as per Patton et al. (1998). We consider the available data for our study in Chapter 4.

2.2 Models of Cigarette Consumption

In the next three sections we review the various models of addictions proposed both by psychologists and by economists. We look in detail at several models. We review the conceptual model of alcoholism proposed by Gregory Bateson. We consider his ideas in the context of the microeconomic model of choice in order to motivate our model presented in the next chapter.

2.2.1 Models from Psychology

The volume of literature from psychology on addictions is vast. Imhof, Hirsch and Terenzi (1983) note that, as of 1980, they had identified over 43 distinct theories of substance abuse and over 1300 *major* research studies. We contain ourselves here to research applicable to our topic of addictive cigarette use. It is a premise of this paper that regular tobacco use in addicting in nearly all cases. Furthermore, we observe that relapse often occurs after a long period of abstinence – well after the pharmacological effects of nicotine is gone. This observation motivates a focus on the psychodynamic[1] determinants of cigarette addiction. Consequently, we will not consider the literature the

[1] Merriam-Webster's Collegiate Dictionary (1996) defines psychodynamics as "the psychology of mental or emotional ... processes developing especially in early childhood and their effects on behavior [...]."

psychopharmacology of nicotine dependence. Rather, we will review the psychodynamic theories of substance abuse of several authors as they relate to our study.

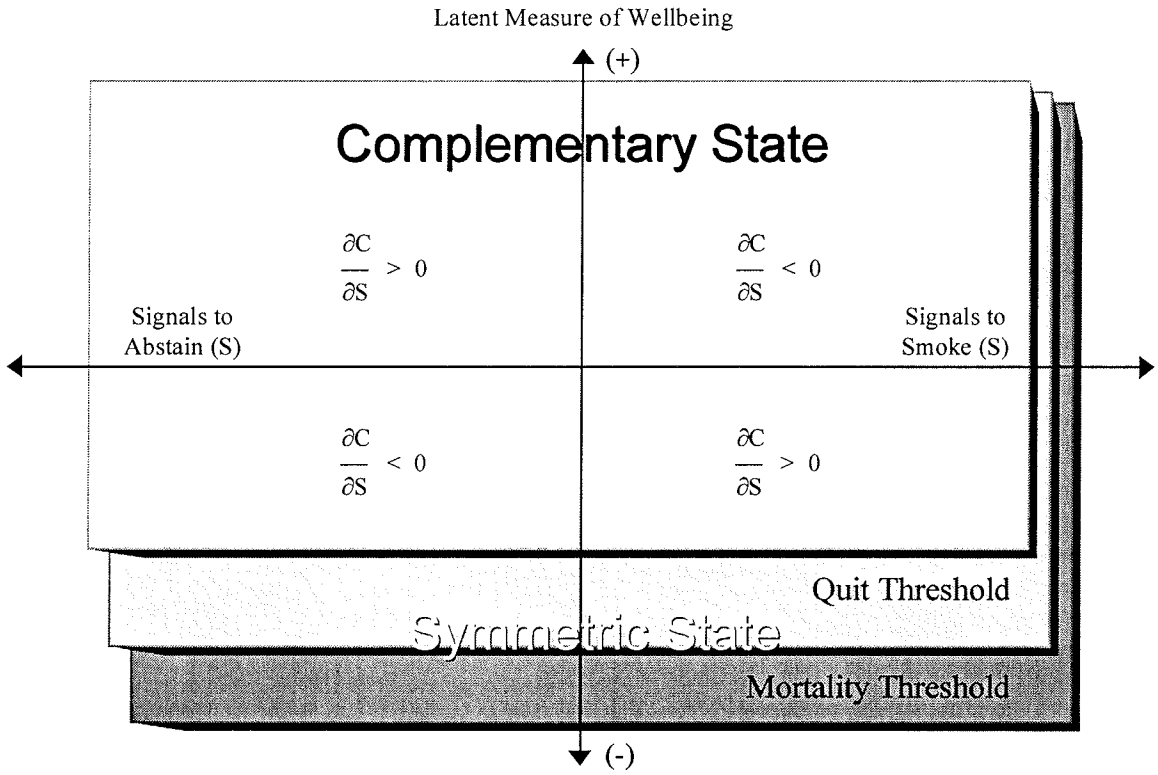
2.2.1.1 Bateson's Theory of Alcoholism

It is helpful to review here certain aspects of Bateson's theory introduced in the first chapter. Bateson (1987) proposed a theory that explained alcoholic behavior as a system of beliefs that lead evidently to destructive behavior. He argues that alcoholism is characterized by a dual system of actors and psychological states. The belief of the drinker is that it himself against the "bottle." The underlying psychological issue is that the alcoholic experiences the addiction as somehow outside himself. The "bottle" itself is a psychological construct – an unconscious amalgam – that may be "totally imaginary or gross distortions" of the people in alcoholic's life. The bottle and the addict represent the two actors in the system as understood, likely in an unconscious way, by the alcoholic.

It is important to emphasize that the alcoholic may not even realize that he or she is engaging in such a system of beliefs. The alcoholic simply experiences the lack of temperance and moderation in his or her drinking practices as the fault of an outside agent, which is in this case the fictitious "bottle".

Bateson proposes that the system, alcoholic—bottle, can be in two states, symmetric or complementary. The symmetric state is characterized as a struggle for control over the bottle. Success in the struggle is looked for externally. Information from the spouse, or perhaps more serious cases, the legal authorities, provides indications of success.

Figure 2.2-1 Symmetry, Complementarity and Consumption



The responsiveness of the addict to information from others will depend on the state of the system. We illustrate the directions of response in Figure 2.2-1 above for the case of cigarette smokers. We are generally interested in behavior that falls in the region to the left of the vertical axis. Behavior in the region to the right typically only occurs in rare instances. An example might be the case cited by Bateson where a member of Alcoholics Anonymous (AA) might tell a new member to "go out and have a few drinks, try to stop abruptly, and then you'll see if you really are in control of bottle".

Bateson characterizes this relationship with the "bottle" as the symmetrical struggle. In the symmetric state, the addict, alcoholic or smoker, will attempt to control his or her consumption level. The symmetric state is characterized by the addict's attempt to control the drug and success is measured by actual abstention, and/or by signals from others, that the addict is in control of the addiction, e.g. the "bottle". Bateson observes:

> *"It will be noted that the possible existence [of such behavior], which will cause a runaway in the direction of increasing discomfort up to some threshold (which might be on the other side of death), is not included in conventional theories [...]. [p. 328]*
>
> *The alcoholic works on the discomforts of sobriety to a threshold point at which he has bankrupted the epistemology of 'self-control.' He then gets drunk because the [bottle] is bigger than he is – and he may as well surrender to it. [p. 330]"*

We will later motivate our analytical and empirical model directly from these observations. In particular, we will operationalize our empirical model with reference to the concept of discomfort as a latent variable. The thresholds become intercept terms in the model. We will discuss the empirical model in depth in Chapter 3.

The transition in the above example is a transition from the symmetric to the complementary state. Bateson notes that in some cases the surrender is spiteful rather than passive. Clearly the opposite behavior holds in the complementary state. In the complementary state the alcoholic has given up all pretenses of abstention. The alcoholic pays little heed to attempts to get him to abstain. Moreover, if the transition is spiteful the

reaction may be adverse. An adverse reaction gives the sign of response as positive. We see this in the figure.

We reemphasize that the addict may not consciously consider all these reactions. Bateson notes:

> *"Alcoholics may appear stiff-necked, but they are not stupid. The part of the mind in which their policy is decided certainly lies too deep for the word "stupidity" to be applicable... [p. 326]"*

Clearly some motivations for the alcoholic's choices lie in the unconscious. Let us look at an example. Suppose that the alcoholic is married and that he or she has been arguing a great deal with the spouse and the arguments are lessening the quality of the marriage. We may why the alcoholic simply doesn't incorporate the knowledge about his or her own pattern of behavior and form an consumption optimal plan conditional on that knowledge? Such a choice would be consistent with the rational expectations hypothesis in the economics literature.

An explanation can be had for this failing in the definition of addictive behavior provided by Schaef (1987). Schaef states that a major characteristic of addictive behavior is that called *denial*. She defines denial as that condition which "allows [the addict] ... to avoid coming to terms with what is really going on inside [p.67]" and therefore it is unlikely that addicts are aware of the extent to which their decision process is dependent on unconscious determinants. A related concept is that of cognitive dissonance. Cognitive dissonance is a state of psychological conflict resulting from disparate beliefs and attitudes held simultaneously. The effect of the dissonance may be to negate the value

information that is not pleasant. An example in the case of an alcoholic would be as follows. Upon hearing from a doctor that their health was being affected adversely by drinking, the alcoholic might respond with a statement such as "my father drank until he was 95 so I am going to fine."

Economically, denial amounts to an unconscious self-imposed filter of information about behavior. Viscusi (1992) refers to such behavior in smokers as cognitively limited. Akerloff and Dickens (1982) provide an example of the use of cognitive dissonance to motivate a model of labor decisions in hazardous industries. To date we know of no economic research that has used the dynamics in Bateson's model to explain economic behavior. Moreover, we know of no economic research on addictions, other than that of Akerloff and Dickens (1982), that explicitly considers the unconscious determinants of behavior.

Bateson's theory significant inasmuch as it became a foundation for an entire branch of psychotherapy. Guerin and Chabot (1997) provide a review of the development of family systems theory and discuss Bateson's contribution to the formation of that body of theory.

2.2.1.2 Contemporary Psychoanalytic Theories of Addiction

Morgenstern and Leeds (1993) provide an excellent review of four modern psychoanalytic theories of substance abuse. We draw from the review to motivate the model in this study. Particularly, several of the theories place emphasis on the effect of trauma in childhood. This is consistent with the findings of Anda et al. (1999) mentioned

earlier. We discuss the relevance of these findings to our economic model in the next chapter.

Morgenstern and Leeds review the work of four authors: Henry Krystal, Joyce McDougall, Leon Wurmser and Edward Khantzian. Morgenstern comments that all describe the use of drugs as a substitute for "missing intrapsychic functions." All the theorists note that substance users have challenges with affect tolerance and regulation. By this we mean that users have difficulty coping with their moods and emotions.

According to the two authors, Leon Wurmser says that internal conflict explains the onset of substance abuse and resolution of the conflict will cure the misuse. Wurmser states that the internal crisis for substance abusers is due to "the harshness of the superego, and use of the substance results from a temporary overthrow of this internal authority." This observation is similar to Bateson (1987) who notes that the complementary surrender (i.e., having a drink) is often seen by the alcoholic as an act of spite against the "bottle."

Wurmser identifies actual trauma as the source of the pattern of substance abuse. Morgenstern and Leeds (1993) comment that Wurmser points to exposure to real aggression and possible parental intrusiveness as the determinant of substance abuse.

Morgenstern and Leeds note that Henry Krystal also points to trauma as a major factor in the etiology of substance abuse. Krystal emphasizes infant trauma and also exposure to rage and aggression. Especially relevant our study, Morgenstern and Leeds cite Krystal as noting that poor tolerance for feelings and emotions results from an

underlying fear of the return of the prior trauma. We use this observation to motivate our analytic model presented in the next chapter.

Krystal also suggests that the poor tolerance can be for either pleasant or unpleasant feelings. This is similar to Wurmser who postulates that the substance user meets anything good (or any success) with suspicion.

Khantzian emphasizes self-medication as a factor in the substance use. He feels that addicts are not trying to damage themselves or are seek pleasure. The addict is rather using the substance as a means to fulfilling some under- or un-developed self-care skills. Khantzian is the only one of the four theorists who proposes that the particular drug used is chosen to meet the specific needs of the under-developed self-care and self-worth traits.

The final author reviewed by Morgenstern and Leeds, Joyce McDougall, proposes that substance abuse is tool that aids the user from the excess of feelings that the drug users experience. Essentially drug use acts as a moderating mechanism for too much affect. McDougall also considers behaviors as addictions rather than substances. She offers a broad view of what constitutes an addiction.

A second excellent reference on psychoanalytic models of substance abuse is Daniel Yasilove (1997). Yasilove present a historical review of major papers on addictions from Freud to Khantzian. Khantzian (1985), Krystal, and Wurmser all have papers presented in the volume.

2.2.2 Models from Economics

In recent years, there has been a growing interest by economists in addictive choice. Addictive behavior appears inconsistent with simple microeconomic models of consumer behavior. In the 1950s and 1960s, addictive choice was typically studied with models of habit formation. Current economic research has investigated addictive choice using the rational expectations hypothesis. A great deal of the literature has focused on the consumption of cigarettes. This appears to be driven by the well-defined market for the cigarettes and the heightened social concern of costs of addiction.

2.2.2.1 The 'Rational Addictions' Model

In the economics literature on addictions, a significant portion of the recent papers follows Stigler and Becker (1977). They discuss a model of household production. Consumers actively produce their own commodity objects of choice using market goods as inputs. In their exposition, they consider some consumer allocation problems that previously were modeled only through *ad hoc* schemes of preference changes. One example that they discuss is addictions. The introduction of household production functions in conjunction with the existence of commodity-specific consumption capital allows them to construct dynamic maximization problems that exhibit stylized characteristics suggestive of addiction. Such characteristics include increased consumption over time even in the presence of stable prices. All of this is developed within the context of a lifetime utility maximization problem. Relevant to present study,

Stigler and Becker's framework is one in which consumers maximize the discounted value of all present and future utility in each period.

Table 2.2-1 Some Milestones in the Economics Literature on Addictions

Date	Authors	Subject
1933	Schoenberg	1st Demand estimate for cigarettes
1966	Houthakker and Taylor	Pioneer habit formation (myopic model)
1977	Stigler and Becker	Propose rational addiction model
1981	Spinnewyn	Equivalence between rational addiction and myopic
1988	Becker and Murphy	Formalize rational addiction model

Becker and Murphy (1988) refine the ideas in Stigler and Becker's paper. In particular, they focus exclusively on a theory of addictions. They state that the foundation of their analysis is the concept of *adjacent complementarity*: They note that, "a person is *potentially* addicted to [a good] if an increase in his current consumption of [that good] increases his future consumption of [that good]. [p.681][2]" This condition occurs if and only if the consumer's consumption behavior exhibits adjacent complementarity. The condition under which adjacent complementarity holds depends not only on the marginal effect of past consumption on present consumption but also the individual's rate of time preference and her depreciation of her existing consumption capital. Their condition shows that a greater the time preference for current consumption, a smaller the rate of capital depreciation, and a greater marginal effect of past consumption on current

[2] We have added italics to for emphasis.

consumption will all work to increase the potential for addiction. Also noteworthy in their analysis is the conclusion that the degree of addiction as given in the adjacent complementarity condition applies equally to harmful and beneficial addictions. Since the complementarity condition depends only on second partial derivatives, whereas the distinction between harmful and beneficial depends only on first partial derivatives of the maximization problem, their conclusion holds.

Their theory gives explanations of the addictive binges and cold turkey withdrawal, unstable steady state consumption paths, and how temporary events can trigger permanent addictions.

Following Becker and Murphy (1988), Dockner and Feichtinger (1993) determine the conditions under which cyclical steady states of consumption will occur. They show that a necessary condition for consumption cycles is expansion of the maximization problem to at least two goods and the existence of externalities in the consumption capital. Dockner and Feichtinger follow the prior two papers in considering addictions in continuous time.

Other papers in this tradition consider discrete-time cases. Boyer (1983) develops the adjacent complementarity condition discussed in Becker and Murphy. Becker, Grossman, and Murphy (1994) develop an empirical model of cigarette addiction. In related papers, Michaels (1988) examines a reformulation of the household production model referenced in Stigler and Becker (1977) but only considers a comparative static analysis.

The literature following Stigler and Becker seems to be the most well developed addiction theory in terms of the familiar utility maximization precepts. This makes attractive for use in a general equilibrium context such as that proposed in the current study. Becker, Grossman, and Murphy (1994) note that single-period models do not give dynamics appropriate to modeling addictive behavior

Note, we have not considered in this discussion the significant body of literature on habit formation. The analytical model we develop below uses forward-looking consumers and the empirical model used in this study only considers current period consumption. Hence the habit formation literature is not immediately applicable. Phlips (1983) provides an introduction to the habit formation literature. Chaloupka (1998) gives a review of economic applications to cigarette smoking with a focus on the rational expectations model.

2.2.2.2 Other Economic Theories of Addiction

A variety of theoretical alternatives to the rational addictions approach exist in the economics literature. Many of these alternatives draw from research in the fields of psychology and psychopharmacology. We discuss a paper by Earl (1990) that provides a survey of the research completed in the field of psychology that is relevant to economics in general. Other models by economists are discussed below.

Earl (1990) suggests that economists can learn from recent results from research in psychology. Relevant to our current study, the author notes that psychologists have found that people do not seem to behave consistently with the von Neumann/Morgenstern

axioms of rationality. The author cites Frey and Eichenberger who note that individuals exhibit availability bias, opportunity cost effects, and certainty effects. Availability bias is when an individual overweighs recent and spectacular events. Opportunity cost effects occur when an individual weighs out-of-pocket costs more than opportunity costs of the same magnitude. Certainty effects occur when an individual weighs certain outcomes more than uncertain ones with known expected utilities. The latter is simply the definition of a risk-adverse individual.

Earl (1990) cites Kelly (1955) who suggested that people behave as though they are intent on trying to control and predict events. People will not engage in a new activity if they see a high likelihood of failure or if it means a loss from another significant activity. Guilt is defined by Kelly as "a person's realization that she is acting in a way that she is not the person she thought she was." We find later that our model exhibits behavior where the actual consumption does not match the normative level of consumption. We do not currently incorporate guilt into the model but Kelly's observations could motivate such a refinement.

Earl also cites the work of Festinger (1957) on cognitive dissonance where Festinger defines cognitive dissonance as "the existence of non-fitting relations among cognitions." Festinger proposes that people act to reduce or avoid dissonance. Earl observes that Akerloff and Dickens (1982) have incorporated Festinger's theories into their model of labor decisions mentioned previously.

Taylor (1988) and Saldanha and Lancry (1991) consider models based on Psychological Opponent Process Theory (POPT). Taylor (1988) cites Solomon and Corbit (1974) as a seminal paper in the development of POPT. POPT postulates the existence of two separate psychological processes that occur within all individuals. One process positively affects moods whereas the other does the opposite. All experiences are filtered through these two separate processes and the utility of the experience will depend on some interaction of the two processes. Taylor notes that a goal of his paper is to introduce time into the decision process in an explicit fashion consistent with psychological theory. POPT is relevant to his goal in that it is a dynamical theory of mood. Taylor incorporates aspects of POPT within a framework of utility maximization.

Saldanha and Lancry (1991) examine myopia and abstinence in a model also based on POPT. They exclude rational optimization of the sort explored by Taylor (1986) and consider the impact of myopic choice on consumption. Their model exhibits such solutions as abstention even when the optimal policy would give positive surplus, and lost surplus due to under-consumption.

Marvel and Hartmann (1986) propose a model based on the psychological trait of hypomania. The authors propose a theory they term "economic" due to resource balance aspects of the model they develop. The model proposes that states of high wellbeing entail a cost to the physiology. This cost is exacted from the individual in a succeeding low/depressive state. The model proposed a homeostatic process in mood dynamics for healthy individuals. For addicts, the process is not homeostatic but rather decreasing.

Barthold and Hochman (1988) consider a consumer with concavities in her indifference maps. The authors comment that question of whether addictive behavior is rational (consistent with self-interest) is irrelevant. They postulate that, for addicts, indifference curves are concave for at least portion of the utility map. The concavity leads to corner solutions to the choice problem and hence the nomenclature of "extreme seekers." The authors motivate concavity with by discerning between compulsivity, a short-term all-or-nothing behavior, and addiction, a long-term pattern of repeated use.

Suranovic, Goldfarb and Leonard (1999) present a model where the agent is "boundedly rational". By this, they mean that the agent chooses how much to consume today but do not attempt to maximize a lifetime utility problem. The agent does however consider the marginal effect of today's choice on the future. The model developed by the authors explicitly considers three sources of utility (disutility): current consumption, future losses, and an adjustment cost. The adjustment costs are directly the negative utility experienced during withdrawal if the addict chooses to abstain. The authors attempt to operationalize the adjustment costs in a fashion consistent with the physiology of detoxification. The model explains several behaviors not exhibited or explained by the model of Becker and Murphy (1988). One interesting result of the Suranovic, Goldfarb and Leonard's model is that older smokers are less likely to quit not because of the addiction being "stronger", as in Becker and Murphy's model, but because of the structure of expected future losses.

Jones (1999) expands on the paper by Suranovic, Goldfarb and Leonard (1999). Jones notes that the adjustment cost approach taken by Suranovic, Goldfarb and Leonard

may be considered in the context of prior research on adjustment costs. Jones proposes a modified adjustment cost function and outlines a research program for further investigation of the adjustment cost approach.

Cameron (2000) discusses the relevance of "scripts", psychopharmacology, and cognitive dissonance to addictions. He defines scripts as complementary bundles of goods and contexts for consumption. An example of a script might be having a drink and a cigarette at the local pub. The cigarette is the good and the bar is the context. The author notes that scripts and the psychopharmacological aspects of addiction are not substitutes for one another. He also comments that the Stigler and Becker (1977) rational addictions approach is stock of habits approach where the stock is a called consumption capital. Cameron suggests this approach is a black box approach. The author models the demand for cigarettes as a demand for delivery of a chemical "high": the model explicitly defines the delivery mechanism. The model also accounts for changes in nicotine content in the commodity.

The models presented here all presume full knowledge by the consumer of their own preferences. Additionally, many of the models assume full information and perfect foresight so that the consumer is able to maximize a forward-looking utility function. Exceptions to the latter include the works of Suranovic et al., Jones, Saldanha and Lancry, and Akerloff and Dickens. Becker and Murphy (1988) also assumed stability in time preferences in the rational addictions model. Brentville-Jensen (1999) researched this assumption and found that, although both past and present drug users tended to have

higher discount rates than individuals that have never used drugs, there were sizable differences in the rates exhibited between current and past users.

To our knowledge, none of the models presented here question the possibility that cognitive limitations in addicts are severe enough to cause misapprehension of preferences. We have seen previously that, at least in the case of substance abusers, the assumption of full information, and even that of full awareness of preferences, is not strongly consistent with the theories and findings in the psychology literature. Our model presented in the next chapter examines a simple case where the individual is not conscious of his or her full preferences and incorrectly allocates consumption as a consequence.

2.2.3 The Estimation of Models of Cigarette Demand

2.2.3.1 A Review of the Literature

Cameron (1998) notes, in a comprehensive review of the literature, that economists since Schoenberg (1933) have estimated demand for tobacco products. Cameron reviewed nearly fifty papers on the topic. He classified the papers into static and dynamic studies of demand. About half of the papers Cameron reviewed fell into each group.

Cameron provides a matrix of results for the elasticity estimates in the papers. The values vary significantly over the studies. Cameron reports own-price elasticities (in absolute value) as large as 1.22 (Schneider et al., 1981) and as low as 0.10 (Stavrinos, 1987). However, Cameron summarizes the findings and notes that there exists a clear

negative relationship between demand and prices observed across all of the studies. Upon review of the matrix we find no apparent difference between the elasticities reported in the dynamic studies versus the static studies. Several studies found zero or insignificant price effects. Cameron cites one study (Tegene, 1991) where the own-price elasticity is shown to have decayed from 0.66 in 1956 to 0.15 in 1985.

Cameron classifies the types of information affecting demand for cigarettes that were studied in the literature. He reports four general classes: health scares, advertising, counter-advertising and media bans. As many as half of the studies considered in his review report the effects of health scares. Health scares in the literature are defined as periods where the public awareness of the hazards of has been manipulated through use of educational campaigns and media interventions. Cameron comments on health scares noting that, in general, the studies show scares to have some effect on consumption but it is of limited duration. Perhaps one third focused on the effects of advertising and counter-advertising. Broadcasting bans are shown to have significant negative effects on consumption although only a few reported results on the effects of bans. Six studies all showed anti-smoking ordinances to have a significant negative effect.

Cameron also comments on the econometric problems experienced in the estimation of demand. He notes that most studies used single equation methods that ignored simultaneity. Moreover, most studies suffer from misspecification in the form of low Durbin-Watson statistics. These observations must be considered in light of the fact that, to date, the majority of cigarette demand studies have been on aggregate time-series consumption data. Cameron reports on five exceptions to this pattern: Lewitt and Coate

(1976), a report on the UK National Health Interview Study (date not cited by Cameron), Wasserman et al. (1991), Chaloupka (1991, 1992) and Labeaga (1993). We are aware of several other studies that use individual level data. These are Labeaga (1999), Chaloupka and Weschler (1997), Yen (1999), Jones (1989), and Mullahy (1985, 1997a, 1997b). We discuss these studies in more detail below.

Cameron notes that Houthakker and Taylor (1966) pioneered the empirical work on habit formation in consumption. A version of their model (with the depreciation rate set to 100%) has been estimated as the "partial adjustment" model by a number of the authors discussed in his review. He states that the theory of rational addiction with respect to cigarettes begins with Becker and Murphy in 1988. Cameron quotes Becker who states that the partial adjustment model is nested in the rational model. Becker and Murphy, and a other authors using the rational addictions model, obtain implausible discount rates as results. Cameron notes that several studies of the model also give insignificant lead consumption terms – the very terms that define the model.

2.2.3.2 Relevant Empirical Models

Jones (1989) estimated a double-hurdle model for cigarette consumption with cross-sectional data. His article forms a basis for the empirical model that we specify in the next chapter. He specifies the hurdles as initial hurdle for the choice to smoke and a second hurdle for a later choice to quit conditional on previously smoking. We follow Jones and refer to the initial hurdle equation as the participation equation. The third

equation in Jones model was one for the level of consumption itself. We simply refer to this equation as the consumption equation.

Jones used a probit model for the hurdles and OLS for consumption. We provide an alternative specification given differences in the data used in our estimation. Jones observed consumption as dollar expenditures. He used the UK General Household Survey as the data source for his empirical work. He derives a very general form of the likelihood for the model. He estimates various models that derive from the general model under different assumptions about the nature of statistical dependence between the hurdles and the consumption equation. He finds that the most restrictive model – one where the equations are fully separable in the parameters in the likelihood – may be a reasonable model to estimate relative to the more complex models. He refers to this model as the complete dominance model. We the result to justify our empirical model.

Jones found that the perceived risks of smoking and the level of education influence participation but not consumption. Notable for our study, Jones finds that the indicator of self-reported health was not shown to be significant in either the full sample or the sub-sample of those who smoked. We suggest that the relationship may be better explained under the model we consider here. In Chapter 4, we present results that show an indicator of problems associated with cigarettes – problems that can include health problems – is strongly related to consumption.

Jones also finds that indicators of health attitudes about smoking are predictive of the risk of participation. The indicators show a negative effect on the choice to

participate. He finds that the indicators of attitude about the risk of smoking have a less clear effect on consumption. Both of these results are consistent with the results in our analysis.

Chaloupka and Weschler (1997) estimate student consumption of cigarettes using a two step procedure with an ordered probit and a pseudo-continuous measure of cigarettes consumed. The data they analyzed was cross-sectional. The authors cite several studies that suggest that youth and young adult smokers exhibit higher elasticities with respect to price as a motivation for their study.

The data for their study was from the 1993 Harvard College Alcohol Study. The survey data for our study is cross-sectional count data for consumption of cigarettes. Chaloupka and Weschler derived two dependent variables from the survey data: a categorical indicator of non-smokers, light smokers, moderate smokers and heavy smokers, and, a pseudo-continuous measure of number of cigarettes smoked daily. They used data from the NIH (1993) to construct independent variables reflecting the state cigarette legislation in force for the individual survey respondent. An ordered probit model was used to estimate the first dependent variable. OLS was used to estimate the pseudo-continuous demands.

Chaloupka and Weschler find that youths are more sensitive to price changes. We investigate such sensitivity through use of a variable that indicates student status. Our results are consistent with the Chaloupka's and Weschler's findings. We do not however utilize their choice of models. We suggest that since the data is reported as count

information, a proper model specification would be count data model. We have data to Chaloupka and Weschler for our study and we use a count data model in our estimates of consumption.

Labeaga (1999) uses a double-hurdle approach with panel information. His study is one of only a few to estimate in panel data. We consider his results for purposes of comparison and in light of his use of a hurdle equation in the model specification. The consumption measure that Labeaga estimates is continuous but does account for censoring. His model is also one of a few that explicitly corrects for censoring. The data he uses is from the Spanish Permanent Survey of Income.

Labeaga's results conflict somewhat from the results that Jones (1989) reported. Labeaga finds that Jones' complete dominance model is rejected as the proper model specification. He chooses a model with participation accounted for by a Tobit-type estimator. He estimates both a myopic model and a rational addiction model. Notably, price enters neither model as significant. Nevertheless, he calculates several price elasticities and finds that they average a value of about -0.35.

Yen (1999) also estimates a hurdle model; however, he uses a negative binomial distribution for estimation of the consumption equation. Yen estimates the joint likelihood of participation and consumption. He uses pooled cross-sectional data from the Continuing Survey of Food Intakes administered by the US Department of Agriculture. The dependent variable for consumption is reported as the number of cigarettes smoked per day from a sample of women ages 18 and older. His results show that African-

Americans and Hispanics have both a lower probability of participation and a lower level of consumption. Regional variation in prevalence of smoking and consumption levels was captured with three dummy variables for the Northeast, South and Midwest. All three dummy variables were found to be significant in the participation equation. All three indicated that these regions had higher prevalence than the control region, the West.

Out of the 19 regressors considered for the consumption equation only seven were significant. Two of these were household size and education. Yen found household size was positively related to consumption and education was negatively related to consumption.

Most other empirical research used variants of least squares many with 2SLS. Examples include Bass (1969), Hamilton (1972), Chaloupka (1991), and Becker, Grossman and Murphy (1994). Given our choice to estimate a model with count data these models are less relevant to our approach and we do not review them here. Cameron (1998) reviews these papers in his article.

The next chapter takes the information we have presented and develops an analytical model. We then formulate the specification for our empirical model.

3 METHODOLOGY

In the previous chapter, we considered the conceptual models of various authors. We discussed in depth the model of alcoholism proposed by Bateson. In the first section of the current chapter, we will illustrate Bateson's observations through a simple analytic economic model of choice. The model exhibits key aspects of the Bateson's model. The model will be used to motivate the empirical model discussed in the second section and in the next chapter.

3.1 An Illustrative Model of Addiction

Consider a consumer that maximizes utility over two periods. The consumer is forward-looking but has cognitive or practical limitations as per Viscusi (1992) and hence considers the effect of current consumption only on the next period[1]. In the previous chapter we noted Viscusi (1979), Schechter (1988) and others have explored the role that anxiety plays in economic decisions. We now expand Schechter's model to develop a model that illustrates certain aspects of Bateson's model.

[1] The model could also be motivated by a three-period lived individual whom takes as given the first period of life namely, childhood. In the second period, the consumer allocates consumption for his entire life (i.e., the two remaining periods) in an optimal fashion conditional on the experiences in the first period.

3.1.1 The Anxiety Model by Schechter

Schechter (1988) proposed a model to describe the effect that anxiety about environmental pollution has on economic choices. In his model, the consumer faces the possibility of an environmental disaster that may result in severe loss of utility. Schechter notes that the anxiety develops out of the uncertainty itself, not simply the expected amount of loss. This is consistent with the research results cited by Earl (1990). Earl notes that psychologists have found that individuals consistently prefer outcomes with certainty to those with uncertainty even when the expected value of the two outcomes is equivalent. Of course this is consistent with a risk-adverse attitude.

Schechter's model[2] maximizes expected utility over the two periods where the second period has two potential outcomes: no disaster occurs and the individual obtains, $\breve{U}_2$, a high utility; and, a disaster occurs and the individual obtains, $\hat{U}_2$, a low utility. The utility problem is:

$$\max U = U_1 + \left[(1-\theta)\breve{U}_2 + \theta\hat{U}_2\right] \qquad \textbf{EQ. 3.1-1}$$

The probability of the disaster occuring is given by θ and utility is a function of the assets, *a*, allocated to the given period. Schechter ignores the effects of relative price changes between the two periods. This assumption can be motivated by the composite good theorem attributable to Hicks (Deaton and Muellbauer, 1980). Therefore total consumption and total wealth may be treated as interchangeable.

The utility in the first period is also a function of the anxiety, X, associated with the uncertainty and the utility at stake. Uncertainty is given by the probability, θ, and the utility at stake, z, is simply the difference in the two potential utility outcomes, $\breve{U}_2 - \hat{U}_2$, for the second period. The anxiety level is therefore, $X(\theta, z)$, first period utility is given by, $U_1(a_1, X(\theta, z))$, and second period utility is either $\breve{U}_2(a_2)$ or $\hat{U}_2(a_2)$. The individual faces a lifetime budget constraint on wealth. The constraint requires $a_1 + a_2 \leq W$ where W is the total of lifetime wealth.

Schechter follows Viscusi (1979), Weinstein (1980) and others and assumes certain characteristics of utility. A utility of zero is obtained, $U(0) = 0$, for a zero asset allocation. Marginal utility is strictly increasing in wealth, $\frac{\partial U_t}{\partial a_t} > 0$, for all periods t=1,2. Moreover, in the second period, $\frac{\partial \breve{U}_2}{\partial a_2} > \frac{\partial \hat{U}_2}{\partial a_2}$, which implies that the utility at stake, z, is a strictly increasing function in wealth.

Anxiety is strictly increasing in all its arguments. Hence, anxiety can be shown to be increasing in the wealth allocated to the second period. The marginal effects on anxiety are therefore, $\frac{\partial X}{\partial \theta} > 0$, $\frac{\partial X}{\partial z} > 0$ and additionally Schechter assumes $\frac{\partial X^2}{\partial^2 \theta} > 0$.

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[2] We present Schechter's model with a notation different from the author's notation. We do this to facilitate the exposition of a model later in the chapter.

With the above assumptions, Schechter states that, in the presence of anxiety, it can be shown that the individual shifts wealth from the second period to the first. This result is given as $\frac{\partial a_1}{\partial \theta} > 0$ given the lifetime wealth constraint.

3.1.2 The Addiction Model

We now consider a model based on Schechter's model. We shall refer to this new model as the addiction model. We shall use the addiction model to investigate the allocation of consumption to an addictive good. From a public health perspective, we are interested in how the knowledge of the potential adverse health effects from use of the addictive good affects the use of the good in the current period. The proposed model focuses on the issues of consistency in choice in addition to responsiveness to signals. We do not consider here such issues as tolerance and binging behaviors.

We motivate the new model as follows. Consider the case of an individual that suffered a trauma in childhood. As mentioned in the previous chapter, Morgenstern and Leeds (1993) reviewed four modern psychoanalytic theories of substance abuse. All of the four theories point to distress during childhood development as a major factor in the onset of substance abuse in adulthood. Two of the four theories point specifically to childhood trauma. Morgenstern and Leeds cite the author, Henry Krystal, of one of the latter two theories who notes that the motivation for substance abuse "results from the fear of the return of the original trauma." The individual who suffers the trauma therefore has a subjective expectation, developed in childhood, of the likelihood of reoccurrence of the trauma.

In the addiction model, we redefine the object of the individual's fear (which was the environmental disaster in Schechter's model) to be the reoccurrence of the childhood trauma. We propose that the expectation is *unconscious* and, as in Schechter's model, we denote the expectation by the subjective probability θ. The fact that the expectation is unconscious is significant to our results. We will discuss the significance further below.

In the second period in the model, the individual faces two possible outcomes – "no trauma" or "trauma" – with associated utilities denoted by $\check{U}_2$ and $\hat{U}_2$. The individual faces an additional possible outcome: death caused by use of the substance. We shall denote the probability of death by Θ and we will assume that the utility associated with the occurrence of death is identically zero. Given these assumptions, the choice problem in the addiction model is:

$$\max U = U_1(c_1, a_1, X) + (1-\Theta)\left[(1-\theta)\check{U}_2(c_2, a_2) + \theta\hat{U}_2(c_2, a_2)\right]$$

$$\textit{subject to}: \qquad \textbf{EQ. 3.1-2}$$

$$p \cdot a_1 + c_1 = W$$

$$p \cdot a_2 + c_2 = W$$

where a is consumption of the addictive good, c is the consumption of the non-addictive good, X is the anxiety, p is the price of good a relative to good c, and W are the available assets. Prices and quantities of assets both are assumed fixed over time.

In the addiction model, the utility in the first period is also a function of the anxiety, X, associated with the uncertainty and the utility at stake. The utility at stake, z, is again the difference in the potential utility outcomes, $\check{U}_2 - \hat{U}_2$, for the second period.

We modify the determinants of anxiety to include the probability of the occurrence of death. Anxiety is therefore denoted as $X(\Theta,\theta,z)$. Anxiety is assumed to be an increasing function of the three arguments. Hence, an increase in the subjective probability of death results in a greater anxiety level. We do not assume, however, any particular relationship between anxiety and the utility at stake in the event of death (versus trauma). Hence, we do not specify anxiety, X, as a function of $z_{death}=\breve{U}_2\text{-}0$.

Schechter explored the allocation of wealth between periods in his model. Here, we are interested in the allocation of wealth within a given period. To allow for this we explicitly introduce a second good in the choice problem. We define utility in the addiction model to be a quasi-concave function of two goods: an addictive good, a, and a non-addictive good, c. The first period utility is thus given by, $U_1(c_1,a_1,X(\Theta,\theta,z))$, and second period utility is either $\breve{U}_2(c_2,a_2)$ or $\hat{U}_2(c_2,a_2)$. In the addiction model, the individual faces an intra-period budget constraint on assets to be allocated. We also abstract from price changes and we disallow savings or borrowing. We assume the individual has a constant amount of assets available in each period and we denote this level as W. The intra-period budget constraint requires $p\cdot a_t + c_t \leq W$ for all periods t. Given the concavity of utility, the budget constraint will be binding at the optimal solution. This fact allows us to write $\frac{\partial c_t}{\partial a_t} = \frac{\partial}{\partial a_t}(W - p\cdot a_t) = -p < 0$.

We assume a utility of zero is obtained, $U(0,0)=0$, for a zero asset allocation to both goods. Marginal utility is strictly increasing in wealth, $\frac{\partial U_t}{\partial c_t} > 0$ and $\frac{\partial U_t}{\partial a_t} > 0$, for all

periods t=1,2. In the second period, we assume, $\frac{\partial \breve{U}_2}{\partial c_2} > \frac{\partial \hat{U}_2}{\partial c_2}$ and $\frac{\partial \breve{U}_2}{\partial a_2} > \frac{\partial \hat{U}_2}{\partial a_2}$, which again implies that the utility at stake, z, is a strictly increasing function in wealth.

Again, as in Schechter's model, we are interested in the sign of $\frac{\partial a_1}{\partial \Theta}$, the effect of the individual beliefs about the likelihood of the occurrence of death on the assets allocated to consumption of the addictive good. From a tobacco control policy perspective, we would like to identify the conditions under which this effect is negative, i.e., an increase in the subjective likelihood implies a decrease in the consumption.

As mentioned in Chapter 2, much of the research on tobacco control (Hamermesh and Hamermesh (1983), Hu et al. (1995), Seigel and Biener (1997), Kozlowski et al. (2000)) has focused on the education of consumers about the hazards of cigarette consumption. The premise of these efforts is that the more consumers know about the hazards involved, the more likely they will be to reduce or cease their consumption of tobacco products. In essence, the efforts are attempts at changing the probability Θ. We therefore make Θ a function of the signals, s, perceived by the individual about the dangers of smoking. This is consistent with the model described by Bateson in the last chapter.

It is helpful to review here certain aspects of the theory of Bateson (1987) presented in the previous chapter. Bateson argues alcoholism is characterized by a dualistic system with two components: the alcoholic and the "bottle." The "bottle" is a psychological construct – a subjective amalgam – that may be "totally imaginary or gross

distortions" of the people in alcoholic's life. The system can be in two states, symmetric or complementary, defined by the alcoholic's relationship to "the bottle." The responsiveness of the alcoholic to signals from relatives or the government will depend on the state of the system. In the symmetric state, the alcoholic will attempt to control his or her drinking. The opposite response will occur in the complementary state. The level of discomfort that the alcoholic feels (which is in part affected by the signals perceived) measures success in control. We treat the discomfort referenced by Bateson as anxiety.

These observations motivate the choice to make the subjective probability of the death, Θ, a function of the signals. We also assume that the individual has some knowledge of the hazards associated with the consumption of the addictive good. Consequently we also make the subjective probability a function of the level consumed. Since the probability of death has a positive effect on anxiety, increases in the signals about the hazards involved in smoking will consequently increase in the anxiety experienced by the individual. We denote the relationship between the signals and the probability of death as $\frac{\partial \Theta}{\partial s} > 0$ .The subjective effect due to consumption is $\frac{\partial \Theta}{\partial a_1} > 0$.

Finally, we propose a soporific effect of the consumption of the addictive good on the addict. In Chapter 2, we saw that Parrott (1995) found the effect of smoking was to decrease the observed stress level in the smoker. Additionally, we saw in Chapter 3 that Khantzian (1985) has developed a theory that explains addiction as a process of self-medication. We motivate the soporific effect on the basis of the research of these authors. We propose for the current model that the soporific effect works through the subjective

likelihood of reexperiencing the childhood trauma. The likelihood is modified by the soothing effects of the drug. In essence, the drug provides a mood alteration that makes the individual more optimistic about the events in the next period.

We now restate the utility maximization problem with all effects made explicit:

$$\max U = \begin{array}{l} U_1\left(c_1,\ a_1,\ X\left(\Theta(a_1,s),\ \theta(a_1),\ z\left(\breve{U}_2,\hat{U}_2\right)\right)\right)+ \\ \left(1-\Theta(a_1,s)\right)\cdot\left[\left(1-\theta(a_1)\right)\cdot\breve{U}_2(c_2,a_2)+\theta(a_1)\cdot\hat{U}_2(c_2,a_2)\right] \end{array} \qquad \textbf{EQ. 3.1-3}$$

where the constraints in EQ. 3.1-2 are implied. We can show (see Appendix A) that under the assumptions we have made that the policy effect of signals on the first period consumption of the addictive good is given by:

$$\frac{\partial a_1}{\partial s} = \frac{\left[\left((1-\theta)\breve{U}_2+\theta\hat{U}_2\right)-\dfrac{\partial U_1}{\partial X}\dfrac{\partial X}{\partial \Theta}\right]\dfrac{\partial \Theta}{\partial s}}{\left[\dfrac{\partial U_1}{\partial a_1}+\dfrac{\partial U_1}{\partial c_1}\dfrac{\partial c_1}{\partial a_1}+\dfrac{\partial U_1}{\partial X}\dfrac{\partial X}{\partial \Theta}\dfrac{\partial \Theta}{\partial a_1}+\dfrac{\partial U_1}{\partial X}\dfrac{\partial X}{\partial \theta}\dfrac{\partial \theta}{\partial a_1}-(1-\Theta)\left[\breve{U}_2-\hat{U}_2\right]\dfrac{\partial \theta}{\partial a_1}-\left[(1-\theta)\breve{U}_2+\theta\hat{U}_2\right]\dfrac{\partial \Theta}{\partial a_1}\right]} \qquad \textbf{EQ. 3.1-4}$$

We are interested in the conditions under which the above effect is negative indicating a decrease in consumption for an increase in signals. We find that the sign of the numerator of EQ. 3.1-4 is always positive. Therefore, the effect of the signals on consumption depends on the sign of the denominator. A negative sign for the denominator will therefore indicate a decrease in consumption for an increase in signals.

The denominator of EQ. 3.1-4 can vary in sign. Under the following condition the denominator will be negative in sign:

$$\frac{\partial U_1}{\partial a_1}+\frac{\partial U_1}{\partial c_1}\frac{\partial c_1}{\partial a_1}+\frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\frac{\partial \Theta}{\partial a_1}+\frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \theta}\frac{\partial \theta}{\partial a_1}<\left((1-\Theta)\left[\breve{U}_2-\hat{U}_2\right]\frac{\partial \theta}{\partial a_1}+\left[(1-\theta)\breve{U}_2+\theta\hat{U}_2\right]\frac{\partial \Theta}{\partial a_1}\right)$$

where the left-hand side of the inequality may be considered as the first period net utility loss resulting from a decrease in consumption of a_1 . The right-hand side of the above condition may be considered as the expected utility loss in the second period. The result is that for an increase in the signals about the hazards of smoking the individual will decrease consumption when the current period loss in utility is less than the expected next period loss.

We note that the left-hand side utility loss is composed of four effects. The term $\frac{\partial U_1}{\partial a_1}$ is the *direct* effect of consumption on utility. The second term $\frac{\partial U_1}{\partial c_1}\frac{\partial c_1}{\partial a_1}$ is the *substitution* effect on utility. The second term captures the gain in utility affected by the increase in consumption of the good c_1 as less of a_1 is consumed. The third term on the left-hand side $\frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\frac{\partial \Theta}{\partial a_1}$ measures the *anxiety* effect due to increased concern over the likelihood of death. Finally, the term $\frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \theta}\frac{\partial \theta}{\partial a_1}$ reflects the change in current utility due to the *soporific* effect – consistent with the self-medication theory of Khantzian – of the consumption of a_1 the addictive good. For a decrease in consumption of a_1 the direct and soporific effects are negatively valued whereas the substitution and anxiety effects are positively valued. The benefits gained from substitution to consumption of the other good and the decreased anxiety are weighed against the loss of utility caused by the soporific (and direct) effect(s).

A relatively small soporific effect relative to the anxiety and substitution effects will incite the desired decrease in consumption, *ceterus paribus*. The key result here is

that the response of the smoker to the increase in signals will depend on the magnitude of the benefit associated with the soporific effects of the addictive commodity. Sufficiently high soporific effects, especially in conjunction with a low probability of death or very little utility at stake, may cause the response to the signals to be an increase in consumption – the opposite of the desired response.

3.1.3 The Impact of the Unconscious

We stated above the subjective probability of re-experiencing the trauma was an *unconscious* element in the choice problem. We emphasize this characteristic of the probability and the utility, $\hat{U}_2$, associated with trauma. We also emphasize that the marginal effect on demand that we derive below is derived under an assumption that is uncommon in the economics literature. We assume that, due to the unconscious nature of the expectation of repeated trauma, the addict is not aware of his or her full preference set – not even in the current period.

In the conscious mind of the individual the choice problem looks different from the choice problem given in the previous section. The belief that trauma may be re-experienced and the associated subjective probability of that trauma re-occurring are not considered explicitly by the addict. They are unconscious. The choice problem, *a priori*, therefore *appears* to the individual as:

$$\max U = \begin{array}{l} U_1(c_1, a_1, X(\Theta(a_1, s))) + \\ (1 - \Theta(a_1, s)) \cdot \breve{U}_2(c_2, a_2) \end{array} \qquad \text{EQ. 3.1-5}$$

where again the wealth constraints given in EQ. 3.1-2 are implied.

The demand that results from the above choice problem is the quantity the addict consciously believes is the appropriate level for the addictive good. We will refer to the above problem as the *normative* choice problem. Friends, family, and even the addict may agree that in light of the hazards of smoking and the relevant costs, the addict's consumption *should* be decided based on the normative problem. The normative choice problem has a simpler form because the expectation of future trauma is unobservable due to its unconscious nature.

We can show that under the normative choice problem the effect, $\frac{\partial a_1^*}{\partial s}$, of the signals on first period consumption of the addictive good is,

$$\frac{\partial a_1^*}{\partial s} = \frac{\left[\breve{U}_2 - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\right]\frac{\partial \Theta}{\partial s}}{\left[\left(\frac{\partial U_1}{\partial a_1} + \frac{\partial U_1}{\partial c_1}\frac{\partial c_1}{\partial a_1}\right) - \left[\breve{U}_2 - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\right]\frac{\partial \Theta}{\partial a_1}\right]} \qquad \textbf{EQ. 3.1-6}$$

$$= \frac{\left[\breve{U}_2 - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\right]\frac{\partial \Theta}{\partial s}}{\left[(A) - \left[\breve{U}_2 - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\right]\frac{\partial \Theta}{\partial a_1}\right]}$$

We can rewrite EQ. 3.1-4 from the addiction model *with* the unconscious expectation of trauma in the following manner,

$$\frac{\partial a_1}{\partial s} = \frac{\left[\left((1-\theta)\breve{U}_2 + \theta\hat{U}_2\right) - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\right]\frac{\partial \Theta}{\partial s}}{\left[(A) - \left[\left((1-\theta)\breve{U}_2 + \theta\hat{U}_2\right) - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \Theta}\right]\frac{\partial \Theta}{\partial a_1} - \left[(1-\Theta)\left[\breve{U}_2 - \hat{U}_2\right] - \frac{\partial U_1}{\partial X}\frac{\partial X}{\partial \theta}\right]\frac{\partial \theta}{\partial a_1}\right]} \qquad \textbf{EQ. 3.1-7}$$

where the quantity A in both EQ. 3.1-6 and EQ. 3.1-7 is the sum of the direct and substitution effects. From these results, we can show easily that the effect in EQ. 3.1-7,

$\frac{\partial a_1}{\partial s}$, of the signals on consumption is strictly less than the normative effect, $\frac{\partial a_1^*}{\partial s}$, given an identical consumption allocation in both models.

The implication of the above discussion is that the *normative* change in consumption in response to new signals will always be greater than the actual change made by the addict. The addict responds in actuality to the signals based on both the conscious and unconscious determinants of utility whereas the normative response only considers the conscious determinants.

Consistency of choice over time is a major research area addressed by Pollack (1968), Hammond (1974) and others. Our result suggests an explanation for the appearance of inconsistency in choice often observed in the consumption of addictive goods.

Bateson's theory predicted that a decrease in consumption due to increased signals would occur while the addict was in the symmetric state. In the complementary state, Bateson predicted the opposite was possible. In the next section, we discuss the methods used to implement the addiction model. Following that, in the discussion in the next chapter, we will consider the signals perceived by the smokers in our study. In the next chapter, we also discuss which signals we can observe in the data and how we know the state of the individual, symmetric or complementary, at the time of the collection of the data. The empirical results show that indeed certain individuals do react in congruence with the addiction model.

3.2 The Empirical Model of Cigarette Demand

In the last section, we described an analytic model that exhibited the consumption behavior expected under the symmetric and complementary states given in Bateson's theory of alcohol. In the current section, we describe the structure of the empirical model used in this study to measure the effects described in the last section. We propose a hurdle model for censored count data and derive the associated maximum likelihood estimator.

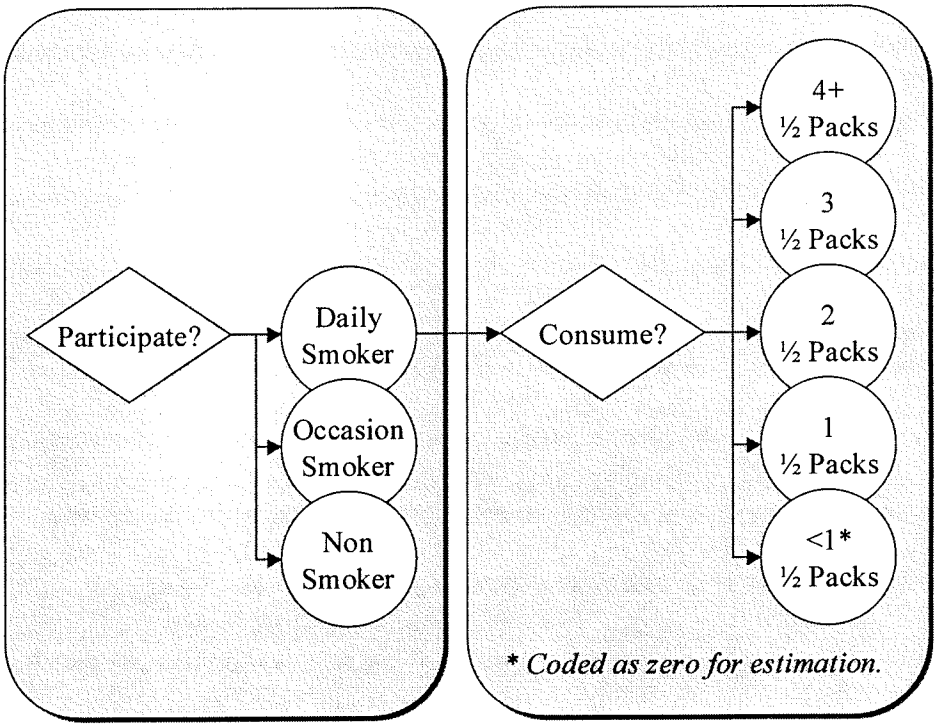

Figure 3.2-1 The Structure of the Model of Choice

In Figure 3.2-1 we present a diagrammatic representation of the choice model to be estimated. The figure shows the relationship between the choices facing the smoker. The choice to smoke a given amount depends first on the choice to smoke daily in the current period. Participation can take on three different states: non-smoker, occasional smoker and daily smoker. Daily smokers then choose a level of daily consumption. Daily consumption is allocated in *½-pack increments* – zero being the lowest.

3.2.1 The Likelihood Function for the Empirical Model

As noted in Chapter 2, much of the micro-data available on cigarette consumption is collected in surveys where the consumption data is reported in discrete quantities: cigarettes, packs, or regular fractions of a pack. Some authors (Chaloupka and Weschler (1997), Mullahy (1997)) have estimated demand with a count-data model. Other authors (Jones (1989), Labeaga (1999)) have implemented hurdle models. Yen (1999) estimates a hurdle model for count data where consumption is measured as the count of cigarettes smoked per day.

Here we propose a count-data hurdle model analogous to that estimated by Yen (1999). However, we modify Yen's model in two ways. First, we explicitly address censoring in the count data and we use a Poisson regression whereas Yen used a negative binomial model. Second, we allow for three levels of participation as a smoker: non-smoker, occasional smoker, and daily smoker. This specification requires an ordered qualitative variable model. We therefore estimate the hurdle with an ordered logit model.

In our model, individuals who smoke daily select their consumption level in ½ pack increments, where consumption, y, ranges from zero[3] to four ½ packs. (The data is censored at four due to the design of the survey used to collect the data.) Non-smokers and occasional smokers have their daily consumption fixed at zero ½ packs. (We motivate this below based on findings by Jones (1989).) Participation, z, is coded with one of three values: zero (0), one (1), or two (2). The value zero indicates a non-smoker; one indicates an occasional smoker; and, two indicates a daily smoker.

Weights are used throughout the empirical analysis to correct for the over-sampling that occurred in the survey data. The survey provides weights based on the national representation of an individual within a given stratum of the population.

The joint likelihood, L_k, of participation and consumption for a given individual, k, with weight, w_k, is:

$$L_k = \prod_{i=0}^{2} \prod_{j=0}^{4} \left(\Pr[J = j \cap I = i]\right)^{m_{ik} \cdot n_{jk} \cdot w_k} \qquad \textbf{EQ. 3.2-1}$$

where m_{ik} is an indicator equal to one when participation, z_k, equals i, and zero otherwise. The indicator n_{jk} is equal to one when the consumption level, y_k, equals j, and zero otherwise. We can use the definition of conditional probability to rewrite:

---

[3] The NHSDA actually collected daily consumption in half pack increments except for the lowest consumption level, which was 1-5 cigarettes per day. We coded this lowest level as zero. We discuss the coding of the consumption variable more in the next chapter.

$$L_k = \prod_{i=0}^{2} \prod_{j=0}^{4} \left(\Pr[J = j \mid I = i] \cdot \Pr[I = i]\right)^{m_{ik} \cdot n_{jk} \cdot w_k}$$

from which we obtain the following loglikelihood:

$$\ell_k = w_k \sum_{i=0}^{2} \sum_{j=0}^{4} m_{ik} \cdot n_{jk} \cdot \left[\ln\left(\Pr[J = j \mid I = i]\right) + \ln\left(\Pr[I = i]\right)\right]$$

Jones (1989) considers the general problem of estimating a hurdle model and examines various ways to simplify the above loglikelihood. With statistical independence between the probabilities and dominance of the participation choice over the consumption choice, the probability of consuming "j" ½ packs daily is independent from the probability being a daily smoker. In this case, the loglikelihood simplifies to,

$$\ell_k = w_n \sum_{j=0}^{4} n_{jk} \cdot \ln\left(\Pr[J = j \mid z_k = 2]\right) + w_n \sum_{i=0}^{2} m_{ik} \cdot \ln\left(\Pr[I = i]\right)$$

where Jones refers to the above model as the "complete dominance" model. He finds evidence to suggest that the "complete dominance" model is acceptable when compared to the alternatives that include statistical dependence between the participation choice and the consumption choice. We therefore can estimate the "complete dominance" model using the method of maximum likelihood in two separate regressions: a regression for participation and a regression for consumption. The loglikelihood is simply the sum of the two separate likelihoods from the regressions.

Cameron and Trivedi (1998) discuss the censored Poisson likelihood. They show that the likelihood is a function of the standard Poisson density, *h(·)*, and the Poisson cumulative distribution function, *H(·)*, where the latter is evaluated at *(c-1)*. The value *c* is the point at which the distribution is censored which in our case is four. Davidson and MacKinnon (1993) discuss the ordered logit likelihood. We follow their specification here. We parameterize our ordered logit model without an intercept term in the linear index and *(I-1)* threshold terms, τ_i. Following these authors, the joint loglikelihood with censored Poisson consumption and ordered logit participation becomes:

$$\begin{aligned}\ell_k = \quad & w_k \sum_{j=0}^{4} n_{jk}\left[(1-d_k)\ln\left(h(y_k, x_k, \beta)\right) + d_k \ln\left(1 - H\left((c-1), x_k, \beta\right)\right)\right] \\ & + w_k \sum_{i=0}^{2} m_{ik} \ln\left(\Lambda\left(\tau_{i+1} - z_k \cdot \gamma\right) - \Lambda\left(\tau_i - z_k \cdot \gamma\right)\right)\end{aligned} \qquad \textbf{EQ. 3.2-2}$$

where d_k is an indicator equal to one when the consumption for individual *k* is censored, Λ is the cumulative logit distribution, and γ and β are the unknown parameter vectors to be estimated for participation and consumption, respectively. The separate likelihoods used in the estimation are as follows. The loglikelihood for participation is,

$$\ell_k^{par} = w_k \sum_{i=0}^{2} m_{ik} \ln\left(\Lambda\left(\tau_{i+1} - z_k \cdot \gamma\right) - \Lambda\left(\tau_i - z_k \cdot \gamma\right)\right) \qquad \textbf{EQ. 3.2-3}$$

where and τ_0 and τ_3 are -∞ and +∞, respectively, and the loglikelihood for consumption is,

$$\ell_k^{con} = w_k \sum_{j=0}^{4} n_{jk}\left[(1-d_k)\ln\left(h(y_k, x_k, \beta)\right) + d_k \ln\left(1 - H((c-1), x_k, \beta)\right)\right] \quad \text{EQ. 3.2-4}$$

3.2.2 Application and Estimation of the Poisson Distribution

The standard Poisson density, *h*, is given by:

$$h(y_k; x_k) = \frac{e^{-\mu_k} \mu_k{}^{y_k}}{y_k!} \quad \text{EQ. 3.2-5}$$

where μ_k is the conditional mean, $E[y_k \mid x_k]$, of consumption. Various functions may be chosen to represent the conditional mean. The most common mean function in use in the literature is the exponential mean function:

$$E[y_k \mid x_k] = e^{x_k \cdot \beta} \quad \text{EQ. 3.2-6}$$

which gives a form for the loglikelihood function that is linear in the mean function. The loglikelihood for individual *k* associated with the standard Poisson density with an exponential mean function is:

$$\ell_k = -\mu_k + y_k x_k \beta - \sum_{j=1}^{y_k} \ln(j) \quad \text{EQ. 3.2-7}$$

Right-censoring of consumption limits the observable values of y and distorts the distribution. The loglikelihood with right-censoring of the data can be derived by classifying the observations of consumption into two ranges: the uncensored observations

and the censored observations. The uncensored observations, those with consumption below the censor point c, follow the standard Poisson density. For the censored observations, we only observe one value, c, the value of the censor point. Thus, the probability associated with all such observations is the probability that consumption is at least c. That probability is also one minus the probability that consumption less than c will be observed. We denote the probability as,

$$\Pr[y_k \geq c] = 1 - \Pr[y_k < c] = 1 - H(c-1) \qquad \textbf{EQ. 3.2-8}$$

and we can therefore write for a given individual,

$$\Pr[y_k = j] = [h(y_k)]^{(1-d_k)} \cdot [1 - H(c-1)]^{d_k} \qquad \textbf{EQ. 3.2-9}$$

We take the log of this result, weighted appropriately, to obtain the loglikelihood associated with the right-censored Poisson distribution as given in EQ 3.2-1.

The standard Poisson distribution has the property that the mean of the distribution is equal to its variance. We derive this property below.

$$
\begin{aligned}
Var[y_k] &= E\left[(y_k - E[y_k])^2\right] = E\left[(y_k - \mu)^2\right] = E\left[(y_k)^2\right] - \mu^2 \\
&= -\mu^2 + \sum_{y=0}^{\infty}\left(\frac{e^{-\mu}\mu^{y}}{y!}\cdot y^2\right) \\
&= -\mu^2 + \sum_{y=0}^{\infty}\left(\frac{e^{-\mu}\mu^{y-1}\mu}{(y-1)!\cdot y}\cdot y^2\right) \\
&= -\mu^2 + \mu\sum_{y=0}^{\infty}\left(\frac{e^{-\mu}\mu^{y-1}}{(y-1)!}\cdot (y-1+1)\right) \\
&= -\mu^2 + \mu\sum_{y-1=1}^{\infty}\left(\frac{e^{-\mu}\mu^{y-1}}{(y-1)!}\cdot (y-1)\right) + \mu\sum_{y-1=1}^{\infty}\left(\frac{e^{-\mu}\mu^{y-1}}{(y-1)!}\right) \\
&= -\mu^2 + \mu(\mu) + \mu(1) = \mu = E[y_k]
\end{aligned}
$$

In practice, the equivalence of the mean and variance of the Poisson distribution often does not hold. The case where the variance is greater than the mean is referred to as overdispersion. Greene (1999) provides a test for overdispersion in the Poisson model. We use the test in our empirical results and find that the test rejects the null hypothesis of no overdispersion. However, our data actually exhibit a variance less than mean. This is referred to as underdispersion. Moreover, Greene's test appears to apply to the uncensored Poisson distribution. Both of these facts confound the result of Greene's test. We discuss these issues more in the next chapter.

As noted above, the consumption equation is estimated using the method of maximum likelihood. The maximum likelihood estimator (MLE) for the consumption equation is the solution of the first order conditions from the loglikelihood equation EQ 3.2-4. The first order conditions from EQ 3.2-4 are:

$$\frac{\partial}{\partial\beta}\ell_k^{con} = w_k\left[(1-d_k)\left(y_k - e^{x_k\beta}\right) + d_k\delta\right]x_k' = 0 \qquad \text{EQ. 3.2-10}$$

where we have suppressed the indicator n for clarity since only one of the n_{jk} will be equal to one for a given individual k. Following Cameron and Trivedi (1998), we have defined δ as,

$$\delta = \frac{e^{x_k\beta}\cdot h(c-1, x_k, \beta)}{1 - H(c-1, x_k, \beta)} \qquad \text{EQ. 3.2-11}$$

The second order conditions follow from EQ. 3.2-10 as,

$$\frac{\partial}{\partial\beta\partial\beta'}\ell_k^{con} = w_k\left[(1-d_k)e^{x_k\beta} + d_k\delta\left(e^{x_k\beta} + \delta - c\right)\right]x_k x_k' \qquad \text{EQ. 3.2-12}$$

with δ defined as above[4].

3.2.3 Application and Estimation of the Ordered Logistic Distribution

Suppose we were interested in whether a particular event would occur. Let us consider the occurrence of an individual smoking in the current month as an example. Suppose further that the occurrence of the event is a function of some latent variable. We note from our discussion about Bateson's model in the previous chapter that we can operationalize his model through reference to a latent variable. We will consider the latent variable, denoted by z^*, as the measure of "discomfort" that Bateson identified in his model of alcoholism.

---

[4] See Appendix B for the derivations of the first- and second-order conditions.

Discomfort z' is a function of some index, $x_k\gamma^*$, namely,

$$z'_k = x_k\gamma^* + u_k \qquad u_k \sim \text{IID}(0, \sigma^2) \qquad \textbf{EQ. 3.2-13}$$

where x_k is some information set and γ^* is vector of unknown parameters. For z' greater than zero we observe the occurrence, z. We identify the occurrence of consumption z as follows,

$$\begin{aligned} z_k &= 1 \qquad if \qquad z'_k > 0 \\ z_k &= 0 \qquad if \qquad z'_k \le 0 \end{aligned} \qquad \textbf{EQ. 3.2-14}$$

The probability that the individual will smoke in the current is given by the expected value of z:

$$\begin{aligned} \Pr[z_k = 1] &= \Pr[z'_k > 0] \\ &= \Pr[x_k\gamma^* + u_k > 0] \\ &= 1 - \Pr[u_k < -x_k\gamma^*] \\ &= \Pr[u_k < x_k\gamma^*] \end{aligned} \qquad \textbf{EQ. 3.2-15}$$

The probability in the final line of EQ 3.2-13 may be specified with several different cumulative distribution functions. For the current study, we shall use the logistic distribution. We denote the logistic distribution as Λ and the above result becomes,

$$\Pr[z_k = 1] = \Lambda(x_k\gamma^*) \qquad \textbf{EQ. 3.2-16}$$

The standard logit model is commonly estimated to measure the probability of occurrence of an event. The model estimates the probability conditional on the fact that

the underlying distribution function is logistic. The logistic cumulative distribution function is given by,

$$\Lambda = \frac{e^{x_k \gamma^*}}{1 + e^{x_k \gamma^*}} \qquad \textbf{EQ. 3.2-17}$$

This function has the following helpful property,

$$\frac{\partial}{\partial \gamma^*} \Lambda = \Lambda(1 - \Lambda) x_k \qquad \textbf{EQ. 3.2-18}$$

which we exploit below.

The above discussion presumes that x_k contains an intercept term so we can partition γ^* as [γ_0 | γ] where γ_0 is the intercept parameter. We therefore can rewrite EQ. 3.2-13 as follows,

$$\begin{aligned} \Pr[z_k = 0] &= \Pr[z_k' < 0] \\ &= \Pr[x_k \gamma^* + u_k < 0] \\ &= \Pr[\gamma_0 + x_k \gamma + u_k < 0] \\ &= \Pr[x_k \gamma + u_k < -\gamma_0] \\ &= \Pr[x_k \gamma + u_k < \tau] \\ &= \Pr[z_k^* < \tau] = \Pr[-\infty < z_k^* < \tau] \end{aligned} \qquad \textbf{EQ. 3.2-19}$$

where we have redefined z' and $-\gamma_0$ as z^* and τ, respectively, and where x_k now contains no intercept term.

The result in equation EQ. 3.2-18 can be used to motivate our discussion of the model for our study – the ordered logit model. Consider the case where *n* possible events may occur. In the binary logit model n=2; in the ordered logit model is defined as n>2. Thresholds τ_1 through τ_n determine the realization of a given event based on the value of z* in relation to the thresholds. In this case, we have,

$$\begin{aligned} z_k &= 0 \quad if \quad -\infty < z_k^* < \tau_1 \\ z_k &= 1 \quad if \quad \tau_1 \le z_k^* < \tau_2 \\ &\vdots \\ z_k &= (n-1) \quad if \quad \tau_n \le z_k^* < +\infty \end{aligned} \qquad \textbf{EQ. 3.2-20}$$

from which we may write,

$$\begin{aligned} \Pr[z_k = i] &= \Pr[\tau_i < z_k^* < \tau_{i+1}] \\ &= \Pr[z_k^* < \tau_{i+1}] - \Pr[z_k^* < \tau_i] \\ &= \Pr[z_k\gamma + u_k < \tau_{i+1}] - \Pr[z_k\gamma + u_k < \tau_i] \\ &= \Pr[u_k < \tau_{i+1} - z_k\gamma] - \Pr[u_k < \tau_i - z_k\gamma] \end{aligned} \qquad \textbf{EQ. 3.2-21}$$

From the above result, we can obtain the loglikelihood given in EQ. 32.-3. We obtain the loglikelihood if the individual probabilities are distributed each as the cumulative logistic distribution, and if we also sum over the three participation choices available to the individual. The loglikelihood can therefore be written as,

$$\begin{aligned}\prod_{i=0}^{2}\left(\Pr[z_k = i]\right)^{n_{ik}} &= \sum_{i=0}^{2} n_{ik}\ln\left(\Pr[u_k < \tau_{i+1} - z_k\gamma] - \Pr[u_k < \tau_i - z_k\gamma]\right) \\ &= \sum_{i=0}^{2} n_{ik}\ln\left(\Lambda(\tau_{i+1} - z_k\gamma) - \Lambda(\tau_i - z_k\gamma)\right)\end{aligned} \qquad \textbf{EQ. 3.2-22}$$

where we have suppressed the weight. Above, we noted simple form of the first derivative of the cumulative logistic. Exploiting the result of EQ. 3.2-18, we can easily show that,

$$\begin{aligned}\frac{\partial}{\partial\gamma}\ln\left(\Lambda(\tau_{i+1}) - \Lambda(\tau_i)\right) &= \left(\frac{\Lambda^2(\tau_{i+1}) - \Lambda^2(\tau_i)}{\Lambda(\tau_{i+1}) - \Lambda(\tau_i)} - 1\right)x_k \\ \frac{\partial}{\partial\tau_i}\ln\left(\Lambda(\tau_{i+1}) - \Lambda(\tau_i)\right) &= \frac{-\Lambda(\tau_i)(1 - \Lambda(\tau_i))}{\Lambda(\tau_{i+1}) - \Lambda(\tau_i)} \\ \frac{\partial}{\partial\tau_{i+1}}\ln\left(\Lambda(\tau_{i+1}) - \Lambda(\tau_i)\right) &= \frac{\Lambda(\tau_{i+1})(1 - \Lambda(\tau_{i+1}))}{\Lambda(\tau_{i+1}) - \Lambda(\tau_i)}\end{aligned} \qquad \textbf{EQ. 3.2-23}$$

where we have suppressed the arguments, x_k and γ, of the cumulative logistic for purposes of clarity. These first-order conditions may then be used to obtain the MLE for participation.

4 DATA, EMPIRICAL ANALYSIS, AND RESULTS

In the three sections in this chapter, we consider the data used for an empirical implementation of the model we proposed in the last chapter. Following a review of the data sources, we discuss the preparation of the data for estimation and the technical issues that arose during the preparation. We also discuss the actual model implementation. We close this chapter with a discussion of the results of the analysis.

4.1 Data Sources

In this section, we review the sources for the data used in the current study. There are four data sources for the study data – three of which were actually used. The fourth source was a monograph from the National Cancer Institute (2000) that documented the state and local tobacco control legislation in effect across the United States. As we note elsewhere in this document, we do not use this data due to the limited variability in the data for our sample. The data from each of the other three sources is first presented separately below. A general discussion of the data is provided at the end of this section.

4.1.1 The National Household Survey on Drug Abuse

The National Household Survey on Drug Abuse is an annual survey administered by the Substance Abuse and Mental Health Services Administration (SAMHSA, 1991, 1992, 1993a-b) of the federal Department of Health and Human Services (DHHS). The

data from the NHSDA public release files from the survey years 1991 to 1993 was used as the primary source of information for the empirical work performed in the current study.

The NHSDA was first administered in 1971 (NHSDA Main Findings, 1990). It continues to be the only survey that regularly collects information on the substance abuse in the civilian non-institutionalized population of the United States for persons 12 years and older. Prior to 1990, the survey was administered periodically for the population of the contiguous 48 states. The survey has been collected annually since 1990, and in 1991, Alaska and Hawaii were added to the regions surveyed.

In 1991 several other innovations were made to the data collection practices (SAMHSA, 1993b). First, residents in noninstitutional group quarters such as dormitories and retirement homes were included in the survey population. Second, six important metropolitan statistical areas (MSA) were oversampled. Additionally, the questions on family income sources were expanded and data was collected as drug treatment and illegal activities. Oversampling of the African-American and Hispanic populations (begun in 1985) continued during the period of 1991 to 1993.

The design of the survey for the three years from 1991 to 1993 is roughly as follows.

i) Select the primary sampling units (PSUs) which are regions aggregated census blocks and/or counties that have at least 75 occupied dwellings and meet certain objectives for oversampling by race.

ii) Identify the low socioeconomic status (SES) areas by use of an index constructed from the 1990 Census results. Use the SES information and the index in the selection of the dwellings to be screened.

iii) Determine the number of dwelling units that must be screened in order to meet the goal of collecting 28000 completed interviews[1]. Screen the dwelling units identified and from the field collect the information necessary to select the within-dwelling roster to be used in the administration of the survey.

iv) From the initial field data, develop the roster of actual individuals to be surveyed based on desired representation in several age-race-smoking status population classes. Administer the survey to the individuals on the roster.

The survey includes questions about the use of cigarettes, alcohol, cocaine, marijuana and numerous other illicit substances. The survey also includes questions about physical and mental health, problems associated with substance use, illegal activities, sources of income, health risk attitudes and the demographics of the household in which the respondent resides.

Survey information from the surveys administered after 1993 was not incorporated into the present study. This choice was made due to the difference in reporting of the data in the public used files. Moreover, the cigarette price information (discussed in the next section) after 1995 was not easily available. Furthermore, the file

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[1] This figure was for 1993. The target figure varies year over year.

format for 1994 was significantly different from the three previous years and due to time constraints, it was deemed that there was adequate information in the surveys from 1991, 1992, 1993 for the purposes of the current study.

Table 4.1-1 Records Available to Study

	NHSDA Survey Year		
	1991	1992	1993
MSAs Used in Study	10877	10522	9805
Los Angeles	2587	2691	2281
Miami MSA	2775	2650	2805
Chicago	2593	2519	2462
New York	2922	2662	2257
Other MSA	4878	5281	5473
Non-MSA	16839	13029	11211
Total Survey Records	32594	28832	26489

Information significant to the current study (and not reported on the public release files for 1991-1993) is the information related to the address of the respondent. There are two exceptions to the non-reporting of address information: the MSA in which the respondent resides, and aggregate 1990 census block information such as mean income in the block. Identification of the MSA was critical to the results of the current study. Lack of any other address-related information limited the survey records that were useable in the current study. In lieu of more accurate address information, the MSA information was used to associate a dollar price per pack of cigarettes, a per pack tax rate and a price index with each individual in the survey. Table 4.1—1 shows the counts of survey records available for the current study. We consider this issue further below.

The surveys also record the information the receptivity and cooperation of the respondent during the collection of the survey. We decided to exclude records for respondents whom displayed open hostility during the survey collection. The exclusion was based on a concern about the accuracy of the data reported by such respondents. Other exclusions were applied to screen records for missing values in the dependent variables of consumption and participation. Table 4.1-2 presents the counts of records dropped through the exclusion criteria for by survey and region.

Table 4.1-2 Records Excluded by MSA and Year

		NHSDA Survey Year			
		1991	1992	1993	Total
Records Available		10877	10522	9805	31204
Excluded	*Los Angeles*	118	108	76	302
	Miami	95	143	126	364
	Chicago	99	117	67	283
	New York	142	75	62	279
Net Records		10423	10079	9474	29976

The bulk of the records excluded were due to non-cooperation in the survey. During the estimation process, some additional records were excluded due to missing data in one of the regressors. We discuss those examples in the portion of this chapter about estimation.

Portions of the data for the surveys are over-sampled. Consequently, the raw survey results do not compose a representative sample. A person level weight variable is provided in the public use files for inferences about the survey population. The weight is

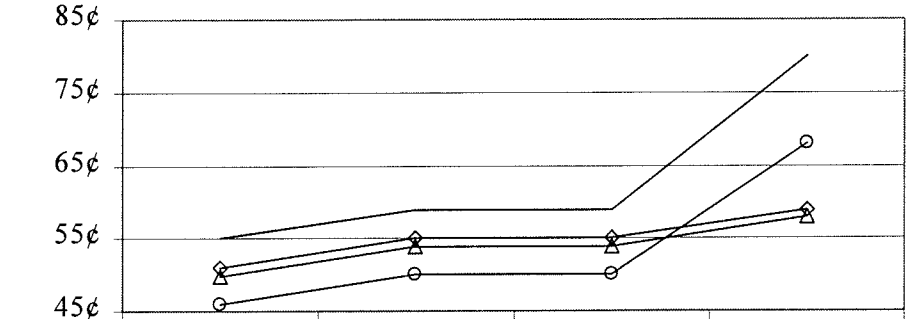
a number determined from the survey design and represents the total number of persons from the target population that a given record represents (SAMHSA, 1993b). The survey weights sum to the target population for the year of the survey. These weights are used in the estimations discussed below and in the statistics presented later in this section.

4.1.2 The Tobacco Institute Cigarette Price Data

The Tobacco Institute (1995) has produced a report on annual basis titled "The Tax Burden on Tobacco." We use the information from the release of the report published in 1995. The report documents, in a great amount of detail, the prices of and taxes on tobacco products over the past century. The report also documents measures of consumption (sales) of the products. We use the tax and price information that contains federal and state taxes on the cigarettes. Information on the local/municipal taxes was not given in sufficient detail to consider for the study. Moreover, even if that data had been available, the lack of detail address information for NHSDA respondents would have prevented the use of local tax data.

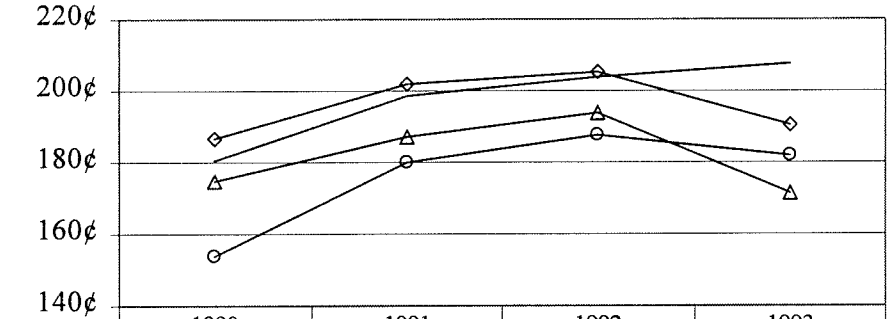
The figures below document the total state and federal taxes per pack and prices reported in the Tobacco Institute document. The prices are reported per pack as of November 30th of each year.

Figure 4.1-1 Total State and Federal Taxes Per Pack



	1990	1991	1992	1993
CA	51.0	55.0	55.0	59.0
FL	49.9	53.9	53.9	57.9
IL	46.0	50.0	50.0	68.0
NY	55.0	59.0	59.0	80.0

Figure 4.1-2 Average Per Pack Prices



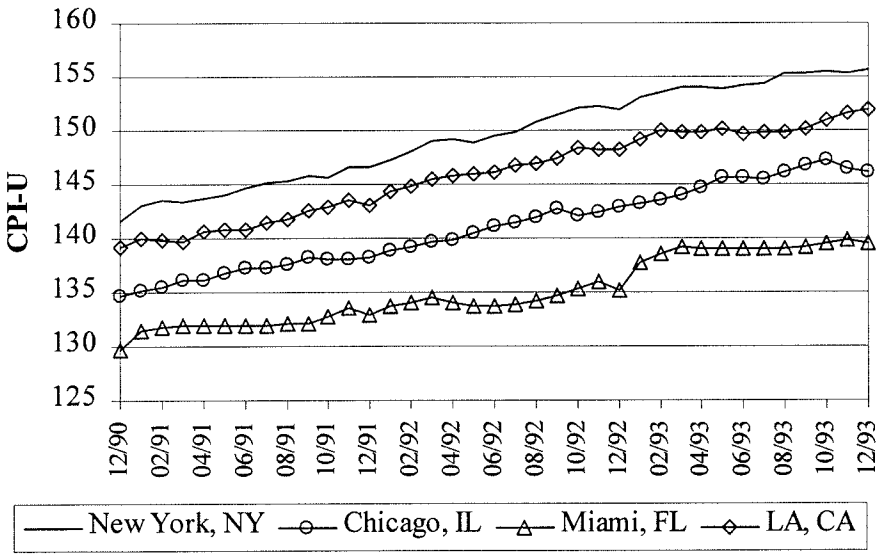
	1990	1991	1992	1993
CA	186.8	201.9	205.1	190.3
FL	174.8	187.0	193.7	171.6
IL	154.0	179.8	187.5	182.1
NY	180.4	198.5	203.8	207.7

The associated prices for the four years are given above in Figure 4.1-2. The prices are nominal sales weighted averages and include sales for all major brands and also generic cigarette brands. It is evident from Figure 4.1—2 that the cigarette industry lowered prices during the period between 1990 and 1993 in response to increasing tax hikes by federal and state agencies. The nominal prices clearly are falling in 1993.

4.1.3 Bureau of Labor Statistics Price Deflators

The U. S. Bureau of Labor Statistics (BLS, 2000) provides a variety of regional and national economic indicators for use in analysis. The BLS data are available in published reports, various electronic media and from the Internet. Amongst other data, BLS regularly produces estimates of price levels for major regions of the United States.

Figure 4.1-3 Price Levels By MSA



The price level data used for the current study was the BLS Consumer Price Index – All Urban Consumers (CPI-U) data series. The CPI-U was obtained from BLS by year, month and MSA. BLS identifies the data via series codes. The current study used the MSA CPI-U series CUURA101SA0 (NY), CUURA207SA0 (IL), CUURA320SA0 (FL) and CUURA421SA0 (CA). The base year period for the indices is the year range from 1982-1984.

4.1.4 Data Preparation

To produce a dataset for analysis, the data from the three sources were combined as follows (see Figure 4.1-4). The cigarette price and tax information from The Tobacco Institute was merged into the NHSDA by year of publication and by state. The state in which the NHSDA MSA resided was used as the state for the merge. This intermediate dataset was then combined with the BLS CPI data. The two datasets were merged by year and month of publication[2], and by MSA to obtain the dataset for analysis.

Three significant data accuracy and consistency issues arose in the preparation of the analysis data. First, the definitions for the New York and Chicago MSAs are such that respondents from those MSAs may actually reside in states other than the primary state associated with the MSA. For the New York MSA, respondents may actually reside in southern Connecticut or northern New Jersey. For the Chicago MSA respondents may reside in Indiana or Wisconsin rather than in Illinois.

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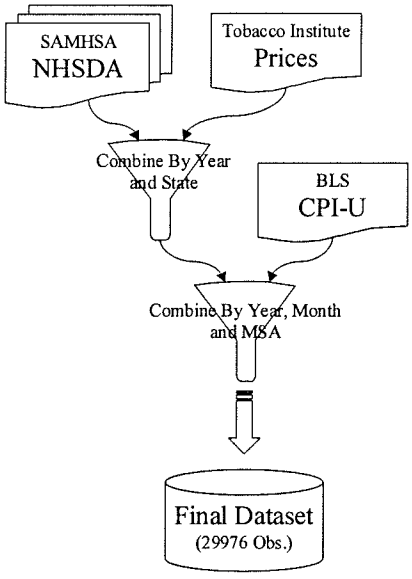
[2] In the case of the NHSDA data the year and month reflect the date of the actual survey interview.

Figure 4.1-4 Preparation of Data for Analysis



The broadness in the MSA definition has no effect on the application of the CPI-U price index since the index was constructed to represent the MSA as defined. However, the tax rate and per pack price of cigarettes associated with the MSA is sensitive to the definition of the MSA. Taxes and per pack prices are reported in the "Tax Burden on Tobacco" (The Tobacco Institute, 1995) by state and year not by MSA.

Several alternatives for resolution of this issue were considered. We considered using the MSA price index for cigarettes, also produced by BLS, in place of the prices given by the Tobacco Institute. This alternative was rejected on the grounds that the prices would no longer be consistent with the tax rate information. We also considered constructing our own sales-weighted prices and tax rates across the states within the New York and Chicago MSAs using the Tobacco Institute information. We rejected this on the basis that our prior belief is that the majority of the residents of those two MSAs probably reside in either New York or Illinois, respectively. Consequently, application of a weighted price or tax rate to all the respondents from either of those MSAs would be biasing the information for the majority in an attempt to correct the inaccuracy of the minority. Ultimately, we chose to use the price information from the Tobacco Institute without adjustments.

The second issue is related to the first. A number of authors have noted that increased taxes on cigarettes have created a market for smuggled cigarettes and have raised cross-state sales. The Tobacco Institute (1995) notes this effect, Becker, Grossman and Murphy (1994) address both short- and long-distance smuggling, and Galbraith and Kaiserman (1997) the smuggling in Canada. The issue for the current study is that the Chicago and New York MSAs are composed of more than one state and that, particularly in the case of New York, the geographic distance between the center city in the MSA and the neighboring states is very small. The short distance lowers the costs to individuals to travel into a neighboring state to purchase lower price cigarettes.

Table 4.1-3 A Price Comparison for 1992

	MSA	
	New York, NY	Chicago, IL
Price in NY, IL	203.8 ¢	187.5 ¢
Price in Neigboring State		
Connecticut	202.3 ¢	
New Jersey	205.4 ¢	
Wisconsin		195.5 ¢
Indiana		157.5 ¢

An examination of Table 4.1-3 suggests that, for New York, cross-state sales are irrelevant to our study. Individuals living in the New York MSA face prices no higher than the prices in either of the neighboring states. However, a comparison of the prices in 1991 and 1993 reveals otherwise. In both years, New Yorkers faced somewhat higher prices than those in the neighboring states. Price comparisons for Chicago are less clear. In 1992, Chicagoans purchased cigarettes locally at price above that in Indiana but below

that in Wisconsin. The effect of the neighboring state prices will clearly depend on the proximity of residence to Indiana. Those respondents in our sample who reside close to Indiana may have chosen to travel across state lines to purchase the lower price cigarettes. This pattern in the Chicago prices holds across all three years of data used in the study.

Our conclusion was that the cross-state sales effect on the prices observed by individual respondents was minor but that it did exist. Unfortunately, without more detailed knowledge about the place of residence of the individual respondent, we could make no corrections for the effect. Moreover, we had no data available on smuggled cigarettes for our sample. Consequently, either smuggling or cross-state sales effects may bias the results presented for our study.

The final data issue we addressed was the availability of the CPI-U for the Miami, FL MSA. Throughout the entire decade of the 1990s, the CPI-U for Miami was reported on a bimonthly basis only. We interpolated the value using the average of the values from prior and subsequent months,

$$CPI_t = \frac{CPI_{t+1} + CPI_{t-1}}{2} \qquad \textbf{EQ. 4.1-1}$$

to obtain estimates of for the non-reported months.

4.1.5 Descriptive Statistics

We present below summary information about the sample used in the study. The statistics presented, except where noted, are weighted by the sample weights prepared from the NHSDA survey weights. The sample weights used here have been normalized. Specifically, we were aware that the weights from each survey are relative to the estimated non-institutionalized population, years 12 and older, in the U.S. for the given year of the survey. Since this base population varies over years, we normalized the records in each year by dividing the records from that year by the total of the weights from that survey. We then scaled the weights by 1000. This last adjustment was to prevent rounding issues associated with the use of very small weights in the later calculations. The final weights are per 1000 persons.

Table 4.1-4 Demographic Profile of the Sample

	Percent of Sample				*Income*	*Age*
Use History	*White*	*Female*	*Married*	*Has Kids*		*(years)*
All Respondents	42.5%	52.7%	50.0%	47.5%	$38,579	40.4
Never Smoked	41.3%	61.9%	45.2%	35.9%	$35,693	38.3
Ever Smoked	43.3%	46.3%	53.4%	55.6%	$40,598	41.8
Not in	43.4%	46.7%	59.0%	59.8%	$43,493	44.5
In Past	43.0%	45.8%	46.5%	50.3%	$36,979	38.5

Table 4.1-4 displays summary demographic information about the analysis sample. The summary statistics describe a population different from the average U.S. population. The Bureau of Census (Statistical Abstract of the United States, 1999) reports in 1992, the racial composition of the U.S. population was 83.5% white. The figures in

the sample are consistent with the sample defined to incorporate only metropolitan areas. In specific, as of 1997 the racial distribution of the Los Angeles MSA was 38.5% Hispanic, 11.1 % Asian, and 8.3% African-American. Clearly, these percentages suggest a low white representation in the Los Angeles MSA. In addition, in 1992 the Bureau of Census reports a median age of 33.4 years. This latter figure, being a median, is not directly comparable with the mean age of our sample but is cited for reference.

There are also marked differences between the class of individual who have never smoked and those who have smoked at some point. Women appear more likely to have never smoked: 61.9% of those who have never-smoked are women versus 46.3% of those who have smoked. Notably, people who have ever smoked appear more likely to be married, have children, and earn a higher income. These observations may be driven by the difference in the mean age of the two populations. Ever-smokers are older than the never-smoker population and hence more likely to have married, had children and advanced in their career.

The income reported here is the nominal dollar household income. The income was calculated from the total household wage income plus food stamp subsidies as reported in the NHSDA data. The nominal household income in 1997 for U.S. as reported by the Bureau of Census, was $37,005. This is somewhat below the income for our sample, which is again consistent with the fact that our sample is specifically for a metropolitan area.

The proportion of married individuals in the sample is noticeably different from that of the U.S. as a whole. In 1990, the Bureau of Census reports that on average over 61% of the over age 18 population was married. We suggest that the difference in the observed percent married from our sample to the Census figures is due to the inclusion of respondents ages 12-18.

Table 4.1-5 Cigarette Use Characteristics

Use History	*Age 1st Tried*	*Daily*	*Packs In Life*	*Price Nominal*	*Real*	*Budget Share*
All Respondents				$1.96	$1.35	0.076
Never Smoked				$1.96	$1.35	0.083
Ever Smoked	15.8	18.7	3575	$1.95	$1.35	0.071
Not in	15.6	18.5	2836	$1.95	$1.35	0.074
In Past	15.9	18.8	4500	$1.95	$1.35	0.067

Table 4.1-5 displays information about cigarette use in the sample. There is not much variation in the age the smoker initiated smoking between the current smokers (smoked in the past year) and those who have abstained. Nor is there significant variation in the first age of daily use. However, the mean number of lifetime packs smoked[3] varies widely between the two populations. This variation is probably driven in part by differences in age.

Note that there is almost no difference in the nominal or real price observed across the several populations in the table, particularly between the current year smoker and current year abstaining populations. The budget share column in the table displays

the proportion that the cost of one pack represents of the average daily household income. The average daily income is the mean annual household income divided by 365. The figures in the budget share column lend support to the standard results from microeconomic theory. The higher the relative cost of a good, the lower the use.

Table 4.1-6 Indicators of Dependence

Use History	*Please No Drinking*	*Argument Over Use*	*Tried to Quit*	*Unable to Quit*	*Abstained For 1 Year*
All Respondents	5.42%	3.18%			
Never Smoked	1.54%	0.85%			
Ever Smoked	8.13%	4.81%			
Not in	4.40%	1.94%			
In Past	12.79%	8.39%	53.52%	37.74%	4.14%

Table 4.1-6 gives information on measures of substance dependence. The first column "Please No Drinking" represents the proportion of respondents that indicated someone close to them, in the past year, had requested that they decrease their alcohol consumption. The second column represents the proportion that indicated they had experienced arguments with family or friends over their substance use in the past year. The substance that caused the argument was not specified.

The third through fifth columns in the table are measures of cigarette dependence. The third column displays the proportion that attempted to quit smoking in the past year and the fourth column displays the proportion that could not quit. The relative frequency in the fifth column is *not* conditional on attempting to quit. The final column in the table

[3] The packs in lifetime figure excludes the number of packs smoked in the month of the survey collection.

gives the proportion of current smokers that had previously abstained from smoking for at least one year.

There appears to be a strong relationship between the indicator of alcohol dependence in the first column and cigarette use. Additionally, arguments over substance use also appear to be related to cigarette use. We examine these two correlates in our discussion of the estimation results.

A very small number of current smokers have ever abstained for more than one year. This rules out a pattern of repeated stops and starts in daily smoking. This does not however rule out the occasional but regular use of cigarettes.

In the table below, we provide sample-wide information on the dependent variables used in the estimation of participation and consumption.

Table 4.1-7 Cigarette Use Prevalence

	In Past Month		*½ Packs*
Use History	*Ever Smoked*	*Smoked Occas.*	*Daily*
All Respondents	21.7%	2.0%	0.29
Never Smoked			
Ever Smoked	36.8%	3.4%	0.49
Not in Past Year			
In Past Year	82.8%	7.7%	1.11

The first column contains the proportion of respondents that smoked ever during the 30 days preceding the collection of the survey. The second column indicates the proportion that smoked occasionally but did not smoke daily during the preceding thirty days. The figures for the prevalence of occasional smokers are *not* reported conditional

on ever smoking in the prior thirty days. The final column displays the mean number of packs, in half pack increments, smoked daily by those respondents whom reported daily use.

4.2 Estimation

In this section, we discuss the estimation of the empirical model. We discuss the characteristics of specific data elements used the model regressions and issues associated with estimations. We also review the software implementation of the empirical model. We consider the results of the estimations in the following section.

4.2.1 Dependent and Independent Variables

Our empirical model has two regression equations: one associated with the participation decision and one associated with the consumption decision. Below we discuss the approach we followed in selecting the data elements for inclusion in the regressions. We then consider the each of the dependent variables.

4.2.1.1 Approach for Estimation

A primary goal of the current study is to discover whether individuals act in a fashion consistent with Bateson's model. Specifically and as we noted in previous sections, we would like to determine whether the direction of an individual's response to new signals will vary dependent on psychological state. In the context of a regression model, we would expect the sign of the coefficient of any regressor that captures a signal

observed by the individual to be negatively valued when the individual is in the symmetric state and *vice versa* in the complementary state.

Investigation of this form of behavior requires a regressor (or set of regressors) that capture signals observed by the smoker. We considered the data available in the NHSDA survey results and found several candidate elements. We also considered the signal implied by the change in the tax rate for a total of eight elements that represent signals observed by the smoker. These elements are described in Table 4.2-1 below[4].

Table 4.2-1 Psychological State and Signal Regressors

Element		All Individuals		Daily Smokers	
Name	Description	Mean	Sum	Mean	Sum
TRY_QUIT	*Tried to Quit Cigarettes*	14.5%	4354	52.7%	3349
QUIT_ANY	*Tried to Quit Other*	22.1%	6617	57.2%	3637
ALCPROBS	*Problems with Alcohol*	5.0%	1489	10.4%	663
ARGUMENT	*Arguments about Drugs*	3.7%	1117	9.9%	628
BOOKED	*Arrested this Year*	2.1%	620	4.3%	276
CIGPROBS	*Problems with Cigarettes*	1.7%	506	5.9%	378
MRJPROBS	*Problems with Marijuana*	1.4%	412	3.3%	210
PHLEGMYR	*Had Very Bad Cough*	7.1%	2118	10.2%	646
PLZ_QUIT	*Asked to Stop Drinking*	5.9%	1773	14.2%	900
TAXRISE	*Rise in Cigarette Taxes*	66.4%	19897	72.5%	4608

The table also provides information about the two other elements, TRY_QUIT and QUIT_ANY. These elements are the indicators of the psychological state of the individual. We identified these variables by considering the characterization of the

symmetric state describe in Bateson's paper (Bateson, 1971). As we discussed in Chapter 2, the symmetric state is characterized by attempts to "prove" by the addict that he or she is able to abstain. More information about failure in the attempts, nagging by the spouse, a warning by the doctor, will cause increased efforts by the addict to reduce or stop all consumption. The important aspect of this state is the attempt at abstention.

The elements TRY_QUIT and QUIT_ANY are both coded from survey questions that ask whether the individual attempted to cut down on use of a drug in the past year. The former element is coded as a one (1) if the respondent answered in the affirmative that he or she attempted to reduce the consumption of cigarettes. The latter is coded as one (1) if the respondent indicated that he or she had tried to reduce consumption of at least one of alcohol, cocaine or marijuana during the past year.

Table 4.2-2 Association Between PASTMNTH and HALFPACK and the Signals

	Odds Ratio[1]		Q_{MH}[2]		
PastMnth	Not Tried	Tried	Not Tried	Tried	All
MRJPROBS	2.875	0.631	44.525	4.486	12.087
PHLEGMYR	1.263	0.853	9.676	1.672	3.742
HalfPack					
ARGUMENT	1.309	0.965	2.753	12.964	15.196
CIGPROBS	2.384	1.213	20.421	9.681	22.839

[1] Odds of observing use in past month (PASTMNTH) or smoking at least 1 pack per day (HALFPACK) for smokers that tried and did not try to quit in the 12 months prior to the survey interview.
[2] Mantel-Haenszel χ^2 statistic for testing the association between PASTMNTH (1 d.f.) or HALFPACK (4 d.f.) and the signal variables.

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[4] Note that these figures are not weighted using the sample weights but represent the true observed counts and means. These variables all indicate the occurrence of the corresponding event within the past 12 months.

Table 4.2-2 details the association between three signal variables, and the occurrence of use (occasional *or* daily) in the last 30 days (PASTMNTH) and daily consumption (HALFPACK), controlling for attempts to quit[5]. The odds ratios are the proportional odds of either smoking in past month or consuming at least one pack per day depending on the table. The Q statistics are Mantel-Haenszel (1959, Mantel (1963)) measures of association distributed χ^2 with 1 degree of freedom except where noted. The null hypothesis for a test of the Q statistic is that there is no association.

The table above documents the direction and strength of the average smoker's response to various signals. Columns titled "Tried" refers to the individuals that attempted to reduce (as measured by either TRY_QUIT or QUIT_ANY) use of a substance in the past year. The Q statistic for all strata measures the average association across individuals who tried and those that did not.

Our prior expectation about the values and signs of the statistics was as follows. Given that a symmetric-state addict responds to signals to decrease consumption with attempts to decrease use, we expected to find an odds ratio below one for smokers that had tried to quit and an odds ratio above one for those that had not tried to quit. In the table, the odds ratios below one indicates a lower probability of choosing to smoke in the

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[5] See Appendix D for a complete set of statistics on the associations between the participation, consumption and signals. We coded the element PASTMNTH directly from PARTICIP where PASTMNTH was coded as a one whenever PARTICIP was either one or two, i.e., either an occasional or daily smoker.