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cigarette smoking**

Chaloupka, Frank Joseph, IV, Ph.D.

City University of New York, 1988

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AN ECONOMIC ANALYSIS OF ADDICTIVE BEHAVIOR:

THE CASE OF CIGARETTE SMOKING

by

FRANK JOSEPH CHALOUKKA IV

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

1988

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

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Abstract

AN ECONOMIC ANALYSIS OF ADDICTIVE BEHAVIOR:

THE CASE OF CIGARETTE SMOKING

by

Frank Joseph Chaloupka IV

Adviser: Professor Michael Grossman

This dissertation applies a theoretical model of rational addictive behavior to cigarette smoking and tests the hypotheses of the model empirically using the Second National Health and Nutrition Examination Survey, a near random sample of the population of the United States during the period from February, 1976 through February, 1980. Cigarette demand equations which explicitly account for the fact that cigarette smoking is an addictive behavior are derived from the Becker-Murphy theoretical model of rational addictive behavior. The effectiveness of two alternative policy measures, increased excise taxation of cigarettes and restrictions on cigarette smoking in public places, is then examined within the addictive framework.

A brief history of the various policies used in the anti-smoking campaign is followed by a review of the economics literature examining the effectiveness of these policies. The various factors which distinguish the consumption of addictive goods from other consumer goods are then discussed, particularly as they relate to cigarette

smoking. After a discussion of the theoretical model, cigarette demand equations are derived under the competing hypotheses of non-addictive and addictive behavior and myopic and rational behavior.

Using instrumental variables techniques, various cigarette demand equations are estimated, with the results generally supporting the hypothesis of the model. In particular, significant intertemporal linkages are found in cigarette consumption, confirming the hypothesis that cigarette smoking is addictive. Future events are found to have a significant impact on current consumption, implying that individuals are not behaving myopically. The long run price elasticities of demand implied by the estimates obtained for the addictive demand equations fall in the range from -0.40 to -0.28 , significantly larger than those obtained from demand equations estimated under the hypothesis of non-addictive behavior. Clean indoor air laws are found to have a significant negative impact on average cigarette consumption. Mixed evidence is obtained concerning the impact of stressful life cycle events on cigarette consumption, with stressful events generally leading to increased consumption. Finally, substantial differences are noted between the cigarette smoking behavior of men and women and between individuals of different ages and with different levels of educational attainment.

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Yamada and Tetsuji Yamada were particularly helpful in teaching me some of the basics involved in doing empirical research and publishing papers. Finally, I'd like to thank Linda Molinari for the time she spent introducing me to computers, without which this work would have been all but impossible.

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time together. I'll always love you Karen.

Finally, the dissertation is dedicated to my parents, Frank and Carol Chaloupka. They instilled in me the thirst for knowledge and the desire to succeed. Although they may not have fully understood my turning to economics, their support for me was unchanged. I only hope that when I become a parent I can do half as well with my children as they have done with my brothers and I.

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Chapter One

Introduction

Until fairly recently, economists have treated the consumption of addictive goods no differently than the consumption of other goods, although other social and physical scientists had long recognized that addictive goods possess several characteristics which distinguish them from most consumer goods. Part of the reason for ignoring the addictive nature of such goods as alcohol, drugs, and cigarettes was that their consumption was not thought to conform to the rational, utility maximizing behavior economists prefer to deal with. Indeed, many chose to treat addiction as an essentially irrational behavior that was not conducive to standard economic analysis.¹

Because of this irrationality, many think that the consumption of addictive goods does not follow the basic law of economics, that of an inverse relationship between the "price" of a good and the consumption of that good, where the "price" of a good in this discussion includes not only the money price but factors such as the negative health consequences and possible legal sanctions associated with consumption. Thus, the argument has been made that policies such as stronger enforcement of drug laws, higher fines and

¹ For example, see Schelling, 1984a and 1984b, Winston, 1980, and Ellster, 1977. Similarly, Barthold and Hochman, 1988, describe addicts as "extreme-seekers," characterized by non-convexities in their indifference curves.

longer imprisonment for drug use, higher taxes on alcohol and cigarettes, more severe and mandatory penalties for drinking and driving, and the dissemination of information concerning the negative health effects of drugs, alcohol, and tobacco will have little, if any, effect on their consumption.

Only recently have attempts been made to model the consumption of an addictive substance as a rational behavior.² These models capture the distinction between the consumption of an addictive good and the consumption of other goods by recognizing that current consumption depends on the level of past consumption (and, therefore, that future consumption decisions will depend on current and past consumption decisions).

The time dependence of consumption put forth in these models incorporates the notions of tolerance, reinforcement, and withdrawal which are generally used to separate addictive and non-addictive substances.³ Tolerance implies that there is a decrease in the body's response to a drug as its use is continued, or that more of a drug must be consumed to attain the same level of satisfaction from its consumption. Reinforcement can be of two types, positive and negative.

² See, for example, Michaels; 1988, Becker, Grossman, and Murphy, 1987; Becker and Murphy, 1986; Iannaccone, 1984; and Stigler and Becker, 1977. See also Mullahy, 1985, for a model of smoking developed using standard economic theory under the assumption of myopic behavior.

³ See, for example, Donegan, Rodin, O'Brien, and Solomon, 1983, and Peele, 1985.

Positive reinforcement implies that some pleasurable reward is associated with an activity which leads to an increase in that activity, while negative reinforcement refers to an action which terminates or prevents some unpleasant situation. Withdrawal refers to a physical reaction resulting from the cessation of the consumption of the addictive substance.

Each of the elements associated with addictive behavior illustrate the dependence of current consumption on past consumption, tolerance through the reduced effects of current consumption as past consumption is larger, reinforcement through the learned responses to past consumption, and withdrawal through the negative physical reaction as consumption is terminated.

This dissertation applies the Becker-Murphy model of rational addictive behavior to cigarette smoking, and empirically tests the implications of the model using data on individuals in the United States.

Cigarette smoking is an ideal choice for the empirical testing of a theoretical model of addictive behavior for several reasons. Of primary importance is the fact that cigarette smoking, due in particular to the nicotine contained in cigarettes, is an addictive behavior. Until just recently, cigarette smoking had been considered an habitual behavior rather than an addictive behavior. Now, however, most health officials and agencies, including U.S. Surgeon General C. Everett Koop, the National Institutes of

Health, and the American Psychiatric Association, consider nicotine both a physiologically and psychologically addictive substance.

Although cigarette smoking participation rates are at their lowest level in thirty years, cigarette smoking remains the most widespread addictive behavior in today's society. About thirty three percent of the male population were smokers in 1985, down from a peak of fifty three percent thirty years earlier, with a falling percentage of young men initiating smoking. Participation rates among women, while never as high as among men, have not shown the same improvement. About twenty eight percent of women were smoking in 1985, down from a peak of thirty four percent in 1964. However, the percentage of former smokers among women has remained relatively constant at about forty five percent since 1970, indicating that women today continue to take up smoking at approximately the same rate as they did fifteen years ago.⁴

Due to the high level of incidence of cigarette smoking and the legality of the behavior, self-reported measures of smoking are likely to be much more reliable than measures of heroin or other illegal drug use. If there was a substantial underreporting of consumption, the estimates of the responsiveness of addicts to various intervention policies would be thrown off significantly.

Just as important as the reliability of the data on the

⁴ U.S. Department of Health and Human Services, 1986b.

consumption of the addictive good is the accuracy of the data on the price of the good. As with the data on the consumption of illegal drugs, the data on the prices of illegal drugs are likely to be extremely inaccurate. On the other hand, the data on cigarette prices and taxes are very well reported at the state and local level.^a Again, to gain meaningful insight into the responsiveness of addicts to policies affecting the price of the addictive substance, the data on prices must be reliable.

Also relevant in understanding the importance of research on smoking behavior is the fact that it imposes a significant burden on the rest of society. If cigarette smoking was similar to coffee drinking, whose addictive substance, caffeine, creates few or no problems for society and/or individuals, then research on strategies designed to reduce smoking would be of little importance. However, cigarette smoking imposes a tremendous burden on society and on individuals. The Surgeon General calls cigarette smoking the "largest single preventable cause of premature death and disability in the United States," responsible for over three hundred thousand premature deaths annually, more than fifteen percent of all mortality.^a

Over the past twenty five years, cigarette smoking has

^a See the Tobacco Institute's The Tax Burden on Tobacco, published annually, and their Municipal Tax Surveys, conducted annually for detailed historical compilations of state, county, and municipal cigarette prices and excise taxes.

^a U.S. Department of Health and Human Services, 1986a.

been established as the leading cause of cancer and chronic obstructive lung disease (including bronchitis and emphysema) in the U.S., in addition to being a major risk factor in the development of cardiovascular and other circulatory diseases.⁷

The costs to the economy from productivity losses and health care expenditures resulting from cigarette smoking have been estimated to be as high as thirty five billion dollars, about \$1.17 per pack of cigarettes sold.⁸

In the most recent report of the U.S. Surgeon General, these findings are extended to show that nonsmokers face a greater risk of cancer from involuntary cigarette smoking than they do from all other air pollutants,⁹ underscoring the importance to all of society of efforts to reduce cigarette smoking.

Since the release of the first Surgeon General's report on the health consequences of cigarette smoking, the Federal and various state and local governments have been involved in a concerted effort to discourage cigarette smoking. This campaign, which includes the restrictions placed on cigarette advertising, the health warning labels required on all cigarette packaging and advertising, and the limitations on smoking in various public places, is the focus of Chapter

⁷ U.S. Department of Health and Human Services, 1982, 1983, and 1984, for example.

⁸ Office of Technology Assessment, 1985.

⁹ U.S. Department of Health and Human Services, 1986a.

Two of the dissertation. In addition, some discussion is presented concerning the use of cigarette excise taxes, and the impact of the taxes on cigarette prices, by both the Federal and state governments. Increased cigarette excise taxation is a policy which, inexplicably, has been all but ignored in the anti-smoking campaign, although increases in taxes would discourage smoking by increasing the price of cigarettes.

The use of the alternative policies of the anti-smoking campaign led to a variety of studies by economists in which the relative effects and merits of each were examined. A discussion of many of these studies and an examination of the findings of each is contained in Chapter Three.

However, as noted above, little attention was paid in these studies to the addictive nature of cigarette smoking and, thus, to the impact of modelling the demand for cigarettes in a framework which accounted for the addictive aspects of consumption. A discussion of the various behavioral, physiological, and psychological mechanisms through which cigarette smoking produces increments to utility and is addictive is presented in Chapter Four. Also, a brief review of the health consequences of cigarette smoking is contained in this chapter.

The Becker-Murphy model of rational addictive behavior is presented in Chapter Five and applied to cigarette smoking, following a discussion of other economic models of addictive and habitual behaviors. The discussion of Chapter

Four is recalled at various points to justify many of the assumptions employed in the development of the model.

Chapter Six uses the theoretical model of Chapter Five to derive cigarette demand equations which explicitly incorporate the assumption that cigarette smoking is a rational addictive behavior. In addition, demand equations are derived under the competing hypotheses that cigarette smoking is a nonaddictive behavior and that cigarette smoking is an addictive behavior but that individuals behave myopically when making consumption decisions. The expectations concerning each of the alternative demand equations are outlined and contrasted. Finally, various price elasticities of demand within the rational addiction framework are developed and discussed.

The data employed in the estimation of the cigarette demand equations is discussed in Chapter Seven. The primary data set is the Second National Health and Nutrition Examination Survey, a survey of approximately twenty eight thousand individuals. The survey, conducted by the National Center for Health Statistics during the years 1976 through 1980, is a near random sample of the civilian, noninstitutionalized population of the U.S., ages six months to seventy four years during that period. The survey data contains, in addition to information on cigarette smoking, a substantial amount of socioeconomic and demographic data, along with a significant quantity of health information obtained from questionnaires and a detailed medical examina-

tion. The process by which the survey data was augmented with cigarette price and excise tax data obtained from the Tobacco Tax Council is outlined in this Chapter, as well as some discussion of the problems associated with the price data. Finally, a discussion of the use of the information on cigarette smoking collected in the survey in the estimation of the cigarette demand equations is presented.

The results from the estimation of a variety of cigarette demand equations are presented in Chapters Eight, Nine, Ten, and Eleven. Chapter Eight contains the results from the basic demand equations developed in Chapter Six, using three alternative measures of the price of cigarettes and making several alternative assumptions concerning the rate at which the accumulation of past cigarette consumption disappears. The impact of clean indoor air laws (laws restricting cigarette smoking in various public places) on cigarette smoking is the focus of Chapter Nine. The Becker-Murphy model of rational addictive behavior allows stressful life cycle events to play a major role in the determination of an individual's lifetime cigarette smoking patterns. The effects of these events on cigarette smoking, in particular those associated with marital status and employment status, are examined in Chapter Ten. Differences in the cigarette smoking patterns of men and women, as well as of individuals of different races, ages and/or educational attainment, have been observed. These differences are examined in the context of the model of rational addiction in Chapter

Eleven, where a subset of the estimates of the cigarette demand equations are presented and discussed for various subgroups of the population.

Finally, Chapter Twelve contains a summary of the work which comprises the dissertation.

Chapter Two

A Brief History of Government Policy and Cigarette Smoking

Almost since the introduction of tobacco to Western civilization by Columbus upon his return from the New World, cigarette smoking has been subject to much controversy and governmental regulation. The anti-smoking campaign is not a relatively new phenomenon, as most people believe, but one that began in 1604 with King James I's statement that smoking "is a custome lothsome to the eye, hatefull to the nose, harmefull to the braine, dangerous to the Lungs, and in the blacke stinking fume thereof, nearest resembling the horrible Stigian smoke of the pit that is bottomelesse," in his Counterblaste to Tobacco. In addition to the opposition in England, several seventeenth century countries had laws prohibiting the sale of tobacco or smoking in public.¹ Similarly, both the Massachusetts and Connecticut colonies outlawed the sale of tobacco and public smoking (where public referred to any place where more than one person was present). During this period, the arguments against smoking were twofold. Firstly, smoking was described as dangerous to health and was linked with almost every disease imaginable, and, secondly, smoking was considered immoral.

¹ These countries included Russia, Turkey, and India, where the punishments were whippings, beheadings, and nose slittings, respectively (Dillow, 1981).

However, as tobacco became a relatively important commodity in the marketplace, government opposition to and regulation of smoking was reduced. Instead, realizing its potential for creating revenues, governments began to tax tobacco and to impose tariffs on imports of tobacco. Even those most associated with the free market philosophy were in favor of taxing tobacco, as can be seen by Adam Smith's statement: "Sugar, Rum, and tobacco are commodities which are no where necessities of life which have become objects of almost universal consumption, and which are therefore extremely proper subjects of taxation" (Book V, page 474).

The high tariffs imposed by England on the tobacco being imported from the colonies, as with those on other commodities, contributed to the colonies' war with England which eventually led to the formation of the United States. Tobacco soon became the leading agricultural export commodity of the United States, and the tobacco industry played a major part in the U.S. economy during the nineteenth century. At this time, the U.S. government experimented with excise taxes on cigarettes, but, due to opposition from both producers and consumers, the taxes, imposed in 1794, 1812, and 1816 were soon repealed.

During the Civil War, in an attempt to raise revenues, the Federal Government once again imposed an excise tax on cigarettes. This time the tax remained in effect. Initially, the tax was set at an effective rate of 2.4 cents per pack of twenty cigarettes, and was subsequently raised,

first to four cents, then to eight cents, then to ten cents during the war. After the war, the tax was reduced to three cents per pack, and eventually to one cent per pack.

In 1883, James Bonsack invented the cigarette machine, which eventually replaced hand-rolling as the primary means of making cigarettes. The Duke family of North Carolina leased the machine, giving them a comparative advantage in the production of cigarettes which enabled them to sell at about half the price of their competitors. Over the next decade, the Dukes formed a holding company made up of their company, the American Tobacco Company, and several competitors they had acquired. In an attempt to avoid anti-trust action, they converted the holding company into the American Tobacco Company, which by 1889 controlled over ninety percent of the cigarette market. This maneuver failed however, and the company was prosecuted under the Sherman Antitrust Act. After being found guilty in 1911, the American Tobacco Company was broken up into four companies, each of which remains a major force in the cigarette industry today.²

Due to the large fall in the price of cigarettes brought on by the introduction of the cigarette rolling machine, cigarettes soon became the major form of tobacco consumption. Prior to this time, the quantity of tobacco

² The four companies formed as a result of the anti-trust action were the American Tobacco Company, Liggett and Myers, R.J. Reynolds, and Lorillard.

consumed as cigarettes was far less than that consumed as chewing tobacco, cigars, or pipe tobacco. Another consequence of the lower price was that women and children began to smoke in much greater numbers.

Opposition to cigarette smoking spread during the late 1800's, largely in response to the increased participation of women and young men. As with the earlier opposition to smoking, the anti-smoking campaign of the late nineteenth century was based on concerns about health and morality. In addition to these concerns, there was an interest in nonsmokers' rights similar to that of the current anti-smoking campaign. The result of this opposition was the passage of laws in many states and territories prohibiting the sale and/or consumption of cigarettes.³ These laws had some impact at first, reversing the increasing trend in cigarette sales for a few years, but it wasn't long before sales surpassed their previous peak and continued to increase.

Largely as a result of soldiers' use of tobacco and cigarettes during World War I, the anti-smoking campaign

³ The first of these laws banning the sale of cigarettes was passed in 1895 in North Dakota. Shortly after, Iowa and Tennessee passed similar laws. These were largely ignored until 1900 when the Supreme Court upheld the Tennessee law. As a result, several other states passed similar laws: Iowa and Oklahoma (1901); Wisconsin, Indiana, and Nebraska (1905); Arkansas and Illinois (1907); Kansas, Washington, South Dakota, and Minnesota (1909); and Utah and Idaho (1921). The law in Illinois was struck down by the Supreme court shortly after its passage. The law in Indiana not only banned the sale of cigarettes but also their possession (Dillow, 1981; Wagner, 1973).

faded and most of the state laws restricting cigarettes and cigarette sales were repealed soon after, with the last going in 1927.⁴

The next important event in the evolution of government policy and cigarettes was the passage of the Agricultural Adjustment Act in 1933, which included tobacco as a commodity whose price was to be supported. This led almost immediately to an increase in the price of tobacco and, as a result, the price of cigarettes rose. The Agricultural Adjustment Act was found unconstitutional in 1936, but tobacco continued to be supported through acreage restrictions under that year's Soil Conservation and Domestic Allotment Act. The price supports of tobacco were continued under the second Agricultural Adjustment Act of 1938, and, later under the Agriculture Act of 1949, and are continued today. Two consequences of the price supports of tobacco have been the relative stability of the real price of tobacco and the maintenance of tobacco prices in the United States above world prices (Johnson, 1984). Eventually, the acreage restrictions were replaced by a limit on poundage.

The tobacco price supports have long been under fire from anti-smoking organizations as a seemingly schizophrenic activity when anti-smoking policies are considered, but the

⁴ The laws began to disappear as early as 1909 in Indiana and 1911 in Washington. The rest were repealed over the following fifteen years: Minnesota (1913); Wisconsin and Oklahoma (1915); South Dakota (1917); Nebraska, Iowa, Arkansas, Idaho, and Tennessee (1919-1921); Utah (1923); North Dakota (1925); and Kansas (1927).

price support system may actually be consistent with the other anti-smoking activities of the Federal government. As Johnson states in his monograph The Economics of the Tobacco Industry, one result of the price support is an increase in the price of cigarettes, which, in turn, discourages consumption.

Cigarette consumption continued to expand rapidly during the first four decades of the twentieth century, from an annual consumption of 2,635 million cigarettes in 1900 to 177,681 million in 1940. During this time, states began to impose excise taxes on cigarettes and the Federal tax was increased several times.^a The final increase in the Federal excise tax, until recently, was to eight cents per pack on November 1, 1951.

It was also around this time that the first scientific studies of the health consequences of cigarette smoking were being conducted. Prior to this, although anti-smoking forces had long blamed cigarettes for many health problems, there had been little more than anecdotal evidence on the health effects of smoking. During the early twentieth century, vital statisticians began to notice a rise in the incidence of lung cancer which paralleled the rise in

^a The first state to impose an excise tax on cigarettes was Iowa in 1921, followed by Georgia, South Carolina, South Dakota, and Utah in 1923. By the end of the 1920's six more states had enacted an excise tax. By 1940, more than half of the states were taxing cigarettes. By 1950, only a handful of states were not imposing an excise tax. Finally, in 1969, North Carolina became the last state to enact an excise tax on cigarettes.

cigarette consumption (Wagner, 1973). In 1938, Dr. Raymond Pearl, a biologist at Johns Hopkins University, published findings linking cigarette smoking to premature death. He noted that 67 percent of his sample of nonsmokers lived past 60 years of age while only 46 percent of smokers lived that long.

The 1940's saw several other studies of the effects of cigarette smoking on health published, and, in response to what they perceived as an attack on the industry, cigarette makers began to promote cigarettes as a healthy behavior in their advertising. This health promotion led the Federal Trade Commission to become involved in the regulation of cigarette advertising, an activity it continues today.

In 1941, a second antitrust suit was brought against several firms in the cigarette industry under the Sherman Antitrust Act. In 1946, the Supreme Court upheld the conviction of the cigarette companies for a conspiracy to restrain trade in an attempt to monopolize the industry. Rather than attempting to correct the problem, however, the firms were fined up to \$250,000 each. One result of this suit was the growth of two new firms in the market, Phillip Morris and Brown and Williamson. In addition to the other four firms formed as a result of the earlier antitrust action, these six firms controlled over 99 percent of the market from 1946 until today (Porter, 1986).

As a result of a study by Dr. E. Cuyler Hammond in 1949 linking lung cancer to heavy smoking, several studies were

undertaken during the early 1950's in the United States (by Hammond and Horn for the American Cancer Society) and the United Kingdom (by Doll and Hill for the British Medical Research Council). The results of these studies began to appear in 1953, when Hammond and Horn reported much higher death rates for smokers than for nonsmokers at the meetings of the American Medical Association, followed shortly afterward by similar reports from Doll and Hill.

For the first time in several decades, cigarette consumption fell in the United States. The fall of 6.4 percent in total consumption and 8.8 percent in per capita consumption from 1953 to 1954 was attributed to the health concerns triggered by the American Cancer Society report. In 1956, U.S. Surgeon General Dr. Leroy Burney set up a council formed from representatives of the National Cancer Institute, the National Heart Institute, the American Cancer Society, and the American Heart Association to review the studies on smoking and health. This committee concluded in 1957 that "the evidence of cause-effect relationship is adequate for considering the initiation of public health measures" (Wagner, 1973, page 81). A few months later, the British Medical Council reached a similar conclusion. That same year, the Surgeon General said "the Public Health Service feels the weight of the evidence is increasingly pointing in one direction: that excessive smoking is one of the causative factors in lung cancer."

The cigarette industry was becoming increasingly

anxious about these reports and, in response, formed the Tobacco Industry Research Committee in 1954 to conduct research of its own on the cigarette-health connection. The industry also began to introduce and promote filter tipped cigarettes, few of which were being sold before 1953. The fall in sales experienced from 1953 to 1954 was reversed in 1955, largely due to the introduction of these filter brands, which quickly came to dominate the market, as seen in Table 2-1.

Table 2-1

Market Share of Filter Tipped Cigarettes, 1952-1985

year	market share	year	market share
1952	1.3	1969	77.5
1953	2.9	1970	80.1
1954	9.2	1971	82.4
1955	18.7	1972	83.7
1956	27.6	1973	85.4
1957	38.0	1974	86.7
1958	45.3	1975	87.7
1959	48.7	1976	88.5
1960	50.9	1977	89.4
1961	52.5	1978	90.9
1962	54.6	1979	91.0
1963	58.0	1980	92.0
1964	60.9	1981	92.0
1965	64.4	1982	93.0
1966	68.2	1983	93.0
1967	72.4	1984	93.0
1968	74.9	1985	94.0

Source: Federal Trade Commission, Report to Congress Pursuant to the Public Health Cigarette Smoking Act, various years.

In addition to regaining lost sales, the cigarette makers were also able to increase their profits with the introduction of the filter tipped cigarette. The filter allowed producers to maintain the length of the cigarette

while using less tobacco, and also enabled them to use lower grades of tobacco leaf which have a stronger taste which is diluted by the filter (Doron, 1979; Ashton and Stepney, 1982).

The cigarette companies began promoting the filter tipped cigarettes as less dangerous, advertisements which led the Federal Trade Commission to step in, in 1955, and introduce advertising guidelines prohibiting any direct or indirect health claims in cigarette advertisements. In fact, as shown by Consumer Reports in its annual compilation of the tar and nicotine content of cigarettes begun in 1953, many of the early filtered cigarettes had a higher tar and nicotine content than nonfilters, a situation which was reversed over time.

Banned from health claims in advertising, the cigarette companies turned to advertising the tar and nicotine content of their cigarettes. In late 1959, the FTC ruled that this advertising could be construed as a health claim and put an end to the "tar derby" by negotiating a voluntary ban on tar and nicotine advertising. Wagner (1973) concludes that this prohibition had the unintended effect of lowering the incentive to produce more effective, lower tar and nicotine, filter cigarettes, and reversed the decline in sales of nonfilter cigarettes.

1955 also saw the initiation of a lawsuit against R.J. Reynolds and Liggett and Myers based on negligence and breach of warranty. The suit was brought by Victoria Lartigue, the

widow of Frank Lartigue who died of lung cancer in 1955. After a mistrial due to jury tampering on behalf of the cigarette companies, a jury returned a verdict in favor of the cigarette makers based on the lack of evidence that cigarette smoking was the causal factor in the development of lung cancer. A wave of similar actions followed brought by both smokers and their relatives, all of which were decided in favor of the cigarette companies. This type of action eventually died out, but has recently been revived as will be discussed below.

Serious policy on cigarettes was slow to develop in the United States due to the economic importance of the cigarette industry, but the evidence mounting over the late 1950's and early 1960's led President Kennedy to call for the formation of a committee to review the evidence on smoking and health. In 1962, a committee was formed headed by Surgeon General Luther Terry which included representatives from several private health associations, Federal agencies, and the tobacco industry. About the same time, the Royal College of Physicians in the United Kingdom released its first report, Smoking and Health.

After more than a year spent reviewing over 11,000 studies, the report of the advisory committee was released on January 11, 1964. The main conclusions of the report were as follows:

- 1) Cigarette smoking is a hazard of sufficient importance in the United States to warrant appropriate remedial action.

- 2) Cigarette smoking is causally linked to lung cancer.
- 3) Cigarette smoking is a contributing factor in the development of emphysema, chronic bronchitis, cancers of the mouth, throat, respiratory tract, and larynx.
- 4) Cigarette smokers have higher death rates from cardiovascular disease and liver cirrhosis, but the association is not proven to be causal.
- 5) The risk of cancer increases with the duration of smoking and the number of cigarettes smoked per day, and is reduced by quitting smoking.

One week after the release of the report, whose findings had been anticipated, the Federal Trade Commission proposed that a warning be placed on all cigarette packages and advertising.*

The cigarette industry had also anticipated the negative implications of the report and responded in several ways. One week before the release of the report, the American Tobacco Company had introduced the first low tar cigarette (a cigarette containing less than fifteen milligrams of tar). The industry also significantly increased advertising and began an attack on the FTC's proposal for warning labels. As with the filter cigarettes, the industry's motivation in introducing low tar cigarettes was not only health oriented but related to profits. Low tar cigarettes were produced using reconstituted tobacco sheet, formed from a combination of tobacco stem and dust, previously an unused waste product. Sales of low tar cigarettes

* This warning was to read "Cigarette Smoking is dangerous to health and may cause death from cancer and other diseases." The warning was to take effect January 1, 1965 on all advertisements, and then July 1, 1965 on all cigarette packaging.

increased slowly after their introduction, mainly in response to health concerns raised by the Surgeon General's report (see Table 2-2).

In what now seems an unusual move, the American Medical Association opposed the FTC's proposed warnings, citing a lack of evidence on the health consequences of smoking. They were rewarded with a \$10 million grant from the big six of the tobacco industry for health research, from which they eventually concluded that cigarette smoking led to significant health problems.

Table 2-2

Market Share of Low Tar Cigarettes

Year	Market Share	Year	Market Share
1964	0.3	1975	13.5
1965	0.2	1976	15.9
1966	0.7	1977	22.7
1967	2.0	1978	27.5
1968	2.5	1979	40.9
1969	3.0	1980	44.8
1970	3.6	1981	56.0
1971	3.8	1982	56.8
1972	6.6	1983	59.0
1973	8.9	1984	54.4
1974	8.9		

Source: Federal Trade Commission, Report to Congress Pursuant to the Public Health Cigarette Smoking Act, various years.

After substantial opposition in Congress, largely the result of lobbying efforts by the cigarette industry, the Cigarette Labelling and Advertising Act of 1965 was passed, to take effect January 1, 1966. Both sides claimed victory after the passage of the law which required a health warning on all cigarette packages, and created the National Clear-

inghouse for Smoking and Health. The cigarette industry successfully blocked warnings on advertisements for a three year period, blocked any state and/or local action on advertising, and watered down the language of the warning which now read "Caution: Cigarette smoking may be hazardous to your health." They also believed that this warning would exempt them from future lawsuits based on negligence claims, a belief which appears to have been supported by the recent legal decisions discussed below.

Anti-smoking forces claimed a victory, albeit a small one, in that they were able to require at least some warning on cigarette packaging. However, there seemed to be little change in consumption as a result of the warning labels. One reason given for the low impact on sales was the increase in cigarette advertising which accounted for more television advertising at this time than any other product, approximately eight percent of all television advertising.

Early in 1966, the FTC reversed its 1959 decision prohibiting the advertising of tar and nicotine contents stating that it "could no longer find expert witnesses to help sustain the charge that such disclosure would be misleading." The FTC also established a laboratory for the testing of cigarettes, and began publishing its semi-annual reports on their tar and nicotine content in November, 1967.

In January of 1967, John F. Banzhaf III wrote to CBS television requesting equal television time under the

Fairness Doctrine to air anti-smoking opinions.⁷ After being turned down twice by CBS, Banzhaf petitioned the Federal Communications Committee which ruled in his favor. In June of 1967, the Committee upheld its decision, stating that "networks should provide free each week a significant amount of time" for the airing of anti-smoking advertisements. The decision was upheld by the U.S. Circuit Court of Appeals in 1968, and, later that year, the Supreme Court upheld the ruling by refusing the industry's appeal. The result of the ruling was a dramatic increase in the number of anti-smoking commercials aired, from 982 in the three and one-half years prior to the ruling (sponsored by the American Cancer Society) to 4,723 in the eight months following it (Wagner, 1973). Banzhaf also formed Action on Smoking and Health about this time to monitor stations' compliance with the ruling. This organization remains at the forefront of anti-smoking activity today.

During 1968 and 1969, in addition to transmitting to Congress their report pursuant to the Federal Cigarette Labelling and Advertising Act concerning the effectiveness of cigarette labelling, current advertising, and recommendations, the FTC was pushing for stronger warning labels which would be included on advertisements, and for a complete ban on cigarette advertising on television and radio. Several

⁷ The Fairness Doctrine was established by the Federal Communications Committee in 1949, and required television and radio stations to air contrasting views on issues of public importance. The policy was reversed by the FCC in August, 1986.

pieces of legislation were introduced in Congress to this effect during 1969, and, on April 1, 1970, the Public Health Cigarette Smoking Act was signed into law by President Nixon. This act strengthened the warning label to read "Warning: The Surgeon General has determined that Cigarette Smoking Is Dangerous to Your Health." It also required the warning to be displayed in any cigarette advertising beginning July 1, 1971, and banned all television and radio advertising after January 1, 1971. The advertising ban has been criticized by many as an ill-conceived policy due to the consequent disappearance of the anti-smoking ads being aired under the Fairness Doctrine (see Chapter 3).

The FTC remained active in the anti-smoking campaign throughout the 1970's and into the 1980's. The commission negotiated an agreement with the cigarette industry in 1971 to display tar and nicotine content in all cigarette advertising. In 1981, it began reporting on the carbon monoxide in cigarettes in addition to its reports on tar and nicotine content. In 1984, after concluding that the existing health warning was ineffective due to its lack of specificity on the health consequences of smoking, the FTC succeeded in passing the Comprehensive Smoking Education Act, legislation which calls for stronger, rotating warnings to be placed on cigarette packages and advertising.*

* The four warnings, rotated quarterly, are: 1) Surgeon General's Warning: Smoking Causes Lung Cancer, Heart Disease, Emphysema, and May Complicate Pregnancy; 2) Surgeon General's Warning: Quitting Smoking Now Greatly Reduces Serious Risks to Your Health; 3) Surgeon General's

Most recently, the Federal Trade Commission began to take an interest in chemical additives that cigarette producers had been putting into cigarettes in an attempt to maintain the length of the cigarette as well as its taste, while reducing its tar and nicotine content. The result of this activity was the reemergence of the "tar derby" in the late 1970's and early 1980's, with cigarette companies competing to produce cigarettes with the lowest tar and nicotine content. The emphasis in cigarette advertising on tar content, as well as the improved taste of low tar cigarettes due to the chemical additives have been cited as the reason for the large increase in the sales of low tar cigarettes during the late 1970's as shown in Table 2-2 (Taylor, 1985). However, little is known about the health effects associated with these additives or even what the additives are, a situation over which the Surgeon General expressed concern in his 1981 Report entitled The Changing Cigarette. The FTC is currently trying to rectify this lack of information concerning the additives used to lower tar content while preserving taste. One result of the second tar derby was a large fall in the average quantity of tobacco contained in a cigarette, as illustrated in Table 2-3.

Warning: Cigarette Smoke Contains Carbon Monoxide; and
4) Surgeon General's Warning: Smoking by Pregnant Women May Result in Fetal Injury, Premature Birth, and Low Birth Weight.

Table 2-3Pounds of Tobacco per Thousand Cigarettes

Year	Pounds	Year	Pounds	Year	Pounds
1953	2.75	1964	2.22	1975	1.87
1954	2.70	1965	2.22	1976	1.79
1955	2.63	1966	2.12	1977	1.78
1956	2.56	1967	2.07	1978	1.73
1957	2.45	1968	2.08	1979	1.81
1958	2.39	1969	2.04	1980	1.76
1959	2.33	1970	1.95	1981	1.70
1960	2.31	1971	1.92	1982	1.73
1961	2.31	1972	1.97	1983	1.75
1962	2.30	1973	1.91	1984	1.71
1963	2.26	1974	1.91		

Source: Federal Trade Commission, Report to Congress Pursuant to the Public Health Cigarette Smoking Act, various years.

State and local governments also took part in the anti-smoking campaign beginning in the 1950's. As noted by Warner (1981a), states initially used increased excise tax rates on cigarettes as their major weapon in the campaign. Historically, this was not the case, as cigarette excise taxes were used to raise revenues, not discourage cigarette smoking.⁹ States' use of excise tax hikes to discourage smoking is easily observed by looking at the number of increases in state excise tax rates after the release of the

⁹ Warner (1981a) states that this can be seen by comparing the average initiation date of the excise tax for the six major tobacco producing states (North Carolina, Tennessee, Virginia, Kentucky, Georgia, and South Carolina) of 1939 to the remaining states' average date of 1940. He feels that the tobacco producers would not have enacted the taxes if the primary intent of the tax was to discourage smoking. Warner also notes that prior to the widespread publicity concerning the effects of cigarette smoking on health the average cigarette excise tax rate was 2.5 cents per pack in the tobacco producing states, only slightly less than the 2.88 cents per pack in the other states.

first reports linking smoking to bad health in the 1950's, and particularly after the release of the 1964 Surgeon General's report (see Table 2-4).

Table 2-4

Number of State Cigarette Excise Tax

Increases (Decreases), By Year, 1950-1986

Year	Increases	(Decreases)	Year	Increases	(Decreases)
1950	2		1969	20	
1951	7	(1)	1970	7	
1952	0		1971	16	
1953	2		1972	5	
1954	3		1973	2	
1955	11		1974	2	
1956	5	(1)	1975	5	
1957	8		1976	1	
1958	4		1977	4	
1959	15		1978	1	(1)
1960	4	(2)	1979	4	
1961	17	(1)	1980	2	
1962	2		1981	6	(1)
1963	15		1982	10	
1964	5		1983	13	
1965	22		1984	4	
1966	4	(1)	1985	11	
1967	12		1986	6	
1968	8				

Source: Compiled from the Tobacco Institute's The Tax Burden on Tobacco, 1987. Data for 1986 are through November 1, 1986.

The number of increases in state cigarette excise tax rates mirrors closely the release of various reports on smoking and health and some of the major Federal initiatives in the anti-smoking campaign. For instance, the latter half of the 1950's, following the publicity surrounding the findings of Hammond and Horn in the U.S. and Doll and Hill in the U.K., saw an average of over eight tax hikes a year,

compared to the less than three per year, on average, in the early 1950's. Similarly, the year following the release of the initial report of the Surgeon General saw a record twenty-two increases in state excise tax rates. This pattern continued during the period when the Fairness Doctrine was invoked, and again after the television and radio advertising ban. As Warner (1981a) notes, the negligible difference between tax rates in the tobacco producing states and in the remaining states widens significantly over this period, leading him to conclude that the tax increases are mainly the result of the anti-smoking campaign. By 1985, the average tax rate in the tobacco producing states had increased to 6.6 cents per pack, while that average tax rate in the remaining forty-five states (including Washington D.C.) had increased to seventeen cents per pack, a difference of over ten cents per pack (Tobacco Institute, 1985).

Over this same period there was similar activity at the local level, with almost four hundred cities and counties imposing local excise taxes on cigarettes in 1985 compared to the handful which imposed them prior to 1950. These local taxes were responsible for generating nearly \$200 million in revenues in 1985.

The result of this activity at the state level was to increase the average state excise tax rate significantly, and, consequently, the average price of cigarettes rose in both real and nominal terms, as illustrated in Table 2-5.

As shown in Table 2-5, the real average state excise taxes peaked in 1972, more than double the real rate in 1955

Table 2-5

Nominal and Real Median Cigarette Prices

and Average State Excise Tax Rates, All Taxing States

Year	Nominal Tax Rate	Real Tax Rate	Nominal Price	Real Price
1955	3.5	4.36	23.2	28.9
1956	3.8	4.67	23.8	29.2
1957	3.9	4.63	25.0	29.6
1958	4.0	4.62	25.6	29.6
1959	4.2	4.81	26.1	29.9
1960	4.7	5.30	26.1	29.4
1961	4.7	5.25	26.9	30.0
1962	5.1	5.63	26.8	29.6
1963	5.2	5.67	27.9	30.4
1964	5.6	6.03	28.2	30.4
1965	5.9	6.24	30.0	31.7
1966	6.9	7.10	30.5	31.4
1967	7.1	7.10	32.3	32.3
1968	8.4	8.06	32.8	31.5
1969	9.1	8.29	37.1	33.8
1970	10.2	8.77	38.9	35.4
1971	10.7	8.82	40.0	33.0
1972	11.6	9.26	40.3	32.2
1973	12.1	9.09	41.8	31.4
1974	12.1	8.19	44.5	30.1
1975	12.2	7.57	47.9	29.7
1976	12.4	7.27	49.2	28.9
1977	12.5	6.89	54.3	29.9
1978	12.9	6.60	56.8	29.1
1979	12.9	5.93	60.0	27.6
1980	13.1	5.30	63.0	25.5
1981	13.2	4.85	69.7	25.6
1982	13.5	4.67	81.9	28.3
1983	14.7	4.93	94.7	31.7
1984	15.3	4.92	97.8	31.4
1985	15.9	4.93	104.5	32.4
1986	16.2	4.93	110.0	33.5

Note: Taxes are a weighted average of taxes imposed by taxing states only (42 in 1955, 51 by 1970), and are on a fiscal year basis. Prices are reported as of November 1 each year. Real taxes and prices are deflated by the annual Consumer Price Index, 1967=100.

Source: Tobacco Institute, U.S. Bureau of Labor Statistics.

when the states began raising rates in response to health concerns. However, ten years later, the average real rate was barely one-half of what it was in 1972, while nominal rates were only slightly higher than they had been.

This abrupt reversal in the trend of increasing state excise tax rates was due primarily to a reluctance by states to raising excise taxes for fear of what had become known as the "buttlegging" problem (Advisory Commission on Intergovernmental Relations, 1977 and 1985). Due to the growing disparity in state cigarette prices, mainly the result of the large differences in state excise tax rates, casual and organized smuggling of cigarettes across state borders had increased rapidly since 1965. The Advisory Commission gives several reasons why states have had difficulty controlling this problem including the easy transport of cigarettes across state lines and the potential for profits from this transport (1977, page 1). Those states which had been vigorous participants in the anti-smoking campaign through their use of increased tax rates became disinclined to raise rates further for fear of losing a substantial amount of the tax revenues generated from cigarettes.¹⁰

The extent of this problem can be illustrated by an

¹⁰ The Advisory Commission on Intergovernmental Relations estimated that this had become a significant problem in fourteen states and a moderate problem in another eight states by 1975. It also estimated the cost of the smuggling to be \$391 million in lost revenues per year by 1975.

example using data from 1977. In this example, per capita cigarette sales in New Hampshire were 247.8 packs as compared to per capita sales of 120.5 in neighboring Massachusetts, where the cigarette excise tax rate was nine cents higher. It's unlikely that residents of New Hampshire were consuming over twice as many cigarettes, on average, than their neighbors in Massachusetts, but rather that a large share of sales in New Hampshire were to residents of other states, particularly Massachusetts.

In response to pressure from high tax states, Congress passed the Federal Contraband Cigarette Act in 1978 which prohibits the "transportation, receipt, shipment, possession, distribution, or purchase of more than 60,000 cigarettes not bearing the tax indicia of the state in which the cigarettes are found." The Act dealt only with the organized cigarette smuggling which the Advisory Commission described as the major problem and ignored the less problematic casual smuggling. The Advisory Commission (1985) suggests that the law was even more effective than its proponents would have predicted,¹¹ but calls for

¹¹ The Commission notes that there were a large number of state cigarette excise tax increases in 1982 and 1983 (see Table 2-3), but they estimate the total loss in fiscal 1983 from smuggling to be \$255 million, about one-third of what it was in 1975 in real dollars. In 1983, only two states, Connecticut and West Virginia, are classified as having serious bootlegging problems, down from fourteen in 1975. Finally, organized and casual smuggling are described as minor problems in 1983, with over seventy percent of the problem due to tax exempt sales on Indian reservations and military bases (which were a small part of the problem in the 1970's).

further action, particularly with respect to tax exempt sales on Indian reservations and military bases.

The burst of activity in state excise tax rates on cigarettes in the early 1980's (see Table 2-4) can be partly attributed to the enactment of the Contraband Cigarette Act, but it is also likely to be the result of the doubling of the Federal excise tax on cigarettes to sixteen cents on January 1, 1983. This was the first increase in the Federal tax since November 1, 1951, when the tax was raised to eight cents. The constancy of the Federal tax over this period is the major reason for the decline in the real price of cigarettes from 1970 through 1981, reversing the increasing trend in price associated with the increases in state excise tax rates. There had been some interest expressed in Congress during the 1970's to use the Federal cigarette excise tax to discourage smoking, but little came of it.¹²

The Federal tax increase was part of the Tax Equity and Fiscal Responsibility Act of 1982, and was initially scheduled to be repealed on October 1, 1985. After being extended several times, the increase was made permanent in 1986. However, Harris (1987) argues that main cause of the increase in the real price of cigarettes (see Table 2-5)

¹² The best example of this interest was the bill introduced by U.S. Senators Gary Hart, Edward Kennedy, and others to establish a "health tax" on cigarettes (Action on Smoking and Health, 1978). The amount of the tax would vary according to the tar and nicotine content of the cigarettes, similar to the New York City cigarette excise tax initiated in 1971.

from 1981 through 1986 was not the increase in either the Federal tax or the state and local tax increases, but rather increases in the wholesale price of cigarettes due to markups by manufacturers. He argues that most of these manufacturers' increases were not justified by increases in the costs of production, but rather that they were the result of oligopolistic behavior on the part of the firms in the industry, coordinated by the preannounced Federal tax increase.

Whatever the reason, the real price of cigarettes rose about thirty-six percent during the period 1981-1986 (Harris, 1987). Part of this increase was the result of a renewed interest on the part of the states in using excise taxes as a policy tool in the anti-smoking campaign. The Federal increase, however, was motivated almost entirely by the growing Federal budget deficit, with increased excise taxes being a politically expedient means of raising revenue. Recent discussions in Congress on doubling the tax to thirty-two cents per pack are again based on the need to raise revenues, with some, such as Senator Bradley, justifying an increase as a way to get smokers to pay a greater share of the economic burden they place on society.

The second major tool of state and local governments in the anti-smoking campaign has been the enactment of laws restricting smoking in public places and in the workplace, beginning with the Minnesota Clean Indoor Air Act of 1975. This relatively new phenomenon is the result of increased

pressure by nonsmokers' rights groups during the 1970's and 1980's.¹³

The increasing success of the nonsmokers' rights groups in pressuring state and local legislatures into enacting clean air legislation is largely attributable to the expanding knowledge concerning the effects of cigarette smoke on the health of nonsmokers. This link was suggested by the Surgeon General in his 1972 Report on the Health Consequences of Cigarette Smoking, and expanded upon in his following reports, culminating in the 1986 Report: The Health Consequences of Involuntary Smoking. The primary conclusions of this report were: involuntary smoking (the result of exposure to cigarette smoke) can cause lung cancer in otherwise healthy nonsmokers; the simple separation of smokers and nonsmokers within the same air space may lower but will not eliminate the hazards of exposure to environmental tobacco smoke; and, the children of parents who smoke have an increased likelihood of developing respiratory illnesses compared to the children of non-

¹³ Groups which have been particularly active in this area include Banzhaf's Action on Smoking and Health (ASH), Group Against Smoking Pollution (GASP), Fresh Air for NonSmokers (FANS), The Coalition on Smoking OR Health, Americans for Nonsmokers' Rights, and the Tri-Agency Tobacco Free Project (formed by representatives of the American Cancer Society, the American Heart Association, and the American Lung Association). The Tri-Agency Tobacco Free Project, for example, states that its goals are to 1) banish tobacco use in public places where nonsmokers are exposed and placed at risk; 2) to force smokers not to smoke while in the presence of nonsmokers; 3) to make the habit of smoking a socially unacceptable practice; and 4) to achieve a smoke-free society by the year 2000.

smokers¹⁴. As a result of the review of studies linking exposure to cigarette smoke to poor health in nonsmokers, the Surgeon General recommended the enactment of laws designed to eliminate cigarette smoking in public places, particularly in the workplace.

While some states had laws in place prior to 1975 which restricted cigarette smoking in limited areas (such as elevators, movie theaters, and food preparation areas), these laws had been enacted with the intent of preventing fires and/or contamination of food. On the other hand, the clean indoor air laws passed over the last thirteen years are designed to prevent or reduce nonsmokers' exposure to tobacco smoke in public places, including restaurants, health care facilities, retail stores, schools, and workplaces (Tri-Agency Tobacco Free Project, 1986).

The Minnesota Clean Indoor Air Act of 1975 was the model for later legislation in several states and cities, explicitly designed to "protect the public health, comfort, and environment." This law banned cigarette smoking in any "enclosed, indoor area used by the general public or serving as a place of work, including, but not limited to, restaurants, retail stores, offices and other commercial establishments, public conveyances, educational facilities, hospitals, nursing homes, auditoriums, arenas and meeting rooms, but excluding private, enclosed offices occupied

¹⁴ U.S. Department of Health and Human Services (1986a), pages 12-14.

exclusively by smokers even though such offices may be visited by nonsmokers." The result was that smoking was prohibited except in areas specifically designated as smoking areas.

As the evidence concerning the health effects of second-hand cigarette smoke for nonsmokers has mounted, a rapidly increasing number of states and cities passed similar legislation (see Tables 2-6 and 2-7), with forty-one states and the District of Columbia having enacted laws

Table 2-6

State Laws Restricting Smoking

Year	Number of New Laws	Cumulative Number of State Laws	Restrictiveness of Newly Enacted Laws	Average Restrictiveness of Laws
1970	0	14	-	.250
1971	2	16	.250	.250
1972	1	17	.250	.250
1973	3	20	.330	.263
1974	3	22	.417	.295
1975	12	27	.479	.389
1976	5	30	.563	.425
1977	6	33	.542	.462
1978	2	34	.625	.478
1979	4	37	.688	.507
1980	1	37	.750	.507
1981	6	39	.500	.513
1982	1	39	.750	.513
1983	4	40	.688	.538
1984	3	41	.667	.549
1985	8	42	.719	.619

Source: U.S. Department of Health and Human Services, The Health Consequences of Involuntary Smoking, A Report of the Surgeon General, 1986.

Note: The restrictiveness level is determined as follows scale: 0=no restrictions; 0.25=nominal restrictions, state regulates smoking in 1-3 public places, excludes restaurants and private workplaces; 0.5=basic, state regulates smoking in 4 or more public places, excludes restaurants and private workplaces; 0.75=moderate, smoking regulated in restaurants but not private workplaces; 1.0=extensive, smoking regulated in private worksites.

prohibiting smoking in at least one public place by 1985 (U.S. Department of Health and Human Service, 1986). As these types of laws became more widespread, the comprehensiveness and restrictiveness of the laws increased (see Tables 2-6 and 2-7). The most prevalent and most stringent

Table 2-7

State Laws Regulating Smoking In
Public Places and In the Workplace

State	Year(s) Enacted	Restrictiveness Index	Workplace Restrictions
Alabama	-	0	0
Alaska	1975, 1984	0.75	1.00
Arizona	1973, 1981	0.50	0
Arkansas	1977, 1985	0.25	0
California	1971, 1976 1980, 1981, 1982	0.75	0.25
Colorado	1977, 1985	0.75	1.00
Connecticut	1973 1974, 1983	1.00	0.50
Delaware	1960	0.25	0
District of Columbia	1979	0.50	0.50
Florida	1983, 1985	1.00	1.00
Georgia	1975	0.25	0
Hawaii	1976	0.50	0.50
Idaho	1925, 1975 1985	0.75	0.50
Illinois	-	0	0
Indiana	-	0	0
Iowa	1978	0.50	1.00
Kansas	1975	0.50	0
Kentucky	1972	0.50	0

Table 2-7 (Continued)

State	Year(s) Enacted	Restrictiveness Index	Workplace Restrictions
Louisiana	-	0	0
Maine	1954,1981 1983,1985	1.00	1.00
Maryland	1957,1975	0.50	0
Massachusetts	1924 1947,1975	0.50	0
Michigan	1967,1968 1978	0.75	0
Minnesota	1971,1975	1.00	1.00
Mississippi	1942	0.25	0
Missouri	-	0	0
Montana	1979	1.00	1.00
Nebraska	1979	1.00	1.00
Nevada	1911,1975	0.50	0.25
New Hampshire	1981	0.50	1.00
New Jersey	1955 1979,1985	1.00	0.75
New Mexico	1985	0.75	0.75
New York	1921,1975 1976	0.50	0.25
North Carolina	-	0	0
North Dakota	1977	0.75	0.75
Ohio	1981,1984	0.50	0.75
Oklahoma	1975	0.50	0
Oregon	1973,1975 1977,1981	0.75	1.00
Pennsylvania	1927 1947,1977	0.50	0
Rhode Island	1976 1977	0.75	0
South Carolina	1937	0.25	0
South Dakota	1974	0.50	0

Table 2-7 (Concluded)

State	Year(s) Enacted	Restrictiveness Index	Workplace Restrictions
Tennessee	-	0	0
Texas	1975	0.50	0
Utah	1976, 1979	1.00	1.00
Vermont	1892	0.25	0.25
Virginia	-	0	0
Washington	1983	1.00	1.00
West Virginia	1913 1919, 1985	0.25	0.25
Wisconsin	1984	0.75	1.00
Wyoming	-	0	0

Source: Adapted from U.S. Department of Health and Human Services The Health Consequences of Involuntary Smoking, A Report of the Surgeon General, 1986.

Note: The Restrictiveness Index is as described in the note to Table 2-6. The workplace restriction index is based on the following scale: 0=no regulations on smoking in the workplace; 0.25=nominal regulations, employer must post a sign prohibiting smoking at the worksite; 0.50=basic regulations, employer must have a written smoking policy; 0.75=moderate regulations, employer must have a policy that provides a nonsmoking area; 1.00=extensive regulations, no smoking except in designated areas.

of the laws are in those states in the west, and, not unexpectedly, the least prevalent and least restrictive are in the southeast where most of the major tobacco producing states are located (U.S. Department of Health and Human Services, 1986).

In the 1980's, this activity spread to the local level, particularly in California where seventy-four cities and counties had passed laws by March, 1986 (Americans for

NonSmokers' Rights, 1986). One of the most publicized of the laws to be passed at the local level was Proposition P in San Francisco in 1983. This law is particularly stringent in that it requires smoking to be banned completely if no compromise can be reached between smokers and nonsmokers on the designation of a smoke-free work area. After several months of public debate and well financed opposition from the cigarette industry, the proposition was passed into law by San Francisco voters by 50.4 percent to 49.6 percent (Martin, 1986).

The publicity surrounding Proposition P induced several other communities to pass similar legislation, with eighty-nine cities and counties passing laws by the end of 1985 (U.S. Department of Health and Human Services, 1986).¹⁵

Since state and local laws regulating smoking were not applicable to Federal buildings, the General Services Administration recently succeeded in enacting tough smoking restrictions to apply to these buildings. The restrictions, covering over 887,000 Federal employees, prohibit smoking except in private offices and designated areas. Similarly, the U.S. Army banned cigarette smoking in all vehicles, aircraft, and most workplaces, allowing it only in specified areas, effective April 7, 1986. Most recently

¹⁵ About three-fourths of these laws were passed by cities in California. Other cities enacting similar legislation include Cincinnati, Kansas City, Tucson, Aspen, San Antonio, Austin, Fort Worth, Newton, and New York, in addition to Suffolk County, New York (U.S. Department of Health and Human Services, 1986). Legislation is pending in many other cities and counties.

(December 22, 1987), Congress enacted a law prohibiting cigarette smoking on all domestic airline flights of two hours or less.

Both the spread of state and local laws restricting smoking and the pressure brought from nonsmokers' rights groups and nonsmoking employees have led many businesses to enact some smoking policy. According to a survey of members of the American Society for Personnel Administration conducted by the Bureau of National Affairs in 1986, thirty-eight percent of the organizations had some policy in place or were in the process of implementing it, with another twenty-one percent considering a policy (Bureau of National Affairs, 1986). These policies include complete bans on smoking, prohibition of smoking except for in designated areas, provision of smoke-free work areas, the hiring of only nonsmokers, and payment of bonuses for nonsmokers or for smokers who quit.¹⁶ In a similar action, New York city taxi-cab drivers recently won the right to prohibit smoking in their cabs. The likelihood that companies will enact a policy covering the smoking behavior of their employees is increasing as insurance companies begin to offer discounted health insurance to companies whose employees engage in healthy activities (or do not engage in unhealthy practices). Similar action is being

¹⁶ These companies include General Motors, Ford, Texas Instruments, Aetna Life Insurance, Campbell Soup, Levi Strauss, Boeing, the Bank of America, Merck & Co., Hewlett-Packard, I.B.M., and Proctor and Gamble.

undertaken in at least one state legislature (Delaware), where required reductions in insurance costs of ten percent for nonsmokers and five percent for regular exercisers, light drinkers, normal weight and blood pressure, seat belt users, and those who avoid the use of illegal drugs are under consideration.¹⁷

Current U.S. Surgeon General C. Everett Koop has been one of the leading advocates of these types of policies, stating that clean indoor air laws and workplace smoking restrictions would have the two-fold effect of reducing the opportunities a smoker has to smoke as well as "creating an environment where the smoker is provided with the support and reinforcement needed to overcome the addiction" (U.S. Surgeon General, 1986). Much of the U.S. population, including smokers, agree with this, as illustrated by a poll conducted by The Gallup Organization for the American Lung Association in 1985, the results of which are reproduced in Table 2-8.

As an increasing number of individuals have won lawsuits based on the nonsmokers' right to a smoke-free workplace, and as more city, county, and state legislatures have passed clean indoor air laws, there has been a resurgence in product liability actions brought by smokers and their survivors against cigarette companies. From 1978 through mid-May, 1987, 158 smoking liability suits had been brought against tobacco companies, most of these origina-

¹⁷ New York Times, Tuesday, September 22, 1987.

Table 2-8Survey of Attitudes Towards Smoking**Should Smokers Refrain From Smoking in the Presence of Nonsmokers?**

	Yes	No	No Opinion
Current Smokers	62%	37%	1%
NonSmokers	85%	15%	0%
Former Smokers	78%	22%	0%
All Adults	75%	24%	1%

Should Companies Have a Policy on Smoking at Work?

	Total Ban	Create Smoking Areas	No Policy	No Opinion
Current Smokers	4%	76%	19%	1%
NonSmokers	12%	80%	6%	2%
Former Smokers	9%	80%	10%	1%
All Adults	8%	79%	12%	1%

Source: The Gallup Organization, 1985.

ting after 1985 (New York Times 8/16/87). The first of the cases to be decided have gone in favor of the tobacco companies, with a few others having been dropped, but most of the cases have yet to be brought to trial. Cigarette manufacturers, in the cases decided thus far, have been protected from states' product liability laws by the Federal Cigarette Labeling and Advertising Act of 1965 which required the health warning labels on all cigarette packaging and printed advertising. However, as they gain more experience, the lawyers for the plaintiffs feel they can turn this trend around, particularly in cases where the individual began smoking long before the warning labels appeared and in states with more liberal liability laws.

What had been considered to be the strongest of these cases to date, that of the family of Nathan Horton versus American Brands Inc.'s American Tobacco Company subsidiary

in Lexington Mississippi, ended with the jury deadlocked 7-5 this February, with the side favored by the majority unknown due to the orders from the presiding judge. The Mississippi product liability laws are among the most favorable in the country with only 9 of the 12 jurors required to find the company as little as one percent responsible for the plaintiff's death or injury in order to award damages under the state's comparative-negligence law. Nevertheless, anti-smoking forces continue to proceed to trial in the about 125 similar suits brought by smokers and their families across the country.

As with their introduction of filter-tip and low-tar cigarettes in response to the health scares of the 1950's and 1960's, the cigarette industry is attempting to develop a new cigarette in response to the environmental smoke issue and the resurgence of product liability suits. R.J. Reynolds recently announced a "smokeless" cigarette, scheduled to be introduced on a limited basis in 1988 (New York Times, 9/15/1987). This cigarette, which warms the tobacco rather than burning it, is supposed to produce no visible smoke, no ash, and no tobacco smoke odor. The taste of the cigarette, as well as the quantities of carbon monoxide and nicotine consumed by the smoker, are supposed to be unchanged. Taste is to be retained through the use of a "flavor capsule," the contents of which are not available, but the safety of which concerns some health officials.

While acknowledging that the new cigarette leads to a significant reduction in environmental smoke, anti-smoking groups do not feel that the "smokeless" cigarette is a major breakthrough due to the maintenance of carbon monoxide and nicotine levels and the questionable health consequences of the "flavor capsule." Others, however, have suggested that the new cigarette might help wean smokers away from the habit, arguing that the "cloud of smoke is part of the behavioral dependence affecting smoking," and that switching to the cigarette may be the first step towards quitting. The health effects of the new cigarette, and its acceptance by both nonsmokers and smokers are questionable, and will be interesting to follow. In particular, the new cigarette will be sold at a premium, leading some current smokers to state that rather than completely switch to it, they will use it as a substitute for their preferred cigarettes in situations where smoking is socially uncomfortable.^{1*}

Finally, there has been a resurgence of interest during the mid-1980's in cigarette advertising. The Federal Trade Commission filed a complaint against R.J. Reynolds for an ad it ran in the Spring of 1985 which misrepresented the findings of various studies making it appear as if smoking had never been linked to heart disease. After taking Reynolds to court on charges of deceptive advertising, the FTC was successful in preventing the company from running

^{1*} The Wall Street Journal, Friday September 18, 1987.

the ad.

The American Medical Association has suggested a ban on all forms of cigarette advertising, including billboards, newspaper and magazine ads, and the sponsorship of sporting and promotional events. Legislation to this effect has been introduced in Congress by Senator Bill Bradley. There has also been a bill submitted in Congress by Senator John Chaffee which proposes to eliminate tax write-offs for cigarette advertising. The outcome of this legislation remains to be seen.

Conclusions

The long campaign against cigarette smoking is only recently beginning to show signs of success. The increasing trend in the aggregate consumption of cigarettes in the United States, with the exception of a few year to year declines, appears to have been halted with the increase in the Federal excise tax at the beginning of 1983 (see Table 2-9). After several one time drops followed by a resumption in its increasing trend, per capita cigarette consumption finally appears to be falling steadily from its peak of 2,905 cigarettes per year in 1976 (see Table 2-9). This fall appears to be associated with a drop in the number of smokers, as current smokers quit the habit and fewer young people take it up, rather than a reduction in the average number of cigarettes consumed by smokers (Harris, 1987).

Although some signs of the success of the anti-smoking campaign are evident, there is still much that can be done. Researchers at the Federal Trade Commission (Myers et al. 1981), after several surveys conducted from 1978 through 1980, conclude that:

1) Many smokers, although they know that the Surgeon General has concluded that smoking is dangerous to health, have little knowledge concerning the diseases linked to smoking, the increased likelihood of these diseases if they smoke, or the increased likelihood of death given that they smoke;

2) Many smokers, albeit they are aware of the health consequences of smoking, feel that it is others that will be affected, not themselves, because of the type of cigarette or quantity of cigarettes they smoke;

3) Smokers find it hard to remember and consider abstract health information, they need, instead, information that they feel is personally relevant.

These conclusions appear to imply that policies which directly impact on the smoker need to be designed in order to reduce smoking. Two such policies to be considered in this research are increased prices of cigarettes brought about by increases in the cigarette excise tax and limitations on smoking arising from restrictions on smoking in public places.

There remains much to be done at all levels of government in designing appropriate policies to discourage cigarette smoking. The relative effectiveness of the various policies used by Federal, state, and local governments in the anti-smoking campaign has been the focus of a substantial amount of research. The findings of this research will be the focus of Chapter Three.

Table 2-9Cigarette Consumption in the United States

<u>Year</u>	<u>Aggregate Consumption (millions)</u>	<u>Per Capita Consumption</u>
1945	238,874	1,808
1946	306,514	2,191
1947	327,218	2,282
1948	345,200	2,364
1949	352,208	2,371
1950	355,099	2,390
1951	369,705	2,434
1952	385,427	2,502
1953	396,695	2,535
1954	378,433	2,380
1955	376,048	2,322
1956	387,260	2,346
1957	402,726	2,397
1958	417,050	2,437
1959	442,780	2,544
1960	468,553	2,645
1961	479,394	2,664
1962	488,437	2,668
1963	502,959	2,707
1964	495,073	2,626
1965	516,958	2,702
1966	516,138	2,663
1967	524,946	2,680
1968	522,555	2,640
1969	520,310	2,603
1970	511,666	2,534
1971	539,577	2,648
1972	542,623	2,631
1973	562,735	2,702
1974	594,881	2,835
1975	570,294	2,698
1976	619,118	2,905
1977	596,256	2,778
1978	609,546	2,818
1979	615,117	2,821
1980	605,765	2,752
1981	633,328	2,796
1982	632,235	2,757
1983	599,821	2,591
1984	596,739	2,550
1985	595,418	2,501
1986	581,024	2,434

Source: The Tobacco Institute, The Tax Burden on Tobacco, 1987.

Note: Data are for fiscal years ending June 30.

Chapter Three

A Review of the Economic Literature on Cigarette Smoking and Public Policy

Research by economists into the demand for cigarettes and the impact of various public policy measures on demand has a long and varied history. This chapter will review the economic literature on the demand for cigarettes and related issues, paying particular attention to those studies conducted over the past twenty years which analyzed the impact of the anti-smoking campaign on cigarette consumption. Less well defined are the economic models of habitual or addictive behaviors, the discussion of which will be reserved for Chapter Five when the basic theoretical model will be developed.

At this point, some mention should be made of the economic justification for government intervention in the cigarette market. As most introductory economics textbooks would note, a properly functioning market can be characterized by the existence of the following conditions:

- 1) Individuals in the market are price takers. In other words, the market is competitive.
- 2) Individuals in the market have perfect information.
- 3) The good bought and sold in the market has no positive or negative externalities associated with its consumption or production.
- 4) The good being traded in the market is not a pure

public good.

If one or more of these conditions is not met, then government intervention in the market can be justified. In the case of the cigarette market, the failure of the second and third of these conditions to be met has been used to rationalize the involvement of the government in the marketplace.

The anti-smoking campaign of the 1950's and 1960's seems to have been motivated by the lack of widespread information on the health consequences of cigarette smoking. Policies such as health warning labels on cigarette advertising and packaging, the dissemination of information concerning the health consequences of cigarette smoking, the collection and publication of the tar and nicotine content of cigarettes, the broadcasting of anti-smoking commercials on television and radio, and the prohibition of cigarette advertising on television and radio are all aimed at increasing the individual's awareness of the effects of cigarette smoking on health. This increased awareness should allow the individual's decision to smoke to be a well-informed, rational decision. The provision of information alone may not be enough, however, if the individual is unable to fully comprehend the information. This inability to completely appreciate the health consequences of smoking, for example, is often used as justification for other governmental efforts to reduce smoking through such means as the increased excise taxation

of cigarettes. It is also likely that increased excise taxation is a relatively costless means of reducing cigarette smoking when compared to campaigns to collect and disseminate information.

The second condition which fails to be met is the absence of externalities in consumption. The presence of significant negative externalities in the consumption of cigarettes has been the focus of the anti-smoking campaign throughout the 1970's and 1980's. The Clean Indoor Air laws discussed above are a direct result of the nonsmokers' rights groups demand to breath air free of the pollution from cigarette smoking. More importantly, as discussed in the 1986 Report of the Surgeon General, the pollutants in cigarette smoke constitute a greater health risk for nonsmokers than other air pollutants. Similarly, cigarette smoking is blamed for a large number of fires which affect more people than just the smoker. Finally, cigarette smoking imposes a significant burden on nonsmokers through increased health care costs, the result of illnesses associated with smoking. The presence of these externalities has also been used as a justification for increased excise taxes on cigarettes and further government involvement in the marketplace.

One argument often used to justify the observed government intervention in the cigarette market is that smoking is an addictive behavior (Warner 1981d, Atkinson, 1974). The addiction to cigarettes (or nicotine) has been

said to preclude rational decisions by the smoker when choosing whether or not to smoke and/or how much to smoke. The model to be outlined below, however, assumes that addicts, in this case cigarette smokers, are behaving rationally, which makes this argument inappropriate for defending government action.

As the focus of this dissertation will be on the relative effectiveness of increased excise taxation of cigarettes and the clean indoor air laws, this chapter will highlight the findings of others concerning these policies, as well as other findings and issues of interest. The chapter will be divided into four main sections: aggregate studies of the demand for cigarettes, micro-level studies of cigarette demand, other related studies, and conclusions. The section on aggregate studies will be further subdivided into sections on time-series studies of demand and cross-sectional time-series studies of demand. A discussion of Becker, Grossman, and Murphy's (1987) empirical application of Becker and Murphy's (1986) theoretical model of addiction to cigarette consumption using a cross-sectional time-series data set will be reserved for later as their work is of much importance for the research conducted in this dissertation.

Aggregate Studies of the Demand for Cigarettes

Time-Series Studies

Much of our understanding of the effects of government policies on cigarette smoking is derived from studies of the demand for cigarettes and/or tobacco using aggregate data. The literature review below will focus on the research conducted beginning in the late 1960's and thereafter, as one interest of this dissertation is in the government's ability to modify behavior (particularly addictive behavior) through its use of policy. Although there had been some research focusing on the cigarette industry prior to this, it had primarily focused on the effects of advertising on cigarette demand and firm sales (the work of Telser (1962) and Bass (1969) stand out in this area).

In the first and, as a result, one of the most referred to papers in this literature, Hamilton (1972) analyzes the effects of the health scare, cigarette advertising, and the advertising ban on cigarette consumption. He uses annual data for the United States covering the period from 1926 through 1970 to estimate ordinary least squares demand equations where the dependent variable is per capita consumption of cigarettes for the population ages 14 and over. The independent variables include the wholesale price of cigarettes, per capita disposable income, indices measuring per capita and aggregate advertising expenditures

in the cigarette industry, and three dummy variables capturing the health scare. The first dummy pertains to the period from 1953 through 1970 and is associated with the release of the studies by the American Cancer Society and the British Medical Research Council reporting higher death rates for smokers. The second covers the period 1964 through 1970, to account for the effects of the first Surgeon General's report on the health consequences of smoking. The final dummy variable captures the effects of the Fairness Doctrine which resulted in the airing of anti-smoking advertising beginning on July 1, 1967.

Hamilton's interest in price and income effects was incidental to the effects of advertising and the health scare leading him to use extraneous estimates of the income and price coefficients in his estimation of the demand equations. The estimate he used for the price elasticity of demand was Lyon and Simon's (1968) median estimate of 0.5. The estimate of the income elasticity of demand he uses is obtained from cross sectional regressions of the states of the U.S. for 1954 and 1965. This allows him to avoid the substantial multicollinearity present in his data, mainly the result of a high correlation between income and price.

Turning to the relative effects of the health scare, advertising, and the advertising ban on cigarette demand, Hamilton finds that the dummies capturing the health scares all have negative and significant effects on cigarette

consumption, while advertising has a small, insignificant, positive effect. He estimates that the anti-smoking commercials reduced cigarette smoking by approximately 5.6 times the increase associated with the advertising done by the cigarette industry. Similarly, the Surgeon General's 1964 report depressed consumption by 2.7 times the increase due to industry advertising.

Hamilton uses these results to argue that the Public Health Cigarette Smoking Act of 1970, which banned all pro-smoking advertising on radio and television, was an unwise policy. This conclusion is the result of a large decrease in anti-smoking advertising, until then subsidized under the Fairness Doctrine, which he found to be much more effective in reducing smoking than pro-smoking advertising had been in increasing smoking.

Richard Schmalensee (1972), in his now classic The Economics of Advertising, used the cigarette industry to empirically test the theory he develops concerning the effects of advertising on demand. He models the demand for cigarettes at both the industry and the firm level as a function of the price of cigarettes, income, various measures of own, other firms', industry, and national advertising expenditures, market share, a variable measuring the monopoly power of a firm, and a dummy for the years 1964 through 1967 to account for the health scare associated with the release of the 1964 Surgeon General's report. In some specifications he includes lagged firm and industry

cigarette sales and/or advertising expenditures. He hypothesizes that the firm may base its advertising expenditures on current sales leading him to estimate a simultaneous equations model where advertising is a function of price, income, the 1964-1967 dummy, lagged advertising expenditures, industry sales, and firm sales.

Schmalensee uses an annual time series covering the period from 1955 through 1967, leaving him just twelve observations when estimating the equations containing lagged variables. He begins in 1955 due to the absence of some data for earlier years and stops in 1967 because of the lack of data on expenditures on the anti-smoking advertising which began in 1968.

Using the wholesale price and the retail price as alternative measures of the price of cigarettes, Schmalensee never finds negative and significant price effects. The wholesale price entered negatively in most specifications, while the retail price was often positive and sometimes significant. He claims that the wholesale price is a better measure because the retail price did not take into account the prices of longer cigarettes whose sales were increasing during this period, while the wholesale price did. With respect to the effect of income on the demand for cigarettes, the results are again disappointing, with income never attaining significance in any specification.

In all of the specifications of his model, Schmalensee never finds a significant relationship between current

advertising and current cigarette demand. Even more surprising was that the advertising done by other firms never had a significant impact on the sales of one firm. If industry advertising had no effect on industry sales, then the advertising by individual firms should have reduced the sales of its competitors. He does find some support for the idea that the effects of advertising initially increase over time, since lagged advertising expenditures enter positively and are occasionally significant.

When included, lagged cigarette sales tend to have the most explanatory power. Also significant in most specifications was the dummy variable associated with the release of the 1964 Surgeon General's report, indicating that the health scare did lower cigarette demand.

Finally, Schmalensee claims that the poor results he obtains may be the result of collinearity and simultaneity in the estimated equations covering the relatively short period he uses. To examine this more closely, he estimates a demand equation using an annual time series covering the period 1947 through 1967 which excludes the advertising variables. In this equation, he does find negative and significant price effects, with an estimated short run price elasticity of demand of -0.32 and an estimated long run price elasticity of approximately unity. Now, income is positive and significant, with demand being income inelastic in the short run but approaching unitary elasticity in the long run. Again, the 1964-1967 dummy has a

negative and significant effect on sales. He concludes that there may be little impact on cigarette sales associated with a reduction in advertising, but suggests that increased excise taxes may be an effective means of reducing smoking.

Sumner (1971), Atkinson and Skegg (1973), McGuinness and Cowling (1975), and Johnston (1980), in a series of papers extending one another's work, analyze the demand for cigarettes in the United Kingdom. Sumner (1971) was interested in the effect on the demand for cigarettes of the 1962 Report of the Royal College of Physicians concerning smoking and health. Using an annual time series on the U.K. covering the period 1951 through 1967, he estimates the demand for cigarettes as a function of the price of cigarettes and a dummy variable for the period 1962 through 1967, where the dependent variable is annual expenditures on tobacco. He finds that the release of the Physician's report had a relatively small impact on the demand for cigarettes, lowering demand by only four percent five years later. He also finds that the demand for cigarettes is inelastic with an own price elasticity of demand of -0.23 .

Atkinson and Skegg (1973) criticize Sumner's (1971) conclusions for several reasons. Firstly, they suggest that he misinterpreted his estimates and that demand was fourteen percent lower in 1967 than it would have been in the absence of the Physician's report. They go on to suggest that the equations that Sumner estimated were mis-

specified in that the measure he used for the publicity associated with the report was incorrect, that he ignored several other factors (including the introduction of filter and smaller cigarettes) which became important during the period in question, and that the dependent variable, expenditures on tobacco, is inappropriate. They estimate two sets of demand equations where the dependent variables are per capita tobacco consumption and per capita cigarette consumption. In all of the equations they estimate, they find a negative relationship between the price of cigarettes and the demand for cigarettes and tobacco, with the price elasticity of demand estimated in the range -0.28 to -0.38 .

With respect to the effect of the publicity on the negative health effects of smoking associated with the 1962 report of the Royal College of Physicians and the 1965 ban on televised cigarette advertising in Britain, Atkinson and Skegg find that the demand for cigarettes fell initially, but eventually returned to its pre-report level. However, in the demand for tobacco equation, they find that there is a large, permanent reduction associated with the negative publicity. These apparently conflicting results are explained by the introduction of filter cigarettes and smaller cigarettes.

Finally, Atkinson and Skegg compared the responses of men and women to changes in the price of cigarettes and to the negative publicity. They find that men are unrespon-

sive to price but do respond significantly to the publicity on the health consequences of smoking while women are unresponsive to publicity, but do show some response to changes in the price of cigarettes, with an estimated own price elasticity of demand in the range -0.17 to -0.48 .

McGuinness and Cowling (1975) take an interesting approach to the measurement of advertising in their analysis of the effects of industry advertising on aggregate cigarette sales in the United Kingdom. They make the argument that the effects of advertising do not disappear rapidly over time but rather that they accumulate. Their argument is based on the durability of printed advertisements and the mental retention of past advertisements. Therefore, they derive a theoretical demand function for cigarettes which includes several lags of their measure of advertising, the number of messages received. Rather than estimate this equation with their relatively short time series, they create a variable to measure the 'stock' of advertising. The stock is a weighted sum of past advertising, where the weights decline geometrically the further in the past the advertisements were placed.

They then use a quarterly time series for the U.K. covering the period 1957II through 1968IV to estimate a demand equation for cigarettes where expenditures on cigarettes are a function of the price of cigarettes, income, a price index for other goods, population, publicity on the negative health effects of smoking, and the stock of adver-

tising. They obtain an estimated own price elasticity of demand of -0.99 in the short run and -1.05 in the long run. They also find that cigarettes are a normal good with an income inelastic demand. Their measure of the health scare is based on the release of the 1962 report of the Royal College of Physicians on smoking and health. They find that the publicity associated with this report had a negative and significant impact on the demand for cigarettes. Finally, McGuinness and Cowling find that advertising has a small, positive, and significant effect on demand, with demand being relatively inelastic with respect to advertising. They suggest that the long run, positive impact of advertising on the demand for cigarettes is due to the addictive nature of cigarette smoking.

Johnston (1980) questions the results presented by McGuinness and Cowling (1975), particularly those concerning the advertising elasticity of demand. He finds several mathematical errors in their analysis which lead them to overstate the short and long run effects of advertising on cigarette demand. This calls into question the remainder of the results they present. McGuinness and Cowling (1980) defend themselves by stating that, after making the corrections Johnston described, they still obtain a positive, albeit smaller, and significant advertising effect.

Two statisticians, Thompson and McLeod (1976) estimated the demand for cigarettes in Canada, for the period 1950 through 1973 using annual data. They include four types of

variables in their demand equations: economic variables, social variables, publicity variables, and inertia variables. The economic variables include the price of cigarettes and income in Canada, as well as the average price of cigarettes in the United States (to take account of the large difference between the two countries' prices which leads to cigarettes being smuggled into Canada).

The significant serial autocorrelation present in their data leads Thompson and McLeod to estimate cigarette demand using a Box-Jenkins autoregressive integrated moving average process. When demand for manufactured cigarettes is estimated as a function of price and income only, they find an own-price elasticity of demand of approximately -0.75 , and an income elasticity of 0.50 , estimates which change relatively little as they change the autoregressive structure. When the U.S. price is included, it enters significantly, with a cross price elasticity of 0.70 . When they estimate demand for both hand rolled and manufactured cigarettes, their estimates of the own-price and income elasticities of demand fall, a finding they attribute to the substitution of hand rolled cigarettes for manufactured cigarettes as the price of cigarettes rises. Also, they estimate that the long run own-price elasticity of demand is greater than the short run elasticity, approaching unity. Finally, they find no effect on Canadian cigarette demand of the publicity surrounding the release of the 1964 Surgeon General's report in the U.S.

In a series of papers on the effects of the anti-smoking campaign on cigarette consumption, Warner (1977, 1979, 1981a, 1981b, 1981c, and 1984b), and Warner and Murt (1982, 1983) estimate what cigarette consumption would have been in the absence of the anti-smoking campaign. In much of this work, Warner emphasizes the effects of excise taxes and the cigarette health scares, as do others, but he also includes some measure of the strength of nonsmokers' rights groups. The effect of the nonsmokers' rights movement is gauged by including the fraction of the U.S. population residing in states with laws restricting cigarette smoking in public places as an independent variable in some of the demand equations he estimates.

Warner finds that the anti-smoking campaign has led to a significant reduction in both per capita cigarette smoking and in smoking participation rates (the fraction of the overall population which smokes). Warner's findings on the effects of the various public policy initiatives used in the anti-smoking campaign can be summarized as follows: the 1953 reports of the American Cancer Society and the British Medical Research Council had significant negative effects on smoking, but these effects fell throughout the 1950's; the 1964 Surgeon General's report also led to an immediate but temporary fall in cigarette consumption; for the period during which the Fairness Doctrine was in effect, anti-smoking advertising had a significant negative effect on the demand for cigarettes, lowering consumption

by approximately four percent annually; the state excise tax increases during the period 1964 to 1972, which Warner describes as the states' involvement in the campaign during this period, also led to a significant reduction in smoking as can be seen from his (1981) estimated own price elasticity of demand of -0.37 ; and, finally, nonsmokers' rights groups, as measured by the fraction of population in states with laws restricting smoking, are found to have a large, significant, and negative impact on smoking. Warner argues that this final finding is unlikely to be as large as suggested by his estimates, but that "the passage of the laws, rather than shaping opinion and affecting behavior may reflect opinion and coincident behavior change." This issue of the potential endogeneity of these laws is of interest to this research as legislation restricting smoking in public places is one of the policies to be considered in the empirical work below. The use of micro-level data will make this less of an issue than it is in Warner's work using U.S. aggregates.

By comparing the predicted cigarette consumption and smoking participation rates obtained from demand equations estimated for periods prior to the various elements in the anti-smoking campaign with the actual levels of consumption and smoking participation, Warner (and Warner and Murt) estimates the magnitude of the effect of the anti-smoking campaign on smoking behavior. Warner estimates that actual per capita consumption was up to thirty six percent lower

in 1978 than it would have been in the absence of the persistent publicity associated with various aspects of the campaign against smoking. Warner and Murt (1982) predict that smoking participation rates would have been up to twenty two percent higher for men and up to twelve percent higher for women than if the anti-smoking campaign had never taken place. Finally, Warner and Murt (1983) estimate that over the period 1964-1978, approximately 206,000 people increased the number of years they lived as a result of their response to the various elements of the anti-smoking campaign, with four times as many men gaining years than women.

In a study for the Federal Trade Commission employing several different data sets, Ippolito, Murphy, and Sant (1979) attempt to explore the changes in smoking behavior resulting from the cigarettes and health information disseminated in the 1950's and 1960's. Using an aggregate time series for the United States covering the period 1925 to 1975, they model per capita cigarette consumption, nicotine per cigarette, and per capita nicotine consumption as functions of the price of cigarettes, income, a time trend, dummies for the Consumer Reports' annual tabulations of the tar and nicotine content of cigarettes beginning in 1953, the 1964 Surgeon General's report, the three year period during which anti-smoking advertisements were aired under the Fairness Doctrine, and the advertising ban of 1971. The dummies are interacted with the time trend in an effort

to estimate the effect each event had on the observed upward trend in per capita cigarette consumption.

Ippolito, Murphy, and Sant find that per capita cigarette consumption was reduced in response to the information provided by Consumer Reports, but that the trend in consumption was unaffected. They find a contrasting response to the 1964 Surgeon General's report in that it had no immediate effect on demand, but instead led to an annual fall of 3.5 percent in consumption. Unlike most previous researchers, they find no discernible impact of the 1968-1970 broadcasts of anti-smoking advertisements on cigarette consumption. Finally, they find that the demand for cigarettes is inelastic with respect to both own price, -0.811 , and income, 0.735 , leading them to conclude that increased excise taxation is an "appropriate and necessary (policy) to supplement the impact of information programs" (page 20).

Fujii (1980) uses Ridge regression techniques in an attempt to reduce the problems of multicollinearity which plagued other aggregate studies of the demand for cigarettes. Others had either dropped variables from the estimated demand functions or used extraneous estimates of price and/or income elasticities, leading to biases in the estimates they do obtain. Fujii recognizes that the Ridge regression will also yield biased estimates but defends it on the grounds that the estimates have lower mean square errors than those obtained using ordinary least squares.

Using an annual time series on the United States covering the period from 1929 through 1973, Fujii estimates a demand function similar to the function estimated by Hamilton (1972). He obtains negative and significant own price effects with implied own price elasticities of demand in the range -0.45 to -0.63 . He finds a relatively small but positive income elasticity of demand. Unlike Hamilton, he finds small, positive, and significant effects of industry advertising on the demand for cigarettes. He also obtains a positive and significant relationship between past and current per capita cigarette consumption.

With respect to the variables associated with the health scare, his results are mixed. He finds that a dummy covering the period 1952 through 1973 has a positive and significant effect. He concludes that this is the result of the relatively unpublicized early reports on smoking and health being dominated by the introduction of television as a powerful marketing tool which was exploited by the cigarette companies. A dummy covering the period beginning in 1964 is found to have no significant effects on smoking leading him to conclude that the Surgeon General's first report did not lead to any reduction in per capita cigarette consumption. Finally, the only dummy found to have a negative and significant effect on smoking is that covering the period beginning in 1968 associated with the broadcasting of anti-smoking advertisements. He finds that these ads reduced cigarette consumption by three to four percent.

In an interesting paper, Young (1983) reestimates the equations Fujii (1980) presented allowing for asymmetrical responses of demand to changes in the price of cigarettes and income. He bases this on the habitual or addictive nature of cigarette smoking and hypothesizes that the responses of demand to increases in price or decreases in income will be less in absolute value than the responses to a fall in price or a rise in income. This is due, Young asserts, to individuals who previously did not smoke taking up the habit as price falls and becoming addicted. As price rises however, the habit will not be easily broken.

Using Ridge regression techniques, Young estimates a demand equation arising from a "ratchet model" of cigarette demand. This model calls for the use of variables for price increases, price decreases, income increases, and income decreases in addition to the variables used by Fujii which measured advertising and the health scare. Young's hypotheses concerning the asymmetric responses to price and income changes are supported by his estimates. He finds that the own price elasticity of demand is -0.33 for price rises, but is -0.61 for price reductions, on average. The income elasticity of demand for increases in income is centered around 0.30 and the income elasticity of demand for decreases in income is 0.15 , on average. Young goes on to suggest that his results show an excise tax policy to be somewhat less powerful than previously believed.

In one of the most well thought out papers of its kind,

Schneider, Klein, and Murphy (1981) estimate the effects of governmental regulation of advertising and the 1953 and 1964 health shocks on the demand for cigarettes after specifying an appropriate demand equation. They feel that the ambiguous results obtained in earlier studies, particularly with respect to the anti-cigarette advertising required under the Fairness Doctrine and the 1953 health shock, are the outcome of estimating misspecified equations. This misspecification is illustrated by the high serial correlation of the residuals obtained when they estimate an equation similar to those estimated by others.

Schneider, Klein, and Murphy develop a measure of income which they use to partially correct the specification problem. They feel that the high rate of growth in cigarette consumption early in their sample leads to an overstatement of the income elasticity of demand, which leads to overestimates of consumption in later years, and an overstatement of the effects of government intervention. Specifically, they state that factory rolled cigarettes are initially (shortly after their introduction) a luxury item that over time become necessities, implying that the income elasticity of demand will fall over time. To account for this problem, they use an instrumental variable, the percentage of tobacco consumed as cigarettes, for income.

A second specification issue they address is the appropriate measurement of cigarette advertising. They argue that the relevant factor is the "advertising service" ob-

tained from expenditures on advertising in creating a "stock" of advertising similar to that of McGuinness and Cowling (1975). Schneider, Klein, and Murphy suggest that the theoretically correct way of modelling the ad ban is not to use a dummy for the appropriate period, but to instead use nonlinear techniques to estimate the stock of advertising, where the marginal productivity of expenditures is lower after the ban than before.

The final specification issue they deal with is the modelling of the health information associated with the 1953 report of the American Cancer Society and the British Medical Research Council and the 1964 Surgeon General's Report on the health consequences of smoking. They argue that the use of a dummy variable for each of these shocks is inappropriate for two reasons. Firstly, the information is released in a series of reports to consumers rather than all at once, and, secondly, smokers will take some time to adjust to this new information. Therefore, they suggest the use of proxy variables for each of the health shocks. They use the market share of filter cigarettes as a proxy for the 1953 report since filter cigarettes were introduced in response to the information contained therein. For similar reasons, they use the market share of low tar cigarettes as a proxy for the Surgeon General's report.

They then estimate a demand for tobacco equation and a demand for cigarettes equation. They find a relatively high own price elasticity of demand in both equations,-

0.95 for tobacco and -1.22 for cigarettes. They obtain an income elasticity of demand of -0.97, close to the unitary elasticity predicted by their theoretical model. They find that although the 1953 health shock led to a rise in the number of cigarettes smoked per capita, it also led to a fall in the tobacco consumed per capita, a more appropriate measure as smokers switch to the less dangerous filter cigarettes. Similarly, they find that the Surgeon General's report further discouraged tobacco consumption. They estimate that by 1978 per capita tobacco consumption was about fifty percent lower than it would have been in the absence of the two health scares.

With respect to the response of demand to cigarette advertising, Schneider, Klein, and Murphy find that there is a 4.9 percent increase in per capita tobacco consumption as a result of the advertising ban. They suggest that the negative effect found by others is the result of misspecification and attribute their result to an elastic demand for the advertising stock created by advertising expenditures. They propose that the ban leads to a fall in the price of cigarettes due to a fall in their fixed costs of production. The fall in price then stimulates the consumption of cigarettes. They also suggest that the ad ban leads to a reduction in the information available to smokers and, therefore, to fewer smokers switching from high tar cigarettes to the less dangerous low tar brands. Finally, they observe that the ad ban led to a reduction in

the number of anti-smoking commercials aired under the Fairness Doctrine. They found that these commercials were effective in reducing smoking and use this evidence to state that the ad ban was a flawed policy initiative.

Using an annual time series covering the period from 1954 to 1981, Leu (1984) estimates the effects of publicity on the demand for cigarettes in Switzerland. In particular, Leu is interested in evaluating whether the effect of publicity is transitory or permanent. He considers the negative publicity associated with the 1964 Surgeon General's report, the large 1966 increase in the Swiss excise tax on cigarettes (justified by the harmful effects of smoking), and the debate in 1978 and 1979 over the banning of tobacco and alcohol advertising in Switzerland (which, when put to a vote, was defeated decisively).

The price of cigarettes (real and nominal), Income, other tobacco prices, a time trend, and dummy variables for each of the three events discussed above are included in the cigarette demand equations estimated by Leu. The demand equation is derived from a partial adjustment model Leu describes as standard in studies of goods characterized by habitual consumption. This demand equation is estimated using Box-Cox (1964) techniques, but is found to be inappropriate, with the "best" equation being a linear "quasi-static" (one which includes lagged income but excludes lagged consumption).

Leu finds no significant substitution among various

forms of tobacco in response to changes in their prices. He also obtains an estimated income elasticity of demand of approximately one, which he calls a spurious finding reflecting other forces.

Leu finds statistically insignificant real price effects, but, when using the nominal cigarette price, finds a significant response, with demand being unit elastic with respect to the nominal own-price. He attributes this result to an indirect effect of anti-smoking publicity, not money illusion, saying that a majority of smokers would prefer to quit due to an awareness of the health effects of smoking and the negative social climate associated with it, and that the increase in the nominal price provides the final push they need to kick the habit (page 113).

With respect to the direct effects of the publicity associated with the events of 1964, 1966, and 1979, Leu finds that the demand for cigarettes is lowered initially, but that the effect diminishes over time. However, demand is permanently lowered by between five and twenty three percent as a result of the publicity, according to his estimates. In conclusion, he suggests that these results may understate the true effects of publicity on smoking behavior due to smokers switching to low tar, filter, or lighter cigarettes, factors which he is unable to measure.

Porter (1985) and Bishop and Yoo (1985) criticize the earlier studies of the demand for cigarettes for failing to take account of the interaction of demand with the supply

of cigarettes. This failure to model the cigarette market as a whole leads to the introduction of simultaneity bias in the estimates obtained in earlier studies.

Porter uses a U.S. annual time series beginning in 1947 and ending in 1982. He notes that the overall market share of the six largest companies changes very little over time, suggesting that the market is oligopolistic. However, the individual market shares of the six firms do vary considerably over time suggesting that the market may be relatively competitive. He goes on to define the cigarette market as being made up of the six largest firms (R.J. Reynolds, Phillip Morris, Brown and Williamson, American Brands, Lorillard, and Liggett). Porter states that his estimates will provide some evidence as to the true structure of the cigarette industry.

Porter's demand equation is similar to that estimated by Schneider, Klein, and Murphy (1981) in that it includes variables accounting for the changes in the types of cigarettes being smoked (i.e. the market shares of low tar and filter cigarettes, the percentage of tobacco consumed as cigarettes, and the average weight of tobacco per cigarette), in addition to the prices of cigarettes and cigars, income, variables capturing the health scares, and a variable measuring the stock of advertising. Price and advertising expenditures are treated as endogenous and the system is estimated using two-stage least squares.

Porter finds that the 1953 health scare led to a per-

manent fall in the demand for tobacco due to the introduction of filter cigarettes it induced, but that it led to no change in price or advertising. Similar results were obtained with respect to the 1964 Surgeon General's report. The use of the Fairness Doctrine in the late 1960's is found to have reduced demand, raised cigarette prices, and lowered advertising. The ban on advertising also led to a reduction in demand and advertising expenditures, but (in contrast to Schneider, Klein, and Murphy's (1981) suggestion) also led to an increase in price of up to six percent (which also induced a fall in the quantity demanded). Porter's estimates of the own price elasticity of demand fall in the range -0.29 to -0.05 , somewhat below those obtained by others due, in part, to the treatment of price as endogenous. Estimates of the income elasticity of demand are negative leading Porter to conclude that cigarettes are an inferior good over the period of his sample.

Finally, with respect to the market structure of the cigarette industry, Porter concludes that the market is characterized by imperfect competition. In fact, he suggests that the advertising ban increased the monopoly power of industry firms by making the introduction of new brands more difficult, and uses the increased price after the ban as evidence of this increased power.

Bishop and Yoo (1985) estimate the supply and demand for cigarettes using a relatively parsimonious set of variables for the period 1954 through 1980. Demand is speci-

fied as a function of price, income, advertising expenditures, and a dummy for the 1964 Surgeon General's report. Supply is determined by price, excise taxes (which shift supply), an index of factor prices, and a dummy for the advertising ban. Bishop and Yoo do not include the advertising ban in the demand equation due to the evidence presented by others that advertising determines only the individual firms' market shares but does not stimulate overall cigarette sales.

Bishop and Yoo find that demand is price inelastic, with the estimated own price elasticity of demand in the range -0.4 to -0.5 . However, supply is found to be relatively elastic, with the price elasticity of supply of approximately 2.2. This leads them to conclude that the price of cigarettes is more affected by supply, while the quantity is determined by demand. They also find a small but significant positive effect of advertising on demand, a negative effect of the 1964 Surgeon General's report on demand, and a small negative effect of the advertising ban on supply. They conclude that increases in cigarette excise taxes are a much more effective policy in reducing smoking than either the health scares or the advertising ban, with the health scare having had little impact on demand.

Bishop and Yoo's findings with respect to the relatively minor impact of the health scare on demand are questioned by Kao and Tremblay (1987) who argue that the

Bishop-Yoo model is misspecified. Kao and Tremblay contend that the Bishop-Yoo modeling of cigarette manufacturers as price-takers is incorrect (as demonstrated by Porter, 1986) and that the estimation of a simultaneous system under this assumption biases the results, that they improperly ignore population effects, and that there are several important determinants of demand omitted from their analysis. Kao and Tremblay also argue that it is tobacco consumption, not cigarette consumption, which should be of interest and that using the latter measure will understate the impact of the health scare due to the reduction in the quantity of tobacco per cigarette it induced (as illustrated in Table 2-3). Finally, Kao and Tremblay argue that, due to the addictive nature of consumption, some measure of past consumption should be included as a determinant of demand.

Estimating the resulting demand equation using the Bishop-Yoo data, Kao and Tremblay find that the release of the 1964 Surgeon General's report had a significant negative impact on demand, while the other events in the health scare had little effect.

Bishop and Yoo (1987) assert that treating the industry as competitive is not incorrect, stating that firms in highly concentrated industries can and do behave competitively. Similarly, they contend that while the average tobacco content of cigarettes has fallen over time, this is not the appropriate measure of tobacco consumption since it does not account for "technological changes in production"

(which include the use of reprocessed leaf and slower burning cigarettes) and the likely changes in the intensity of smoking. Thus, they argue that it is not necessarily true that a greater quantity of cigarettes must be consumed for tobacco consumption to remain constant. Finally, they note that they did not conclude that the health scare had no impact on demand but rather that its impact was smaller than that found by earlier researchers who ignored the simultaneity issue.

Cross-Sectional, Time-Series Studies of the Demand for Cigarettes

Lyon and Simon (1968) take a unique approach to the estimation of the effects of cigarettes price and tax changes on cigarette sales. To be included in their sample, a state had to have changed its excise tax on cigarettes. Given that the state changes its tax, the observations for the state are per capita cigarette sales before and after the tax change. They claim that this method allows them to avoid the collinearity problems that plague other studies of demand and to control for the cultural, religious, and other factors influencing demand whose exclusion biases the estimates obtained using a time series.

Using the pre- and post-tax change sales and prices, they calculate the arc elasticity of demand for each of the changes over the period from 1950 through 1965. They

obtain a mean own-price elasticity of demand of -0.571 and a median of -0.511 for their seventy-three trials. After excluding an observation (Maine, 1961), their mean falls to -0.477 . They repeatedly emphasize the fact that their estimated elasticities are short run estimates, pertaining to the twelve month period centered around the six to eighteen months following the tax change.

Lyon and Simon state that another useful property of their "quasi-experimental" approach is that it allows them to test for differences in the price elasticity of demand among regions and population subgroups as well as differences over time. They find that there are no systematic regional differences in the price elasticity of demand. They also find, after dividing their sample based on state income, that there is no relationship between income and the price elasticity. Finally, they conclude that there is no evidence of a time trend in the price elasticity of demand.

Manchester (1976) uses quarterly state cigarette sales data for three groups of states to examine the extent of interstate cigarette smuggling due to differences in cigarette prices arising from differences in state excise tax rates on cigarettes. The groups of states he examines in detail are the Northern New England states, Kentucky and Tennessee, and Oregon and Washington, due to their large deviations from national averages for per capita sales. He finds that sales to nonresidents are a statistically sig-

nificant factor in explaining state cigarette sales, accounting for fifteen percent of the sales in low tax states for 1970 to 1971.

In its 1985 re-examination of the cigarette bootlegging problem, the Advisory Commission on Intergovernmental Relations estimates the demand for cigarettes using state level data for the early 1980's. The commission includes state and local cigarette excise taxes, per capita income, an index of tourism, the fraction of state population who are Mormons, measures of state ethnicity, and variables accounting for the smuggling problem as regressors in the demand equation. The smuggling variables consist of state dummies for the lowest price state in the northeast (New Hampshire) and the two lowest price states in the south (North Carolina and Kentucky), a dummy for Western states (where the majority of tax exempt Indian reservations and military bases are located), and an index of border state price differentials. The state dummies are an attempt to measure long distance, organized smuggling. The border index is constructed based on the number of borders, the price differential, the state population, and the population on the border in the own state and the border state and is a measure of casual smuggling.

The commission obtains an own price elasticity of demand of -0.45 . When they reduce the sample to the fifteen states they feel have little or no problem with bootlegging, this estimate falls to -0.26 , illustrating the

importance of smuggling in explaining variation in state cigarette sales, since cigarettes purchased in border states are a substitute for own state purchases. The dummy variables capturing the long distance smuggling problem are found to have a significant impact on sales, as expected. The border price differential index is found to be positive and significantly related to sales. When the variables capturing long and short distance smuggling are omitted from the demand equation, the standard error of the regression triples, emphasizing how important these variables are in explaining sales patterns across states. These results are used to then estimate the cost, in terms of lost revenues, to the high tax states arising from the bootlegging problem at \$255 million. This is significantly lower than the estimate of \$391 million obtained for 1975, using similar techniques.

In an unpublished paper, Lewit (1982) conducts the most detailed analysis of the bootlegging problem to date. Using data from the 1976 Health Interview Survey, Lewit estimates the per capita cigarette consumption in each state and adjusts the estimates to conform to national sales in an attempt to avoid the problems inherent in using the sales data others had used. To account for smuggling, he estimates cigarette imports and exports (both casual and organized) based on the price of cigarettes in each state and the distances between states. He also uses data on cigarette sales on military bases and indian reservations

where sales are tax free. In addition to using states as the unit of observation, Lewit includes New York city and Chicago as separate observations due to their well defined geographical areas and high local excise taxes. He then estimates tax-paid sales as a function of consumption, price, a set of import and export measures, reservation and military sales, a measure of tourism, the fraction of the state population living within twenty miles of a border with a lower price state, and a dummy for North Carolina in various combinations. After restricting the sum of net exports to be zero, Lewit estimates the losses to states at less than half the loss estimated by the Advisory Commission (1977). This difference is, as Lewit points out, the result of the zero restriction he imposes which was not imposed by the Commission. However, smuggling is still significant in explaining state cigarette sales.

Baltagi and Levin (1986) estimate a "dynamic" model of cigarette demand in which they attempt to account for the bootlegging problem discussed above. Their sample consists of forty six states over the period 1963 through 1980. In addition to their interest in the magnitude of the bootlegging problem, they are interested in measuring the impact of advertising on demand to determine the effectiveness of the Fairness Doctrine and the advertising ban in reducing cigarette smoking.

The theoretical model used by Baltagi and Levin can be summarized by the following two equations:

$$(3-1) \quad \ln C_t - \ln C_{t-1} = \delta (\ln C^* - \ln C_{t-1}) + e_t$$

$$(3-2) \quad \ln C^* = \alpha + \beta_1 \ln P + \beta_2 \ln Y + \beta_3 \ln P_n +$$

$$\phi \sum_{i=0}^{\infty} \tau^i A_{t-i} \quad i=0, \dots, \infty$$

They describe the partial adjustment process depicted by equation (3-1) as the typical approach to modelling the consumption of a good characterized by habitual consumption, where C^* is the desired level of consumption. Desired consumption, in their model, is a function of own price, income, bordering states' cigarette prices, and current and lagged advertising. In the demand equation they estimate, they compute a measure of cumulative advertising similar to that of McGuinness and Cowling (1975), where the weights associated with past advertising decline geometrically. To capture the bootlegging across state lines due to disparities in cigarette prices among states, Baltagi and Levin use a single variable, the minimum real price of cigarettes in any bordering state. Finally, their interest in government policy, advertising, and cigarette demand leads them to include variables which account for the period of the Fairness Doctrine and the advertising ban.

They estimate the demand equation using an error component model, the Hausman-Taylor (1981) procedure (which accounts for state invariant factors), and then apply a

Zellner-Geisel (1970) procedure to separate the lagged effects due to advertising and habit. They obtain a significant own-price elasticity of demand of -0.22 , and an insignificant income elasticity of 0.73 . They also find a small but significant bootlegging effect as illustrated by the border price elasticity of 0.08 . However, they find no significant evidence of advertising having any impact on demand. They use these results to dispute Hamilton's (1972) conclusion that the advertising ban would lead to an increase in cigarette smoking. As noted by the Advisory Commission on Intergovernmental Relations (1977, 1985), Baltagi and Levin conclude that any changes in excise taxes, unless uniform across states, will lead to significant changes in not only own-state consumption but also in consumption in neighboring states.

Before continuing, several flaws in Baltagi and Levin's analysis should be pointed out. The most important is their seeming misunderstanding of the data with which they are working. They repeatedly refer to their measure of smoking as per capita state consumption, when, in reality, it is per capita state cigarette sales. This leads to a misinterpretation of the effects of a single state increasing its cigarette excise tax. They must realize that, using their example, per capita cigarette consumption in New Hampshire is not nearly double that in Massachusetts, but rather that a large share of cigarettes sold in New Hampshire are being sold to residents of other states.

Secondly, the variable they describe as capturing the bootlegging effect is, at best, a crude measure. It is unclear what value this variable takes on when a state is the lowest price state in its area, although it appears that they still use the price in the lowest priced bordering state, when it seems that they should set the variable equal to the own state price. This is important for the reasons pointed out by Becker, Grossman, and Murphy (1987) to be discussed below. Thirdly, it makes no attempt to account for residents of neighboring high price states purchasing cigarettes in a state. Finally, it fails to incorporate the dependence of the magnitude of the problem on both the price difference and the fraction of the state population for whom purchases in another state are a viable option or the long distance, organized smuggling problem which many states have identified as the major source of the bootlegging (Advisory Commission on Intergovernmental Relations, 1977 and 1985).

Micro-Econometric Studies of Cigarette Demand

Particularly relevant to this dissertation are the studies of the demand for cigarettes using data on individuals. Many of the methodological issues which will arise in the research conducted in this dissertation have been faced by others who have used micro-data. As such, the discussion of their treatment of various difficulties,

in particular the choice of an appropriate price variable and the stratification of their samples based on various factors will only be mentioned briefly here, with a much fuller discussion given below.

In an Urban Institute working paper, Hadley (1979) presents the first estimates of the own-price elasticity of the demand for cigarettes obtained using survey data. He uses several subsamples based on race and sex from his data set, the 1970 Health Interview Survey, to estimate both the demand for cigarettes (by smokers only and by both smokers and nonsmokers) as well as the decision to smoke. The equations he estimates are derived from a simple, single period utility maximization model similar in some ways to the instantaneous utility function defined in Chapter 5.

Using ordinary least squares methods to estimate the demand and decision equations, Hadley, with one exception, never finds own-price effects significantly different from zero. The one significant estimate, which is also the largest estimate for all samples, for the white male sample, implies an own-price elasticity of demand of -0.24 . He attempts to explain the relatively low micro estimates he obtains as due, in part, to the systematic bias in cross-sectional estimates present when the smuggling problem is not controlled for. He goes further and states that his estimates may be overestimates resulting from non-random measurement error in the price variable. This is the result of using state level, mean cigarette prices and

the likelihood that heavy smokers will buy cigarettes at lower prices, i.e. by the carton or in lower price states, while infrequent smokers may buy higher priced cigarettes, i.e. those from vending machines. That he makes no attempt to control for any of these factors, particularly the smuggling issue, is a weakness in his study. Hadley concludes that higher cigarette excise taxes will do little to discourage cigarette consumption and suggests that the additional revenues obtained from such taxes could be used to finance education or anti-smoking campaigns designed to discourage smoking.

Hadley finds a negative and significant income effect for white females, but a positive and significant income effect for both black and white males. Also, the only group for which education exhibits any significant impact is white males, for whom education is negatively related to demand and the decision to smoke.

Finally, Hadley notes that it would be more appropriate to employ estimation techniques which take account of the binary dependent variable in the smoking decision equation and the truncated dependent variable in the quantity equations to eliminate the bias which results from the use of least squares methods. However, he states that these techniques are unlikely to improve his estimates given the large sample sizes and the results obtained in the smoker only demand equations.

In their 1981 study, Lewit, Coate, and Grossman examine

the effects of government regulations on teenage smoking behavior. They focus on teens in the anti-smoking campaign arguing that government actions will have their most substantial long run impact on teens due to the habitual nature of cigarette smoking, since the quantity smoked and the negative health effects from smoking are negatively related to the age at which an individual begins smoking. In particular, they examine youths' responses to the anti-smoking advertisements broadcast under the Fairness Doctrine and to changes in cigarette prices, and make predictions about the impact of the advertising ban.

Using data from Cycle III of the Health Examination Survey, Lewit, Coate, and Grossman construct a sample of about 5,300 youths, ages twelve to seventeen, surveyed over the period from 1966 to 1970. Approximately one third of the sample was surveyed prior to the application of the Fairness Doctrine to cigarette advertising, with the remainder being surveyed during the period when the anti-smoking ads were broadcast, allowing them to estimate the impact of these ads on teen smoking.

Both the quantity of cigarettes smoked and the decision to smoke are modelled as functions of the price of cigarettes, a border price variable, various family and youth characteristics, parents' smoking, mean smoking by youths in the same locality, the Fairness Doctrine, televised cigarette advertising, and the time spent watching television. In addition to using dummy variables to control for

the anti-smoking commercials aired under the Fairness Doctrine, Lewit, Coate, and Grossman estimate the number of pro- and anti-smoking commercials each youth would have seen based on the amount of time spent watching television and the number of both messages aired over the period 1965-1970. They are unable to control for parental and peer smoking behavior in the equations they estimate given the data available to them. A state-specific price index (Fuchs, Michael, and Scott, 1979) is used to control for regional differences in the cost of living, and much care is taken in the development of the relevant price variable for those youths who live near lower priced localities, two factors to be considered in greater detail below.

Two sets of equations are estimated for both the smoke-don't smoke and quantity functions, one using the entire sample and another using only those youths not living near a lower price locality. In all equations, the estimated own-price elasticities of demand are substantial, in the range from -0.97 to -1.43 in the participation equations, and centered around -1.43 in the quantity equations. They also estimate the conditional own-price elasticities (the price elasticity of demand condition on smoking) to be in the range -0.01 to -0.45. With respect to the Fairness Doctrine, Lewit, Coate, and Grossman find that, although it had no impact on the quantity smoked by smokers, the broadcast of anti-smoking ads had a significant negative effect on teenage smoking participation. Finally, they note that

the observed increase in teenage smoking during the five year period beginning in 1970 is consistent with their estimates, and was due to the falling real price of cigarettes.

In the best published cross-sectional microeconomic study of cigarette demand by adults, Lewit and Coate (1982) examine the potential for using increases in cigarette excise taxes to reduce cigarette smoking. They conduct an analysis similar in many ways to the Lewit, Coate, and Grossman (1981) study described above, including the ordinary least squares estimation of both the quantity smoked and smoking participation functions, and the reestimation of these equations for the subsample which does not live near a lower priced locality. Additionally, they estimate the demand for cigarettes by smokers only, and reestimate all equations using a variance-components generalized least squares procedure to control for geographical-specific factors which can't be measured. The data set they used was comprised of over 19,000 individuals ages 20 through 74, taken from the 1976 Health Interview Survey.

Lewit and Coate use the lowest retail price within 20 miles of the site in which an individual was surveyed to control for the casual smuggling problem, a procedure which may understate the actual price faced by part of their sample. However, they do present estimates for the subsample for which there are no nearby lower priced localities, and compare the two sets of results.

Both the demand for cigarettes and the decision to smoke are specified as functions of the price of cigarettes, income, education, age, race, sex, marital status, self-rated health, family size, labor force participation, and regional dummies. Lewit and Coate find that the own-price elasticities of demand are substantially larger in absolute value levels in the restricted subsample (-0.42 for the quantity demanded, -0.26 for participation, and -0.10 for the quantity smoked by smokers) than they are in the full sample (-0.22 , -0.14 , and -0.04 for quantity, participation, and quantity smoked by smokers respectively). Due to their greater statistical significance and the possible measurement error in the price variable, they use the estimates for the restricted sample in the remainder of their analysis. These estimates are employed to compute the overall own-price elasticity of demand as -0.42 .

Because the majority of the impact of a price increase appears to be on the decision to smoke rather than on the quantity smoked by smokers, Lewit and Coate go on to estimate demand equations for subsamples of their restricted sample, stratified on the basis of race and sex. They are now able to use a more appropriate full-information, maximum likelihood logistic specification when estimating the decision to smoke due to their relatively small subsamples. Consistent with the result obtained in their research with Grossman, they find that the smoking behavior of younger people, particularly those ages 20 to 25, is more affected

by price than that of older individuals, with the primary impact again being on the smoking decision. They find that men, particularly those under 20 and over 35, are more responsive to changes in the price of cigarettes than was implied by the results obtained in their combined male-female sample, while cigarette demand by women is unresponsive to price.

Finally, they find a weak, positive relationship between income and the demand for cigarettes, with an estimated income elasticity of demand of 0.08. Based on these results, Lewit and Coate conclude that increased Federal excise taxes on cigarettes are a potent policy option, even if smokers compensate by switching to higher tar and nicotine cigarettes, reducing idle burn, or inhaling more deeply. Their results also suggest that a maintained increase in price would have the effect of reducing the number of young people who begin smoking, implying much lower smoking participation rates in the long run.

Mullahy (1985), in his University of Virginia Ph.D. dissertation, conduct a microeconometric analysis of cigarette demand in which he attempts to correct the shortcomings of the earlier studies described above. He uses the most appropriate estimation techniques when fitting the demand for cigarettes by smokers and the smoking decision equations, estimating the demand for cigarettes by smokers after estimating a decision to smoke equation using probit techniques. He also attempts to model the habitual nature

of cigarette smoking. However, he does not model the demand for cigarettes over the life-cycle, but instead models habits in consumption in a single period, static framework. Failing to fully model the life-cycle behavior of cigarette smokers, as Mullahy notes, implies that smokers are myopic rather than farsighted. Modelling smoking as myopic implies that past consumption has an affect on current consumption, but ignores the effects of current consumption on future consumption and other factors. In addition, Mullahy attempts to account for the unobserved heterogeneity in individuals' tastes and productive efficiency as well as health concerns in his estimation framework.

Mullahy's model is set in a simple, single period, constrained utility maximization framework, where the individual's past consumption is important in determining current consumption, but where the individual's future behavior has no effect on current actions. He postulates a stock of habits, the depreciated sum of past cigarette consumption, which is important in the production of a commodity not directly available in the market (i.e. health and the satisfaction received from smoking).

Mullahy uses 1979 Health Interview Survey to construct samples of 6174 men and 7620 women (he stratifies he sample on the basis of sex due to several behavioral differences in the smoking habits of men and women), which he then augments with state level price data from the Tobacco

Institute. To control for the border crossing problem, Mullahy uses a weighted average of own-state price and border-state price (when lower than own-state price) for the price of cigarettes in some specifications as an alternative to the own-state price he uses in others. In addition to cigarette prices, the Fuchs-Michael-Scott state price index (used by Lewit, Coate, and Grossman 1981) is used to account for geographical variations in the prices of goods. He constructs several proxies for the habit stock based on the information collected in the survey, and assorted assumptions about past consumption paths and discount rates. Other variables of interest included in the demand equations he estimates are family income, and the individual's age, race, and educational attainment.

Mullahy uses probit techniques to estimate the decision to smoke equation, and uses the models proposed by Cragg (1971) to then estimate the demand for cigarettes by smokers, after rejecting the sample selection methods developed by Heckman (1976, 1979), and the Tobit methods developed by Tobin (1958) as less appropriate. Instrumental variable and two stage least squares techniques are used due to the possibility of some correlation between the heterogeneous unobserved variables and the habit stock, which, if not accounted for, would lead to biases in the estimated coefficients. Some of the models of the quantity smoked by smokers are reestimated so that the parameters are allowed to vary deterministically with the habit stock (all in-

dependent variables are interacted with the habit stock).

Mullahy's main results can be summarized as follows: negative own-price elasticities of demand are obtained for both males and females regardless of the habit and price variable used, with mean own-price elasticities of -0.18 for males and -0.11 for females; cigarettes are a superior good for males (income elasticity 0.08) but are an inferior good for females (income elasticity -0.02); habit stocks have a positive and significant effect on demand by both males and females, as expected; white smokers (male and female) smoke more than their black counterparts; estimates from the interaction models imply that smokers with larger habit stocks are less responsive to price than those with smaller habit stocks, but own-price effects are still important for all smokers; the probability of smoking is negatively related to the price of cigarettes for both sexes, with the probability being more price elastic for males; the income elasticity of smoking probability is negative for both sexes, which Mullahy interprets as implying that smoking, in an economic sense, is an inferior activity (page 182); larger habit stocks increase the probability that an individual will smoke; and the probability of smoking is significantly lower as an individual receives more schooling. The mean total own-price elasticities of demand, centered around -0.47 , are similar to those obtained by Lewit and Coate (1982), with the elasticity being somewhat greater for men than for women.

A comparison of Mullahy's results with the results of this research should be quite interesting. One of the hypotheses of the life-cycle model of Becker and Murphy (1986) is that the more addicted an individual is, the greater should be his response to changes in price, a prediction arising from the farsighted nature of the model. Mullahy's myopic model, on the other hand, suggests that those individuals with stronger habits will be less responsive to price, a prediction supported by the results he presents.

Warner (1978) examines the possibility of underreporting of cigarette consumption in survey data after noting that observed cigarette consumption, as measured by aggregate sales, increased over eighteen percent in the ten years beginning in 1964, while self reported consumption only increased by less than five percent. He offers several explanations for this divergence, including the decreased social acceptance of cigarette smoking leading to individuals understating their consumption. This is a potential difficulty for the research to be conducted below and should be kept in mind when interpreting the results, although Williams and Gillies (1984) present some evidence that truthful responses are given, at least by adolescents, in some types of surveys.¹ There are objective measures

¹ The data to be used contains several measures, particularly the level of carboxyhemoglobin in the individual's bloodstream, which can be used to corroborate the self-reported consumption data.

included in the survey to be used in the empirical work which will help determine the extent of this problem.

In an interesting attempt to deal with the possibility that cigarette consumption is underreported in survey data, Deaton and Irish (1984) use household data for the United Kingdom to analyze expenditures on tobacco, alcohol, and durable goods in 1973-1974. They note that there are several possible explanations for the apparent discrepancies between aggregate tobacco and alcohol production and sales figures and consumption estimates derived from survey data, including the omission from the survey of groups thought to be relatively high consumers (convicts, seamen, tourists) and the misreporting of consumption by those surveyed.

Deaton and Irish develop what has come to be known as a "double hurdle" model in an attempt to capture the nature of underreporting. The basic equation in the model is:

$$(3-3) \quad z_1 = w_1 * \max (y_1, 0),$$

where the z_1 are the recorded expenditures of the i^{th} household, the y_1 are its actual expenditures, and the w_1 are variables equal to one with probability p_1 and zero with probability $(1-p_1)$. The variable w_1 is one, therefore, for a household which reports positive expenditures, and zero for a households which, correctly or incorrectly, reports zero expenditures. Deaton and Irish go on to model

the variable w_1 using a probit formulation whose results are used in the estimation of the expenditure equation. These results are then compared to those obtained using a Tobit specification to test for the appropriateness of the model.

Their results for tobacco expenditures show no evidence of any importance for the binary censor variable w_1 , implying that Tobit is an appropriate specification. However, they do find some evidence to support the use of a double hurdle specification when modelling expenditures on alcohol or durable goods.

Finally, Deaton and Irish find that tobacco is an inferior good for all but low income households, tobacco use is positively related to the number of adults in the household but is less if there are older children or the head of the household is a woman, and purchases of tobacco increase with age until age sixty after which they fall off rapidly. The main finding of interest for this dissertation is Deaton and Irish's rejection of the suggestion that consumption of tobacco is deliberately underreported in survey data based on their double hurdle model. This conclusion lends support to the results obtained in other microeconomic studies of cigarette demand.

Other Related Studies

There have been a variety of other theoretical and

empirical studies by economists which are of some interest in this research. These include the discussions of the education-smoking link, the modelling of utility as dependent on tar and nicotine intake, the evaluations of the economic costs of cigarette smoking, and the debate over the extent to which increases in cigarette excise taxes are passed on to smokers. The review below is by no means exhaustive, but does include a representative sampling of this diverse literature.

In a paper using the results presented by Bishop and Yoo (1985), Porter (1986), Baltagi and Levin (1986), Lewit and Coate (1982), Ippolito, Murphy, and Sant (1979) and Schneider, Klein, and Murphy (1981), Harris (1987) estimates the impact on cigarette consumption and smoking participation rates of the doubling of the Federal excise tax, effective January 1, 1983. Harris tries to determine how much of the fall in cigarette consumption during the early 1980's is due to the thirty-six percent rise in real cigarette prices from 1981 to 1986 which he attributes to the eight cent increase in the Federal tax and the manufacturers' price increases it induced.²

² Harris argues that the increases in the manufacturers' wholesale cigarette prices are partly due to rises in the costs of production, but that they are also due to the tax increase serving as a coordinating mechanism for oligopolistic behavior on the part of the cigarette producers. He concludes that the tax induced an increase in cigarette prices of eight cents that would not have been observed otherwise, for a total increase of sixteen cents. While noting the increase in state tax rates on cigarettes, he does not attribute these to the Federal tax increase. It is likely (see Tables 2-4 and 2-5) that the sudden increase

He concludes that most of the drop can be explained by the rise in the price, but allows that unmeasured trends may be important. He also concludes that the tax increase and associated wholesale price increases led two million adults to stop smoking and kept 600,000 teenagers from starting to smoke. Using these results and evidence obtained from epidemiological studies on smoking and health, Harris goes on to predict that the tax increase will lead to 54,000 more teenagers surviving past the age of sixty-five, as well as 45,000 more adults. He concludes by stating that these predictions are dependent on a sustained increase in the real price of cigarettes, and may change significantly if real prices are allowed to fall as they did during the 1970's.

In a series of papers, Barzel (1976), Johnson (1978), and Sumner and Ward (1981) examine the impact of state level cigarette excise taxes on the price of cigarettes. Barzel finds that the price of cigarettes is raised by significantly more than the cigarette excise tax, when it is a per unit tax, after controlling for shipping costs, but this doesn't hold for an ad valorem excise tax. Johnson argues that Barzel ignores an important factor in the determination of price, the labor costs of distributing

in the number of states raising their taxes in 1982 and 1983 is at least partly a result of the Federal tax increase. If this is the case, then the resulting increase in price would be even larger than the sixteen cents Harris uses, making his estimates conservative assessments of the impact of the tax increase on consumption and health.

cigarettes. After including state dummies to account for this cost difference, Johnson also finds that the constant, per unit tax raises price by more than the amount of the tax. His results indicate that price rises by more than Barzel found. Unlike Barzel however, Johnson finds that ad valorem taxes are less than fully passed on to smokers. Sumner and Ward criticize both Johnson and Barzel, arguing that they ignore the discontinuous nature of cigarette prices, due to the costs of changing prices. After accounting for this by adding a variable, the change in the wholesale price of cigarettes, they find that per unit excise taxes on cigarettes are less than fully passed on to consumers. They attribute this result to interstate competition in the cigarette market. Sumner (1981) uses Barzel's (1976) theory to test the competitiveness of the cigarette market, concluding that the market can not be characterized by atomistic competition. This conclusion is the result of his finding that increases in cigarette excise taxes are more than fully passed on to smokers, a finding questioned by Bulow and Pfleiderer (1983) in their generalization of Sumner's model.

Cox and Smith (1984) compare the smoking control policies of 15 OECD countries in an attempt to see which type of strategies are most effective. They broadly categorize policies as one of two types, a comprehensive legislated policy or a piecemeal voluntary policy. They estimate the demand for tobacco in each country as a function of the

relative price of tobacco, real income, and a linear trend, and state that the more negative the coefficient on the trend, the more successful is policy in discouraging smoking in that country. They also estimate a first difference version of the same equation using annual data for each country over the period 1962 through 1980. Their estimated own-price elasticities of demand, for the most part, fall in the range -0.7 to -0.1 , with income elasticities in the range 0.2 to 1.0 . They find that the coefficients on the trend variable are consistent with their hypothesis that the countries where anti-smoking policies are comprehensive and legislated have been most successful in discouraging demand. Finally, they find that price elasticities are about the same in their two classifications of countries based on policy, while demand is more income elastic in the countries with legislated anti-smoking policies.

In a similar type of study, Hamilton examines the effect of various advertising restrictions on cigarette demand. He finds that the advertising bans enacted by seven countries led to no discernible reduction in demand. Similarly, when the countries which ban advertising are grouped together and compared to those with no bans, consumption trends were not noticeably different. Hamilton concludes, as with his study on the U.S. (1972), that cigarette advertising bans are an ineffective, unproductive policy measure.

Lewit (1987) considers the evolution of cigarette and

tobacco policy in developing countries in a neo-classical welfare economics framework. His recommendations include a strong endorsement of labelling requirements, weaker support for advertising restrictions, some backing for health education programs depending on the commitment of resources they require, and relatively high excise taxes on cigarettes. He also argues against tobacco support programs contending that they aid in the development of a large, self-protective tobacco sector which will inhibit the development of tobacco control policies.

There exists an extensive literature on the economic costs to society of smoking. The "costs" of smoking as defined in this literature include not only the increased costs of health and medical care, but the lost productivity costs attributed to illnesses and deaths associated with smoking, along with property damage (i.e. due to fires) and increased production costs (i.e. the costs of maintaining non-smoking and smoking sections in restaurants and the maintenance of smoking cars on commuter railroads) connected with cigarette smoking.

The most comprehensive analysis of the costs of smoking in terms of increased health care expenditures and lost productivity is the 1985 study by the Office of Technology Assessment. They estimate that, for 1982, about 5.3 million life-years were lost due to smoking related diseases, with 1.2 million lost before the age of 65. Increased health care costs resulting from smoking are estimated to

be in the range from \$12 billion to \$35 billion, with a median estimate of \$22 billion, about seventy-two cents per pack of cigarettes sold in the U.S. Of this, between \$2.1 billion and \$6.6 billion of the costs are paid by the Federal government through Medicare and Medicaid. In addition, the productivity losses for the economy are estimated to be between \$27 billion and \$61 billion for 1985, with the median amounting to about \$1.45 per pack. These estimates are described as conservative assessments of the costs, as they ignore property damage and other costs associated with smoking. However, as the Office of Technology notes in its conclusions, there are future costs associated with reductions in current smoking. These costs, including increased Social Security and Medicare payments and increased health care expenditures by the elderly, were not treated in this study, but the Office concludes that even modest expenditures aimed at reducing smoking are a cost effective means of improving health and preventing premature death.

Kristein (1983) has attempted to estimate the costs to business of smoking. These costs include health insurance, fire losses, workers' compensation, absenteeism, and lost productivity for both smokers and nonsmokers exposed to secondhand smoke. He estimates the total costs to be in the range from \$336 to \$601 per smoker, for an aggregate cost of approximately \$47.5 billion to American industry. Another researcher, Dr. William Weiss, estimates the costs

to be significantly higher, at about \$4,611 per smoker employed (Carlson, 1986), which leads him to calculate that the work of 100 smokers could be accomplished by 92 non-smokers.

In a recent National Bureau of Economic Research working paper, Shoven, Sundberg, and Bunker attempt to estimate the social security costs of reducing cigarette smoking. They estimate that a median wage male smoker will lose \$20,000 in Social Security benefits as a result of smoking, with a median wage female smoker losing about \$10,000. This implies a "savings" of hundreds of billions of dollars for the Social Security system which would be lost if there is a large reduction in smoking. Similar results were obtained in a study sponsored by the British government (Atkinson and Townsend, 1977) which estimated that an extensive anti-smoking campaign would provide some short run savings, but, by the year 2000, would lead to net loss of twenty-nine million pounds due to benefits received by survivors.

Leu and Schaub (1983) attempt to combine both the increase in current health care expenditures associated with smoking with the increase in future expenditures associated with the increased longevity resulting from reduced smoking. They find that the total impact of smoking on medical care expenditures is marginal, with reduced expenditures now being offset by increased expenditures later, the result of living longer after refraining from

smoking. In a similar vein, Stoddart et al. (1986) conclude that it is extremely unlikely that Canadian smokers use more publicly financed health care than they contribute to revenues through cigarette excise taxes.

Farrell and Fuchs (1982) attempt to establish an empirical link between cigarette smoking and schooling, applying the more general ideas contained in Grossman's (1975) examination of the relationship between health and schooling. Noting the observed correlation between health and schooling, Grossman examines three alternative explanations: increases in schooling lead to increases in health; increases in health lead to increases in schooling; and there exist some unobserved variables which affect schooling and health in the same direction. Grossman finds that there is some evidence that there is a causal link from schooling to health. Thaler and Shefrin (1981) argue that this link can be explained by increases in schooling increasing the individual's ability to develop self-control strategies, including the cessation of a smoking habit.

Fuchs and Farrell use survey data to examine the relationship between schooling and smoking and are unable to accept the hypothesis that additional years of schooling play a causal role in the schooling-smoking correlation. They find that the likelihood of smoking is well established by age 17 and that additional schooling has no significant effect on changing the likelihood. These results imply that some third variable is important, but

Fuchs and Farrell are unable to determine what this may be after considering social class and mental ability, and offer different rates of time discount as a possible explanation.³ Warner (1982) argues that these results may be due to the inappropriateness of the number of years of schooling as a measure of education, and defends mental ability as the unobserved third variable of import. The work to be done in this dissertation may be able to shed some additional light on these questions.

In a unique approach to the demand for cigarettes, Harris (1980) argues that the utility derived from cigarette smoking is dependent on the quantity of tar and nicotine consumed, in addition to the quantity of cigarettes consumed. This leads him to argue that a cigarette excise tax (similar to the one proposed by Senators Hart and Kennedy in the mid-1970's) based on tar and nicotine content would be an effective way to correct what he sees as the smokers' misperception of the health consequences of smoking. He shows that the extent to which this type of policy is effective depends on the health tradeoff between smoking relatively few high tar/nicotine cigarettes and smoking many low tar/nicotine cigarettes.

³ In a separate analysis, Fuchs (1982) states two ways in which the observed correlation between schooling and health could be explained by differences in individuals' rates of time preference. These are: the rate of time preference is an unobserved third variable, difference in which result in differences in the optimal level of schooling and investment in health; and individuals' with more schooling (those with a higher return on their investment in health) will be more healthy (due to a greater investment).

Using a similar utility maximization paradigm in which the individual's satisfaction from smoking depends, in part, upon the tar and nicotine content of the cigarette they smoke, Ippolito and Ippolito (1982 and 1984) formally model consumers' reactions to new information on the health effects of smoking. They argue that the smoking decision is based on two factors: "tastes" which are predetermined and have no effect on the quantity smoked, but which are changed as a result of new information leading to a once and for all adjustment in consumption; and price, changes in which alone induce changes in consumption in each period. In their model, there are two types of cigarettes, high tar and nicotine, high taste cigarettes and low tar and nicotine, low taste cigarettes, the smoking of the former leading to a greater increase in the probability of early death than the smoking of the latter. In the absence of information on the health consequences of smoking, all smokers will choose to smoke the high taste cigarette, since they produce a greater level of satisfaction at the same price. However, as information is released on the health effects of smoking, this greater quality is now available only at a premium, a shorter lifespan. This model leads to differences in smoking behavior (smoke/don't smoke, quantity and type of cigarettes smoked) as individuals' tastes and the value they place on life differs.

Using aggregate data in an application of their theoretical model, Ippolito and Ippolito conclude that per capita

cigarette consumption would have been approximately twice as large and over twenty percent more of the population would be smokers in 1980 had there been no information released on the health consequences of smoking. They also estimate that the average nicotine content of cigarettes smoked would have been fifty percent higher, with no low tar, low nicotine cigarettes on the market. Finally, they estimate the own-price elasticity of demand to be -0.48 , and they predict that individuals would have been willing to pay \$1.15 more per pack of cigarettes in 1980 (when mean price was 66 cents) had there been no information on the adverse consequences of smoking. These final estimates imply an average value of life saving in the range of \$300,000 to \$600,000.

Conclusions

The active campaign against smoking of the past few decades has been somewhat successful in reversing the upward trend in aggregate and per capita cigarette consumption and has reduced the fraction of the population which smokes to its lowest level in some years. However, given the large body of research conducted by economists, it appears that the most successful policy tool of government in reducing smoking is to increase the price of cigarettes through an increase in the excise tax on cigarettes. Paradoxically, at the infrequent times when these taxes have

been raised, particularly the Federal tax, the reason has been to increase revenues rather than to discourage smoking. The estimated own-price elasticities of demand in the relatively tight range from -0.7 to -0.2 , with a median estimate of -0.5 found in most of the research reviewed above, suggest that, although cigarette demand is inelastic, there is some potential to further discourage smoking through increases in cigarette taxes.

While having some impact on cigarette demand, the other elements of the anti-smoking campaign have been found to be somewhat less effective in discouraging smoking. In fact, one of these elements, the ban on radio and television advertising and the subsequent reduction in the broadcast of anti-smoking advertisements it induced, has been faulted in much of the research discussed above.

Despite this large body of research into the impact of the anti-smoking campaign and prices on cigarette demand, some issues remain to be resolved. Most important among these is the treatment of cigarette smoking as an addictive behavior and the implications of this treatment in developing new policy to reduce smoking. Formally modelling the addictive nature of cigarette smoking and the development of an appropriate estimation framework will result in a better understanding of the long run responses of smokers to changes in the price of cigarettes as well as other elements of the anti-smoking campaign.

Chapter Four

Behavioral and Health Factors in Cigarette Smoking

To provide some motivation for several of the assumptions of the theoretical model of cigarette smoking to be developed in Chapter Five, the important behavioral factors and health concerns associated with smoking will be discussed in this chapter. Specifically, some discussion will be made concerning the "satisfaction" or "relaxation" produced by cigarette smoking, the addictive nature of cigarette smoking, and, finally, the health considerations arising from cigarette smoking. Each of these factors has been the subject of a significant body of sociological, psychological, and biomedical research, a comprehensive evaluation of which is beyond the scope of this dissertation. There are, however, several definitive conclusions drawn from this research which can be summarized nicely.

The chapter will be organized as follows: first, there will be a discussion of the utility derived from cigarette smoking, focusing on the pharmacological and psychological mechanisms through which cigarette smoking (in particular nicotine) produces satisfaction; second, a formal definition of an addictive substance will be presented along with an analysis of how cigarette smoking fulfills the accepted criteria for classification as an addictive behavior; third, a brief review of the extensive literature on the health consequences of cigarette smoking will be presented;

and, finally, several conclusions will be made.

Before beginning, it should be noted that the fundamental goal of this chapter is to characterize cigarette smoking as a rational addictive behavior. Rational, in this context, implies that individuals are maximizing utility subject to a resource constraint and behave consistently over time (Becker and Murphy, 1986). Consistent behavior implies that an individual is increasing utility by smoking, understands the addictive nature of cigarette consumption (the fact that their current consumption is determined, in part, by their past consumption and that both current and past consumption will affect their future decisions), and is farsighted (aware of the future consequences of their current behavior). While this may not be a perfect description of smoking behavior, it appears to be much more appropriate than assuming that smokers are unaware of the addictive aspects of cigarette smoking and the future consequences of their addiction.

The Satisfaction Derived from Smoking

Any treatment of cigarette smoking would be incomplete without some discussion of the mechanisms through which individuals, at least those individuals who choose to smoke, derive satisfaction from smoking. That is, in an economic sense, individuals must in some way be increasing their utility through their consumption of cigarettes, or

as Mullahy (1985) puts it, some service flows augmenting utility must be produced by smoking cigarettes,¹ otherwise no- one would choose to smoke. In one of the most comprehensive analyses of the pharmacological and psychological mechanisms involved in cigarette smoking, Ashton and Stepney (1982) state that "probably the most important single factor in the whole smoking phenomenon is that smoking is pleasurable to smokers; they like doing it."² They go on to state that the pleasure derived from smoking arises from a variety of sources, both nonpharmacological and pharmacological.

Included in the important nonpharmacological factors through which cigarette smoking provides pleasure are the pleasant sensations of smell, taste, or irritation produced by smoking and the "oral erotic gratification it provides," as suggested by Freud. Smoking is unique in providing these sensory gratification in that it provides 'continuous gratification' without uncomfortably accumulating in the body as do food and drink.³

¹ Mullahy (1985), page 70.

² This statement, and much of this and the following section, are drawn from Heather Ashton and Rob Stepney's 1982 text Smoking: Psychology and Pharmacology, and, to a lesser extent from the National Institute on Drug Abuse Research Monographs number 23, Cigarette Smoking as a Dependence Process, edited by Norman A. Krasnegor (1979), and number 26, The Behavioral Aspects of Smoking, edited by Norman A. Krasnegor (1979). In some respects, these two sections parallel the discussion by Mullahy (1985), pages 70-83. This statement appears in Ashton and Stepney (1982), page 54.

³ Ashton and Stepney (1982), pages 18-21.

Others have suggested that smoking is important simply as an activity, an argument based on two aspects of smoking. It is argued firstly that smoking in some way legitimizes relaxation (in a way similar to a 'coffee break') and secondly that smoking is a displacement activity (an activity which channels the smoker's attention and provides an outlet for nervous energy) in situations of internal conflict, uncertainty, anger, anxiety, or excitement (during which nonsmokers may engage in some other behavior such as nail-biting or pen chewing).⁴

Ashton and Stepney, however, reject the primacy of these nonpharmacological reasons for smoking in favor of pharmacological factors stating that:⁵

All of the supposed satisfactions of smoking related to oral and manual manipulation and taste and aroma can be obtained without drawing smoke into the lungs . . . (yet) eighty to ninety per-cent of cigarette smokers inhale. Why then do smokers inhale? The inhalation of smoke is not a natural behavior - it has to be learned, often at the cost of some initial discomfort. It is, however, an exceptionally fast and efficient way of getting a drug into the body, and in this respect is rivalled only by intravenous injection. It is therefore our view that both the unique role of tobacco, and the prevalence of inhalation, can best be accounted for by the assumption that smoking is essentially a means of nicotine self-administration.

Jarvik (1979), uses a similar argument to support the dominance of chemical factors over psychological and other nonpharmacological factors in smoking. He reviews the large

⁴ Ashton and Stepney (1982), pages 19-20.

⁵ Ashton and Stepney (1982), page 27.

number of compounds which may act as pharmacological reinforcers found in cigarette smoke, focusing on its three major components: carbon monoxide, tar, and nicotine.

Jarvik rejects carbon monoxide as the primary reinforcing agent in tobacco smoke, pointing out that rather than providing pleasurable sensations it instead produces headaches. He also notes that carbon monoxide was not produced in the consumption of chewing tobacco and snuff, two of the earliest and most popular forms of tobacco consumption prior to the marketing of inexpensive, factory produced cigarettes.⁶

He finds it more difficult to reject tar as the principal reinforcer due to the tendency of the tar and nicotine levels found in a cigarette to covary. However, Jarvik and Ashton and Stepney note studies where the tar and nicotine contents of cigarettes were dissociated that find that the number of cigarettes smoked was unrelated to their tar content, but was directly related to their nicotine content. Neither Jarvik nor Ashton and Stepney entirely dismiss the possibility that tar is the important factor, but both defer to nicotine as the dominant element.⁷

With respect to nicotine, Jarvik states that "whether or not it is the only reinforcing agent, it is still the most powerful pharmacological agent in cigarette smoke," but

⁶ Jarvik (1979), pages 11-12.

⁷ Jarvik (1979), page 12, and Ashton and Stepney (1982) page 75-76.

leaves open the possibility of interactions between nicotine and carbon monoxide and/or tar. Schachter (1979), Jarvik, and Ashton and Stepney note the large number of studies in which smokers were given cigarettes yielding different levels of nicotine, the majority of which conclude that smokers smoking cigarettes which deliver a lower level of nicotine compensate in some way as compared to those smoking higher nicotine delivery cigarettes. The compensation can be in the form of an increased consumption of cigarettes, an increase in the number of puffs per cigarette, an increase in the length and volume of smoke consumed per puff, deeper inhalation of the smoke, the smoking of the cigarette to a shorter butt length, and/or the more rapid smoking of the cigarette.* They also discuss the rejection in the marketplace of cigarettes which contain no or extremely low quantities of nicotine, produced using either a tobacco substitute or a very small quantity of tobacco. Each notes that one problem with these studies is that lower nicotine delivery cigarettes also tend to deliver less of the other chemicals produced in cigarette smoking, particularly tar.° However, Schachter notes two studies in which tar and nicotine content were dissociated that find compensation for low

* Ashton and Stepney (1982), page 76; Schachter (1979), page 123; and Jarvik (1979), page 12.

° Schachter (1979) notes that the correlation between the tar and nicotine yields of commercially available cigarettes is +0.91 (page 123).

nicotine delivery but not for low tar delivery.¹⁰ Moreover, Ashton and Stepney note that the converse is also true: that cigarettes which yield a high level of nicotine are smoked less intensively, take longer to smoke, and contain more unsmoked tobacco in the butt.¹¹

This behavior implies that smokers in some way regulate their intake of nicotine. That is, they have some optimal nicotine intake, and if a cigarette yields less than this quantity of nicotine the smoker will smoke it more intensively, and if it yields greater than this quantity, it will be smoked less intensively. The widespread view that nicotine is the primary agent in cigarette smoking, though not the only one, will serve as the basis of this research also. Accepting this, some discussion should be made of the physiological impacts of nicotine, or the process through which nicotine produces increments to utility.

Nicotine, an alkaloid containing carbon, hydrogen, and nitrogen, is a colorless liquid in its pure state, which turns brown upon exposure to air, and is largely responsible for tobacco's odor. It is a chemical so toxic that a single drop can kill a man within minutes. However, the minute quantity of nicotine consumed from a burning cigarette has a much different effect. For a smoker to derive any pleasure from nicotine, the smoke has to be inhaled into the lungs rather than just taken into their mouth, after which the

¹⁰ Schachter (1979), page 123.

¹¹ Ashton and Stepney (1982), pages 76-77.

nicotine is efficiently and rapidly absorbed into the bloodstream. From there, it is swiftly diffused throughout the body, easily passing through cell membranes, including those of the fetus if the smoker is pregnant.¹² However, the distribution of nicotine throughout the body is not uniform, with relatively large quantities concentrating in tissues receiving the quickest and most direct blood supply, in particular brain tissue and other parts of the nervous system, including the adrenal gland and ganglion cells. This diffusion process is enhanced by the intermittent nature of cigarette consumption, with each puff exposing tissue to higher concentrations of nicotine than if the same amount of nicotine were consumed smoothly. However, just as it is rapidly diffused, nicotine is also rapidly metabolized.

As nicotine diffuses into the tissues of the nervous system, what Ashton and Stepney call its "biphasic effects" become evident.¹³ By biphasic, they mean the ability of nicotine to act both as a stimulant when the smoker is either depressed or relaxed and as a depressant when the smoker is excited, or even a mixture of the two effects, a characteristic singling it out from most other drugs.

These biphasic effects of nicotine are largely at-

¹² Ashton and Stepney (1982), pages 28-33. They state that the nicotine ingested in the first puff of a cigarette takes approximately seven seconds to reach the brain and fifteen to twenty seconds to get to the big toe.

¹³ Ashton and Stepney (1982), pages 36-41, and Jarvik (1979), pages 16-18.

tributable to its ability to emulate the body chemical acetylcholine (ACh). ACh is a neurotransmitter important in several areas of the nervous system, particularly those concerned with physical and mental arousal, learning and memory, and several aspects of emotion.¹⁴ As Ashton and Stepney describe it:¹⁵

The initial combination of nicotine with the ACh receptor at first stimulates an ACh-like response, but the fixity of the drug/receptor combination (the combination of nicotine and the receptor is much more enduring than the combination of ACh and the receptor) then blocks any further response to ACh (or to more nicotine). The degree of stimulation versus block depends on the amount of nicotine present relative to the number of available ACh receptors: in general, small doses of nicotine produce a predominantly stimulant effect at synapses, larger doses produce a mainly depressant effect, while the effect of a lethal dose is to block nervous transmission altogether.

This again implies that the smoker can achieve the desired effect from nicotine (either to relax or excite the individual) through the regulation of nicotine intake. That is, the dose of nicotine ingested, controlled through the depth of inhalation, length of puff, and/or rapidity of puffs, serves to determine whether the nicotine acts as a stimulant or a depressant. Additionally, nicotine has been shown to release norepinephrine from postganglionic sympathetic sites and epinephrine for the adrenal gland, body chemicals which act similarly to adrenaline, stimulating the

¹⁴ Ashton and Stepney (1982), page 37.

¹⁵ Ashton and Stepney (1982), pages 38-39.

heart and increasing muscle strength and endurance.¹⁶ Others have hypothesized, but been unable to show, that nicotine prompts the release of dopamine, noradrenaline, and several amino acids and polypeptides, each with their own effects on the body.¹⁷

To summarize, nicotine, the primary reinforcing agent in cigarette smoke, produces utility through its ability to either stimulate or relax an individual without otherwise altering the smoker's ability to function. Ashton and Stepney describe smoking as a convenient way of manipulating the smoker's psychological state in that it may lead to the maintenance of performance in the face of monotony or fatigue, an increase in the selectivity of attention, the alleviation of anxiety or aggression, or the attenuation of the affects of stress.¹⁸

Cigarette Smoking as an Addictive Behavior

The primary distinction between the research conducted in this dissertation and other research into the demand for cigarettes is that this work formally models cigarettes as an addictive substance whose demand differs from the demand for other goods and services while most others have treated it no differently. As will be discussed below, this treat-

¹⁶ Jarvik (1979), pages 16-18.

¹⁷ Ashton and Stepney (1982), page 40.

¹⁸ Ashton and Stepney (1982), pages 91-119.

ment leads to several implications about the response of smokers to price and other factors influencing demand which are not implied by models ignoring the addictive nature of smoking. Therefore, it is important to establish that cigarette smoking is, in fact, an addictive behavior.

There are two accepted definitions of what constitutes an addictive behavior or of what characteristics are associated with the consumption of an addictive substance.¹⁹

¹⁹ Historically, there has been a great deal of confusion over the precise definition of an addiction, and over what behaviors should be considered addictive. Illustrative of this confusion is the definition presented by the U.S. Department of Health and Human Services in its 1982 Guide to Drug Abuse Research Terminology, part of which reads (pages 5-6):

From the Latin verb "addicere," to give or bind a person to one thing or another. Generally used in the drug field to refer to chronic, compulsive, or uncontrollable drug use, to the extent that a person cannot or will not stop the use of some drug. Beyond this, the term is ambiguously used with a wide variety of often arbitrary meanings and connotations; sometimes interchangeably with sometimes in contrast to two other ill-defined terms, HABITUATION and (DRUG) DEPENDENCE, the former imprecisely referring to some lesser form of chronic drug use, the latter capable of being either of psychological or physical origin, often in varying combinations depending on the drug. It usually implies a strong (PSYCHOLOGICAL) DEPENDENCE resulting in a WITHDRAWAL SYNDROME when use of the drug is stopped. Many definitions place primary stress on psychological factors such as the loss of self-control and overpowering desires; i.e. addiction is any state in which one craves the use of a drug and uses it frequently. Others use the term as a synonym for physiological dependence; still others see it as a combination.

The primary popular stereotype, what has been called the "classical definition of addiction," is that it is an extraordinarily debilitating vice or disease--even an evil and sinful state--rooted in the invariable pharmacological effects of a drug

on the human body, an irrevocable process that involves the presence of tolerance and results in a withdrawal syndrome that can be avoided only by total abstinence (Peele 1977). The classical definition of addiction further links this phenomenon particularly to the OPIATE NARCOTICS. Like the popular concept of narcotics, this classical definition emerged in the 1920s out of a blending of popular and scientific terminology laden with emotional and imprecise meanings. The term addict began to be increasingly stigmatized and used by both the scientific and lay communities to express that the compulsive use of opiates was not just a bad habit but was worse both to the individual and society than other forms of habituation, such as to tobacco and alcohol, and resulted in debility, insanity, crime, and death.

Recent historical and research data have shown, however, that the two fundamental components of this classical definition--that addiction is purely physiological and that opiate narcotics are the sole source of addiction--are not valid and in fact the stereotype of the addict is often fictional (Peele 1977; Johnson 1978).... Many emphasize that addiction cannot be used solely as a synonym for physiological dependence: "Addiction cannot be used interchangeably with physical dependence. It is possible to be physically dependent on a drug without being addicted. It is possible to be addicted without being physically dependent" (Jaffe 1975, 285).

From the 1920s to the early 1960s an attempt was made to differentiate between ADDICTION and HABITUATION. In the mid 1960s the World Health Organization recommended that both terms be abandoned in favor of drug dependence. Since then, many authorities have recommended that, like the term "abuse," the term "addiction" has been applied so arbitrarily and illogically that its use should be entirely abandoned. Nevertheless, "addiction" and "addict" are still widely used this may be due to the popularity of the term as well as the fact that it is simply easier to refer to an "addict" than a "drug dependent person" and that the substitutions so far recommended, such as "drug dependence" have only marginally affected the underlying definitional problems surrounding this word. Others increas-

The first, more popular definition is that an addiction is an extreme involvement with any substance or action. This definition includes not only cigarette smoking and the consumption of drugs and alcohol, but also compulsive gambling, overeating, love, golfing, watching television, workaholism, and any other activity characterized by extreme involvement.²⁰ A selective application of this explanation of addiction has been used to characterize only illegal or dangerous activities as addictive or to differentiate healthy activity from addiction by the "degree" of involvement. Any use of this definition to describe a behavior as addictive is, however, arbitrary, as a loose interpretation of it can encompass any activity one desires. Rather than characterizing addictive behavior, this definition appears to identify compulsive or habitual behavior, behaviors which include addictive activities, but all of which should not be considered addictions.

A second, more restrictive definition of addiction as a physiological and/or psychological dependence serves as the basis for the model presented below. This definition cha-

ingly emphasize that the solution to this definitional problem is not to avoid all use of "addiction" but to cultivate and understanding that addiction is not a purely pharmacological process It is not drugs who addict people but people who become addicted to drugs, just as they can and do become addicted to any compelling experience (Laurie 1971; Peele 1976, 1977, 1978).

²⁰ This definition can be found in many places, including Alexander (1982), Barthold and Hochman (1987), and Peele (1985).

racterizes addiction by the presence of three factors: reinforcement, tolerance, and withdrawal. The presence of all three of these factors simultaneously is necessary for an activity to be considered addictive under this more formal definition. While none of these factors can explain why an individual takes up the smoking habit, they are successful in illustrating why individuals continue to smoke.

Historically, cigarette smoking had not been considered an addictive behavior under this definition as most researchers felt that the only factor present in smoking was reinforcement. However, evidence accumulating over the past twenty years has shown that there is an acquired tolerance to cigarettes and that there are symptoms of withdrawal upon the cessation of smoking. Moreover, in the recently revised American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-III), dependence upon tobacco, characterized by the existence of the three factors above, is classified as a substance use disorder, placing it in the same classification as dependence on opiates.²¹ In a similar vein, the National Institute on Drug Abuse concluded that "cigarette smoking behavior should be considered a form of addiction, and tobacco in the form of cigarettes an addicting substance."²²

²¹ U.S. Department of Health and Human Services (1986b), page 27.

²² National Institute on Drug Abuse (1979), page 6.

Nicotine has been established as the primary addictive substance in cigarette smoking. The reinforcement, acquired tolerance, and withdrawal syndromes resulting from the nicotine consumed through cigarettes all have an impact on the ability of the smoker to increase utility through his or her consumption of cigarettes.

The reinforcement effects of cigarette smoking (and nicotine consumption) have been discussed above, to a large degree, and will be only briefly reviewed here. Reinforcement is broadly defined as a psychological mechanism whereby the response to a stimulant is strengthened. In other words, reinforcement is a learning mechanism implying that a behavior is controlled by its consequences, with the probability that the behavior is continued increasing as the rewards associated with the behavior increase. The reinforcement mechanism associated with cigarette smoking can be of two types: positive reinforcement and negative reinforcement.²³ Positive reinforcement in smoking is the pleasure derived from each puff on a cigarette, as discussed above. Negative reinforcement, on the other hand, has to do with learning that cigarette smoking can be used to remove a negative stimulus. Examples of positive reinforcement include the use of cigarette smoking to enhance pleasure, to facilitate performance (particularly for repetitive and/or boring tasks), and to improve memory. More common, however, are the negative reinforcement factors in cigarette smoking.

²³ Ashton and Stepney (1982), pages 154-161.

These include smoking to alleviate stress, reduce anxiety and tension, to avoid weight gain, and to avoid nicotine withdrawal, among others.

Health officials (U.S. Department of Health and Human Services, 1982b) have defined acquired tolerance as a decrease in the response to a drug dose that occurs with the continued use of the drug. Stated differently, tolerance implies that increased quantities of a previously ingested substance must be consumed to achieve the original effect of the substance. Ashton and Stepney distinguish between several forms of tolerance in cigarette smoking which can be characterized in one of two ways: either short term, acute tolerance or a longer lasting acquired tolerance.²⁴

Acute tolerance is the changing response of the body to smoking due to the ability of nicotine to emulate the body chemical ACh as described above. To repeat, nicotine initially serves as a stimulant when bonding with the ACh receptors at nerve endings, but, due to its stronger bonding, it can, during the course of smoking a single cigarette, begin to act as a depressant.

The longer lasting acquired tolerance can be broken down further into three types: drug dispositional or metabolic tolerance, tissue or pharmacodynamic tolerance, and behavioral tolerance.²⁵ Jarvik discusses evidence that the body develops tolerance to all three of the primary con-

²⁴ Ashton and Stepney (1982), pages 58-60.

²⁵ Jarvik (1979), page 19.

stituents of cigarette smoke, tar, nicotine, and carbon monoxide,²⁶ but the focus here will be on tolerance to nicotine.

Metabolic tolerance implies that the body becomes more efficient in metabolizing (eliminating or deactivating) the substance in question. Ashton and Stepney present evidence suggesting that smokers begin to metabolize nicotine much more rapidly than nonsmokers as early as a few weeks after initiating smoking.²⁷

Pharmacodynamic tolerance is described in "regular smokers as a result of some type of tissue adaptation to a nicotine-impregnated environment."²⁸ As with the effects of nicotine on various tissues, the development of a tolerance to nicotine is not uniform throughout the body. Most individuals, when initiating smoking, experience adverse effects including nausea and coughing, in addition to the pleasurable effects derived from nicotine. The tissue producing these reactions appears to develop a tolerance to cigarette smoke relatively quickly, while other tissue, particularly brain tissue, retains its sensitivity to nicotine.

Little is known about the development of a behavioral tolerance to nicotine in man, but there is some evidence that nicotine's effects on the spontaneous activity of

²⁶ Jarvik (1979), pages 18-23.

²⁷ Ashton and Stepney (1982), page 59.

²⁸ Ashton and Stepney (1982), page 59.

animals is reduced with repeated injections of nicotine.²⁹

Finally, the acquired tolerance to nicotine differs in one important way from the acquired tolerance to other substances. For most drugs, tolerance implies a continuing escalation of dosage is required to produce the same effects. However, casual observation of cigarette smokers shows that they reach a plateau level in consumption where they no longer require increased dosages to achieve the same satisfaction (i.e. the smoker has a pack-a-day habit).³⁰ Instead, after some point, the same level of consumption will produce the same level of satisfaction, or, as Mullahy puts it, "nondecreasing doses are required to elicit the same physiological response."³¹ One of the unique features of Becker and Murphy's model of addictive behavior to be discussed below is that the maintenance of consumption at some plateau is a possible outcome of the utility maximization process.

The final characteristic of an addiction is the presence of a withdrawal syndrome, defined as "a cluster of characteristic reactions and behavior, of varying intensity,

²⁹ Ashton and Stepney (1982), page 59.

³⁰ Ashton and Stepney (1982, page 60) discuss the possibility of a physical limitation on the number of cigarettes which can be consumed per day as an explanation for this observed behavior, but reject this argument, noting that if the smoker so desired, he/she could increase their intake of nicotine by taking longer, deeper puffs, smoking stronger cigarettes, or any of the other compensatory actions discussed above.

³¹ Mullahy (1985), page 78.

... which ensue upon abrupt cessation of a drug upon which the body has developed dependence."³² The symptoms of tobacco withdrawal, as described by Shiffman (1979), are numerous, and include reductions in heart rate and diastolic blood pressure, decreased production of adrenaline and norepinephrine, increased sleeplike activity and decreased arousal, weight gain (arising either from increased appetite and consumption or, as suggested more recently, from a decreased metabolic rate), an inability to concentrate, increased irritability or hostility, and increased anxiety in both neutral and more stressful situations. However, the most common and clinically important symptom is a craving for tobacco, found among more than ninety percent of smokers in withdrawal, and appearing in twenty percent of former smokers ten years after they quit.³³ All of these symptoms can appear as soon as six hours after cessation, and seem to reach their peak twenty-four to forty-eight hours later.

As Ashton and Stepney characterize it, the presence of these withdrawal symptoms leads to the evolution from "taking the drug in order to feel better to taking it in order to avoid feeling worse."³⁴ There appears to be some direct relationship between the degree of addiction, as measured by the level of acquired tolerance, and the severity of, at

³² U.S. Department of Health and Human Services (1982b), page 100.

³³ Shiffman (1979), page 160.

³⁴ Ashton and Stepney (1982), page 61.

least some of, the withdrawal symptoms experienced upon cessation.³⁵

The presence of these withdrawal symptoms is an important factor in understanding the high relapse rate among smokers who attempt to quit. Interestingly, some evidence has been presented showing that the gradual reduction in consumption of an addictive substance which reduces the withdrawal symptoms associated with the substance and increases the chances for success in quitting is inappropriate for cigarette smoking. Shiffman, based on his research, states that:³⁶

partial abstinence from smoking leads to more, rather than less, discomfort in withdrawal, since the withdrawal syndrome experienced by those who "cut down" on smoking (by sixty percent) is as severe as that in an abrupt cessation group and lasts longer. The result is that a partially abstinent smoker is in a chronic state of with-

³⁵ Ashton and Stepney (1982 pages 62-63) state that "the severity of the (withdrawal) symptoms is associated with the degree of tolerance which the subject has built up, and all the symptoms can immediately be alleviated by an appropriate dose of the original drug (however) the degree and duration of the craving seem to bear little relation to previous cigarette consumption or duration of smoking." Shiffman (1979, pages 161-162) also raises the issue of the relationship between past consumption levels and the severity of withdrawal, noting that his own work shows no relationship, a conclusion supported by others in the field. However, he also discusses research which shows that the symptoms are more severe for those who smoked longer or were heavier smokers. He postulates that this apparent inconsistency is due to the inappropriateness of the number of cigarettes consumed as a measure of dose due to the smokers ability to regulate nicotine intake in other ways. Finally, he points to a study in which the nicotine dose was controlled for which found that the withdrawal symptoms experienced by heavier nicotine consumers were much greater than their lower consuming counterparts.

³⁶ Shiffman (1979), page 171.

drawal.

As with the maintenance of a plateau level of consumption, this observed behavior, quitting smoking cold-turkey, is a possible outcome in the Becker-Murphy model of rational addictive behavior discussed in the following chapter.

To summarize, cigarette smoking can be viewed as an addictive behavior whether one chooses to use a loose, popular definition of addiction (which can encompass almost any behavior) or the more rigorous definition which requires the simultaneous presence of reinforcement in consumption, acquired tolerance, and a withdrawal syndrome associated with the cessation of consumption. It is the incorporation of each of these aspects of addictive consumption into the model of cigarette smoking discussed below which differentiates this work from the work of others on cigarette demand.

The Health Consequences of Cigarette Smoking

It is no coincidence that the title of this section is the same as the title of the annual Surgeon General's reports from which most our knowledge concerning cigarette smoking and health is derived. Since 1964, the Surgeon Generals of the United States have been reviewing the extensive medical evidence concerning the impact of cigarette

smoking on health.³⁷ Their now annually released reports³⁸ at first reviewed a wide variety of health issues, but have, more recently, focused on the role of cigarettes in the development of specific diseases: cancer (1982), cardiovascular disease (1983), and chronic obstructive lung disease (1984); as well as the differential effects of cigarette smoking for women (1980), the interaction of cigarette smoking with pollutants found in the workplace (1985), and the effects on nonsmokers of exposure to environmental tobacco smoke (1986)³⁹.

As discussed in Chapter Two, the dawn of the modern day anti-smoking campaign came with the release of the 1964 report stating that cigarette smoking was causally linked to lung cancer, and contributed to the development of emphysema, chronic bronchitis, cancers of the mouth, throat, res-

³⁷ While the Reports of the Surgeon General are not the only discussions of the Health Consequences of Cigarette Smoking, they contain the most comprehensive reviews of smoking and health, and, as such, this section contains a discussion of their findings.

³⁸ The reports, one of the measures called for in the Federal Cigarette Labeling and Advertising Act of 1965, have been released annually since 1967, with the exceptions of 1970 and 1977.

³⁹ The material presented in this section is an attempt to summarize the information presented in the Surgeon General's reports on the Health Consequences of Cigarette Smoking 1975 through 1986, a more complete discussion of which is well beyond the reach of this dissertation. To avoid much repetitive typing, information drawn from any specific report will be referred to as coming from SG## (for example, information pertinent to the role of cigarette smoking in the development of cancer, taken from the 1982 report The Health Consequences of Smoking: Cancer, A Report of the Surgeon General will be referenced as SG82).

piratory tract, and larynx. The conclusion was also made that the health consequences of smoking were directly related to the intensity of smoking, as measured by the duration of smoking, the number of cigarettes smoked daily, and inhalation, and were reduced by quitting. Finally, it was noted that smokers had higher death rates from cardiovascular disease, cirrhosis, and a variety of other cancers, but no causal links were established. More than twenty years later, a significant amount of evidence has accumulated which causally links cigarette smoking to a wide range of health problems.

Cancer

The earliest and most well establish connection between cigarette smoking and health, first suggested in the 1920s, is the establishment of cigarette smoking as a major cause of several cancers as well as a contributing factor in the development of many others, with tar appearing to act as the primary carcinogen, with the possibility of nicotine as a cocarcinogen.⁴⁰ The Surgeon General concluded in 1982 (page 8) that overall cancer death rates are twice as high for male smokers than those for nonsmokers (with the corresponding rates thirty percent higher for female smokers than those for nonsmokers, but increasing), and that these rates

⁴⁰ The best summary of the evidence establishing smoking as a primary factor in the onset of cancer is SG82.

are directly related to smoking intensity. Finally, lower cancer death rates are noted among smokers consuming low tar or filtered cigarettes as compared to those smoking unfiltered or higher tar brands, but these rates are still significantly higher than the comparable rates for nonsmokers⁴¹.

The most well known cancer tied to cigarette smoking is lung cancer, a disease which was almost nonexistent before the widespread use of cigarettes. Lung cancer is easily the most prevalent form of cancer, accounting for about one-fourth of all cancer deaths in the U.S., with over eighty-five percent of these deaths due to cigarette smoking (115,000 lung cancer deaths were expected to result from cigarette smoking in 1986).⁴² Moreover, cigarette smokers are ten to twenty-five times more likely to contract lung cancer than nonsmokers, with those who develop lung cancer facing a less than one in ten chance of surviving five years, among the lowest survival rates of any cancer.⁴³ As stated in SG82 (page vi) "the best preventive measure a smoker can take to reduce the risk of lung cancer is to quit smoking, and for a nonsmoker, to not take up the habit."

Cigarette smoking is also a major cause of cancers of the larynx and oral cavity and esophagus, responsible for approximately 13,000 and 8,300 deaths in 1982, respectively.

⁴¹ SG82, page viii.

⁴² SG82, page vi, and SG86, page 8.

⁴³ SG82, page vi.

Fifty to seventy percent of the larynx and oral cavity cancers are estimated to result from smoking, while smokers have esophageal cancer mortality rates five times higher than nonsmokers (a risk which increases significantly with the use of alcohol, which has a synergistic interaction with smoking in the development of cancer of the esophagus).⁴⁴

Finally, while not ruling smoking out as a causal factor in their development, the Surgeon General (1982, pages 7-8) notes that cigarette smoking contributes to the development of bladder, kidney, and pancreatic cancers, and that there appears to be a somewhat less well-defined relationship between cigarette smoking and cancers of the stomach and uterine which needs to be more fully explored.

Cardiovascular Disease

In SG83, the Surgeon General conducts a comprehensive review of the relationship between cigarette smoking and cardiovascular disease hypothesized in SG64. Cardiovascular disease, which includes coronary heart disease, sudden cardiac death, and cerebrovascular disease (stroke), is the largest health problem in the United States accounting for approximately half of all deaths annually (more than twice the number of deaths attributed to all cancers). The development of arteriosclerosis, the most important underlying cause of cardiovascular disease, has been found to acceler-

⁴⁴ SG82, pages vi-vii.

ate with cigarette smoking. Of the active agents contained in cigarette smoke, carbon monoxide and nicotine appear to play the major roles in the development of these diseases. Finally, there is little evidence that smoking low tar rather than high tar cigarettes reduces the probability of contracting these diseases.

Coronary heart disease (CHD) is the most important of the cardiovascular diseases, accounting for roughly sixty percent of cardiovascular deaths, or nearly thirty percent of all deaths. There are three major risk factors for CHD: cigarette smoking, hypertension, and elevated serum cholesterol. However, according to the Surgeon General (SG83, page iv) "Cigarette smoking should be considered the most important of the known modifiable risk factors for coronary heart disease in the United States." Additionally, cigarette smoking acts synergistically with the other two major risk factors for CHD. Deaths due to CHD are seventy percent higher for smokers than for nonsmokers, with heavy smokers experiencing a death rate two to three times that of nonsmokers.⁴⁵ As with cancers, the likelihood of CHD increases directly with the intensity of the smoking habit, and is reduced by quitting. Finally, the Surgeon General predicted that unless Americans changed their current smoking habits, ten percent of all persons alive today would die prematurely from heart disease as a result of their smoking practices.⁴⁶

⁴⁵ SG83, page 7.

⁴⁶ SG83, pages 7-8.

Similar conclusions are made regarding the effects of cigarette smoking on sudden cardiac death, strokes, and other cardiovascular diseases.

Chronic Obstructive Lung Disease

In SG84, after reviewing the evidence on the link between cigarette smoking and respiratory conditions, reported on as early as 1870, the Surgeon General strengthened the conclusions made in SG64 and the reports that followed. The primary conclusion reached was that "Cigarette Smoking is the major cause of chronic obstructive lung disease (COLD) in the United States for both men and women. The contribution of cigarette smoking to COLD disease morbidity and mortality far outweighs all other factors."⁴⁷ Included in COLD are emphysema, chronic bronchitis, and several other respiratory conditions, with shortness of breath during exertion being the primary symptom. Approximately 60,000 people die in this country each year from these diseases, with between eighty and ninety percent of these individuals dying prematurely as a result of cigarette smoking. Moreover, the morbidity associated with COLD has a much greater impact on society than the mortality due to the long period of disability associated with these diseases and the likelihood that the individual dies from something else during

⁴⁷ SG84, page vii.

this disability period.⁴⁸

Unlike some of the other diseases linked to cigarette smoking which take many years to develop, these diseases can appear within a few years of smoking initiation.⁴⁹ As with these other diseases, the risk of COLD increases with the intensity of an individual's smoking habit. However, unlike most other smoking related diseases, once some respiratory functions begin to deteriorate as a result of smoking, there is no evidence that quitting will enable the smoker to regain these functions. At best, quitting appears to slow the rate at which the functions are deteriorating.⁵⁰ Finally, there is little to indicate that smoking low tar, low nicotine cigarettes will reduce all of the symptoms of COLD.⁵¹

Cigarette Smoking and Women

Almost all of the earliest studies of the links between smoking and health focused on the consequences of smoking

⁴⁸ SG83, pages vii-viii. For example, the Surgeon General reports that in 1979, more than half of those with emphysema, one of the conditions included in COLD, reported that the disease limited their activity, with half of these requiring one or more bed days per year. These number of people with emphysema reporting limited activity is forty percent greater than that number for people with hearth conditions.

⁴⁹ SG84, page ix.

⁵⁰ SG84, page ix.

⁵¹ SG84, page 12.

for men. These studies focused on men due to the greater prevalence of smoking among men. It wasn't until the 1940's that women began to smoke in numbers comparable to men, and, as a result, it wasn't until some time later that the diseases linked to smoking began to appear in women.⁵² As the Surgeon General states, "women are not immune to the damaging effects of smoking already documented for men. The apparently lower susceptibility to smoking-related diseases among women smokers is an illusion reflecting the fact that women lagged one-quarter century behind men in the widespread use of cigarettes."⁵³ All of the conclusion concerning the link between smoking and ill-health discussed above apply to women as well as men. However, there are several unique health concerns facing women, particularly pregnant women, which will be discussed here.

Cigarette smoking during pregnancy has been linked to a

⁵² As discussed in Chapter Two, widespread use of the cigarette as the primary form of tobacco consumption came with the introduction of relatively inexpensive, factory produced cigarettes shortly before the turn of the century. Cigarette consumption accelerated rapidly in the forty to fifty years thereafter among both women and men. However, consumption among men was increasing much more briskly. By the mid-1920's, half of the adult male population were smokers. This figure reached seventy percent by 1950 in some urban areas. On the other hand, the fraction of women who were smokers didn't reach one-quarter until the beginning of the second world war. Thereafter, the number of women smokers increased until approximately one-third of all women smoked. While smoking rates among men have fallen substantially over the past two decades, comparable rates among women have fallen much more slowly, so that there is now only a few percentage point difference between the smoking rates of men and women (SG80, New York Times, 9/11/87, Newsweek, 11/25/87).

⁵³ SG80, page v.

variety of negative birth outcomes due to the ability of the more hazardous constituents of cigarette smoke to cross the placenta and affect the unborn fetus directly. One of the most serious consequences of smoking during pregnancy is that the carbon monoxide contained in cigarette smoke enters the blood stream of the fetus, depriving the blood of the oxygen it would otherwise carry. Oxygen deprivation directly slows fetal growth, leading to lower birth weight (by two hundred grams on average) and size than would otherwise have occurred. Additionally, women who smoke during pregnancy have more spontaneous abortions and a greater incidence of bleeding during pregnancy. They also have more premature births and more still births than nonsmokers.⁵⁴

The consequences of the mother's smoking habit do not disappear after birth. The children of women who smoke during pregnancy have greater neonatal and infant mortality rates than those born to nonsmokers. There is also an increase in the risk of the infant developing the sudden infant death syndrome. Finally, there may be adverse effects on the child's long-term growth, intellectual development, and behavioral characteristics due to the mother's smoking during pregnancy.⁵⁵

All of the consequences of smoking during pregnancy are dose-related, that is, the likelihood of their occurrence increases with increased smoking by the mother during preg-

⁵⁴ SG80, pages 10-11.

⁵⁵ SG80, page 11.

nancy. However, if the mother quits smoking early in her pregnancy, the risks of each of the outcomes discussed above approach those faced by nonsmokers.

Finally, there is a synergistic effect of cigarette smoking with the consumption of birth control pills (any oral contraceptive containing estrogen) which increases the likelihood of developing a cardiovascular disease, particularly heart attacks and strokes. Women who both smoke and use birth control pills are ten times more likely to suffer a heart attack and twenty times more likely to suffer a stroke than those who neither smoke nor use the pill.⁶⁶ These increased risks arising from smoking and the use of the pill have led the Food and Drug Administration to require all oral contraceptives to display a warning concerning their use and smoking.⁶⁷

Cigarette Smoking and the Workplace

In 1985, the Surgeon General reviewed the research concerning interactions between occupational hazards and cigarette smoking, concluding that cigarette smoking represents a greater hazard than those faced in the workplace, and

⁶⁶ SG80, pages 98-99.

⁶⁷ The warning reads: Cigarette smoking increases the risk of serious adverse effects on the heart and blood vessels from oral contraceptive use. This risk increases with age and heavy smoking (15 or more cigarettes per day) and is quite marked in women over 35 years of age. Women who use oral contraceptives should not smoke.

acts synergistically with at least some of the pollutants smokers are exposed to on the job.⁸⁸ The most deadly combination is that of occupational exposure to asbestos and cigarette smoking which leads to a risk of developing and dying from lung cancer five thousand percent higher than if the individual was neither exposed to asbestos nor smoked cigarettes.⁸⁹ Multiplicative effects between cigarette smoking and occupational exposure are also discussed for exposure to radon, coal dust, silica, petrochemicals, aromatic amines, pesticides, and cotton dust.⁹⁰ As with the development of other smoking related diseases, the likelihood of cancer and COLD due to interactions between smoking and occupation pollution exposure increases with smoking intensity.

Summary

The health consequences of cigarette smoking have been thoroughly established over the past forty years. The variety of disease linked to smoking, discussed above, are responsible for over three hundred thousand premature deaths annually in the United States, approximately fifteen percent of all deaths. These numbers make cigarette smoking the single largest preventable cause of premature mortality in

⁸⁸ SG85, page ix.

⁸⁹ SG85, page x.

⁹⁰ SG85, pages 14-17.

the U.S., responsible for more than five times the number of deaths from the second leading cause, alcohol, and greater than fifteen times the number of deaths from motor vehicle accidents, the third major cause.⁶¹

In addition to the excess mortality associated with cigarette smoking, there are a variety of illnesses and disabilities resulting from smoking. These illnesses lead to an excess of thirty-three percent and forty-five percent more work days lost for male and female smokers, respectively, than their nonsmoking counterparts. Similarly, male and female smokers have fourteen and seventeen percent more bed disability days than male and female nonsmokers, respectively, with current and former smokers reporting more hospitalization than nonsmokers. Aggregated over all smokers, illnesses and disabilities resulting from cigarette smoking were responsible for eighty-one million lost work days and one hundred and forty-five million bed days in 1974, the last year for which such numbers are available.⁶² There can be little doubt that cigarette smoking is the single largest public health problem in this country.

The likelihood of morbidity and/or mortality associated with each of the smoking related diseases is directly related to smoking intensity as measured by the age at which the individual began smoking, the number of years the smoker

⁶¹ SG86, page ix, and Council of Economic Advisers (1987), page 184.

⁶² SG79, pages I12-I13.

has smoked, and the number of cigarettes consumed daily. There is some evidence that smoking low tar and low nicotine cigarettes reduces the health risks from smoking, but these risks are still significantly higher than those faced by nonsmokers. Moreover, evidence reviewed by the National Research Council's Committee on Substance Abuse and Habitual Behavior shows that smokers who smoke low tar/nicotine cigarettes tend to compensate by smoking the cigarette more intensively, resulting in a tar and nicotine yield per cigarette similar to the yield from "more dangerous" cigarettes, leading to little reduction in the risk from cigarette smoking.⁶³ Finally, the risks of developing each of the smoking related diseases fall when a smoker quits, in some cases approaching the risks faced by nonsmokers as soon as five to ten years after stopping. However, some of the damage done by smoking is permanent, with quitting only reducing the deterioration which would continue if the individual continued to smoke.

Conclusions

The primary purpose of this chapter, as noted above, was to lay the groundwork for many of the assumptions to be made in the discussion of the theoretical model which follows. To summarize, an attempt was made to characterize cigarette smoking as a rational addictive behavior, for at

⁶³ Gerstein and Levison (1982), pages 4-17.

least those who choose to smoke, and to portray cigarette smokers as aware of both the addictive nature of smoking and the potential health consequences associated with smoking.

To do so, a discussion of the physiological and psychological mechanisms through which cigarette smoking produces increments to utility was presented. It was shown that, through the regulation of their nicotine intake and its physiological effects, cigarette smokers are able to use smoking to modify their psychological state. That is, they can smoke both to relax themselves when excited or stressed and to stimulate themselves when depressed or tired.

The characterization of cigarette smoking as an addictive behavior began with two competing definitions of addiction: a popularized definition identifying an addiction as an extreme involvement in something (apparently anything), and a more formal definition describing addiction by the simultaneous existence of reinforcement, tolerance, and withdrawal. Cigarette smoking can readily be characterized as an addictive behavior under the first definition, but, as discussed above, so can almost any activity. This work chooses to use the more formal definition, and a discussion of each of the characteristics of addiction as they pertain to cigarette smoking was presented. Cigarette smokers must be aware of each of these mechanisms, at least implicitly, as they apply to smoking.

Reinforcement in consumption is demonstrated by the smoker's use of cigarettes to achieve a desired psychologi-

cal state in varying situations. In large part, the reinforcing nature of consumption is a learned factor based on past experience in which cigarette smoking either led to a "reward" or terminated an uncomfortable feeling.

An acquired tolerance to cigarette smoking is rapidly developed, as any smoker who experienced the initial discomfort of smoking can attest. This tolerance also appears in the smoker's increasing "dose" early in their smoking history, until they reach a level of consumption at which the number of cigarettes smoked no longer needs to be increased to achieve the desired effects, but rather needs to be maintained at that level, again a factor of which smokers are, at least implicitly, aware.

The final addictive characteristic of cigarette smoking, the withdrawal syndrome associated with quitting, was presented, noting that some of the symptoms of withdrawal, a craving for nicotine and/or cigarettes in particular, appear as soon as a few hours after smoking the last cigarette. Given the large numbers of cigarette smokers who have attempted to quit unsuccessfully, or even the length of time between the last cigarette they smoke at night and the first cigarette they smoke in the morning, smokers are likely to be aware that they will experience some withdrawal when they go without cigarettes for even a short period of time.

Finally, a discussion of the health consequences of cigarette smoking was presented. The use of rationality in the theoretical model developed below includes farsighted

behavior on the part of individuals. In particular, it implies that cigarette smokers are aware of the future consequences of their current and past smoking behavior and that they incorporate this interdependence between the past, present, and future into their decision making process. This requires not only that they are aware of the addictive elements of current cigarette consumption, but also that they are aware of the future health consequences of their smoking behavior. As Ashton and Stepney put it, "there can be few smokers in the modern world who have not been exposed to information concerning the relationship between smoking, death, and disease."⁶⁴ Due to the extensive dissemination of information on the health consequences of cigarette smoking which has been the major element in the anti-smoking campaign of the past thirty years, smokers will be assumed to be making an informed choice when they decide to smoke.

⁶⁴ Ashton and Stepney (1982), page 135.

Chapter Five

A Theoretical Model of Cigarette Smoking as a Rational Addictive Behavior

Discussions of the effects of habits on demand are by no means a recent phenomenon. The first mention of the influence of habits on demand can be found in Marshall's Principles of Economics (1920) where he notes:¹

whether a commodity conforms to the law of diminishing or increasing return, the increase in consumption arising from a fall in price is gradual; and, further, habits which have once grown up around the use of a commodity while its price is low are not quickly abandoned when its price rises again.

The question of how to incorporate habits into demand functions is also addressed by Haavelmo (1944), Duesenberry (1949), and Modigliani (1949) under the rubric of irreversible demand functions. For the most part, however, economists have felt that discussions concerning the formation of tastes belonged outside the realm of economics. This attitude can be seen in Milton Friedman's Price Theory (1962) where he states:²

Economic theory proceeds largely to take wants as fixed. This is primarily a case of division of labor. The economist has little to say about the formation of wants; this is the province of the psychologist. The economist's task is to trace the consequences of any given set of wants. The legitimacy of and justification for this abstraction must rest ultimately, in this case as with any other abstraction, on the light that is shed

¹ Marshall (1920), Appendix H, section 3, page 807.

² Friedman (1962), page 13.

and the power to predict that is yielded by the abstraction.

Since then, however, there have been several different theoretical and empirical discussions of how best to model the consumption of an habituating good which attempt to explain, to some degree, the development of tastes. The models of the demand for habituating goods are similar in almost all respects to the models of the demand for addictive goods. These discussions treat habitual or addictive consumption in three distinct, though sometimes overlapping, ways.

One group of economists draws upon the discussions of sociologists, psychologists, and philosophers to describe addictive behavior as either irrational or imperfectly rational, seeming to require either weak-willed individuals or split-personalities. A second group, whose origins are closely linked to those of the first group, models the consumption of addicting substances as an activity in which future preferences are altered by current consumption. In some of these models of endogenous tastes, individuals are assumed to behave myopically while in others they are assumed to act rationally. The third group sees addictive behavior as a rational activity where preferences are consistent (stable over the life-cycle) but where individuals' future productive abilities are altered as a result of current consumption. Finally, some theorists attempt to incorporate aspects of two or all of these competing theor-

ies into a coherent model of addictive behavior.

This chapter will begin with a short review of the competing models of the consumption of addicting or habituating goods, and will then move on to the development of a theoretical model of cigarette smoking as an addictive behavior. The theoretical model presented in this chapter is based heavily on the unpublished work of Gary Becker and Kevin Murphy which has evolved from the Stigler-Becker (1977), Iannaccone (1984), Ryder-Heal (1973), Boyer (1978, 1983), and Spinnewyn (1981) models to be discussed below.³ Many of the arguments made in the previous chapter will be recalled as various assumptions are made in the development of the model.

Economic Models of Addictive Behavior

Ellster (1977), McKenzie (1979), and Schelling (1978, 1980, 1984a, 1984b) best exemplify the body of thought characterizing addictive consumption as an imperfectly rational behavior. Unlike the single, stable set of preferences assumed in the standard analysis of consumer behavior, or the endogenous preferences used by others to describe addictive consumption, these researchers postulate the existence of stable but inconsistent short run and long run preferences. Using the examples of a smoker trying to kick

³ The relationship between the Becker-Murphy models and these models is stated in Becker, Grossman, and Murphy (1987), page 2.

the habit and of an overweight person trying to diet, Schelling states:⁴

Everybody behaves like two people, one who wants clean lungs and long life and another who adores tobacco, or one who wants a lean body and another who wants dessert. The two are in a continual contest for control; the "straight" one often in command most of the time, but the wayward one needing only to get occasional control to spoil the other's best laid plan.

Strotz (1955) was among the first to attempt to explicitly model this type of behavior, describing the basic problem as one in which an individual chooses a future consumption path subject to a budget constraint so as to maximize present utility, but upon later consideration changes this plan "even though his original expectations of future desires and means of consumption are verified."⁵ Thaler and Shefrin (1981) describe the problem as one in which the individual is at any point in time both a "far-sighted planner and a myopic doer," with the planner and the doer in conflict.⁶

Strotz's basic conclusion is that the inconsistency between current and future preferences only arises when the individual discounts the future with a non-exponential discount function. Strotz goes on to suggest that rational individuals realize this inconsistency and may precommit their future behavior, or, when unable to precommit, will

⁴ Schelling (1978), page 290.

⁵ Strotz (1955), page 165.

⁶ Thaler and Shefrin (1981), page 392.

modify their consumption plans so that they are consistent with future preferences. Pollak (1968) challenges Strotz's conclusions concerning consistent planning when unable to precommit, showing that an individual may behave "naively" (that is, the individual believes that the plan he commits to in each period will be held to in all future periods, but then reconsiders the plan in each future period) even when discounting the future with an exponential discount function.

This "naive" or myopic behavior is the basis for many of the models of endogenous tastes.⁷ These models are characterized by the basic assumption that past consumption affects current consumption through an accumulated stock of habits. The myopic models of the demand for habituating or addictive goods are similar in many ways to models of the demand for consumers' durable goods which use a stock adjustment process for these goods.⁸

⁷ Theoretical discussions and/or models of endogenous tastes can be found in Gorman (1967), Pollak (1970, 1976, 1978), von Weizsäcker (1971), Hammond (1976a, 1976b), and El-Safty (1976a, 1976b). Discussions of the empirical implementation of these models and, in some cases, estimates obtained based upon these models, can be found in Farrel (1955), Houthakker and Taylor (1966, 1970), Pollak and Wales (1967), Philips (1972, 1983), Taylor and Weiserbs (1972), and Philips and Pieraerts (1979).

Models of endogenous tastes where tastes are determined by other factors rather than by past consumption can be found in discussions of the impact of advertising on demand (for example Galbraith (1958, 1972), and Dixit and Norman (1978)), and of the impact of prices on the formation of tastes (Pollak, 1977).

⁸ For example, see Chow's (1960) analysis of the demand for automobiles, and Stone and Rowe (1960), Nerlove (1960), and Garcia dos Santos' (1972) treatment of the demand for

The earliest models of the myopic demand for habituating goods can be found in the irreversible demand models of Duesenberry (1949), Modigliani (1949), and Farrell (1952). Farrell states that "the most general form of (an) irreversible demand function would make the individual's demand a function of all his past price-income consumption positions."⁹ In his empirical treatment of the demand for tobacco, beer, and spirits, however, Farrell uses a more tractable specification where current demand is a function of current price and income, and lagged price, income, and consumption.

More formally, using the Houthakker-Taylor (1966) model as an example of the incorporation of habits into a model of consumer demand,¹⁰ the depreciated sum of past consumption is assumed to affect current demand as follows:

$$(5-1) \quad C(t) = \alpha + \beta S(t) + X(t)\Gamma ,$$

household durables, in addition to the work of Houthakker and Taylor (1966 and 1970) on the demand for a variety of consumer goods. Pollak (1970), however, notes that the models of the demand for consumers' durables should be rational in the sense that they should incorporate not only the dependence of current consumption on past consumption but also the dependence of future consumption on current consumption. Nevertheless, these models do not explicitly account for the intertemporal nature of the demand for durables.

⁹ Farrell (1952), page 175.

¹⁰ This is only one exposition of these models. Similar derivations of a demand function which incorporates habit formation can be found, for example, in Philips (1972, 1983), Pollak (1970), and the others mentioned in footnote #7 above.

where $S(t)$ is the level of the habit stock at time t , $C(t)$ is the consumption of the habituating or addictive good at time t , and $X(t)$ is a vector of other variable influencing demand. The following process is used to describe the accumulation of the habit stock:

$$(5-2) \quad \dot{S}(t) \equiv C(t) - \delta S(t) ,$$

where δ is the assumed constant rate of depreciation on the "psychological" stock of habits. Making the appropriate substitutions, the following demand equation is derived:

$$(5-3) \quad C(t) = A + B C(t-1) + [X(t)-X(t-1)]C + X(t)D .$$

That is, the habitual nature of consumption is incorporated by making current consumption dependent on the stock of habits, or, after appropriate simplifications, on past consumption.

Again, it should be emphasized that the behavior of the individual in this model is assumed to be myopic. At each time t , the individual is maximizing his or her instantaneous utility function subject to an appropriate budget constraint and subject to the stock accumulation process. As Pollak (1975) describes it, the consumer is behaving naively or myopically in that he or she recognizes the dependence of current consumption on the stock of habits resulting from past consumption, but ignores the impact of

current and past consumption on his or her future consumption decisions.¹¹

One interesting question addressed in some of the work on myopic utility maximization with endogenous preferences concerns the existence of long run utility functions or long run preferences. Some (Pollak, 1970, and von Weizsäcker, 1971, for example) have demonstrated the existence of long run preferences under certain conditions as the steady-state consumption consistent with the set of short run demand functions, describing these preferences as representing the individual's "true" preferences. However, Pollak (1976) shows that the restrictions needed to generate a consistent long run utility function (or demand function) are extensive, with only a "narrow class of short run utility functions generat(ing) long run demand functions which can be rationalized by a utility function."¹²

In contrast to the naive or myopic utility maximization models which assume that individuals ignore the effects of their current decisions on their future preferences and consumption, a growing number of theorists have modelled habit formation as a "sophisticated" or rational behavior.¹³ Models of endogenous preferences with rational habit forma-

¹¹ Pollak (1975), page 188.

¹² Pollak (1976), page 273.

¹³ For example, see Lluch (1974), Spinnewyn (1981), and Boyer (1983). In addition, these endogenous taste models assuming farsighted behavior can be found in the optimal growth literature, including the work of Wan (1970), Samuelson (1971), Ryder and Heal (1973), and Boyer (1978).

tion have been less widespread than those with myopic habit formation, largely the result of what Deaton and Muellbauer call the exceedingly complicated formulation of the intertemporal problem. Again, habit formation in these models is described as a rational behavior in that the intertemporal dependence between current and future consumption is incorporated into the individual's maximization process in addition to the interdependence between past and current consumption.

Spinnewyn (1981) and Philips and Spinnewyn (1982) argue that the incorporation of rational decision making, as described above, into models of utility maximization with habit formation results in models which are "formally equivalent to models without habit formation."¹⁴ Spinnewyn describes the process by which this equivalence is obtained as follows:¹⁵

Formal equivalence between a model with habit formation and a model without habit formation is obtained by redefining wealth and the cost of current consumption in the following way. Starting a period with a stock of habits constrains the choice of a consumption plan and thus imposes a cost. The cost of the initial stocks of habits is computed for each period and is subtracted from wealth. Current consumption affects the stock of habits in future periods. The cost of induced consumption through habit formation is added to

¹⁴ Spinnewyn (1981), page 92.

¹⁵ Spinnewyn (1981), page 92. He states that Lluh (1974) overlooked this equivalence considering habit formation as a problem "sui generis" (unique). He goes on to state that his approach has the advantage of being simpler and allows the extension of the results of models without habit formation to models with habit formation, including, for example, the demand for durable goods.

the cost of current consumption.

The estimable demand equations obtained from modelling demand in this way are equivalent to the demand equations obtained from the myopic models of the demand for goods characterized by habit formation.

Pashardes (1986) presents a model which generates the opposite result. In his model, demand functions derived under the assumptions of myopic and rational behavior are not equivalent, but are instead the limiting cases of a general model. Pashardes' more general model begins with the specification of the intertemporal utility function:

$$(5-4) \quad U = v (Z_{1t}, Z_{2t}, \dots, Z_{nt}; Z_{1t+1}, \dots, Z_{nt+1}; Z_{1T}, \dots, Z_{nT})$$

where the Z_{1t} are "utility yielding stocks of commodities which the consumer has at time t ."¹⁶ These stocks are the depreciated sum of all past consumption as follows:

$$(5-5) \quad Z_{it} = \sum_{\tau=0}^{\infty} d_i^{\tau} q_{it-\tau} = q_{it} + d_i Z_{it-1} .$$

Pashardes then characterizes goods in the following manner: consumers' durables are goods with $0 < d_i < 1$; habituating or addictive goods are those for which $-1 < d_i < 0$; and goods which are "net non-durable" are goods with $d_i = 0$. Pashardes states that, for addictive goods, the assumption

¹⁶ Pashardes (1986), p388.

that $d_1 < 0$ implies that:¹⁷

the effective satisfaction from consuming the purchased quantity of the i^{th} commodity is reduced by an amount proportional to last period's effective satisfaction from consuming this commodity. This captures the essence of the addictive effect implied by habituation and has the great advantage that the traditional analysis of the demand for durables in an intertemporal framework can be immediately applied to habit forming goods.

This assumption appears to incorporate one aspect of addiction, the notion of acquired tolerance, into the model of the demand for an addictive good. Defining the rental price or user cost of good i in period j as follows:

$$(5-6) \quad \hat{p}_{ij} = p_{ij} - \frac{d_i p_{ij+1}}{(1+r_{j+1})}$$

where p_{ij} is the market price of good i in period j and r_j is the market rate of interest in j , builds in the notion that the consumption of the addictive good raises the price of the good for the consumer, or "reflects the costliness of habits."¹⁸ Pashardes goes on to derive demand equations for the rational consumer in which current consumption is determined by past consumption and current preferences under full knowledge of the impact current consumption on the future costs of consumption. The structure of the demand equation he derives allows him to test the hypotheses that consumers behave either myopically or rationally.

¹⁷ Pashardes (1986), pages 388-389.

¹⁸ Pashardes (1986), page 389.

Testing his model empirically, using data from Britain for a variety of commodities over the period 1947 through 1980, Pashardes finds a significant amount of evidence rejecting the hypothesis that demand is myopic. The hypothesis that consumers behave rationally is accepted, with a final note suggesting that the model could be improved by incorporating expectations.

The third distinctive treatment of the demand for addictive goods is based on the household production theory associated with Gary Becker, among others.¹⁹ In these models, households are maximizing a utility function whose arguments are commodities the household produces using their purchases of market goods, own time, human capital, and other inputs. More formally, the household is maximizing the utility function:

$$(5-7) \quad U = U (Z_1, Z_2, \dots, Z_n) ,$$

subject to an appropriate budget constraint and the following set of production functions for the i^{th} commodity is:

$$(5-8) \quad Z_i = F_i (X_{i1}, \dots, X_{im_i}; t_{i1}, \dots, t_{in_i}; S_1, \dots, S_h; Y_i) , \quad i = 1, \dots, n ,$$

¹⁹ Expositions of what has become known as the "new theory of consumer choice" can be found in, for example, Becker (1965), Muth (1966), Lancaster (1966, 1971), Michael and Becker (1973), and Ghez and Becker (1975).

where X_{j1} is the quantity of the j^{th} market good used in the production of the i^{th} commodity, t_{k1} is the amount of time spent by the k^{th} member of the household in the production of the i^{th} commodity, S_k is the human capital of the k^{th} member of the household, and Y_1 is a vector of other inputs used in the production of the i^{th} commodity. Associated with the Z_1 are shadow prices based on the market prices of the goods used in their production, the wages of those in the household who produce them, and the efficiency of the household in producing them.

Stigler and Becker (1977) were the first to model the demand for addictive goods in this fashion. In the Stigler-Becker model, preferences are assumed to remain stable over the life-cycle, but the ability of individuals to produce the commodities from which utility is derived changes. The change in productive ability is the result of what they call "the accumulation of ... 'consumption capital'."²⁰ This consumption capital is a measure of the individual's past consumption of the good in question.

Stigler and Becker describe two types of addiction: "beneficial" addiction and "harmful" addiction.²¹ They use the example of music appreciation first employed by Marshall²² to illustrate the concept of a beneficial addiction.

²⁰ Stigler and Becker (1977), page 78.

²¹ Stigler and Becker (1977), page 78.

²² Marshall (1920), page 94, states, during a discussion of the law of diminishing marginal utility, that "it is therefore no exception to the law the more good music a man

The result of a beneficial addiction is that the productivity of the individual's own time spent in the production of the commodity "music appreciation" is increased as his or her stock of "music capital" is increased. They state the similarity of this idea to the notion of "learning by doing" or "on-the-job experience" used in production theory.²³

Alternatively, they describe a harmful addiction as one for which the productivity of the individual's own time spent in the production of, for example, heroin services, falls as past consumption (and, therefore, heroin consumption capital) increases.²⁴

Iannaccone (1984) extends the Stigler-Becker model of the demand for habit forming goods in his unpublished Ph.D. dissertation. He then applies the model he develops to religious participation which, in his model, depends on a "stock of religious experience."²⁵ Iannaccone draws several interesting conclusions from his theoretical model of "experience effects" including the following: The more harmful the effect of experience in the consumption of a commodity

hears, the stronger is his taste for it likely to become."

²³ Stigler and Becker (1977), page 78. The idea of "learning by doing" originated with Arrow (1962) and is discussed more fully in Arrow (1968) and Arrow and Kurz (1970).

²⁴ The notion of a harmful addiction, or one in which past consumption has a negative impact on current productive ability, is similar to the congestion technology discussed by Färe (1980) and Färe and Svensson (1980), and used by Mullahy (1985).

²⁵ Iannaccone (1984), page 2.

the greater the shadow price and the lower the incentive to consume the commodity, *ceteris paribus*; and the responsiveness of input demand to changes in the current price of an input is weaker the more harmful is experience, as is the responsiveness to intertemporal price changes when experience is defined as the depreciated sum of past inputs, implying that the demand for inputs into the production of a harmful addictive commodity will be inelastic.²⁶ Iannaccone obtains results consistent with the predictions of the model he develops in his empirical treatment of religious participation.

In two unpublished working papers, Léonard (1985a, 1985b) uses a slightly modified version of the Stigler-Becker model to discuss the market behavior of rational addicts. In his model, an individual is maximizing a lifetime utility function subject to an appropriate budget constraint, where instantaneous utility is a linear function of the addictive commodity and a composite commodity. Léonard chooses to avoid the use of discount factors in the utility function, as well as interest rates on savings due to their effects on the monotonicity of consumption paths on which he focuses.²⁷ The production function at any time t for the addictive commodity $z(t)$ is linear in the level of

²⁶ Iannaccone (1984), pages 8-10.

²⁷ Léonard (1985b), page 5. This seems to be an important omission given the emphasis that he places on the consumption paths of goods used to produce the addictive commodity.

the addictive stock $S(t)$ and the market good(s) used in its production $x(t)$ as follows:

$$(5-9) \quad z(t) \leq \alpha S(t) + \beta x(t), \quad \alpha, \beta > 0$$

The stock in this model can be positive (implying a beneficial addiction), zero (implying no addiction), or negative (implying a harmful addiction). The stock accumulates according to the following function:

$$(5-10) \quad \dot{S}(t) = \Gamma z(t) - \delta S(t), \quad \delta > 0$$

with $\Gamma > 0$ if the addiction is beneficial, and $\Gamma < 0$ if the addiction is harmful. Maximizing the utility function subject to the budget constraint and equation (5-10) yields several interesting predictions about the addicts behavior. With respect to a beneficial addiction, Léonard concludes first that if an individual stops purchasing the market good used in the production of the addictive commodity, he will never purchase it again, and, secondly, that the consumption of the addictive commodity by individuals purchasing the market good used in its production always decreases. Alternatively, for the production and consumption of a harmfully addictive commodity, Léonard concludes that the consumption of the addictive commodity by users of the market good always increases, and that once an individual begins purchasing the market good (subject to certain initial condi-

tions), that individual will continue to purchase the good in increasing quantities. However, he states that his model does allow for both temporary and permanent quitting on the part of the addict.

Léonard shows that the market good and the addictive commodity (either beneficial or harmful) are normal goods with respect to changes in income. With respect to uncompensated changes in price, he shows that when the price of the market good increases, its demand decreases over the life cycle. This is true at each instant for the good used in the production of the harmful commodity, but, for the good used in the production of the beneficial commodity, there may be periods during which demand rises. Consumption of the addictive commodity (both beneficial and harmful), however, falls at all times in response to an increase in the price of the market good used in its production.

This model, while accounting for some of the observed behavior of addicts, fails to be general enough to account for the consumption of any addictive good. In particular, the prediction that once hooked an addict always increases his consumption of the market good used in the production of a harmfully addictive commodity seems to contradict the maintenance of a plateau level of consumption seen in, for example, cigarette smoking. Whether or not this model accurately describes other addictive behaviors is also questionable given the restrictive assumptions on which it is based.

In his unpublished Ph.D. dissertation, Mullahy (1985) chooses to develop a single period, static model similar to that used by Stigler-Becker-Iannaccone (SBI) in its use of stocks of consumption capital. He chooses to work in a static framework, describing the farsighted model of SBI as an important theoretical contribution but one which is "too sophisticated to enable straightforward empirical application given conventionally-available data."²⁸ Due to its static nature, Mullahy's model necessitates treating the individual as myopic. The results obtained by Mullahy in his empirical implementation of this myopic model to the demand for cigarettes should make for an interesting comparison to those obtained below.

Finally, there have been a small number of economists who have either attempted to combine various aspects of the theories discussed above in an attempt to develop a more coherent model of addictive behavior or have developed models based on ad hoc assumptions concerning behavior. Of note here is the model developed by Winston (1981). He incorporates several of the notions developed by Stigler and Becker into a model where individuals have dual preferences (myopic-short run vs. farsighted-long run). The model of compulsive consumption he develops generates several unusual predictions, including the evolution of "anti-markets," (firms or institutions which charge individuals to help them not to consume, such as Alcoholics Anonymous and SmokEnd-

²⁸ Mullahy (1985), page 47.

ers).²⁹

As can be seen in the evolution of models of the demand for habituating or addictive goods discussed above, there are two major choices to be made when modelling demand. These are: first, should individuals be treated as having a single set of stable preferences over the life cycle (requiring the use of the SBI consumption capital concept) or should their preferences be modelled as unstable (either dual, inconsistent but constant preferences, or endogenous preferences)?; and, second, should the individual be treated as myopic or farsighted?

As Iannaccone (1984), Philips (1983), Pollak (1978) and others note, modelling preferences as exogenous or endogenous is a "purely semantic" distinction, as the mathematics of both and, hence, their explanatory power are essentially identical.³⁰ However, as Stigler and Becker discuss, the choice appears to depend upon whether one prefers to rely on standard economic theory or on ad hoc assumptions. They firmly reject the use of endogenous tastes as an ad hoc method of dealing with a complex phenomenon in favor of the standard, constant preference approach of economics, using the following argument:³¹

We have not considered systematic differences in tastes by wealth or other classifications. We

²⁹ Winston (1981), pages 322-323.

³⁰ Iannaccone (1984), page 7, Philips (1983), pages 287-288, and Pollak (1978), page 375.

³¹ Stigler and Becker (1977), pages 89-90.

also claim, however, that no significant behavior has been illuminated by assumptions of differences in tastes. Instead, they, along with assumptions of unstable tastes, have been a convenient crutch to lean on when the analysis has bogged down. They give the appearance of considered judgement, yet really have only been ad hoc arguments that disguise analytical failures.

We have partly translated "unstable tastes" into variables in the household production function for commodities. The great advantage, however, of relying only on changes in the arguments entering household production functions is that all changes in behavior are explained by changes in prices and incomes, precisely the variables that organize and give power to economic analysis. Addiction, advertising, etc., affect not tastes with the endless degrees of freedom they provide, but prices and incomes, and are subject therefore to the constraints imposed by the theorem on negatively inclined demand curves, and other results....

...Our hypothesis is trivial, for it merely asserts that we should apply standard economic logic as extensively as possible. But the self-same hypothesis is also a demanding challenge, for it urges us not to abandon opaque and complicated problems with the easy suggestion that the further explanation will perhaps someday be produced by one of our sister behavioral sciences.

Moreover, at least one empirical study, that of Landsburg (1981), analyzing the constancy of tastes finds that preferences are stable over time.³² The Becker-Murphy model of addiction, presented below, the basis of the empirical work performed in this dissertation, is deeply rooted in the traditional economic analysis of Stigler-Becker-Iannaccone.

The second issue which must be resolved is whether to model consumers as myopic or farsighted. Again, as Philips

³² Landsburg looks at the demand for goods in the United Kingdom over the period 1900-1955. He uses both aggregated and disaggregated groups of goods, including tobacco and alcohol, in his empirical work, based on a wide variety of data. In no case does he find evidence of changes in tastes

(1983) and Philips and Spinnewyn (1982) point out, in many cases, the myopic and farsighted models of habitual or addictive consumption are observationally equivalent.³³ Treating consumers as rational, in these cases, only complicates the model without providing additional insight. Additionally, even when a farsighted model makes a useful contribution, the empirical treatment of the model may require data not generally available, an argument made by Mullahy (1985) in favor of the model he uses.³⁴ Finally, some have argued that consumers, especially those whose current consumption depends upon their past consumption, are not fully aware of the future implications of their current actions.³⁵

In the model developed below, these arguments are rejected in favor of arguments supporting the rationality of the consumer. It seems somewhat contradictory to describe consumers as aware of the dependence of their current consumption on their past consumption and in the next breath to assume that they ignore the dependence of future consumption on current consumption. Additionally, the few empirical

³³ Philips (1983), page 268, and Philips and Spinnewyn (1982), page 4.

³⁴ Mullahy (1985), page 47.

³⁵ For example, Deaton and Muellbauer (1980) state that "intertemporal models in which tastes in each period depend upon past consumption and in which this is foreseen by the consumer are technically very difficult to handle and, by making no concession to imperfect knowledge or to questions of calculation, are extremely implausible as descriptions of observed behavior" (page 374).

studies which attempt to test the relative farsightedness of consumers, notably that of Pashardes (1986) discussed above, reject myopic behavior in favor of rational behavior. Finally, the empirical framework derived in the following chapter allows for the testing of myopic versus rational behavior by the addict.

A Theoretical Model of Cigarette Smoking as a Rational Addictive Behavior

The model of cigarette smoking as an addictive behavior presented in this section is based heavily upon the unpublished work of Iannaccone (1984) and Becker and Murphy (1986), and incorporates some elements of the models developed by Léonard (1985a, 1985b) and Mullahy (1985). The model is one of an individual maximizing lifetime utility subject to a lifetime budget constraint and various production functions in a continuous time framework. At any moment in time, the individual's utility is a function of three commodities, $H(t)$, $R(t)$, and $Z(t)$,

$$(5-11) \quad U(t) = u[H(t), R(t), Z(t)],$$

where $H(t)$ is the individual's health at time t , $R(t)$, for lack of a better word, is the individual's "relaxation" at time t , and $Z(t)$ is a composite commodity. U is assumed to be a concave function with negative second derivatives with

respect to each of its arguments:

$$(5-12) \quad u_i(t) > 0, \quad i = H(t), R(t), Z(t)$$

and:

$$(5-13) \quad u_{ii}(t) < 0 \quad i = H(t), R(t), Z(t).$$

The arguments in the utility function are produced according to the following functions:

$$(5-14) \quad H(t) = H[M(t), A(t)],$$

with:

$$(5-15) \quad H_M(t) > 0, H_{MM}(t) < 0, H_A(t) < 0, \text{ and } H_{AA}(t) < 0,$$

$$(5-16) \quad R(t) = R[C(t), A(t)],$$

with:

$$(5-17) \quad R_C(t) > 0, R_{CC}(t) < 0, R_A(t) < 0, R_{AA}(t) > 0, \\ \text{and } R_{CA}(t) < 0,$$

and:

$$(5-18) \quad Z(t) = Z[X(t)],$$

with:

$$(5-19) \quad Z_x(t) > 0, \text{ and } Z_{xx}(t) < 0.$$

Health at time t , $H(t)$ is assumed to be a function of a vector of market goods and the individual's own time $M(t)$ used in the production of health and of the level of the addictive stock at time t $A(t)$ as described by equations (5-14) and (5-15). $M(t)$ includes such inputs as medical care, and the individual's own time, spent, for example, on exercise, denoted by the vector $M(t)$, which enter into the production of health. These inputs have positive but diminishing effects on health.

The second argument in the production function for health is the level of the addictive stock at time t , $A(t)$. This stock is an attempt to capture the dependence of current utility on the past consumption of the addictive good. I assume that the greater the level of the addictive stock (the larger the degree of addiction), the lower the level of health, all else constant. This is a reasonable assumption for a model of cigarette smoking given the extensive body of research on the health consequences of smoking.³⁶ Also, the assumption is made that the health effects of the stock

³⁶ See, for example, any of the Surgeon General's Reports on the Health Consequences of Smoking (1964 through 1986). In particular, see the 1982 report detailing the link between cigarette smoking and cancer, the 1983 report tying smoking to cardiovascular disease, and the 1984 report relating smoking to chronic obstructive lung disease, which includes emphysema and bronchitis.

become increasingly negative as the stock increases ($H_{AA} < 0$). This assumption is also based on the smoking and health literature summarized in the Surgeon General's reports where, for example, it is noted that the risk of lung cancer increases more than proportionately as the number of cigarettes smoked per day increases (U.S. Surgeon General, 1982). The hypothesis is that these assumptions partially incorporate the notion of physical dependence, on the addictive substance resulting in withdrawal when consumption is terminated, one of the characteristics which distinguishes the consumption of an addictive substance from the consumption of other goods, since the negative health benefits of the stock of past consumption are no offset by the positive utility derived from current consumption.

The second argument in the instantaneous utility function is the "relaxation" produced by the consumption of the addictive good, cigarettes, represented by $C(t)$. Relaxation can be thought of as the physiological and psychological effects which result from the consumption of the addictive substance. For example, Ashton and Stepney (1982) include in the short term psychological and physiological effects of smoking the maintenance of performance levels in the face of fatigue and the attenuation of the effects of stress. They go on to suggest that smokers use smoking as a convenient way of 'manipulating their psychological state', i.e. a person will smoke to reduce boredom or tension.

Increased consumption of the addictive substance is

assumed to have a positive effect on the production of relaxation due to the physiological and psychological effects of nicotine discussed above. On the other hand, greater past consumption, which results in a larger addictive stock, is assumed to have a negative effect on the production of relaxation. This assumption is made to incorporate the notion of tolerance into the model, the second factor distinguishing addictive consumption from the consumption of most consumer goods. An acquired tolerance in cigarette smoking, primarily to nicotine, implies that a smoker either gets less satisfaction from smoking the same number of cigarettes as he or she did in the past or, alternatively, a greater number of cigarettes must be smoked to achieve the same level of satisfaction from smoking as in the past. The acquired tolerance, in the case of cigarette smoking, is not characterized, however, by continuously escalating consumption, as in the case of (some) other addictive goods. Evidence of this is the eventual maintenance of cigarette consumption at some plateau level, leading to the assumption of $R_{AA} > 0$.

To capture the final factor which differentiates addictive consumption from the consumption of most goods, I assume that the marginal productivity of the consumption of the addictive good at time t in the production of relaxation is larger the larger is the level of the addictive stock at time t ($R_{CA} > 0$). This assumption illustrates the notion of reinforcement in the consumption of an addictive good. In

other words, an individual who has a larger addictive stock (one who has smoked more in the past) will better understand how to use smoking to manipulate his or her current psychological state. The effects of reinforcement in consumption have been emphasized by psychologists and sociologists as playing a major role in the development of an individual's smoking behavior. For example, Pomerleau (1979) uses a 'social learning model' which states that an individual begins smoking due to peer pressure and that smoking results in acceptance by one's peers (social reinforcement). This learned behavior then carries over to other situations where the individual feels stressed.

The vector of consumption commodities, $Z(t)$, is produced using inputs $X(t)$, which include market goods and the individual's own time. All inputs are assumed to have positive but diminishing marginal productivity in the production of Z . The implicit assumption has been made that the consumption of the addictive substance has no direct effect on the individual's ability to produce Z . The production of Z could be modelled as a function of the addictive stock also under the assumption that as the level of the addictive stock rises, the person becomes less efficient in the production of the consumption commodities. I feel the effects of the stock are more relevant in the production of health and relaxation and that little additional insight would be gained by including the stock in the production of Z .

Based on the assumptions above, the instantaneous

utility function can be rewritten:

$$(5-20) \quad U(t) = U[C(t), A(t), Y(t)],$$

where C and A are as above, and Y(t) is a vector which includes all market goods which are inputs into the production of consumption goods and health, as well as the individual's own time in their production. At any time t, the following will be true:

$$(5-21) \quad U_C = u_R^R C > 0,$$

$$(5-22) \quad U_A = u_R^R A + u_H^H A < 0,$$

$$(5-23) \quad U_Y = u_H^H Y + u_Z^Z Y > 0,$$

$$(5-24) \quad U_{CA} = u_{RR}^R C R_A + u_R^R C A > 0,$$

and:

$$(5-25) \quad U_{ii} < 0, \quad i = C, A, Y.$$

Equations (5-21)-(5-24) can be used to reillustrate the three basic characteristics of addictive consumption. Firstly, equation (5-21) can be thought of as incorporating withdrawal since it implies that total utility will be lower if consumption is reduced. Tolerance is illustrated by the negative marginal utility of the addictive stock shown in (5-22), which states that the greater the level of past

consumption, the lower the level of utility, *ceteris paribus*. Finally, reinforcement is illustrated by (5-24) which states that the marginal utility of current consumption is larger the larger the level of past consumption, or that past consumption reinforces current consumption.

At this point, some mention should be made of the process by which the addictive stock is accumulating. Following Becker and Murphy, a simple investment function for the addictive stock is specified as:

$$(5-26) \quad \dot{A}(t) = C(t) - \delta A(t) - g[E(t)].$$

$C(t)$, the consumption of the addictive good, cigarettes, at time t , can be thought of as the gross investment in the addictive stock at time t , $A(t)$. δ is the constant rate of depreciation of the addictive stock over time. Finally, $g[E(t)]$ is what Becker and Murphy call the endogenous depreciation of the addictive stock at time t . Endogenous depreciation includes any attempt the individual makes to 'kick-the-habit'. A large market has developed in recent years designed to help smokers stop smoking, and includes hypnosis, subliminal persuasion, group therapy, and many other activities. Endogenous depreciation attempts are assumed to provide no utility directly.

This function can be integrated over time to find the level of the stock at time t , which is given by:

$$(5-27) \quad A(t) = A(0)e^{-\delta t} + \int_0^t (C(\tau) - g[E(\tau)])e^{-\delta(t-\tau)} d\tau,$$

where $A(0)$ is the initial level of the addictive stock.

Assuming that the utility function is additive over time, and that the individual has an infinite lifetime and a constant rate of time preference, σ , the lifetime utility function is:

$$(5-28) \quad U = \int_0^{\infty} e^{-\sigma t} U[C(t), A(t), Y(t)] dt.$$

Making the assumption, following Becker and Murphy, that the addict behaves rationally implies that this function is maximized subject to a lifetime budget constraint. If the individual's allocation of time over the life-cycle is ignored, $Y(t)$ is treated as a composite good whose price, $P_Y(t)$, is the numeraire, and perfect capital markets are assumed, the appropriate budget constraint is:

$$(5-29) \quad \int_0^{\infty} e^{-rt} [Y(t) + P_C(t)C(t) + P_E(t)E(t)] dt \leq R(0).$$

$P_C(t)$ is the price of the addictive good, cigarettes, at time t , $P_E(t)$ is the price of endogenous depreciation attempts at time t , r is the market interest rate at which the individual can borrow or save, assumed constant over time, and $R(0)$ is the discounted value of lifetime income and assets.

Maximizing the lifetime utility function subject to the budget constraint, the stock accumulation function, and the initial stock condition above yields an optimal path as the solution to:

$$(5-30) \quad V^*[R(0), A(0), P] = \mu R(0) +$$

$$\begin{aligned} & \text{Max}_{CY} \left[\int_0^{\infty} e^{-\sigma t} U[C(t), A(t), Y(t)] dt \right. \\ & \left. - \mu \int_0^{\infty} e^{-rt} [Y(t) + P_C(t)C(t) + P_E(t)E(t)] dt \right] \end{aligned}$$

$V^*[\cdot]$ is the value of the solution in utility terms given the person's discounted lifetime income, initial level of assets, and the prices he faces over his lifetime, represented by P . μ is defined as $\delta V^*[\cdot]/\delta R(0)$.

The optimal paths for the consumption of the addictive good and the composite good can be determined by the following first order conditions:

$$(5-31) \quad U_Y(t) = \mu e^{-(\sigma-r)t},$$

$$(5-32) \quad U_C(t) = \mu \pi_C(t),$$

and:

$$(5-33) \quad g_E(t)a(t) = \mu P_E(t)e^{(\sigma-r)t}$$

where:

$$(5-34) \quad \pi_C(t) = P_C(t)e^{-(\sigma-r)t} + a(t),$$

and:

$$(5-35) \quad a(t) = -\int_t^\infty e^{-(\sigma+\delta)(\tau-t)} U_A(\tau) d\tau.$$

$\pi_C(t)$ can be thought of as the full price of the addictive good, and consists of two parts: the money price, $P_C(t)$, appropriately discounted, and the discounted utility cost of additional consumption through the effects of the increased addictive stock on future utility, $a(t)$, the "shadow price" of an additional unit of the addictive stock.

The derivation of equations (5-32) and (5-33) merit a more detailed discussion. The first order condition for the consumption of the addictive good at any time t illustrates the two effects on utility of a change in the market price of cigarettes at time t . The first effect consists of the change in utility at time t as a result of the change in consumption at time t induced by the change in price. However, a change in consumption at any time will affect utility in all future periods through the change in all future levels of the addictive stock. The first effect is given as:

$$(5-36) \quad e^{-\sigma t} U_C(t) - \mu e^{-rt} P_C(t),$$

and the second is:

$$(5-37) \quad \int_t^{\infty} e^{-\sigma\tau} U_A(\tau) \frac{\delta A(\tau)}{\delta C(t)} \delta\tau,$$

where:

$$(5-38) \quad \frac{\delta A(\tau)}{\delta C(t)} = e^{-\delta(\tau-t)}.$$

Utility maximization implies that the sum of these two effects will be zero at each t , which, after the appropriate simplifications and the above substitutions, yields equation (5-32).

Similarly, a change in the price of endogenous depreciation efforts will impact on utility in all future periods through its effect on the level of the addictive stock in all future periods, as described by (5-33).

Several points are worth noting at this time. Since $U_A(t)$ is negative at all t , the full price of the consumption of the addictive good will be greater than its money price. It is also clear that the shadow price of the addictive stock will be affected by both the exogenous rate of depreciation on the stock, δ , and by the rate of time preference, σ , all else constant. The larger the rate of depreciation, the lower the shadow price of the stock, resulting in an increase in consumption. Similarly, the greater the rate of time preference, the lower the full price of the addictive good, cigarettes, and, therefore, the greater its consumption. It should also be noted that the shadow price

of the stock is rising as the level of the stock increases, since $U_{AA} < 0$.

Because of the rising shadow price of the addictive stock as the stock becomes larger, the amount of endogenous depreciation and the expenditures on endogenous depreciation will increase as the stock increases. These expenditures will also increase as the rate of time preference and/or the rate of depreciation on the addictive stock decrease, all else constant.

This basic model is more fully developed by Becker and Murphy, along with a detailed discussion of the effects of changes in prices and income and various life-cycle events on consumption. The model described above will serve as the basic for the empirical framework developed in the following chapter.

Chapter Six

Empirical Models of Cigarette Smoking

Using the Becker-Murphy model of rational addictive behavior outlined in the previous chapter, an empirical model of the demand for cigarettes is developed in this chapter under several simplifying assumptions. The cigarette demand equations are derived under the assumption of rational addictive behavior and then compared to the analogous demand equations derived under the competing assumptions of non-addictive and myopic behavior. A variety of price elasticities of demand are then derived for each of these demand equations. Finally, some discussion of the empirically verifiable predictions of the model and the estimation strategy employed is presented.

Empirical Models of Cigarette Smoking as a Rational Addictive Behavior

Following Becker and Murphy (1986) and Becker, Grossman, and Murphy (1987), a quadratic utility function in the three arguments $Y(t)$, $C(t)$, and $A(t)$ is assumed at each time t . The individual is assumed to engage in no endogenous depreciation attempts over the life-cycle [$E(t)=0$]. The assumption is also made that the individual's rate of time preference (σ) is equal to the market rate of interest faced by the individual (r). Given these assumptions, the instan-

taneous utility function is:

$$\begin{aligned}
 (6-1) \quad U(t) = & b_Y Y(t) + b_C C(t) + b_A A(t) + \frac{U_{YY}}{2} Y(t)^2 + \\
 & \frac{U_{CC}}{2} C(t)^2 + \frac{U_{AA}}{2} A(t)^2 + U_{YC} Y(t)C(t) + \\
 & U_{CA} C(t)A(t) + U_{YA} Y(t)A(t) \quad .
 \end{aligned}$$

Lifetime maximization of this utility function subject to the following budget constraint:

$$(6-2) \quad \int_0^{\infty} e^{-\sigma t} [Y(t) + P_C(t)C(t)] dt \leq R(0)$$

implies that the optimal consumption paths are yielded as the solution to:

$$\begin{aligned}
 (6-3) \quad V^* [R(0), A(0), P] = & \mu R(0) + \text{Max}_{CY} \left[\int_0^{\infty} e^{-\sigma t} \right. \\
 & \left. [U(t) - \mu[Y(t) + P_C(t)C(t)]] dt \right]
 \end{aligned}$$

subject to the stock accumulation equation:

$$(6-4) \quad \dot{A}(t) = C(t) - \delta A(t)$$

and the initial condition $A(0) = A_0$, where the marginal utility of wealth, μ , is defined as $\mu \equiv \delta V^*[\cdot] / \delta R(0)$ and is constant over time.

Using the first-order condition for $Y(t)$, the following substitution can be made for $Y(t)$ at each point in time:

$$(6-5) \quad Y(t) = \frac{1}{U_{YY}} \left[\mu - b_Y - U_{YA}A(t) - U_{YC}C(t) \right] .$$

Making this substitution results in the maximization problem being a function of only cigarette consumption and the accumulated stock of past smoking, as follows:

$$(6-6) \quad V^*[\cdot] = K + \text{Max}_C \left[\int_0^\infty e^{-\sigma t} F[C(t), A(t)] dt \right]$$

where:

$$(6-7) \quad F[C(t), A(t)] = \alpha_A A(t) + \alpha_C C(t) + \frac{\alpha_{AA}}{2} A(t)^2 + \\ \frac{\alpha_{CC}}{2} C(t)^2 + \alpha_{CA} C(t)A(t) - \\ \mu P_C(t)C(t) ,$$

and:

$$(6-8) \quad K = \mu R_0 + \left[\frac{(\mu - b_Y^2)}{2\sigma U_{YY}} \right] * \left[1 - \frac{1}{e^{-\sigma t}} \right]$$

where:

$$(6-9) \quad \alpha_A = b_A - \frac{U_{YA}}{U_{YY}} (b_Y - \mu)$$

$$(6-10) \quad \alpha_C = b_C - \frac{U_{YC}}{U_{YY}} (b_Y - \mu)$$

$$(6-11) \quad \alpha_{AA} = U_{AA} - \frac{U_{YA}^2}{U_{YY}}$$

$$(6-12) \quad \alpha_{CC} = U_{CC} - \frac{U_{YC}^2}{U_{YY}}$$

and:

$$(6-13) \quad \alpha_{CA} = U_{CA} - \frac{U_{YC}U_{YA}}{U_{YY}} .$$

The function in (6-6) is being maximized subject to the stock accumulation process described by (6-4) as well as the following transversality condition:

$$(6-14) \quad \lim_{t \rightarrow \infty} e^{-\sigma t} A(t)^2 = 0 .$$

Given the specification of the stock accumulation process in equation (6-4), $C(t)$ can be replaced by $\delta A(t)/\delta t + \delta A(t)$, making the maximization problem one involving only $A(t)$ and $\delta A(t)/\delta t$. This maximization problem is now part of a class

of economic problems known as control problems, where the control variable is $C(t)$, the consumption of the addictive good (cigarettes), the state variable is $A(t)$, the accumulated stock of the addictive good, and the equation of motion is the stock accumulation equation given in (6-4). This class of problems can be solved using a variety of techniques including the Calculus of Variations and Optimal Control Theory.¹

As discussed by Becker and Murphy, (6-14) is the quadratic analogue of the standard transversality condition which requires that the discounted value of the state variable ($A(t)$) multiplied by its shadow price (given as $a(t)$ in equation (5-35)) goes to zero as time goes to infinity.

Based on the modelling of addiction in Chapter 5, α_A is expected to be negative. This negative effect is the result of the negative marginal productivity of the addictive stock in the production of relaxation, the acquired tolerance effect, as well as the result of the negative effects of cigarette addiction on health. Similarly, α_C is expected to be positive due to the positive effect of cigarette smoking on the production of relaxation and, hence, on utility. Both α_{AA} and α_{CC} are negative from the assumption of concavity. Finally, assuming that the marginal utility of the composite good is independent of the level of the addictive stock ($U_{YA} = 0$) implies that the marginal utility of con-

¹ For the solution to this problem and an interesting discussion of the addicts response to changes in various factors over the life cycle, see Becker and Murphy (1986).

sumption increases as the level of the addictive stock increases ($\alpha_{CA} > 0$). This expectation is based on the modelling of the reinforcement factors in the consumption of addictive goods.

At this point, in order to obtain an empirically tractable demand equation for cigarettes, the model is converted to a discrete time framework. In discrete time, the maximization process described by (6-6) is the following:

$$(6-15) \quad V^*[\cdot] = K + \text{Max}_C \left[\sum_{t=0}^{\infty} (1+\sigma)^{-t} F[C(t), A(t)] \right]$$

where:

$$(6-16) \quad A(t) = C(t-1) + (1-\delta)A(t-1) .$$

A typical first order condition with respect to cigarette consumption for this maximization problem is:

$$(6-17) \quad \frac{\delta V^*[\cdot]}{\delta C(t)} = \left[\frac{1}{(1+\sigma)^t} \right] * \left[\frac{\delta F[C(t), A(t)]}{\delta C(t)} \right] +$$

$$\left[\frac{1}{(1+\sigma)^{t+1}} \right] * \left[\frac{\delta F[C(t+1), A(t+1)]}{\delta A(t+1)} \right] * \left[\frac{\delta A(t+1)}{\delta C(t)} \right] +$$

$$\left[\frac{1}{(1+\sigma)^{t+2}} \right] * \left[\frac{\delta F[C(t+2), A(t+2)]}{\delta A(t+2)} \right] * \left[\frac{\delta A(t+2)}{\delta C(t)} \right] +$$

$$\left[\frac{1}{(1+\sigma)^{t+3}} \right] * \left[\frac{\delta F[C(t+3), A(t+3)]}{\delta A(t+3)} \right] * \left[\frac{\delta A(t+3)}{\delta C(t)} \right] +$$

$$\dots = 0$$

where:

$$(6-18) \quad \frac{\delta F[C(t), A(t)]}{\delta C(t)} = \alpha_C + \alpha_{CC} C(t) + \alpha_{CA} A(t) - \mu P_C(t)$$

$$(6-19) \quad \frac{\delta F[C(t+i), A(t+i)]}{\delta A(t+i)} = \alpha_A + \alpha_{AA} A(t+i) + \alpha_{CA} C(t+i)$$

and:

$$(6-20) \quad \frac{\delta A(t+i)}{\delta C(t)} = (1-\delta)^{i-1}.$$

To simplify the notation somewhat, make the following substitutions:

$$(6-21) \quad U_C(t) = \alpha_C + \alpha_{CC} C(t) + \alpha_{CA} A(t)$$

and:

$$(6-22) \quad V_A(t) = \alpha_A + \alpha_{AA} A(t) + \alpha_{CA} C(t).$$

Making these substitutions and multiplying through by $(1+\sigma)^t$, the first-order condition with respect to cigarette consumption at time t , given above in equation (6-17), can be rewritten as:

$$(6-23) \quad U_C(t) = \mu P_C(t) - \sum_{i=1}^{\infty} V_A(t+i) \left[\frac{(1-\delta)^{i-1}}{(1+\sigma)^i} \right] .$$

Similarly, at time $t-1$, this first order condition is:

$$(6-24) \quad U_C(t-1) = \mu P_C(t-1) - \sum_{i=1}^{\infty} V_A(t+i) \left[\frac{(1-\delta)^i}{(1+\sigma)^{i+1}} \right] \\ - \frac{V_A(t)}{(1+\sigma)}$$

and, at time $t+1$, adding and subtracting $(1-\delta)^{-1}V_A(t+1)$:

$$(6-25) \quad U_C(t+1) = \mu P_C(t+1) - \sum_{i=1}^{\infty} V_A(t+i) \left[\frac{(1-\delta)^{i-2}}{(1+\sigma)^{i-1}} \right] \\ + \frac{V_A(t+1)}{(1-\delta)} .$$

Multiplying equation (6-23) by $(1-\delta)$, then dividing by $(1+\sigma)$ and subtracting equation (6-24) from the result yields:

$$(6-26) \quad \left[\frac{(1-\delta)}{(1+\sigma)} \right] U_C(t) - U_C(t-1) = \mu \left[\frac{(1-\delta)}{(1+\sigma)} \right] P_C(t) \\ - \mu P_C(t-1) + \frac{V_A(t)}{(1+\sigma)} .$$

Likewise, multiplying equation (6-25) by $(1-\delta)$, then dividing by $(1+\sigma)$ and subtracting equation (6-23) from the resulting equation yields:

$$(6-27) \quad \left[\frac{(1-\delta)}{(1+\sigma)} \right] U_C(t+1) - U_C(t) = \mu \left[\frac{(1-\delta)}{(1+\sigma)} \right] P_C(t+1) \\ - \mu P_C(t) + \frac{V_A(t+1)}{(1+\sigma)} .$$

Multiplying equation (6-26) by $(1-\delta)$ and subtracting the resulting equation from equation (6-27) yields the following equation:

$$(6-28) \quad \left[\frac{(1-\delta)}{(1+\sigma)} \right] \left[U_C(t+1) - (1-\delta)U_C(t) \right] - \\ \left[U_C(t) - (1-\delta)U_C(t-1) \right] = \\ \mu \left[\frac{(1-\delta)}{(1+\sigma)} P_C(t+1) - \left[1 + \frac{(1-\delta)^2}{(1+\sigma)} \right] P_C(t) + (1-\delta)P_C(t-1) \right] \\ + \frac{1}{(1+\sigma)} V_A(t+1) - \frac{(1-\delta)}{(1+\sigma)} V_A(t) .$$

Recalling the definitions of $U_C(t)$ and $V_A(t)$ given above and noting that:

$$(6-29) \quad A(t+1) - (1-\delta)A(t) = C(t)$$

the following equation is obtained:

$$\begin{aligned}
 (6-30) \quad & \left[\frac{(1-\delta)}{(1+\sigma)} \right] \left[\delta\alpha_C + \alpha_{CC}C(t+1) + [\alpha_{CA} - (1-\delta)\alpha_{CC}]C(t) \right] \\
 & - \left[\delta\alpha_C + \alpha_{CC}C(t) + [\alpha_{CA} - (1-\delta)\alpha_{CC}]C(t-1) \right] \\
 & = \\
 & \mu \left[\frac{(1-\delta)}{(1+\sigma)} P_C(t+1) - \left[1 + \frac{(1-\delta)^2}{(1+\sigma)} \right] P_C(t) + (1-\delta)P_C(t-1) \right] \\
 & + \frac{1}{(1+\sigma)} \left[\delta\alpha_A + \alpha_{CA}C(t+1) + [\alpha_{AA} - (1-\delta)\alpha_{CA}]C(t) \right] .
 \end{aligned}$$

Solving equation (6-30) for $C(t)$ yields the following cigarette demand equation:

$$\begin{aligned}
 (6-31) \quad C(t) = & \beta_0 + \beta_1 P_C(t) + \beta_2 P_C(t-1) + \beta_3 P_C(t+1) \\
 & + \beta_4 C(t-1) + \beta_5 C(t+1)
 \end{aligned}$$

where:

$$(6-32) \quad \Omega = \frac{2(1-\delta)}{(1+\sigma)} \alpha_{CA} - \frac{1}{(1+\sigma)} \alpha_{AA} - \left[\frac{(1-\delta)^2}{(1+\sigma)} + 1 \right] \alpha_{CC}$$

$$(6-33) \quad \beta_0 = \frac{1}{\Omega} \left[\frac{\delta\alpha_A}{(1+\sigma)} - \delta\alpha_C \left[\frac{(1-\delta)}{(1+\sigma)} - 1 \right] \right]$$

$$(6-34) \quad \beta_1 = \frac{\delta C(t)}{\delta P_C(t)} = - \frac{\mu}{\Omega} \left[\frac{(1-\delta)^2}{(1+\sigma)} + 1 \right]$$

$$(6-35) \quad \beta_2 = \frac{\delta C(t)}{\delta P_C(t-1)} = \frac{\mu}{\Omega} (1-\delta)$$

$$(6-36) \quad \beta_3 = \frac{\delta C(t)}{\delta P_C(t+1)} = \frac{\mu}{\Omega} \left[\frac{(1-\delta)}{(1+\sigma)} \right]$$

$$(6-37) \quad \beta_4 = \frac{\delta C(t)}{\delta C(t-1)} = \frac{1}{\Omega} \left[\alpha_{CA} - (1-\delta)\alpha_{CC} \right]$$

and:

$$(6-38) \quad \beta_5 = \frac{\delta C(t)}{\delta C(t+1)} = \frac{1}{\Omega(1+\sigma)} \left[\alpha_{CA} - (1-\delta)\alpha_{CC} \right] .$$

Based on the assumptions of the model discussed above, the signs of each of the coefficients on the variables entering the cigarette demand equation can be predicted. To begin with, the term Ω which enters each of the coefficients is positive since α_{CA} is assumed to be greater than zero (due primarily to the reinforcement effects involved in addictive consumption) and from concavity. β_1 , the coefficient on the market price of cigarettes in time t , is expected to be negative, as one would expect. Past and future consumption of the addictive good are expected to have a positive effect on current consumption of the addictive good (that is, β_4 and β_5 are expected to be positive) with the effect of past consumption expected to be larger in mag-

nitute than the effect of future consumption. More directly, the effect of future consumption on current consumption is expected to be equal to the discounted effect of past consumption on current consumption [$\beta_5 = \beta_4/(1+\sigma)$].

Similarly, the effect of past and future cigarette prices on current consumption is predicted to be positive (β_2 and $\beta_3 > 0$) with the effect of the past price larger than the effect of the current price by the factor $(1+\sigma)$.

The prediction that a positive relationship exists between one lag and one lead of cigarette prices and current cigarette consumption seems somewhat contradictory given that the main implication of the model of rational addictive behavior is that consumption of the addictive good, cigarettes, is complementary, not substitutable, over time. In fact, Becker, Grossman, and Murphy, in their application of the Becker-Murphy model of rational addiction to cigarette consumption using aggregate data, define a good as addictive "if and only if an increase in past consumption leads to an increase in current consumption" holding prices and the marginal utility of wealth fixed.² They go on to say that "finding that [β_4] is positive would be evidence that cigarettes are addictive, while a finding that [β_4] is negative or insignificantly positive (in an economic sense) would be evidence against the claim that cigarettes are addictive."³ However, past and future consumption are being held con-

² Becker, Grossman, and Murphy (1987), page 8

³ Becker, Grossman, and Murphy (1987), page 8.

stant. Hence, the fact that an increase (decrease) in past price would result in a decrease (increase) in past consumption which would lead to a decrease (increase) in current consumption (if consumption is addictive) is being controlled for by the inclusion of past consumption in the demand equation (and similarly for increases/decreases in future prices).

Therefore, the implication that higher (lower) past and/or future prices lead to greater (less) current consumption holding past and future consumption constant implies that some other factor must be leading to greater current consumption. Becker, Grossman, and Murphy suggest that this "other force" is the addictive stock. Evidence of the notion that the past and future cigarette prices are picking up the effects of the unmeasured addictive stock is that the coefficients on past and future price (β_2 and β_3 in demand equation (6-31), respectively) depend on the rate of depreciation on the addictive stock. That is, if the rate of depreciation on the addictive stock is assumed to be one hundred percent, the addictive stock at time t is then given by consumption at time $t-1$ (see equation (6-16)) and the coefficients on past and future price go to zero, since the addictive stock is fully captured by past consumption.

More formally, if the rate of depreciation on the addictive stock is one hundred percent, the quadratic version of the utility function described in equation (6-1), at time t , becomes:

$$\begin{aligned}
 (6-39) \quad U(t) = & b Y(t) + b C(t) + b C(t-1) + \frac{U_{YY}}{2} Y(t)^2 + \\
 & \frac{U_{CC}}{2} C(t)^2 + \frac{U_{AA}}{2} C(t-1)^2 + U_{YC} Y(t)C(t) + \\
 & U_{CA} C(t)C(t-1) + U_{YA} Y(t)C(t-1) .
 \end{aligned}$$

Following the same logic as before, the typical first-order condition with respect to cigarette consumption at time t from the constrained utility maximization process is now given by:

$$\begin{aligned}
 (6-40) \quad \frac{\delta V^*[\cdot]}{\delta C(t)} = & \frac{\alpha_C + \alpha_{CC}C(t) + \alpha_{CA}C(t-1) - \mu P_C(t)}{(1+\sigma)^t} + \\
 & \frac{\alpha_A + \alpha_{AA}C(t) + \alpha_{CA}C(t+1)}{(1+\sigma)^{t+1}} = 0 .
 \end{aligned}$$

Solving this first order condition for $C(t)$ yields the following cigarette demand equation:

$$(6-41) \quad C(t) = \Gamma_0 + \Gamma_1 P_C(t) + \Gamma_2 C(t-1) + \Gamma_3 C(t+1) .$$

where:

$$(6-42) \quad \epsilon = \frac{\alpha_{AA}}{(1+\sigma)} + \alpha_{CC}$$

$$(6-43) \quad \Gamma_0 = - \frac{1}{\epsilon} \left[\frac{\alpha_A}{(1+\sigma)} + \alpha_C \right]$$

$$(6-44) \quad \Gamma_1 = \frac{\delta C(t)}{\delta P_C(t)} = -\frac{\mu}{\epsilon}$$

$$(6-45) \quad \Gamma_2 = \frac{\delta C(t)}{\delta C(t-1)} = -\frac{\alpha_{CA}}{\epsilon}$$

and:

$$(6-46) \quad \Gamma_3 = \frac{\delta C(t)}{\delta C(t+1)} = -\frac{\alpha_{CA}}{\epsilon(1+\sigma)} .$$

The predictions of this simpler model of addictive consumption concerning the effects of the current price of cigarettes, as well as the effects of past and future cigarette consumption, on current cigarette consumption are identical to those of the less restrictive model outlined above. Again, the past and future cigarette prices fall out of the demand equation when the rate of depreciation on the addictive stock is one hundred percent, indicating that in the less restrictive model these prices are picking up those parts of the past and future addictive stocks which are not being captured by past and future consumption and which are exerting a positive influence on current consumption.

Finally, an alternative cigarette demand equation developed within the Becker-Murphy rational addiction framework can be obtained directly from equation (6-27) which uses the first order conditions with respect to cigarette consumption at time t and $t+1$. Making use of the definition of the addictive stock at time $t+1$, this equation can easily be solved for cigarette consumption at time t . The result-

ing cigarette demand equation is:

$$(6-47) \quad C(t) = \theta_0 + \theta_1 P_C(t) + \theta_2 P_C(t+1) + \theta_3 C(t+1) + \theta_4 A(t)$$

where:

$$(6-48) \quad \Phi = \left[\frac{(1-\delta)}{(1+\sigma)} \right] \alpha_{CA} - \alpha_{CC} - \frac{\alpha_{AA}}{(1+\sigma)}$$

$$(6-49) \quad \theta_0 = \frac{1}{\Phi} \left[\frac{\alpha_A}{(1+\sigma)} - \alpha_C \left[\frac{(1-\delta)}{(1+\sigma)} - 1 \right] \right]$$

$$(6-50) \quad \theta_1 = \frac{\delta C(t)}{\delta P_C(t)} = - \frac{\mu}{\Phi}$$

$$(6-51) \quad \theta_2 = \frac{\delta C(t)}{\delta P_C(t+1)} = \frac{\mu}{\Phi} \left[\frac{(1-\delta)}{(1+\sigma)} \right]$$

$$(6-52) \quad \theta_3 = \frac{\delta C(t)}{\delta C(t+1)} = \frac{1}{\Phi} \left[\frac{\alpha_{CA}}{(1+\sigma)} - \frac{(1-\delta)}{(1+\sigma)} \alpha_{CC} \right]$$

and:

$$(6-53) \quad \theta_4 = \frac{\delta C(t)}{\delta A(t)} = \frac{1}{\Phi} \left[\left[1 - \frac{(1-\delta)^2}{(1+\sigma)} \right] \alpha_{CA} + \left[\frac{(1-\delta)}{(1+\sigma)} \right] \alpha_{AA} \right]$$

As before, current cigarette consumption is expected to

be negatively related to the current price of cigarettes but positively related to next period's price. Similarly, increases in future consumption are predicted to lead to increased current consumption. However, the direction of the relationship between cigarette consumption at time t and the level of the addictive stock at time t can not be predicted by the model. This ambiguity is due to two opposing forces represented by the stock. As discussed in Chapter Five, an increase in the stock of past consumption leads to an increase in the shadow price of the addictive stock and, as a result, to an increase in the full price of cigarette smoking (due to the increases in all future stocks and, hence, reductions in all future utility levels). The increase in the full price of smoking should discourage consumption. If this were the only effect, then θ_4 would be expected to be negative. However, because of the reinforcement factors associated with the consumption of an addictive good (represented by $\alpha_{CA} > 0$), increased past consumption may lead to increased current consumption. If the positive effects of reinforcement in consumption outweigh the negative effects of the increase in the full price of smoking associated with an increase in the addictive stock, then θ_4 would be positive.

This demand equation reemphasizes the earlier discussion concerning the predicted positive relationship between current cigarette consumption and the past and future prices of cigarettes when past and future cigarette consumption and

the marginal utility of wealth are being held constant. The basic argument was that the past and future prices were proxies for the unmeasured aspects of the addictive stock not controlled for by the presence of past and future cigarette consumption. In this final model, both the past price of cigarettes and past cigarette consumption are replaced by the stock of past cigarette consumption, lending some support to the earlier arguments.

Myopic and Other Models of Cigarette Smoking

Rationality, in the context of this dissertation, implies not only that individuals realize that cigarette smoking is an addictive behavior, but that they are aware of the future consequences of their addiction and take these into account when making current consumption decisions. Myopia, on the other hand, suggests that individuals recognize that smoking is addictive but ignore the repercussions of their addiction. In other words, they ignore not only the negative impact of cigarette smoking on their future health, but also the fact that all future consumption decisions will be dependent on current and all past consumption decisions. All future consumption decisions are affected due to the effects of consumption at any time on the addictive stock at all later times and the resulting impacts on productivity and, consequently, utility. In this context, therefore, myopia implies that individuals completely dis-

count the future (or $\sigma \rightarrow \infty$).

Demand equations comparable to those derived under the assumption of rational behavior above can easily be derived under the alternative assumption of myopic behavior. Using the basic model defined above, begin from equation (6-15). Recalling the typical first order condition with respect to cigarette consumption for this maximization problem given in equation (6-17), multiply through by $(1+\sigma)^t$, and impose the assumption of myopia ($\sigma \rightarrow \infty$). The resulting equation is as follows:

$$(6-54) \quad \alpha_C + \alpha_{CC}C(t) + \alpha_{CA}A(t) - \mu P_C(t) = 0 \quad .$$

Solving this equation for $C(t)$ yields a cigarette demand equation comparable to equation (6-47) under the assumption of myopia as follows:

$$(6-55) \quad C(t) = \theta_0^M + \theta_1^M P_C(t) - \theta_4^M A(t)$$

where:

$$(6-56) \quad \theta_0^M = - \frac{\alpha_C}{\alpha_{CC}}$$

$$(6-57) \quad \theta_1^M = \frac{\delta C(t)}{\delta P_C(t)} = \frac{\mu}{\alpha_{CC}}$$

and:

$$(6-58) \quad e_4^M = \frac{\delta C(t)}{\delta A(t)} = - \frac{\alpha_{CA}}{\alpha_{CC}} .$$

An inverse relationship is predicted between cigarette consumption in time t and the relative price of cigarettes in time t , as before. Under the assumption of myopic behavior, however, a definite prediction can be made concerning the relationship between the addictive stock at time t and cigarette consumption at that time. Current consumption is expected to be positively related to the level of the addictive stock.

The prediction of a positive relationship between current cigarette consumption and the depreciated sum of past consumption is consistent with expectations given the way in which the rationality versus myopia distinction is introduced. Recalling the earlier discussion about the ambiguity of the effect of the addictive stock on current cigarette consumption in the fully rational specification derived above, it was noted that increases in the addictive stock increased the full price of cigarette smoking through an increase in the shadow price of the stock. The increase in the shadow price of the stock was due to the increase in all future stocks which decreased all future utility levels. If, however, people are behaving myopically and completely ignoring all of the future consequences of their addiction, then the shadow price of the stock will be zero and the full price of smoking will be equal to the market price of cigar-

ettes. Therefore, the only effect of the addictive stock is through its reinforcement of current cigarette consumption, implying the positive relationship between the current consumption predicted by the myopic model.

Similarly, using equation (6-54), if the rate of depreciation on the addictive stock is assumed to be one hundred percent, then the following cigarette demand equation is obtained:

$$(6-59) \quad C(t) = \Gamma_0^M + \Gamma_1^M P_C(t) - \Gamma_2^M C(t-1)$$

where:

$$(6-60) \quad \Gamma_0^M = - \frac{\alpha_C}{\alpha_{CC}}$$

$$(6-61) \quad \Gamma_1^M = \frac{\delta C(t)}{\delta P_C(t)} = \frac{\mu}{\alpha_{CC}}$$

and:

$$(6-62) \quad \Gamma_2^M = \frac{\delta C(t)}{\delta C(t-1)} = - \frac{\alpha_{CA}}{\alpha_{CC}}$$

Again, the predicted relationships between current cigarette consumption and the current cigarette price and lagged cigarette consumption are qualitatively identical to those of the demand equation derived under the assumption of fully rational behavior given as equation (6-41).

To obtain the myopic equivalent of the demand equation

given by equation (6-31) above, consider equation (6-54) for time (t-1):

$$(6-63) \quad \alpha_C + \alpha_{CC}C(t-1) + \alpha_{CA}A(t-1) - \mu P_C(t-1) = 0 \quad .$$

Multiplying this equation by (1- δ) and subtracting the resulting equation from equation (6-54) yields the following:

$$(6-64) \quad C(t) - (1-\delta)C(t-1) = - \frac{\delta\alpha_C}{\alpha_{CC}} + \frac{\mu}{\alpha_{CC}} P_C(t) - \frac{\mu(1-\delta)}{\alpha_{CC}} P_C(t-1) - \frac{\alpha_{CA}}{\alpha_{CC}} A(t) + (1-\delta) \frac{\alpha_{CA}}{\alpha_{CC}} A(t-1) \quad .$$

Recalling equation (6-29), solving (6-64) for C(t) yields the following cigarette demand equation:

$$(6-65) \quad C(t) = \beta_0^M + \beta_1^M P_C(t) + \beta_2^M P_C(t-1) + \beta_4^M C(t-1)$$

where:

$$(6-66) \quad \beta_0^M = - \frac{\delta\alpha_C}{\alpha_{CC}}$$

$$(6-67) \quad \beta_1^M = \frac{\delta C(t)}{\delta P_C(t)} = \frac{\mu}{\alpha_{CC}}$$

$$(6-68) \quad \beta_2^M = \frac{\delta C(t)}{\delta P_C(t-1)} = - \frac{\mu(1-\delta)}{\alpha_{CC}}$$

and:

$$(6-69) \quad \beta_4^M = \frac{\delta C(t)}{\delta C(t-1)} = 1 - \delta - \frac{\alpha_{CA}}{\alpha_{CC}} .$$

As in the cigarette demand equation derived under the assumption of rational behavior, current cigarette consumption is expected to be inversely related to the current price of cigarettes, but directly related to the lagged price of cigarettes and lagged cigarette consumption.

Finally, if cigarette smoking is modelled as a non-addictive behavior, then consumption is expected to be intertemporally independent. The cigarette demand equation resulting from this behavioral assumption will then be solely a function of relative prices and income. All past and future consumption effects will be excluded.

Empirically Testable Implications of the Model of Rational Addiction

Comparing the demand equations derived under the alternative assumptions of non-addictive, addictive but myopic, and addictive and rational behavior leads to several empirically verifiable hypotheses. The two main tests of the model are to test whether or not cigarette smoking is an addictive behavior and, if addictive, are individuals behav-

ing rationally or myopically.

As noted earlier, the Becker-Grossman-Murphy test of addiction is relatively straightforward. The main implication of addiction in their model is that consumption of the addictive good displays "adjacent complementarity". In this work, that implies that cigarette consumption in consecutive periods is positively related, or that increases (decreases) in past consumption lead to increases (decreases) in current consumption. Therefore, to test for the presence of addiction, one has to simply look at the estimates obtained for the coefficients on past consumption when estimating the demand equations. If these coefficients (β_4 in equation (6-31) and Γ_2 in equation (6-41)) are positive and significant, then the addictive model discussed above is an accurate description of cigarette smoking.

As Becker, Grossman, and Murphy note, an interesting test of the appropriateness of the model of addiction outlined in Chapter Five would be to estimate demand equations similar to those derived earlier in this chapter for goods which are a-priori nonaddictive. If the model is accurately describing addiction and not just the effects of persistence or habits on demand, then the effects of past consumption on current consumption should be either negligible or negative.

Comparing the two sets of demand equations derived above under alternative assumptions yields a relatively simple test for rational behavior versus myopic behavior. The predictions of the myopic models and the rational models

of cigarette smoking are identical with respect to the direction of the relationships between current cigarette consumption and the current price of cigarettes, the lagged price of cigarettes, and lagged cigarette consumption.

The key differences between the models involve future effects. The rational model predicts that current cigarette consumption will be positively affected by the future price of cigarettes and future cigarette consumption, with the magnitude of these effects less than their respective past effects by the factor $(1+\sigma)$. The myopic models, however, predict that future price and consumption will have no impact on current consumption decisions. The best example of a myopic model of the demand for cigarettes is presented by Mullahy (1985), in which a demand equation comparable to (6-47) is derived within a utility maximization framework, and subsequently estimated.

Therefore, if positive and significant coefficients of the appropriate magnitude are estimated for the future price and consumption of cigarettes, the rationality hypothesis would be validated. If, on the other hand, these estimated coefficients are not significantly different from zero or are negative, then the hypothesis of rational behavior would be rejected in favor of the alternative hypothesis of myopic behavior. Finally, with respect to demand equation (6-47), finding no significant positive relationship between current cigarette consumption and future cigarette consumption, but obtaining positive and significant estimates of the coeffi-

cient on the addictive stock would lend additional support to the argument that individuals are behaving myopically.

The most important test of rationality versus myopia appears to be the estimated coefficient on future consumption (β_s in demand equation (6-31), Γ_s in demand equation (6-41), and θ_s in demand equation (6-47)). Relatively high rates of depreciation on the addictive stock would imply a fairly weak relationship between the future (and past) cigarette price and current cigarette consumption, while the coefficients on future consumption are less affected. As will be discussed more completely below, much of the evidence concerning the effects of cigarette smoking on health after quitting and on the duration of cigarette withdrawal syndromes suggests that relatively high rates of depreciation are appropriate.

Finally, Becker and Murphy and Becker, Grossman, and Murphy derive several testable implications of the short and long run responses to changes in price. Additionally, Becker, Grossman, and Murphy distinguish between the effects of unanticipated versus anticipated changes in prices as well as the relative effects of temporary versus permanent price changes. The discussion which follows draws heavily on this work.⁴

As noted by Becker, Grossman, and Murphy (page 11), the

⁴ For a much more complete derivation of the responses of consumption to changes in price see the papers by Becker and Murphy (section 4) and Becker, Grossman, and Murphy (pages 10-14).

cigarette demand equations derived above as equations (6-31) and (6-41) are second order difference equations in current cigarette consumption, $C(t)$. The dynamics of consumption, therefore, can be described by the two roots of the quadratic equation (based on equation (6-31)):

$$(6-70) \quad 0 = -\phi^2 \beta_4 + \phi - \beta_5$$

where the two roots of this equation are:

$$(6-71) \quad \phi_1 = \frac{1 - \sqrt{(1 - 4\beta_4\beta_5)}}{2\beta_4}$$

and:

$$(6-72) \quad \phi_2 = \frac{1 + \sqrt{(1 - 4\beta_4\beta_5)}}{2\beta_4}$$

Becker, Grossman, and Murphy note that both ϕ_1 and ϕ_2 are real (from the assumption of concavity which implies that $4\beta_4\beta_5 < 1$) and, therefore, will both be the same sign as β_4 . This implies that both roots are positive if consumption is addictive (indicated by $\beta_4 > 0$, as discussed above). Similar equations are obtained for demand equation (6-41), replacing β_4 and β_5 with Γ_2 and Γ_3 , respectively, where Γ_2 positive and significant indicate addiction. Finally, comparable equations can be derived for (6-47), replacing β_4 with θ_4/δ and β_5 with θ_3 . These equations are based on the assumption that a constant optimal level of the

addictive stock is maintained in the steady state and that consumption at any time just offsets depreciation on the addictive stock.

Becker, Grossman, and Murphy develop several different price elasticities of demand based on the basic demand equations derived above (with a detailed development of the elasticities corresponding to their version of the cigarette demand equation derived as equation (6-41) above).^a These price elasticities of demand are based upon the general solutions to the second-order difference equations represented by each of the cigarette demand equations above, and each will be developed below for each of these demand functions.

The general solution to the second-order difference equation represented by the demand equation in which the rate of depreciation on the addictive stock is assumed to be one hundred percent (equation (6-41)) is, using the appropriate roots:^a

$$(6-73) \quad C(t) = \frac{1}{\Gamma_2 \phi_1 (\phi_2 - \phi_1)} \left[\sum_{s=1}^{\infty} \phi_1^s h(t+s) \right] + \\ \frac{1}{\Gamma_2 \phi_2 (\phi_2 - \phi_1)} \left[\sum_{s=0}^{\infty} \phi_2^{-s} h(t-s) \right] +$$

^a Becker, Grossman, and Murphy (1987), pages 11-13.

^a This is the solution presented by Becker, Grossman, and Murphy (1987), page 11.

$$\frac{1}{\phi_2^t} \left[C^0 - \frac{1}{\Gamma_2 \phi_1 (\phi_2 - \phi_1)} \left[\sum_{s=1}^{\infty} \phi_1^s h(s) \right] \right]$$

where:

$$(6-74) \quad h(t) = \Gamma_0 + \Gamma_1 P_C(t-1) \quad ,$$

and C^0 is assumed constant.

Using this equation, the effect of changes in past, current, and future prices on current consumption can easily be determined. Using the Becker-Grossman-Murphy nomenclature, the effect of changes in current price on demand are:

$$(6-75) \quad \frac{\delta C(t)}{\delta P_C(t)} = \frac{\Gamma_1}{\Gamma_2 (\phi_2 - \phi_1)} \left[1 - \left[\frac{\phi_1}{\phi_2} \right]^t \right]$$

The effect of a change in past price on current consumption is given as (where $\tau < t$):

$$(6-76) \quad \frac{\delta C(t)}{\delta P_C(\tau)} = \frac{\Gamma_1 \phi_2^{\tau-t}}{\Gamma_2 (\phi_2 - \phi_1)} \left[1 - \left[\frac{\phi_1}{\phi_2} \right]^\tau \right] \quad .$$

The effect of a change in future price on demand is (where $\tau > t$):

$$(6-77) \quad \frac{\delta C(t)}{\delta P_C(\tau)} = \frac{\Gamma_1 \phi_1^{\tau-t}}{\Gamma_2(\phi_2 - \phi_1)} \left[1 - \left[\frac{\phi_1}{\phi_2} \right]^t \right]$$

Each of these will be negative if consumption is addictive ($\Gamma_2 < 0$). These price effects are defined for temporary changes in the price of cigarettes and are what Becker, Grossman, and Murphy refer to as "anticipated" price effects. Letting the term in brackets become $(\phi_2 - \phi_1)/\phi_2$, the Becker-Grossman-Murphy "unanticipated" price effects are obtained.

More interesting are the effects on cigarette demand of permanent changes in the price of cigarettes. Becker, Grossman, and Murphy define the effects of two different permanent price changes. The first is what they call the "short-run" price effect. This is the effect on current consumption of a permanent change in price beginning in the current period, and is obtained by summing all future price effects and the current price effect defined above. The resulting price effect (their "all future prices anticipated") is:

$$(6-78) \quad \frac{\delta C_\infty}{\delta P_\infty} = \frac{\Gamma_1}{\Gamma_2(1-\phi_1)(\phi_2 - \phi_1)}$$

with the comparable unanticipated price effect as:

$$(6-79) \quad \frac{\delta C_{\infty}}{\delta P} = \frac{\Gamma_1}{\Gamma_2(1-\phi_1)(\phi_2 - \phi_1)} \left[\frac{\phi_2 - \phi_1}{\phi_2} \right] .$$

Finally, the effect on current consumption of a change in prices in all periods is given as:

$$(6-80) \quad \frac{\delta C_{\infty}}{\delta P} = \frac{\Gamma_1}{\Gamma_2(1-\phi_1)(\phi_2 - 1)} .$$

This is the long run or steady state price effect. Based on these equations, several points can be made. If consumption is addictive, then an increase in past, current, or future price should lead to a reduction in current consumption, with the response to changes in future prices a potential test for rationality. Also, if consumption is addictive, the long run price effect should be larger in magnitude than the short run price effect (in this case by the term $(\phi_2 - \phi_1)/(\phi_2 - 1)$). Additionally, if consumption is addictive, the anticipated price effects should be larger in magnitude than the comparable unanticipated price effects (by the factor $\phi_2/(\phi_2 - \phi_1)$ for this demand equation). Finally, it should be clear that if the addictive aspects of consumption are ignored then the estimated price effects would be significantly different from those defined above.

It remains to develop the comparable price effects for the other two demand equations developed above. The same basic conclusions outlined above with respect to the magini-

tudes of the expected price effects of modelling consumption as a rational addictive behavior will apply to the price effects developed here as well.

The general solution to the second-order difference equation derived as demand equation (6-31) above is, with ϕ_1 and ϕ_2 as defined above:

$$\begin{aligned}
 (6-81) \quad C(t) = & \frac{1}{\beta_4 \phi_1 (\phi_2 - \phi_1)} \left[\sum_{s=1}^{\infty} \phi_1^s g(t+s) \right] + \\
 & \frac{1}{\beta_4 \phi_2 (\phi_2 - \phi_1)} \left[\sum_{s=0}^{\infty} \phi_2^{-s} g(t-s) \right] + \\
 & \frac{1}{\phi_2^t} \left[A^0 - \frac{1}{\beta_4 \phi_1 (\phi_2 - \phi_1)} \left[\sum_{s=1}^{\infty} \phi_1^s g(s) \right] \right]
 \end{aligned}$$

where:

$$(6-82) \quad g(t) = \beta_0 + \beta_1 P_C(t-1) + \beta_2 P_C(t-2) + \beta_3 P_C(t) ,$$

and A^0 is assumed constant.

The effects on consumption of temporary, anticipated changes in current, past, and future prices are as follows:

$$(6-83) \quad \frac{\delta C(t)}{\delta P_C(\tau)} = \frac{\beta_1 + \beta_2 \phi_1 + \beta_3 \phi_2^{-1}}{\beta_4 (\phi_2 - \phi_1)}$$

$$(6-84) \quad \frac{\delta C(t)}{\delta P_C(t-1)} = \frac{1}{\beta_4(\phi_2 - \phi_1)} \left[\beta_2 + \frac{\beta_1}{\phi_2} + \frac{\beta_3}{\phi_2^2} \right]$$

and:

$$(6-85) \quad \frac{\delta C(t)}{\delta P_C(t+1)} = \frac{\beta_3 + \phi_1 \beta_1 + \phi_1^2 \beta_2}{\beta_4(\phi_2 - \phi_1)}$$

with the comparable unanticipated effects of temporary changes in current, past, and future price defined as:

$$(6-86) \quad \frac{\delta C(t)}{\delta P_C(t)} = \frac{\beta_1 + \beta_2 \phi_1}{\beta_4 \phi_2}$$

$$(6-87) \quad \frac{\delta C(t)}{\delta P_C(t-1)} = \frac{\beta_1}{\beta_4 \phi_2^2} + \frac{\beta_2}{\beta_4(\phi_2 - \phi_1)} \left[1 - \frac{\phi_1^2}{\phi_2^2} \right]$$

and:

$$(6-88) \quad \frac{\delta C(t)}{\delta P_C(t+1)} = \frac{\beta_3 + \phi_1 \beta_1 + \phi_1^2 \beta_2}{\beta_4 \phi_2}$$

The effect on current consumption of an anticipated permanent change in price beginning in the current period, the short-run price effect, is defined as:

$$(6-89) \quad \frac{\delta C_\infty}{\delta P_\infty} = \frac{\beta_1 + \phi_1 \beta_2 + \beta_3 \left[1 + (1-\phi_1)/\phi_2 \right]}{\beta_4(1 - \phi_1)(\phi_2 - \phi_1)}$$

with the unanticipated effect given as:

$$(6-90) \quad \frac{\delta C_{\infty}}{\delta P_{\infty}} = \frac{\beta_3 + \beta_1 + \phi_1 \beta_2}{\beta_4 (1 - \phi_1) \phi_2} \quad .$$

Finally, the effect on current consumption of a change in prices in all periods, the long-run or steady state price effect, is given as:

$$(6-91) \quad \frac{\delta C_{\infty}}{\delta P} = \frac{\beta_1 + \beta_2 + \beta_3}{\beta_4 (1 - \phi_1) (\phi_2 - 1)} \quad .$$

Finally, for the second-order difference equation described by demand equation (6-47) above (under the assumption that steady state consumption is just sufficient to offset the depreciation on the optimal level of the addictive stock), the general solution is:

$$(6-92) \quad C(t) = \frac{1}{\theta \phi_1 (\phi_2 - \phi_1)} \left[\sum_{s=1}^{\infty} \phi_1^s f(t+s) \right] +$$

$$\frac{1}{\theta \phi_2 (\phi_2 - \phi_1)} \left[\sum_{s=0}^{\infty} \phi_2^{-s} f(t-s) \right] +$$

$$\frac{1}{\phi_2^t} \left[A^0 - \frac{1}{\theta \phi_1 (\phi_2 - \phi_1)} \left[\sum_{s=1}^{\infty} \phi_1^s f(s) \right] \right]$$

where:

$$(6-93) \quad f(t) = \theta + \theta_1 P_C(t-1) + \theta_2 P_C(t) \quad ,$$

A^0 is assumed constant, θ is defined as θ_4/δ , and the two roots are as described above.

The effects on consumption of temporary, anticipated changes in current, past, and future prices are as follows:

$$(6-94) \quad \frac{\delta C(t)}{\delta P_C(t)} = \frac{\theta_1 + \theta_2 \phi_2^{-1}}{\theta(\phi_2 - \phi_1)}$$

$$(6-95) \quad \frac{\delta C(t)}{\delta P_C(t-1)} = \frac{\theta_1 + \theta_2 \phi_2^{-1}}{\theta(\phi_2 - \phi_1) \phi_2}$$

and:

$$(6-96) \quad \frac{\delta C(t)}{\delta P_C(t+1)} = \frac{\theta_2 + \phi_1 \theta_1}{\theta(\phi_2 - \phi_1)}$$

with the comparable unanticipated effects of temporary changes in current, past, and future price defined as:

$$(6-97) \quad \frac{\delta C(t)}{\delta P_C(t)} = \frac{\theta_1}{\theta \phi_2}$$

$$(6-98) \quad \frac{\delta C(t)}{\delta P_C(t-1)} = \frac{\theta_1}{\theta \phi_2^2}$$

and:

$$(6-99) \quad \frac{\delta C(t)}{\delta P_C(t+1)} = \frac{\theta_2 + \phi_1 \theta_1}{\theta \phi_2} .$$

The effect of a permanent price change beginning in the current period which was anticipated, the anticipated short-run effect, is:

$$(6-100) \quad \frac{\delta C_\infty}{\delta P_\infty} = \frac{\theta_1 + \theta_2 [1 + (1-\phi_1)/\phi_2]}{\theta(1-\phi_1)(\phi_2-\phi_1)}$$

with the unanticipated effect given as:

$$(6-101) \quad \frac{\delta C_\infty}{\delta P_\infty} = \frac{\theta_1 + \theta_2}{\theta(1-\phi_1)\phi_2}$$

Finally, the effect of a permanent price change in all periods on current consumption, the long-run or steady state effect, is:

$$(6-102) \quad \frac{\delta C_\infty}{\delta P} = \frac{\theta_1 + \theta_2}{\theta(1-\phi_1)(\phi_2-1)}$$

Again, as noted by Becker, Grossman, and Murphy, the various price elasticities of demand derived within the rational addiction framework are quite different from those developed in a non-addictive framework, implying that ignoring the addictive aspects of consumption will lead to incor-

rect estimates of the responses by addicts to changes in past, current, and/or future price changes. Also, within the addictive framework, the effects of anticipated changes in price differ from the effects of unanticipated price changes. Finally, models of the demand for addictive goods which fail to account for the addictive aspects of consumption predict no differences in the short-run versus long-run price elasticities of demand, as they are defined above, while the Becker-Murphy model of rational addiction predicts that the long-run response to a permanent change in price will be greater than the short-run response.

One final point to be made briefly in this chapter concerns the appropriate estimation strategy. Each of the cigarette demand equations derived above contains both next period's consumption of the addictive good and some measure of past consumption, in addition to current cigarette prices and alternative sets of the price of cigarettes last period and the price of cigarettes next period. However, both future consumption and the measures of past consumption employed are themselves dependent on current consumption. As noted by Becker, Grossman, and Murphy, the general solutions to the second-order difference equations represented by these demand equations suggest a solution to the endogeneity problem. These solutions show that consumption at any time is a function of all past, current, and future cigarette prices. However, the demand equations derived include at most one lead and one lag of the price of cigarettes, in

addition to the current price of cigarettes. This suggests that estimating the demand equations derived above using instrumental variables for future and past consumption, where the instruments are further leads and lags of cigarette prices, will alleviate the endogeneity problem.

Chapter Seven

Data and Variable Construction

This chapter contains a description of the Second National Health and Nutrition Examination Survey, the primary data set employed in the estimation of the demand equations derived in Chapter Six, followed by a discussion of the construction of the various consumption measures used in the estimation. Finally, discussions of the price variables utilized and the methodological problems associated with developing an appropriate measure of price are presented.

The Second National Health and Nutrition Examination Survey (NHANES2) was a stratified probability sample of the civilian, noninstitutionalized population of United States over the period from February, 1976 to February, 1980. The survey was conducted by the National Center for Health Statistics, U.S. Department of Health, Education and Welfare, as part of the Center's ongoing program in the collection of health data which included the Health Examination Surveys and the First National Health and Nutrition Examination Survey.

Individuals was surveyed in sixty four primary sampling units (PSU's - defined as a county or small group of contiguous counties) chosen from Washington D.C. and the fifty states, with sixteen sites in each of the four basic regions of the country. A list of the PSU's and their

Table 7-1

Primary Sampling Units and Survey Dates for NHANES2

Primary Sampling Unit	Survey Date
Dade County, Florida	2/20-3/25/76
Santa Clara County, California	2/25-3/19/76
Caddo County, Louisiana	4/2-5/8/76
Fresno County, California	3/26-5/4/76
Newport News, Hampton, Virginia	5/18-6/16/76
Pierce County, Washington	5/13-6/5/76
New Madrid, Stoddard Counties, Missouri	6/24-8/4/76
Bingham County, Idaho	6/15-7/14/76
Polk County, Iowa	8/11-9/9/76
Laramie County, Wyoming	7/21-8/12/76
Dakota County, Minnesota	9/15-10/7/76
Hennepin County, Minnesota	8/20-9/16/76
Lake County, Illinois	10/14-11/6/76
Cook County, Illinois	9/23-11/4/76
Craven, Pitt Counties, North Carolina	11/13-12/18/76
Bledsor, McMinn, Meigs, Rhea Counties Tennessee	11/11-12/18/76
Lafayette County, Louisiana	1/20-3/3/77
Brevard County, Florida	1/19-2/12/77
Banks, Hall, Towns, White Counties Georgia	3/10-4/13/77
Blount, St. Claire Counties, Alabama	2/19-3/30/77
Bronx County, New York	4/21-6/3/77
Manhattan County, New York	4/7-5/19/77
Union County, New Jersey	6/9-7/1/77

Table 7-1 (continued)

Primary Sampling Unit	Survey Date
Bergen County, New Jersey	5/25-6/17/77
Norfolk County, Massachusetts	7/20-8/16/77
Hartford, New Haven Counties, Connecticut	7/7-8/6/77
Bristol, Norfolk Counties, Massachusetts	8/20-9/24/77
Cumberland County, Maine	8/12-9/15/77
Delaware County, New York	9/18-10/30/79
Lycoming County, Pennsylvania	8/3-9/11/79
Allegheny County, Pennsylvania	10/13-11/12/77
Erie County, Pennsylvania	10/13-11/18/77
Green, Rockingham, Harrisonburg Counties, Virginia	1/30-2/27/80
District of Columbia	11/3-12/14/79
Los Angeles County, California	1/19-2/18/78
Los Angeles County, California	1/19-2/18/78
San Diego County, California	2/25-3/28/78
Honolulu County, Hawaii	2/25-3/23/78
Linn County, Oregon	4/6-5/4/78
Yolo County, California	3/31-5/4/78
Sedgwick County, Kansas	5/17-6/17/78
Hickory, St. Clair Counties, Missouri	5/17-6/29/78
Cheboygan, Emmett Counties, Michigan	6/28-8/5/78
Racine County, Wisconsin	7/7-8/5/78
Ionia, Montcalm Counties, Michigan	8/11-9/16/78
Wayne County, Michigan	8/11-9/28/78
Marion County, Indiana	5/31-7/3/79
Greene, Monroe Counties, Indiana	4/18-5/25/79

Table 7-1 (concluded)

Primary Sampling Unit	Survey Date
Floyd, Johnson, McGoffin Counties, Kentucky	10/20-12/5/79
Hardin, Larue, Nelson Counties, Kentucky	11/19-12/17/77
Cherokee, York Counties, South Carolina	1/15-2/27/80
DeKalb County, Georgia	11/28-12/17/77
Parmer County, Texas	1/18-3/1/79
Harris County, Texas	1/18-2/22/79
Potter, Randall Counties, Texas	3/8-4/4/79
Poinsett County, Arkansas	3/1-4/12/79
Cumberland, Coles County, Illinois	4/12-5/24/79
Hamilton County, Ohio	6/1-7/7/79
Montgomery County, Ohio	8/1-9/1/79
Richland County, Ohio	9/8-10/16/79
Mercer County, New Jersey	11/15-12/15/78
Montgomery County, Pennsylvania	11/17-12/14/78
Orange County, New York	10/12-11/11/78
Westchester County, New York	10/12-11/7/78

sampling dates is contained in Table 7-1. 27,803 persons were surveyed in these sixty four sites (with between three and six hundred surveyed in any one PSU), with 20,325 undergoing a detailed examination by a physician. Various subgroups of the population - pre-school children (ages six months to five years), the elderly (ages sixty to seventy four years), and the poor (persons below the poverty level as defined by the U.S. Bureau of the Census) were oversampled. The oversampling was done to obtain reliable

statistics for each of these populations.

Household interviews were conducted to collect information on household composition, and a variety of demographic and socioeconomic data was collected. Individuals were also asked numerous questions on their medical histories and were asked to come in for an examination by a physician. Approximately 73.1 percent of those surveyed consented to the physical examination which took place in NHANES2 mobile examination centers. During the examination, individuals were interviewed on their dietary patterns and medication and vitamin usage and additional, detailed information on their health was collected. X-rays, electrocardiograms, body measurements (including height and weight), spirometries, and blood pressure measurements were taken, auditory, speech and allergy tests performed, and urine and blood samples were collected for later analysis.

Of particular importance for this research was the information collected on individuals' cigarette smoking histories. These data were collected for individuals ages eighteen years and above at the time of their survey as part of the medical history questionnaire, conducted in the individual's home. For those ages twelve years to seventeen years, these data were collected as part of the dietary questionnaire given at the individual's physical examination, and were not collected in the presence of the youth's parents. Finally, no data was collected on cigarette smoking by individuals less than twelve years of age. All

individuals ages eighteen years and older were asked the following questions concerning their lifetime smoking patterns:

1) Have you smoked at least one hundred cigarettes in your life?

2) Do you smoke cigarettes now?

3) On the average, how many a day do you smoke?

4) How long has it been since you smoked cigarettes fairly regularly?

5) On the average, how many cigarettes a day were you smoking twelve months ago?

6) During the period when you were smoking the most, about how many cigarettes a day did you usually smoke?

7) About how old were you when you first started smoking cigarettes regularly?

The same questions were asked of all individuals ages twelve to seventeen who underwent the physical examination. Due, however, to the differences in other data collected for those less than age eighteen, only those individuals ages eighteen and above were included in the sample used in the estimation of the cigarette demand equations reported below. These data will be used to construct the various measures of cigarette consumption and the addictive stock for use in the estimation of the cigarette demand equations. Frequency distributions for these variables based on the final sample employed are contained in Table 7-2. These frequencies are consistent with what has happened to cigarette smoking in the general population over the two decades prededing the survey, as discussed in Chapter Two. They illustrate both

the decline in smoking participation and the reduced cigarette consumption by smokers that have contributed to overall declines in smoking participation cigarette consumption.

Table 7-2*

Cigarette Smoking Patterns, NHANES2

Percentage of the sample who had smoked at least one hundred cigarettes during their lifetime:	55.5%
Percentage of the sample smoking one year prior to their interview:	35.7%
Percentage of the sample smoking at the time of their interview:	34.9%
Percentage of the sample (smokers) who smoked one pack (20 cigarettes) or less each day, on average, at the time of their interview:	25.2% (72.2%)
Percentage of the sample (smokers) who smoked two packs or less, but more than one pack each day, on average, at the time of their interview:	8.5% (24.4%)
Percentage of the sample (smokers) who smoked more than two packs each day, on average at the time of their interview:	1.2% (3.4%)
Percentage of the sample (smokers) who ever smoked one pack (20 cigarettes) or less regularly:	31.8% (57.2%)
Percentage of the sample (smokers) who ever regularly smoked two packs or less, but more than one pack:	18.3% (33.1%)
Percentage of the sample (smokers) who ever smoked more than two packs regularly:	5.4% (9.6%)

*These frequencies are based on a sample of 14,305 individuals ages 18 to 74 years at the time of their interview.

In addition to the information on cigarette consumption patterns, a variety of other socioeconomic and demographic information collected as part of NHANES2 was used in the estimation of the demand equations. These data include variables indicating the individual's age, sex, race and ancestry, marital status (measured by a set of dichotomous variables indicating married, single, divorced, separated, or widowed), labor force status (captured by a set of dichotomous variables indicating nonparticipants, unemployed participants, and employed participants), educational attainment (both the number of years of formal education completed and a set of dichotomous variables indicating different levels of education), family income, and daily activity and exercise.

A complete list of the variables taken from the survey, their definitions, and the sample means and standard deviations of each are presented in Table 7-3. After deleting observations with missing or inconsistent data, and using only individuals ages eighteen to seventy four years of age at the time of their survey, a final sample of 14,305 individuals was obtained.

Finally, the date of the individual's examination is reported along with the primary sampling unit in which the individual resides. Using the information on the place of residence and date of survey, cigarette prices and excise taxes, clean indoor air law indicators, and a geographical cost of living index were added to the data set, as will be

Table 7-3*

Variable Definitions, Means, and Standard Deviations
for Data Taken from NHANES2

Variable	Definition, Mean, and Standard Deviation
Current Cigarette Consumption	Number of cigarettes the individual was smoking each day, on average, at the time of their interview. $\mu=7.196$, $\sigma=12.241$.
Lagged Cigarette Consumption	Number of cigarettes the individual was smoking each day, on average, one year prior to their interview. $\mu=7.811$, $\sigma=13.065$.
Maximum Cigarette Consumption	Number of cigarettes the individual was smoking each day, on average, during the period when the individual was smoking the most. $\mu=14.358$, $\sigma=17.272$.
Smoking Years	Number of years since the individual has begun smoking, calculated by subtracting the age at initiation from age at the time of the survey. $\mu=15.156$, $\sigma=18.434$.
Years Stopped	For former smokers, the number of years since the individual was last smoking regularly. Equal to 0 otherwise. $\mu=2.180$, $\sigma=6.288$.
Age	Individual's age, in years, at the time of their interview. $\mu=46.520$, $\sigma=18.016$.
Sex	Dichotomous variable equal to one if the individual is male, equal to zero if female. $\mu=0.459$, $\sigma=0.498$.
White	Dichotomous variable equal to one if the individual is white (includes Puerto Ricans, Mexicans, and others of Latin American descent unless definitely nonwhite) equal to zero otherwise. $\mu=0.872$, $\sigma=0.334$.
Black	Dichotomous variable equal to one if the individual is black, equal to zero otherwise. $\mu=0.110$, $\sigma=0.313$.

Table 7-3 (continued)

Variable	Definition, Mean, and Standard Deviation
Other Races	Dichotomous variable equal to one if the individual is neither white nor black (includes orientals, American Indians and Eskimos), equal to zero otherwise. $\mu=0.018$, $\sigma=0.032$.
Active	Dichotomous variable equal to one if the individual describes a normal day, aside from recreational activities, as very or moderately active, equal to zero otherwise. $\mu=0.857$, $\sigma=0.350$.
Exercise	Dichotomous variable equal to one if the individual describes his/her recreational activities as providing much or moderate exercise, equal to zero otherwise. $\mu=0.631$, $\sigma=0.483$.
Married	Dichotomous variable equal to one if the individual is married, spouse present, at the time of the interview, equal to zero otherwise. $\mu=0.654$, $\sigma=0.476$.
Single	Dichotomous variable equal to one if the individual has never been married at the time of the interview, equal to zero otherwise. $\mu=0.166$, $\sigma=0.372$.
Separated	Dichotomous variable equal to one if the individual is married but separated from his/her spouse at the time of the interview, equal to zero otherwise. $\mu=0.028$, $\sigma=0.166$.
Divorced	Dichotomous variable equal to one if the individual is not married and divorced at the time of the interview, equal to zero otherwise. $\mu=0.053$, $\sigma=0.225$.
Widowed	Dichotomous variable equal to one if the individual is not married and widowed at the time of the interview, equal to zero otherwise. $\mu=0.099$, $\sigma=0.298$.

Table 7-3 (continued)

Variable	Definition, Mean, and Standard Deviation
Not in the Labor Force	Dichotomous variable equal to one for individuals not participating in the labor force at the time of the interview, equal to zero for participants. $\mu=0.467$, $\sigma=0.499$.
Unemployed	Dichotomous variable equal to one for individuals participating in the labor force but unemployed at the time of the interview, equal to zero otherwise. $\mu=0.008$, $\sigma=0.090$.
Employed	Dichotomous variable equal to one for individuals employed at the time of the interview, equal to zero otherwise. $\mu=0.525$, $\sigma=0.499$.
Years of Education	The number of years of formal education completed by the individual (17 includes 17 years and above). $\mu=11.099$, $\sigma=3.445$.
No Education	Dichotomous variable equal to one if the individual had completed no years of formal education, equal to zero otherwise. $\mu=0.009$, $\sigma=0.092$.
Less than Grade School Education	Dichotomous variable equal to one if the individual had completed at least one but fewer than eight years of formal education, equal to zero otherwise. $\mu=0.055$, $\sigma=0.227$.
Grade School Education	Dichotomous variable equal to one if the individual had completed eight years of formal education, equal to zero otherwise. $\mu=0.146$, $\sigma=0.353$.
Some High School Education	Dichotomous variable equal to one if the individual had completed more than eight but fewer than twelve years of formal education, equal to zero otherwise. $\mu=0.090$, $\sigma=0.286$.
High School Graduates	Dichotomous variable equal to one if the individual had completed twelve years of formal education, equal to zero otherwise. $\mu=0.412$, $\sigma=0.492$.

Table 7-3 (concluded)

Variable	Definition, Mean, and Standard Deviation
College	Dichotomous variable equal to one if the individual had completed more than twelve years of formal education, equal to zero otherwise. $\mu=0.289$, $\sigma=0.453$.
Native Americans	Dichotomous variable equal to one if the individual is a Native American (includes American Indians and Alaskan Natives), equal to zero otherwise. $\mu=0.013$, $\sigma=0.111$.
Family Income	Imputed Family income based on the following categorical responses in dollars: \$500 if less than \$1000 \$1500 if $\geq$ \$1000, but $\leq$ \$1999 \$2500 if $\geq$ \$2000, but $\leq$ \$2999 \$3500 if $\geq$ \$3000, but $\leq$ \$3999 \$4500 if $\geq$ \$4000, but $\leq$ \$4999 \$5500 if $\geq$ \$5000, but $\leq$ \$5999 \$6500 if $\geq$ \$6000, but $\leq$ \$6999 \$8500 if $\geq$ \$7000, but $\leq$ \$9999 \$12500 if $\geq$ \$10000, but $\leq$ \$14999 \$17500 if $\geq$ \$15000, but $\leq$ \$19999 \$22500 if $\geq$ \$20000, but $\leq$ \$24999 \$30000 if $\geq$ \$25000 $\mu=13582.663$, $\sigma=8594.666$.

*The sample means and standard deviations are for the 14,305 individuals ages eighteen years to seventy four years drawn from the Second National Health and Nutrition Examination Survey.

described below.

Before turning to a discussion of the variables added to the NHANES2 data set, some discussion concerning the use of the data collected in the survey in the estimation of the cigarette demand equations derived above is required.

Recall the alternative demand specifications derived above:

$$(7-1) \quad C(t) = \beta_0 + \beta_1 P_C(t) + \beta_2 P_C(t-1) + \beta_3 P_C(t+1) \\ + \beta_4 C(t-1) + \beta_5 C(t+1) \quad ,$$

$$(7-2) \quad C(t) = \Gamma_0 + \Gamma_1 P_C(t) + \Gamma_2 C(t-1) + \Gamma_3 C(t+1)$$

and:

$$(7-3) \quad C(t) = \theta_0 + \theta_1 P_C(t) + \theta_2 P_C(t+1) + \theta_3 C(t+1) + \theta_4 A(t) \quad .$$

To estimate the first two cigarette demand equations, information on cigarette consumption in three consecutive periods is required. To estimate the third demand equation, information on current, future, and all past consumption is required. However, the cigarette smoking data collected in NHANES2 contains information on cigarette consumption at three points only, two of which pertain to consecutive periods (current and lagged consumption) with the timing of the third (maximum consumption) unknown. Using this information, in addition to the data on the number of years since the individual began smoking and, for former smokers, the number of years since the individual quit smoking, these variables were used to construct the measures of consumption employed in the estimation of the demand equations.

The measures of lagged, current, and led consumption used in the estimation of equations (7-1) and (7-2) were constructed as follows. What is reported in the survey as current consumption, $C(t)$, is treated as future consumption, $C^*(t+1)$. What is reported in the survey as lagged consump-

tion, $C(t-1)$, is treated as current consumption. Finally, to get an estimate of lagged consumption, $C^*(t-1)$, the following procedure was followed: for those individuals who never smoked, lagged consumption was set equal to zero (approximately 44.5% of the sample); similarly, for individuals who began smoking less than two years prior to the time at which they were surveyed, lagged consumption was set equal to zero (about 0.6% of the sample); for individuals who had smoked, but had quit smoking two or more years prior to the time at which they were surveyed, lagged consumption was also set equal to zero (about 17.5% of the sample); finally, for the remainder of the sample, those individuals who were smoking two years prior to the time at which they were surveyed, lagged consumption was set equal to maximum consumption, $C(\max)$. Any prices entering the two demand equations were then lagged appropriately (i.e. $P_C^*(t) = P_C(t-1)$, etc.). These demand equations were then estimated using instrumental variables for $C^*(t+1)$ and $C^*(t-1)$:

$$(7-4) \quad C^*(t) = \beta_0 + \beta_1 P_C^*(t) + \beta_2 P_C^*(t-1) + \beta_3 P_C^*(t+1) \\ + \beta_4 C^*(t-1) + \beta_5 C^*(t+1) \quad ,$$

and:

$$(7-5) \quad C^*(t) = \Gamma_0 + \Gamma_1 P_C^*(t) + \Gamma_2 C^*(t-1) + \Gamma_3 C^*(t+1)$$

Of course, the lagged consumption variable $C^*(t-1)$ is now subject to measurement error. As long as the error is additive, the only consequence is that the resulting coefficients will be biased and inconsistent. As stated earlier, instrumental variables will be used for both future and past consumption. The use of instrumental variables is one method for handling variables with measurement error and will yield consistent estimates as long as an appropriate set of instruments is used. As described in the previous chapter, an appropriate set of instruments is readily available and consists of further leads and lags of the price of cigarettes.

To estimate equation (7-3), in addition to measures of current and future cigarette consumption, some measure of the depreciated sum of all past consumption is required. The procedure described above for obtaining current and future consumption, given the data available in NHANES2, is followed here as well. For those individuals who never smoked regularly, the addictive stock can be set equal to zero assuming that the initial stock is zero. To obtain a measure of the addictive stock at time t^* (time $t-1$) for current and former smokers, recall its definition:

$$(7-6) \quad A^*(t) = C^*(t-1) + (1-\delta)A^*(t-1)$$

or:

$$(7-7) \quad A^*(t) = \sum_{i=0}^{t-1} (1-\delta)^{t-1-i} C^*(i) + A_0 .$$

Assuming the initial stock (A_0) is zero for all individuals, defining the depreciation term $(1-\delta)^{t-1}$ as $D(i)$ and recalling the definition of the covariance between the depreciation term and cigarette consumption, the following equation for the addictive stock at time t^* is obtained:

$$\begin{aligned}
 (7-8) \quad A^*(t) &= t^* \bar{CD} + t^* \text{Cov}[D(i), C^*(i)] \\
 &= \bar{C} \left[\frac{1 - (1-\delta)^t}{\delta} \right] + t^* \text{Cov}[D(i), C^*(i)]
 \end{aligned}$$

where a $\bar{}$ over the variables D and C indicates the mean of the depreciation term and cigarette consumption, respectively. Given observed lifetime smoking patterns, in particular the tendency to reach a plateau level of consumption around which cigarette consumption changes relatively little, there is good reason to assume that the covariance term above is equal to zero. Making this assumption results in an estimate of the addictive stock which depends on the number of years since the individual began smoking, mean cigarette consumption over that time, and the rate of depreciation on the addictive stock. Therefore, to obtain estimates of the addictive stock, data on average cigarette consumption during the period in which the individual smoked, the length of the period over which the individual smoked, and the rate of depreciation on the addictive stock are required. Assuming that the individual smoked continuously from the time they

began smoking until the present (for current smokers) or until the time they quit smoking (for former smokers), the information obtained in the survey can be used to determine the length of the period during which the individual smoked.

Several alternative methods could be followed, given the available data, to obtain an estimate of mean cigarette consumption during this period. A weighted average of the cigarette consumption data provided in the survey could be used as a proxy for mean consumption. One problem with this, however, is that a mechanistic relationship would then exist between the addictive stock and the dependent variable, $C^*(t)$, which may result in a spurious relationship between the two.

Alternatively, one could compare current and maximum consumption and construct a lifetime cigarette consumption path along the following lines. For current smokers: (1) if current consumption and maximum consumption are identical, then (i) assume that this consumption level was attained when smoking was initiated and maintained at this level since that time, or (ii) assume that consumption was increased linearly (or nonlinearly) from zero to the maximum, and that the maximum was attained at the midpoint of the smoking period where it was maintained until the present, or (iii) assume that consumption increased linearly (or nonlinearly) until the maximum was reached in the current period; or (2) if maximum consumption is greater than current consumption, then (i) assume that the maximum level

was attained when smoking was initiated after which it declined linearly to the present level, or (ii) assume that the maximum consumption was attained at the midpoint of the smoking period after increasing linearly (or nonlinearly), and then declined linearly (or nonlinearly) to the present level. For former smokers, similar assumptions could be made concerning the timing of maximum consumption and the path of consumption during the smoking period. These procedures were employed by Mullahy in his construction of the habit stock variables he used in the estimation of cigarette demand equations developed under the assumption of myopic behavior. Constructing the addictive stock variable in this manner, at least for current smokers, again builds in a relationship between current consumption and the stock which may result in a spurious finding.¹ Instead, the maximum cigarette consumption reported in the survey is used as a proxy for mean cigarette consumption. This is equivalent to assuming that the maximum consumption level was attained upon initiation of smoking and maintained throughout the smoking period (the entire period for former smokers and the period from the initiation of smoking until two years prior to NHANES2 for current smokers). Based on this assumption, an estimate of the addictive stock at time t^* , for current

¹ Similar procedures could have been followed to construct a measure of past consumption for use in the estimation of cigarette demand equations (7-1) and (7-2). Again, however, the constructed variable would have had some mechanistic relationship with the dependent variable, possible leading to spurious findings.

smokers, is:

$$(7-9) \quad \hat{A}(t) = C(\max) \left[\frac{1 - (1-\delta)^t}{\delta} \right]$$

where t is the number of years the individual has been smoking. The comparable equation for former smokers is given as:

$$(7-10) \quad \hat{A}(t) = (1-\delta)^k C(\max) \left[\frac{1 - (1-\delta)^{t-k}}{\delta} \right]$$

where t is the number of years since the individual began smoking and k is the number of years since the individual quit smoking.

Based on these assumptions, all that remains to construct the addictive stock variable is the rate of depreciation on that stock. Different rates of depreciation on the stock, ranging from ten percent to one hundred percent in increments of ten percent, will be assumed with the results presented below for several of these assumed rates, along with a discussion of the sensitivity of the results to changes in the assumed rate of depreciation. Finally, based on the discussion of both the health consequences of quitting smoking and the length of the withdrawal syndromes associated with smoking cessation, presented in Chapter Four, it appears that relatively high rates of depreciation should be

assumed. The withdrawal syndrome associated with smoking cessation appears to peak one to two days after quitting. Similarly, many of the detrimental effects of cigarette smoking on health, including its role in the development of cancers and cardiovascular disease, are reversed by quitting smoking. However, neither the craving for tobacco associated with withdrawal nor the damage to the respiratory system caused by cigarette smoking ever disappear completely, implying that the depreciation rate should be less than one hundred percent.

As with the measure of lagged consumption defined above, the measures of the addictive stock constructed in this manner will be subject to measurement error. Using instrumental variables for the addictive stock will alleviate this problem and consistent estimates will be obtained.

The means and standard deviations of the lagged consumption measures (the various measures of the addictive stock and $C^*(t-1)$) employed in the estimation of the cigarette demand equations are contained in Table 7-5, along with the means and standard deviations of the variables added to the data set to be described below.

The primary interest in this work is to examine the effects of changes in cigarette prices on cigarette consumption when cigarette smoking is modelled as a rational addictive behavior. Hence, the NHANES2 data must be augmented with cigarette prices.

To add cigarette prices to the data set, information on

the timing of the individual's interview and the individual's place of residence is required. The survey contains information on the PSU in which the individual resides. Similarly, for individuals who underwent the physical examination, the date of the examination is reported. Finally, for individuals who were interviewed but not examined, the timing of the interviews in the PSU in which the individual resides are known. Using this information, these persons were assumed to have been interviewed at the midpoint of the interview period for their PSU.

State level average cigarette prices are reported by the Tobacco Tax Council in their annual publication The Tax Burden on Tobacco, which also contains a significant amount of historical cigarette price, tax, and sales information. The cigarette prices reported by the Council are the average retail price of cigarettes in the states and are constructed as a weighted average of the prices of single-pack sales (over the counter sales and sales through vending machines are considered separately) and carton sales. The weights used in the construction are the national shares of each type of sale in overall cigarette sales. These prices are inclusive of Federal cigarette excise taxes and any state level sales tax applied to cigarettes. The prices are given as of November 1 each year. Additionally, the date of any state cigarette excise tax changes are reported. Based on this information, cigarette prices exclusive of cigarette excise taxes were computed for the first of each month as-

suming a linear rate of change in the year to year prices. The state excise tax rate as of the first of the month was then added back to the tax-exclusive monthly price. Finally, if any municipal or county cigarette excise taxes were imposed in the PSU in question, these were added to the price. If the tax was in effect throughout the county, the full tax was added to the state price. If the tax was in effect in only part of the county, then a weighted average of the local taxes was added to the state price where the weights were the fraction of the county population covered by each local tax, based on population figures from the 1970 Census of the Population. The local cigarette excise taxes were obtained from unpublished data contained in the Tobacco Tax Council's Municipal Tax Surveys, kindly made available by the Council. The result is a county specific monthly cigarette price series, where prices are as of the first of the month. Individuals were then assigned the monthly price closest to the date of their examination (or, for those who did not undergo an examination, the midpoint of the interview period in the PSU in which they reside).

The cigarette demand equations developed above include, in some cases, one lead and one lag of the cigarette price, in addition to the current price. Also, due to the endogeneity of past and future consumption measures and the potential measurement error associated with the past consumption variables, instrumental variables techniques were employed, where the set of instruments employed included several addi-

tional leads and lags of the price of cigarettes. Under the assumption that individuals did not change their county of residence, multiple leads and lags of the price of cigarettes were added to the data set.

In addition to the set of cigarette prices, cigarette excise tax rates were also added to the data set based on the same procedure. In some of the estimated equations, cigarette excise taxes were used as instruments for past and future consumption, in addition to prices, due to their high correlation with cigarette prices.

One major problem with these cigarette prices is that they may not accurately reflect the price the individual pays for cigarettes. The true price of cigarettes faced by the individual may, in fact, be endogenous, with the potential endogeneity of price arising from two basic sources. Heavier smokers have a greater incentive to purchase cigarettes at the lowest possible price. In all states, the price per pack of cigarettes is lowest when they are purchased by the carton, with the price of cigarettes purchased through vending machines being the highest. However, as argued by Lewit and Coate (1982), using the average price of cigarettes rather than the actual purchase price of cigarettes may be preferable since using purchase prices would lead to estimates which would be biased due to the reverse causality between the quantity smoked and price of cigarettes. Mullahy (1985) puts forth a similar argument in favor of using average market price rather than actual

price.

A second, less easily dealt with, source of potential endogeneity in the cigarette price variable comes from the differences in cigarette prices across counties and states, due primarily to the differences in the excise taxes imposed on cigarettes in each.² That is, smokers living in a high tax county have an incentive to purchase cigarettes in lower tax areas for consumption in their own, higher price area. This incentive will depend on the difference between the own-county price and any border-county prices, and the cost of transporting cigarettes from the low-price county to their own county. The greater the difference between own-price and border-price, the greater the incentive to purchase cigarettes in the border area. Similarly, the lower the cost of transporting the cigarettes from one county to another, the greater the incentive to do so. This cost will be lower the closer the low-price county is to the own county, and will also be lower for individuals who travel to this county regularly for other reasons, so that cigarette purchases are incidental (i.e. individuals who work in the

² Similar problems exist when attempting to estimate the demand for alcoholic beverages, another commodity whose price differs across states primarily due to the state excise taxes imposed on alcohol (see, for example, Wales (1968), Smith (1976), and Ornstein and Hanssens (1985)). A comparable problem exists in many other studies of the effects of policy on demand. One interesting example was the work by Grossman, Coate, and Arluck (1987), Saffer and Grossman (1987a and 1987b), and Coate and Grossman (forthcoming) analyzing the effects on youth alcohol use and motor vehicle mortality of changes in the minimum purchase age for alcoholic beverages.

lower price area).

In an attempt to control for the possibility of "butt"-legging, a second series of cigarette prices and excise taxes was added to the data set. This price series consists of the lowest price for cigarettes within a twenty-five mile radius of the county in which the individual resides (and similarly for the excise tax series). This price is equal to the own-price for those individuals residing in counties which had no lower priced counties within twenty-five miles of their own county. The choice of a twenty-five mile radius is somewhat arbitrary. However, twenty-five miles was chosen because it is likely that purchases within this distance of the individual's own county of residence are incidental to the trip. If purchases are incidental to the purpose of the trip, then the travel cost, for which no good data is available, is unimportant. At the time of the survey, forty-seven percent of those surveyed lived in counties within twenty-five miles of a lower priced county. Means and standard deviations of deflated own- and border-prices and taxes, along with smoking participation rates and mean cigarette consumption for individuals residing in counties with and without lower priced counties within twenty-five miles are presented in Table 7-4.

Ideally, both the own-price of cigarettes and the difference between own-price and border-price could be entered into the cigarette demand equations. As noted by Lewit, Coate, and Grossman (1981), this is the most flexible

Table 7-4

**Cigarette Prices, Excise Taxes, Participation and
Average Consumption, Own and Low Samples***

	Own Price	Low Price
Own Cigarette Price	0.275 (0.034)	0.298 (0.028)
Own Cigarette Tax	0.057 (0.023)	0.082 (0.024)
Low Cigarette Price	---	0.267 (0.038)
Low Cigarette Tax	---	0.054 (0.030)
Smoking Participation	33.9%	35.9%
Average Cigarette Consumption	6.924	7.498
Sample Size	7538	6767

*All cigarette prices and taxes are deflated by a time and state specific price index, to be described in the text. The own price sample refers to the sample for which there is no lower priced county within twenty-five miles of the own county. The low price sample refers to the sample of individuals residing in a county which has a lower price county within twenty-five miles of the own county.

specification. Using a price/price-difference specification, however, results in the inclusion of two price variables for each lead and lag, in addition to the two variables capturing current prices. In the demand equations above, this would amount to including from two to six variables for price. Since the price and price-difference variables are highly correlated, severe multicollinearity problems are likely to arise.

Alternatively, one measure of price could be used. One possibility is to include only the own-price of cigarettes.

However, this price is likely to overstate, for at least a large part of the sample, the price of cigarette the individual faces. Similarly, only the border-price could be entered. This procedure has the opposite effect of understating, for at least part of the sample, the price of cigarettes the individual faces. Either of these methods is likely to result in biased estimates for prices, and, hence, the price elasticities of demand.

One method which captures to some extent this problem without exacerbating the multicollinearity problem already present in the data is to use a weighted average of own-price and border-price. The rationale for this is similar to the rationale for using the weighted average of the various types of cigarette sales. In this work, the weights are arbitrarily set equal to one-half.

One final point concerns the appropriate deflator for prices, taxes, and income. All prices and taxes are deflated by the appropriate monthly national Consumer Price Index taken from the Department of Labor's Monthly Labor Review. Annual family income is deflated by the annual national Consumer Price Index for the year in which the individual was surveyed.

All prices, taxes, and income are then deflated by a geographical cost-of-living index constructed by Mullahy (1985) for the year 1977. As Cebula (1983) notes, there are significant differences in the price of many goods across states, due primarily to population, population density, and

per capita income.

The price index employed is constructed using data taken from the U.S. Department of Commerce according to the procedure outlined by Fuchs, Michael, and Scott (1979) in an unpublished National Bureau of Economic Research Working Paper. The assumption is made that the relative price structure implied by the index for 1977 is representative of the period covered by the survey, as well as several years prior to and following the survey.

The Fuchs-Michael-Scott index is constructed for each of the fifty states and Washington D.C. using national and state specific data on personal income and retail sales. The index is constructed under the assumption that there are two types of goods: those with substantial variation across states, such as housing, food, and services prices, and those with insignificant cross-state price variation, including durables, clothing, and drugs. Creating a Laspeyres price index for two goods (a composite of those goods with significant cross-state price variation and a composite of those with almost no cross-state price variation), and making some simplifying assumptions, Fuchs, Michael, and Scott derive their state-level cost-of-living index.

Finally, as stated above, a secondary interest in this research is to examine the impact of the state laws restricting cigarette smoking in public places. The laws of interest here are those defined as "comprehensive clean

indoor air laws" by the Public Health Service. These laws were passed expressly to discourage cigarette smoking, unlike earlier restrictions on public smoking which were passed due to fire safety concerns. To measure the impact of these laws, a dichotomous variable indicating the presence of the law in the state in which the individual resides was added to the data set. These data were taken from the Public Health Service's annual publication State Legislation on Smoking and Health.

The definitions, means, and standard deviations of the variables added to the NHANES2 data set as well as those constructed using the data collected in NHANES2 are presented in Table 7-5.

Table 7-5

Definitions, Means and Standard Deviations of Variables
Added to or Constructed from the NHANES2 Data"

Variable	Definition, Mean, and Standard Deviation
State Cost-of-Living Index	Fuchs-Michael-Scott state cost-of-living index. $\mu=1.008$, $\sigma=0.116$.
Clean Indoor Air Law	Dichotomous variable equal to one if the individual resides in a state with a "comprehensive clean indoor air law" in effect in the year in which the individual was surveyed, equal to zero otherwise. $\mu=0.315$, $\sigma=0.464$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Real Own-Price of Cigarettes, $P_c(t)$	Price, in dollars, of a pack of twenty cigarettes in the county in which the individual resides at the time of the survey, inclusive of Federal, state, and local excise taxes on cigarettes and state level sales taxes applied to cigarettes, deflated by the National Consumer Price Index (1967=1) and the Fuchs-Michael-Scott state cost-of-living index. $\mu=0.286$, $\sigma=0.033$.
Real Own-Price of Cigarettes Lagged Once, $P_c(t-1)$	Real Own-Price of Cigarettes one year prior to the survey. $\mu=0.292$, $\sigma=0.032$.
Real Own-Price of Cigarettes Lagged Twice, $P_c(t-2)$	Real Own-Price of Cigarettes two years prior to the survey. $\mu=0.295$, $\sigma=0.034$.
Real Own-Price of Cigarettes, Three Lags, $P_c(t-3)$	Real Own-Price of Cigarettes three years prior to the survey. $\mu=0.300$, $\sigma=0.038$.
Real Own-Price of Cigarettes, Four Lags, $P_c(t-4)$	Real Own-Price of Cigarettes four years prior to the survey. $\mu=0.310$, $\sigma=0.042$.
Real Own-Price of Cigarettes, Five Lags, $P_c(t-5)$	Real Own-Price of Cigarettes five years prior to the survey. $\mu=0.318$, $\sigma=0.044$.
Real Own-Price of Cigarettes, One Lead, $P_c(t+1)$	Real Own-Price of Cigarettes one year following the survey. $\mu=0.276$, $\sigma=0.035$.
Real Own-Price of Cigarettes, Two Leads, $P_c(t+2)$	Real Own-Price of Cigarettes two years following the survey. $\mu=0.265$, $\sigma=0.031$.
Real Own-Price of Cigarettes, Three Leads, $P_c(t+3)$	Real Own-Price of Cigarettes three years following the survey. $\mu=0.262$, $\sigma=0.023$.
Real Own-Price of Cigarettes, Four Leads, $P_c(t+4)$	Real Own-Price of Cigarettes four years following the survey. $\mu=0.271$, $\sigma=0.027$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Real Own-Price of Cigarettes, Five Leads, $P_o(t+5)$	Real Own-Price of Cigarettes five years following the survey. $\mu=0.285$, $\sigma=0.031$.
Real Border-Price of Cigarettes, $P_o(t)$	Lowest price, in dollars, of a pack of twenty cigarettes within twenty-five miles of the county in which the individual resides at the time of the survey, inclusive of Federal, state, and local excise taxes on cigarettes and state level sales taxes applied to cigarettes, deflated by the National Consumer Price Index (1967=1) and the Fuchs-Michael-Scott state cost-of-living index for the state in which the individual resides. $\mu=0.271$, $\sigma=0.036$.
Real Border-Price of Cigarettes Lagged Once, $P_o(t-1)$	Real Border-Price of Cigarettes one year prior to the survey. $\mu=0.277$, $\sigma=0.035$.
Real Border-Price of Cigarettes Lagged Twice, $P_o(t-2)$	Real Border-Price of Cigarettes two years prior to the survey. $\mu=0.278$, $\sigma=0.036$.
Real Border-Price of Cigarettes, Three Lags, $P_o(t-3)$	Real Border-Price of Cigarettes three years prior to the survey. $\mu=0.282$, $\sigma=0.040$.
Real Border-Price of Cigarettes, Four Lags, $P_o(t-4)$	Real Border-Price of Cigarettes four years prior to the survey. $\mu=0.290$, $\sigma=0.043$.
Real Border-Price of Cigarettes, Five Lags, $P_o(t-5)$	Real Border-Price of Cigarettes five years prior to the survey. $\mu=0.298$, $\sigma=0.044$.
Real Border-Price of Cigarettes, One Lead, $P_o(t+1)$	Real Border-Price of Cigarettes one year following the survey. $\mu=0.263$, $\sigma=0.035$.
Real Border-Price of Cigarettes, Two Leads, $P_o(t+2)$	Real Border-Price of Cigarettes two years following the survey. $\mu=0.253$, $\sigma=0.032$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Real Border-Price of Cigarettes, Three Leads, $P_c(t+3)$	Real Border-Price of Cigarettes three years following the survey. $\mu=0.250$, $\sigma=0.024$.
Real Border-Price of Cigarettes, Four Leads, $P_c(t+4)$	Real Border-Price of Cigarettes four years following the survey. $\mu=0.259$, $\sigma=0.029$.
Real Border-Price of Cigarettes, Five Leads, $P_c(t+5)$	Real Border-Price of Cigarettes five years following the survey. $\mu=0.274$, $\sigma=0.034$.
Real Own-Tax on Cigarettes, $T_c(t)$	State and local cigarette excise tax, in dollars, on a pack of twenty cigarettes in the county in which the individual resides at the time of the survey, deflated by the National Consumer Price Index (1967=1) and the Fuchs-Michael-Scott state cost-of-living index. $\mu=0.069$, $\sigma=0.026$.
Real Own-Tax on Cigarettes Lagged Once, $T_c(t-1)$	Real Own-Tax on Cigarettes one year prior to the survey. $\mu=0.074$, $\sigma=0.028$.
Real Own-Tax on Cigarettes Lagged Twice, $T_c(t-2)$	Real Own-Tax on Cigarettes two years prior to the survey. $\mu=0.078$, $\sigma=0.030$.
Real Own-Tax on Cigarettes, Three Lags, $T_c(t-3)$	Real Own-Tax on Cigarettes three years prior to the survey. $\mu=0.084$, $\sigma=0.032$.
Real Own-Tax on Cigarettes, Four Lags, $T_c(t-4)$	Real Own-Tax on Cigarettes four years prior to the survey. $\mu=0.090$, $\sigma=0.036$.
Real Own-Tax on Cigarettes, Five Lags, $T_c(t-5)$	Real Own-Tax on Cigarettes five years prior to the survey. $\mu=0.094$, $\sigma=0.037$.
Real Own-Tax on Cigarettes, One Lead, $T_c(t+1)$	Real Own-Tax on Cigarettes one year following the survey. $\mu=0.063$, $\sigma=0.025$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Real Own-Tax on Cigarettes, Two Leads, $T_c(t+2)$	Real Own-Tax on Cigarettes two years following the survey. $\mu=0.057$, $\sigma=0.023$.
Real Own-Tax on Cigarettes, Three Leads, $T_c(t+3)$	Real Own-Tax on Cigarettes three years following the survey. $\mu=0.052$, $\sigma=0.021$.
Real Own-Tax on Cigarettes, Four Leads, $T_c(t+4)$	Real Own-Tax on Cigarettes four years following the survey. $\mu=0.052$, $\sigma=0.020$.
Real Own-Tax on Cigarettes, Five Leads, $T_c(t+5)$	Real Own-Tax on Cigarettes five years following the survey. $\mu=0.051$, $\sigma=0.020$.
Real Border-Tax on Cigarettes, $T_c(t)$	Lowest county cigarette excise tax, in dollars, on a pack of twenty cigarettes within twenty-five miles of the county in which the individual resides at the time of the survey, deflated by the National Consumer Price Index (1967=1) and the Fuchs-Michael-Scott state cost-of-living index for the state in which the individual resides. $\mu=0.055$, $\sigma=0.026$.
Real Border-Tax on Cigarettes Lagged Once, $T_c(t-1)$	Real Border-Tax on Cigarettes one year prior to the survey. $\mu=0.060$, $\sigma=0.028$.
Real Border-Tax on Cigarettes Lagged Twice, $T_c(t-2)$	Real Border-Tax on Cigarettes two years prior to the survey. $\mu=0.063$, $\sigma=0.031$.
Real Border-Tax on Cigarettes, Three Lags, $T_c(t-3)$	Real Border-Tax on Cigarettes three years prior to the survey. $\mu=0.067$, $\sigma=0.032$.
Real Border-Tax on Cigarettes, Four Lags, $T_c(t-4)$	Real Border-Tax on Cigarettes four years prior to the survey. $\mu=0.072$, $\sigma=0.035$.
Real Border-Tax on Cigarettes, Five Lags, $T_c(t-5)$	Real Border-Tax on Cigarettes five years prior to the survey. $\mu=0.076$, $\sigma=0.036$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Real Border-Tax on Cigarettes, One Lead, $T_c(t+1)$	Real Border-Tax on Cigarettes one year following the survey. $\mu=0.052$, $\sigma=0.025$.
Real Border-Tax on Cigarettes, Two Leads, $T_c(t+2)$	Real Border-Tax on Cigarettes two years following the survey. $\mu=0.047$, $\sigma=0.023$.
Real Border-Tax on Cigarettes, Three Leads, $T_c(t+3)$	Real Border-Tax on Cigarettes three years following the survey. $\mu=0.043$, $\sigma=0.021$.
Real Border-Tax on Cigarettes, Four Leads, $T_c(t+4)$	Real Border-Tax on Cigarettes four years following the survey. $\mu=0.042$, $\sigma=0.020$.
Real Border-Tax on Cigarettes, Five Leads, $T_c(t+5)$	Real Border-Tax on Cigarettes five years following the survey. $\mu=0.041$, $\sigma=0.020$.
Weighted Real Current Cigarette Price, $P_c(t)$	Equally weighted average of current own-price and current border-price. $\mu=0.279$, $\sigma=0.040$.
Weighted Real Price of Cigarettes, Lagged Once, $P_c(t-1)$	Weighted Real Price of Cigarettes one year prior to the survey. $\mu=0.285$, $\sigma=0.038$.
Weighted Real Price of Cigarettes, Lagged Twice, $P_c(t-2)$	Weighted Real Price of Cigarettes two years prior to the survey. $\mu=0.286$, $\sigma=0.038$.
Weighted Real Price of Cigarettes, Three Lags, $P_c(t-3)$	Weighted Real Price of Cigarettes three years prior to the survey. $\mu=0.291$, $\sigma=0.043$.
Weighted Real Price of Cigarettes, Four Lags, $P_c(t-4)$	Weighted Real Price of Cigarettes four years prior to the survey. $\mu=0.300$, $\sigma=0.046$.
Weighted Real Price of Cigarettes, Five Lags, $P_c(t-5)$	Weighted Real Price of Cigarettes five years prior to the survey. $\mu=0.308$, $\sigma=0.048$.
Weighted Real Price of Cigarettes, One Lead, $P_c(t+1)$	Weighted Real Price of Cigarettes one year following the survey. $\mu=0.270$, $\sigma=0.042$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Weighted Real Price of Cigarettes, Two Leads, $P_c(t+2)$	Weighted Real Price of Cigarettes two years following the survey. $\mu=0.260$, $\sigma=0.041$.
Weighted Real Price of Cigarettes, Three Leads, $P_c(t+3)$	Weighted Real Price of Cigarettes three years following the survey. $\mu=0.256$, $\sigma=0.033$.
Weighted Real Price of Cigarettes, Four Leads, $P_c(t+4)$	Weighted Real Price of Cigarettes four years following the survey. $\mu=0.265$, $\sigma=0.033$.
Weighted Real Price of Cigarettes, Five Leads, $P_c(t+5)$	Weighted Real Price of Cigarettes five years following the survey. $\mu=0.280$, $\sigma=0.034$.
Weighted Real Current Cigarette Tax, $T_c(t)$	Equally weighted average of current own-tax and current border-tax. $\mu=0.062$, $\sigma=0.025$.
Weighted Real Tax on Cigarettes, Lagged Once, $T_c(t-1)$	Weighted Real Tax on Cigarettes one year prior to the survey. $\mu=0.067$, $\sigma=0.026$.
Weighted Real Tax on Cigarettes, Lagged Twice, $T_c(t-2)$	Weighted Real Tax on Cigarettes two years prior to the survey. $\mu=0.070$, $\sigma=0.028$.
Weighted Real Tax on Cigarettes, Three Lags, $T_c(t-3)$	Weighted Real Tax on Cigarettes three years prior to the survey. $\mu=0.075$, $\sigma=0.030$.
Weighted Real Tax on Cigarettes, Four Lags, $T_c(t-4)$	Weighted Real Tax on Cigarettes four years prior to the survey. $\mu=0.081$, $\sigma=0.033$.
Weighted Real Tax on Cigarettes, Five Lags, $T_c(t-5)$	Weighted Real Tax on Cigarettes five years prior to the survey. $\mu=0.085$, $\sigma=0.033$.
Weighted Real Tax on Cigarettes, One Lead, $T_c(t+1)$	Weighted Real Tax on Cigarettes one year following the survey. $\mu=0.057$, $\sigma=0.023$.
Weighted Real Tax on Cigarettes, Two Leads, $T_c(t+2)$	Weighted Real Tax on Cigarettes two years following the survey. $\mu=0.052$, $\sigma=0.023$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Weighted Real Tax on Cigarettes, Three Leads, $T_c(t+3)$	Weighted Real Tax on Cigarettes three years following the survey. $\mu=0.047$, $\sigma=0.020$.
Weighted Real Tax on Cigarettes, Four Leads, $T_c(t+4)$	Weighted Real Tax on Cigarettes four years following the survey. $\mu=0.047$, $\sigma=0.019$.
Weighted Real Tax on Cigarettes, Five Leads, $T_c(t+5)$	Weighted Real Tax on Cigarettes five years following the survey. $\mu=0.046$, $\sigma=0.019$.
"Lagged" Cigarette Consumption, $C^*(t-1)$	Number of cigarettes the individual was smoking each day, on average, two years prior to their interview. $\mu=9.979$, $\sigma=15.866$.
Addictive Stock, $A^*(t)$, $\delta=10\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of ten percent. $\mu=94.342$, $\sigma=136.956$.
Addictive Stock, $A^*(t)$, $\delta=20\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of twenty percent. $\mu=50.262$, $\sigma=74.502$.
Addictive Stock, $A^*(t)$, $\delta=30\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of thirty percent. $\mu=33.908$, $\sigma=51.113$.
Addictive Stock, $A^*(t)$, $\delta=40\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of forty percent. $\mu=25.506$, $\sigma=38.875$.

Table 7-5 (continued)

Variable	Definition, Mean, and Standard Deviation
Addictive Stock, $A^*(t)$, $\delta=50\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of fifty percent. $\mu=20.411$, $\sigma=31.355$.
Addictive Stock, $A^*(t)$, $\delta=60\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of sixty percent. $\mu=16.999$, $\sigma=26.271$.
Addictive Stock, $A^*(t)$, $\delta=70\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of seventy percent. $\mu=14.556$, $\sigma=22.608$.
Addictive Stock, $A^*(t)$, $\delta=80\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of eighty percent. $\mu=12.723$, $\sigma=19.846$.
Addictive Stock, $A^*(t)$, $\delta=90\%$	Depreciated sum of past cigarette consumption one year prior to the interview, calculated with an assumed rate of depreciation of ninety percent. $\mu=11.297$, $\sigma=17.691$.

*The sample means and standard deviations are for the 14,305 individuals ages eighteen years to seventy four years drawn from the Second National Health and Nutrition Examination Survey. See the text for details on the construction of each of these variables and, for those added to the data set, the sources of the variables.

Chapter Eight

Results from the Basic Models

This chapter contains the results from the estimation of the demand equations derived in Chapter 6. Before presenting these estimates, the results from demand equations estimated under the assumption of non-addictive behavior are presented. The price elasticities of demand for each of the demand equations estimated are then presented.

The results obtained for the demand equations estimated under the assumption that cigarette smoking is a non-addictive behavior are presented in Tables 8-1 through 8-6. These results are comparable to much of the work that has been done by economists in the past on the demand for cigarettes and offer an interesting comparison to the results obtained for equations estimated under the competing hypothesis that cigarette smoking is an addictive behavior. Consumption in each of these equations is assumed to be a function of the current price of cigarettes, variables indicating the individual's sex, race and ethnicity, age, income, and educational attainment.

Cigarette consumption at time t , in every model, addictive or non-addictive, is expected to be negatively related to the price of cigarettes in time t . For this reason, cigarette consumption is expected to be positively related to the variable indicating American Natives. Most of the individuals for whom this variable takes on a value

of one will be American Indians. Because cigarette sales on Indian reservations are tax exempt, those individuals residing on Indian reservations will face a lower price for cigarettes than individuals residing elsewhere. Unfortunately, no data was collected on whether or not individuals reside on reservations. This variable, therefore, is an imperfect attempt to capture the possibility that Indians face lower prices for cigarettes and, hence, may smoke greater quantities.

The variable indicating the individual's sex takes on a value of one for males and zero for females. This variable is also expected to be positively related to consumption as males have historically had both greater smoking participation rates and greater cigarette consumption than females.

There is no a priori expectation on the sign of the coefficients on the variables capturing race. Blacks have historically had greater smoking participation rates than whites, but black smokers have smoked less on average than their white counterparts, leaving the overall impact ambiguous.

Similarly, there were no expectations on the directions of the relationships between age and smoking, captured by variables indicating the individual's age and age squared, and income and smoking. Some, as discussed in Chapter Three, have found that cigarette smoking is an inferior behavior, in an economic sense, while others have found a positive relationship between income and cigarette consump-

tion.

Educational attainment is captured in two alternative manners. The first model presented in each table contains a variable indicating the number of years of formal education each individual had completed. Smoking is expected to be negatively related to this measure of education. Alternatively, the second model presented in each table includes a set of dichotomous variables indicating different levels of educational achievement - no formal education, less than a grade school education, a grade school education, some high school education, and some education beyond high school, with the omitted category being high school graduates with no education beyond high school. This set of variables is used to allow for the possibility of differential effects in education, primarily due to peer pressure. Most individuals who take up cigarette smoking do so during high school, largely in response to peer pressure. Individuals who are either never exposed to this pressure or exposed to it for a shorter time may, therefore, be less likely to smoke than others.

These two models are then reestimated including variables indicating the individual's daily activity and the amount of exercise provided by the activities the individual participates in for recreation, presented as Models 3 and 4 in the tables below. These are included in an attempt to incorporate, at least to some degree, the individual's attitude towards health and healthy behaviors. Cigarette

smoking is expected to be negatively related to the variable indicating that the individual's recreational activities provide much or moderate exercise. However, there is no a priori expectation concerning the relationship between smoking and daily activity. Individuals who describe their average day as very or moderately active may be more health conscious than their inactive counterparts and would, therefore, smoke less. On the other hand, this variable may be indicative of the stress the individual is under each day and might, therefore, have a positive effect on consumption.

Tables 8-1, 8-2, and 8-3 contain the results from the estimation of demand equations where the dependent variable is current cigarette consumption, as reported in the survey, while Tables 8-4, 8-5, and 8-6 contain equations with lagged consumption, as reported in the survey, as the dependent variable. This second set of equations is presented in order to offer a direct comparison with the equations estimated under the assumption of addictive behavior which, due to the nature of the data, use lagged consumption as the dependent variable. Tables 8-1 and 8-4 contain estimates using a weighted average of the own-county and border-county cigarette prices, as described in Chapter 7. Each of the equations was also estimated using own-price and border-price, with the results from these equations presented in Tables 8-2 and 8-5 and Tables 8-3 and 8-6, respectively.

As expected, cigarette smoking at time t is inversely

Table 8-1*
OLS Estimates of Non-Addictive Demand Equation
Current Cigarette Consumption, Weighted Price

Variable	(1-1)	(1-2)	(1-3)	(1-4)
Current Cigarette Price, Weighted	-0.832 (-0.33)	-0.311 (-0.12)	-0.694 (-0.28)	-0.218 (-0.09)
Age	0.739 (18.60)	0.719 (18.09)	0.715 (17.91)	0.693 (17.35)
Age Squared	-0.009 (-21.14)	-0.009 (-20.47)	-0.009 (-20.64)	-0.009 (-19.96)
Sex	3.255 (16.32)	3.380 (16.96)	3.355 (16.71)	3.487 (17.39)
Black	-2.411 (-7.43)	-2.353 (-7.30)	-2.464 (-7.61)	-2.418 (-7.51)
Other Races	-3.630 (-4.81)	-3.181 (-4.23)	-3.763 (-4.99)	-3.309 (-4.40)
American Natives	2.708 (3.04)	2.634 (2.97)	2.789 (3.13)	2.721 (3.07)
Family Income	-0.009 (-3.45)	-0.009 (-3.63)	-0.008 (-3.23)	-0.008 (-3.35)
Number of Years of Formal Education	-0.249 (-7.62)	----	-0.220 (-6.68)	----
No Formal Education	----	-1.731 (-1.60)	----	-2.192 (-2.03)
Less than Grade School Education	----	-0.315 (-0.68)	----	-0.651 (-1.40)
Grade School Education	----	-0.617 (-1.94)	----	-0.858 (-2.69)
Some High School Education	----	1.702 (4.66)	----	1.620 (4.45)
College	----	-2.695 (-11.02)	----	-2.684 (-10.98)
Active	----	----	-1.065 (-3.61)	-1.289 (-4.38)
Exercise	----	----	-1.102 (-4.96)	-1.133 (-5.12)
Intercept	-1.973 (-1.73)	-3.944 (-3.68)	-0.161 (-0.14)	-1.508 (-1.35)
R ²	0.069	0.077	0.072	0.081
F	117.08	91.34	100.77	83.64

* Asymptotic t-ratios are shown in parentheses. The critical asymptotic t-ratios are: 1.28 for a one-tailed test and 1.64 for a two-tailed test at the ten percent level; 1.64 for a one-tailed test and 1.96 for a two-tailed test at the five percent level; and 2.33 for a one-tailed test and 2.58 for a two tailed test at the one percent level. The F statistic for each equation is significant at the one percent level.

Table 8-2*
OLS Estimates of Non-Addictive Demand Equation
Current Cigarette Consumption, Own Price

Variable	(2-1)	(2-2)	(2-3)	(2-4)
Current Cigarette Price, Own	-0.299 (-0.18)	0.352 (0.14)	-0.133 (-0.05)	0.480 (0.19)
Age	0.740 (18.61)	0.719 (18.07)	0.715 (17.92)	0.694 (17.36)
Age Squared	-0.009 (-21.16)	-0.009 (-20.49)	-0.009 (-20.66)	-0.009 (-19.97)
Sex	3.256 (16.32)	3.380 (16.96)	3.355 (16.72)	3.488 (17.39)
Black	-2.407 (-7.43)	-2.350 (-7.30)	-2.460 (-7.60)	-2.415 (-7.51)
Other Races	-3.641 (-4.83)	-3.192 (-4.24)	-3.774 (-5.01)	-3.320 (-4.42)
American Natives	2.710 (3.04)	2.636 (2.97)	2.791 (3.14)	2.722 (3.07)
Family Income	-0.009 (-3.48)	-0.009 (-3.66)	-0.008 (-3.26)	-0.008 (-3.39)
Number of Years of Formal Education	-0.249 (-7.60)	----	-0.220 (-6.66)	----
No Formal Education	----	-1.740 (-1.61)	----	-2.202 (-2.04)
Less than Grade School Education	----	-0.314 (-0.68)	----	-0.650 (-1.40)
Grade School Education	----	-0.619 (-1.95)	----	-0.860 (-2.70)
Some High School Education	----	1.701 (4.66)	----	1.619 (4.44)
College	----	-2.694 (-11.02)	----	-2.683 (-10.98)
Active	----	----	-1.065 (-3.61)	-1.289 (-4.38)
Exercise	----	----	-1.102 (-4.96)	-1.134 (-5.13)
Intercept	-2.124 (-1.83)	-4.132 (-3.83)	-0.321 (-0.27)	-1.706 (-1.52)
R ²	0.069	0.077	0.072	0.081
F	117.07	91.34	100.76	83.64

* See note to Table 8-1.

Table 8-3*
OLS Estimates of Non-Addictive Demand Equation
Current Cigarette Consumption, Border Price

Variable	(3-1)	(3-2)	(3-3)	(3-4)
Current Cigarette	-1.176	-0.835	-1.080	-0.784
Price, Border	(-0.50)	(-0.36)	(-0.46)	(-0.34)
Age	0.739	0.719	0.715	0.693
	(18.59)	(18.04)	(17.89)	(17.33)
Age Squared	-0.009	-0.009	-0.009	-0.009
	(-21.13)	(-20.46)	(-20.63)	(-19.94)
Sex	3.255	3.380	3.355	3.487
	(16.32)	(16.96)	(16.71)	(17.39)
Black	-2.417	-2.359	-2.470	-2.424
	(-7.44)	(-7.31)	(-7.62)	(-7.52)
Other Races	-3.619	-3.169	-3.752	-3.296
	(-4.79)	(-4.21)	(-4.98)	(-4.38)
American Natives	2.704	2.631	2.785	2.718
	(3.03)	(2.93)	(3.13)	(3.07)
Family Income	-0.009	-0.009	-0.008	-0.008
	(-3.44)	(-3.61)	(-3.22)	(-3.33)
Number of Years of	-0.249	----	-0.220	----
Formal Education	(-7.61)	----	(-6.68)	----
No Formal Education	----	-1.726	----	-2.186
	----	(-1.60)	----	(-2.03)
Less than Grade	----	-0.318	----	-0.654
School Education	----	(-0.69)	----	(-1.41)
Grade School	----	-0.618	----	-0.859
Education	----	(-1.94)	----	(-2.69)
Some High School	----	1.701	----	1.619
Education	----	(4.66)	----	(4.44)
College	----	-2.694	----	-2.683
	----	(-11.02)	----	(-10.98)
Active	----	----	-1.066	-1.290
	----	----	(-3.62)	(-4.38)
Exercise	----	----	-1.101	-1.132
	----	----	(-4.96)	(-5.12)
Intercept	-1.883	-3.800	-0.059	-1.352
	(-1.71)	(-3.69)	(-0.05)	(-1.25)
R ²	0.069	0.077	0.072	0.081
F	117.10	91.35	100.78	83.65

* See note to Table 8-1.

Table 8-4*
OLS Estimates of Non-Addictive Demand Equation
Lagged Cigarette Consumption, Weighted Price

Variable	(4-1)	(4-2)	(4-3)	(4-4)
Lagged Cigarette Price, Weighted	-1.782 (-0.64)	-1.206 (-0.43)	-1.613 (-0.58)	-1.080 (-0.39)
Age	0.773 (18.60)	0.753 (18.10)	0.746 (17.89)	0.726 (17.37)
Age Squared	-0.010 (-20.99)	-0.009 (-20.34)	-0.009 (-20.47)	-0.009 (-19.81)
Sex	3.741 (17.57)	3.868 (18.17)	3.850 (17.97)	3.986 (18.61)
Black	-2.849 (-8.23)	-2.794 (-8.12)	-2.906 (-8.41)	-2.865 (-8.34)
Other Races	-3.949 (-4.91)	-3.512 (-4.37)	-4.092 (-5.10)	-3.649 (-4.55)
American Natives	3.128 (3.29)	3.060 (3.23)	3.217 (3.39)	3.154 (3.33)
Family Income	-0.011 (-4.28)	-0.012 (-4.53)	-0.011 (-4.05)	-0.011 (-4.25)
Number of Years of Formal Education	-0.250 (-7.17)	----	-0.218 (-6.21)	----
No Formal Education	----	-1.010 (-0.88)	----	-1.512 (-1.31)
Less than Grade School Education	----	-0.121 (-0.24)	----	-0.488 (-0.98)
Grade School Education	----	-0.873 (-2.57)	----	-1.135 (-3.33)
Some High School Education	----	1.655 (4.24)	----	1.565 (4.02)
College	----	-2.680 (-10.26)	----	-2.667 (-10.22)
Active	----	----	-1.164 (-3.70)	-1.383 (-4.40)
Exercise	----	----	-1.210 (-5.10)	-1.249 (-5.29)
Intercept	-1.350 (-1.10)	-3.377 (-2.94)	0.602 (0.50)	-0.763 (-0.63)
R ²	0.069	0.075	0.072	0.080
F	116.85	89.69	100.86	82.38

* See note to Table 8-1.

Table 8-5*
 OLS Estimates of Non-Addictive Demand Equation
 Lagged Cigarette Consumption, Own Price

Variable	(5-1)	(5-2)	(5-3)	(5-4)
Lagged Cigarette	-1.410	-0.657	-1.217	-0.502
Price, Own	(-0.51)	(-0.24)	(-0.44)	(-0.18)
Age	0.773	0.754	0.746	0.726
	(18.62)	(18.11)	(17.91)	(17.39)
Age Squared	-0.010	-0.009	-0.010	-0.009
	(-21.00)	(-20.35)	(-20.49)	(-19.83)
Sex	3.741	3.868	3.851	3.989
	(17.57)	(18.17)	(17.91)	(18.62)
Black	-2.842	-2.789	-2.900	-2.860
	(-8.22)	(-8.11)	(-8.40)	(-8.33)
Other Races	-3.952	-3.510	-4.094	-3.646
	(-4.91)	(-4.37)	(-5.10)	(-4.55)
American Natives	3.132	3.062	3.220	3.155
	(3.29)	(3.23)	(3.39)	(3.33)
Family Income	-0.011	-0.012	-0.011	-0.011
	(-4.29)	(-4.55)	(-4.07)	(-4.27)
Number of Years of Formal Education	-0.251	----	-0.218	----
	(-7.17)	----	(-6.21)	----
No Formal Education	----	-1.016	----	-1.519
	----	(-0.88)	----	(-1.32)
Less than Grade School Education	----	-0.118	----	-0.485
	----	(-0.24)	----	(-0.98)
Grade School Education	----	-0.872	----	-1.135
	----	(-2.56)	----	(-3.33)
Some High School Education	----	1.655	----	1.565
	----	(4.24)	----	(4.02)
College	----	-2.681	----	-2.667
	----	(-10.26)	----	(-10.22)
Active	----	----	-1.164	-1.383
	----	----	(-3.70)	(-4.40)
Exercise	----	----	-1.211	-1.250
	----	----	(-5.11)	(-5.29)
Intercept	-1.447	-3.532	0.496	-0.927
	(-1.17)	(-3.05)	(0.39)	(-0.77)
R ²	0.069	0.075	0.072	0.080
F	116.83	89.68	100.84	82.37

* See note to Table 8-1.

Table 8-6*
OLS Estimates of Non-Addictive Demand Equation
Lagged Cigarette Consumption, Border Price

Variable	(6-1)	(6-2)	(6-3)	(6-4)
Lagged Cigarette Price, Border	-1.817 (-0.71)	-1.480 (-0.58)	-1.694 (-0.66)	-1.400 (-0.55)
Age	0.772 (18.59)	0.723 (18.09)	0.746 (17.88)	0.725 (17.36)
Age Squared	-0.010 (-20.98)	-0.009 (-20.32)	-0.009 (-20.46)	-0.009 (-19.80)
Sex	3.741 (17.57)	3.868 (18.17)	3.851 (17.97)	3.986 (18.62)
Black	-2.854 (-8.23)	-2.800 (-8.12)	-2.912 (-8.41)	-2.871 (-8.34)
Other Races	-3.942 (-4.90)	-3.508 (-4.37)	-4.089 (-5.09)	-3.646 (-4.55)
American Natives	3.124 (3.28)	3.056 (3.22)	3.213 (3.38)	3.150 (3.33)
Family Income	-0.011 (-4.29)	-0.012 (-4.53)	-0.011 (-4.06)	-0.011 (-4.25)
Number of Years of Formal Education	-0.250 (-7.16)	----	-0.218 (-6.20)	----
No Formal Education	----	-1.009 (-0.88)	----	-1.510 (-1.31)
Less than Grade School Education	----	-0.127 (-0.26)	----	-0.493 (-0.99)
Grade School Education	----	-0.876 (-2.58)	----	-1.138 (-3.34)
Some High School Education	----	1.653 (4.24)	----	1.564 (4.02)
College	----	-2.679 (-10.26)	----	-2.666 (-10.22)
Active	----	----	-1.165 (-3.70)	-1.384 (-4.40)
Exercise	----	----	-1.210 (-5.10)	-1.249 (-5.29)
Intercept	-1.356 (-1.16)	-3.304 (-3.01)	0.612 (0.51)	-0.677 (-0.59)
R ²	0.069	0.075	0.072	0.080
F	116.86	89.70	100.87	82.39

* See note to Table 8-1.

related to the price of cigarettes at that time, albeit never significantly, with the exception of the equations estimated for current consumption using the own-price of cigarettes and the set of variables indicating education, where an insignificant positive effect was found. Comparing the magnitudes of the estimated coefficients on price, one sees that in both sets of equations, the coefficients on price when using the border-price are largest in absolute value, with the coefficients on price when using the own-price the smallest. As discussed in the previous chapter, using the own-price of cigarettes is likely to overstate, for at least part of the sample, the true price the individual faces for cigarettes, while the border-price is likely to understate, for part of the sample, the true price of cigarettes. The weighted average of the two should be less subject to misrepresenting the price the individual faces for cigarettes, and the estimates obtained for it, which lie between those obtained for the others, should be more reliable. Finally, the estimated coefficients on the other variables included in the demand equations appear to be unaffected by the choice of price.

As expected, American Natives smoke significantly more than other individuals. As argued above, this is likely to be due to the fact that they face lower prices for cigarettes. However, there may also be some cultural factors involved. Also, as expected, the estimates indicate that men smoke significantly less than women. The results also

demonstrate that whites smoke significantly more, on average, than either blacks or other races. Age is found to have a positive and significant but diminishing effect on cigarette smoking, as indicated by the significant positive coefficient obtained for age and the significant negative coefficient obtained for age squared in each specification.

Based on these estimates, it would appear that cigarette smoking is an inferior behavior in an economic sense. A negative and significant relationship is obtained between income and average cigarette consumption in each of the equations estimated under the assumption of non-addictive behavior, with the income elasticity of demand implied by these estimates in the range from -0.108 to -0.099.

Individuals who have completed more years of formal schooling smoke significantly less than those with fewer years of schooling, while there appear to be differential effects of education. Individuals completing one or more years of schooling beyond high school smoke significantly less than high school graduates, while those attending high school who do not graduate smoke significantly more. However, individuals with only a grade school education smoke significantly less than those who graduated from high school. This may be due to the fact that they were not exposed to the same pressure from their peers faced by those individuals who went on to high school. Finally, there appears to be little significant difference between the average cigarette consumption of individuals with either no

formal education or less than a grade school education and those who graduated from high school.

Finally, individuals who are fairly active and/or participate in activities providing at least moderate exercise smoke significantly less than those individuals who are inactive and/or do little or no exercise, as shown by the negative and significant coefficients on both of these variables in each of the equations in which they were included.

The results of the demand equations estimated under the assumption that cigarette smoking is an addictive behavior are presented in Tables 8-7 through 8-24. The first group of results, presented in Tables 8-7, 8-8, and 8-9, are for the demand equation where there is no assumed rate of depreciation on the addictive stock. These are followed by the results for equations estimated assuming that the rate of depreciation on the addictive stock is one hundred percent (Tables 8-10, 8-11, and 8-12), eighty percent (Tables 8-13, 8-14, and 8-15), sixty percent (Tables 8-16, 8-17, and 8-18), forty percent (Tables 8-19, 8-20, and 8-21), and twenty percent (Tables 8-22, 8-23, and 8-24). The first set of results for each equation uses the weighted average of the own-price and border-price of cigarettes as the relevant measure of price. The second table in each set contains the results using the own-price of cigarettes as the price measure, with the final table containing equations estimated using the border-price as the appropriate measure.

Instrumental variables are used for future consumption and the measure of past consumption (either lagged consumption or the addictive stock) employed in each of the demand equations. The first set of results in each table, presented as Models 1-4, use four lags of the relevant measure of price, current price, and four leads of price as instruments for past and future consumption, in addition to the other exogenous determinants of demand. The second set of results, Models 5-8, use four lags, current, and four leads of the appropriate excise tax on cigarettes as instruments, in addition to the set of prices and the exogenous determinants of demand.

A cursory examination of the estimates of the effects of sex, race, age, education, income, activity, and exercise on consumption would lead one to conclude that none of these are significant determinants of demand. With few exceptions, the coefficients on these variables are statistically insignificant. Given the importance of each of these in the equations estimated under the assumption of non-addictive behavior presented above, however, gives one pause in rejecting them entirely. Whenever one of the variables is included as a determinant of "current" consumption, it is also included in the set of instruments employed for future and past consumption. Much of the impact of these variables may be being captured indirectly through their roles in determining both past and future consumption.

The findings for the sex, race, and age variables, with

Table 8-7*
TSLS Estimates of Cigarette Demand Equation
No Assumed Rate of Depreciation, Weighted Price

Variable	(7-1)	(7-2)	(7-3)	(7-4)
Past Cigarette	10.567	9.698	10.395	9.629
Price, Weighted	(1.32)	(1.20)	(1.31)	(1.20)
Current Cigarette	-16.161	-14.961	-16.070	-14.975
Price, Weighted	(-1.78)	(-1.66)	(-1.78)	(-1.67)
Future Cigarette	3.591	3.288	3.724	3.406
Price, Weighted	(0.76)	(0.71)	(0.79)	(0.73)
Past Consumption	0.638	0.656	0.627	0.649
	(2.55)	(2.44)	(2.53)	(2.44)
Future Consumption	0.028	0.036	0.042	0.042
	(0.07)	(0.09)	(0.11)	(0.10)
Age	0.179	0.151	0.175	0.149
	(1.87)	(1.61)	(1.87)	(1.60)
Age Squared	-0.002	-0.002	-0.002	-0.002
	(-1.72)	(-1.46)	(-1.71)	(-1.44)
Sex	0.388	0.303	0.425	0.343
	(0.90)	(0.72)	(0.94)	(0.76)
Black	-0.466	-0.354	-0.479	-0.372
	(-1.37)	(-1.10)	(-1.36)	(-1.09)
Other Races	-0.691	-0.492	-0.721	-0.526
	(-1.15)	(-0.90)	(-1.16)	(-0.93)
American Natives	0.796	0.724	0.804	0.736
	(1.43)	(1.33)	(1.43)	(1.32)
Family Income	0.001	0.001	0.001	0.001
	(0.46)	(0.52)	(0.45)	(0.51)
Number of Years of	-0.065	----	-0.060	----
Formal Education	(-1.67)	----	(-1.67)	----
No Formal Education	----	0.535	----	0.493
	----	(0.94)	----	(0.83)
Less than Grade	----	-0.203	----	-0.234
School Education	----	(-0.72)	----	(-0.81)
Grade School	----	-0.163	----	-0.193
Education	----	(-0.93)	----	(-1.00)
Some High School	----	-0.022	----	-0.027
Education	----	(-0.08)	----	(-0.10)
College	----	-0.621	----	-0.616
	----	(-1.46)	----	(-1.44)
Active	----	----	0.038	0.040
	----	----	(0.18)	(0.18)
Exercise	----	----	-0.232	-0.214
	----	----	(-1.32)	(-1.19)
Intercept	-0.988	-1.342	-0.827	-1.159
	(-1.53)	(-1.70)	(-1.25)	(-1.61)
R ²	0.262	0.287	0.273	0.298
F	389.28	337.71	358.40	319.69

Table 8-7 (Continued)
 TSLS Estimates of Cigarette Demand Equation
 No Assumed Rate of Depreciation, Weighted Price

Variable	(7-5)	(7-6)	(7-7)	(7-8)
Past Cigarette	6.675	6.723	6.622	6.684
Price, Weighted	(1.09)	(1.08)	(1.09)	(1.08)
Current Cigarette	-12.209	-12.186	-12.190	-12.183
Price, Weighted	(-1.71)	(-1.68)	(-1.71)	(-1.69)
Future Cigarette	3.890	3.827	3.941	3.877
Price, Weighted	(0.96)	(0.94)	(0.97)	(0.95)
Past Consumption	0.508	0.517	0.508	0.517
	(3.31)	(3.16)	(3.29)	(3.15)
Future Consumption	0.280	0.268	0.281	0.268
	(1.27)	(1.10)	(1.28)	(1.10)
Age	0.115	0.111	0.111	0.108
	(2.24)	(2.04)	(2.25)	(2.04)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.99)	(-1.79)	(-1.99)	(-1.79)
Sex	0.235	0.248	0.249	0.266
	(0.95)	(0.98)	(0.98)	(1.00)
Black	-0.331	-0.305	-0.332	-0.310
	(-1.54)	(-1.42)	(-1.52)	(-1.40)
Other Races	-0.447	-0.400	-0.457	-0.415
	(-1.07)	(-0.98)	(1.08)	(-1.00)
American Natives	0.578	0.590	0.576	0.592
	(1.36)	(1.37)	(1.35)	(1.36)
Family Income	0.001	0.001	0.001	0.001
	(0.45)	(0.34)	(0.48)	(0.36)
Number of Years of	-0.039	----	-0.036	----
Formal Education	(-1.67)	----	(-1.63)	----
No Formal Education	----	0.621	----	0.598
	----	(1.27)	----	(1.20)
Less than Grade	----	-0.109	----	-0.132
School Education	----	(-0.48)	----	(-0.57)
Grade School	----	-0.165	----	-0.183
Education	----	(-1.12)	----	(-1.18)
Some High School	----	-0.075	----	-0.084
Education	----	(-0.38)	----	(-0.43)
College	----	-0.412	----	-0.404
	----	(-1.62)	----	(-1.60)
Active	----	----	0.072	0.054
	----	----	(0.46)	(0.33)
Exercise	----	----	-0.147	-0.158
	----	----	(-1.22)	(-1.27)
Intercept	-0.765	-1.019	-0.709	-0.905
	(-1.44)	(-1.76)	(-1.28)	(-1.60)
R ²	0.317	0.336	0.328	0.348
F	510.54	425.40	464.56	400.42

* See note to Table 8-1.

Table 8-8*
TSLS Estimates of Cigarette Demand Equation
No Assumed Rate of Depreciation, Own Price

Variable	(8-1)	(8-2)	(8-3)	(8-4)
Past Cigarette	9.259	10.676	8.737	9.920
Price, Own	(1.16)	(1.11)	(1.13)	(1.09)
Current Cigarette	-14.203	-15.156	-13.657	-14.424
Price, Own	(-1.59)	(-1.47)	(-1.57)	(-1.47)
Future Cigarette	3.229	2.759	3.232	2.813
Price, Own	(0.71)	(0.56)	(0.72)	(0.59)
Past Consumption	0.597	0.691	0.595	0.675
	(1.78)	(1.68)	(1.80)	(1.70)
Future Consumption	0.090	-0.045	0.110	-0.005
	(0.19)	(-0.07)	(0.24)	(-0.01)
Age	0.171	0.178	0.155	0.159
	(1.67)	(1.41)	(1.62)	(1.37)
Age Squared	-0.002	-0.002	-0.002	-0.002
	(-1.52)	(-1.29)	(-1.46)	(-1.24)
Sex	0.394	0.396	0.362	0.365
	(0.76)	(0.68)	(0.69)	(0.63)
Black	-0.463	-0.421	-0.428	-0.389
	(-1.19)	(-0.99)	(-1.11)	(-0.92)
Other Races	-0.669	-0.582	-0.626	-0.546
	(-1.05)	(-0.88)	(-0.98)	(-0.83)
American Natives	0.772	0.818	0.729	0.769
	(1.37)	(1.28)	(1.31)	(1.23)
Family Income	0.001	0.001	0.001	0.001
	(0.28)	(0.35)	(0.35)	(0.40)
Number of Years of Formal Education	-0.062	----	-0.054	----
No Formal Education	----	0.476	----	0.471
	----	(0.76)	----	(0.74)
Less than Grade School Education	----	-0.227	----	-0.249
	----	(-0.66)	----	(-0.73)
Grade School Education	----	-0.175	----	-0.194
	----	(-0.86)	----	(-0.88)
Some High School Education	----	0.033	----	-0.010
	----	(0.10)	----	(-0.03)
College	----	-0.739	----	-0.666
	----	(-1.27)	----	(-1.23)
Active	----	----	0.054	0.037
	----	----	(0.22)	(0.14)
Exercise	----	----	-0.205	-0.227
	----	----	(-1.14)	(-1.08)
Intercept	-0.981	-1.594	-0.837	-1.300
	(-1.39)	(-1.47)	(-1.11)	(-1.35)
R ²	0.272	0.264	0.289	0.286
F	412.32	301.50	387.62	300.92

Table 8-8 (Continued)
 TSLS Estimates of Cigarette Demand Equation
 No Assumed Rate of Depreciation, Own Price

Variable	(8-5)	(8-6)	(8-7)	(8-8)
Past Cigarette	4.118	4.206	4.132	4.208
Price, Own	(0.72)	(0.71)	(0.72)	(0.71)
Current Cigarette	-8.905	-8.903	-8.947	-8.933
Price, Own	(-1.32)	(-1.31)	(-1.33)	(-1.31)
Future Cigarette	3.325	3.283	3.356	3.308
Price, Own	(0.85)	(0.84)	(0.86)	(0.84)
Past Consumption	0.449	0.450	0.452	0.453
	(2.07)	(1.96)	(2.06)	(1.96)
Future Consumption	0.409	0.411	0.407	0.409
	(1.43)	(1.32)	(1.42)	(1.32)
Age	0.074	0.071	0.072	0.067
	(1.69)	(1.50)	(1.69)	(1.49)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.39)	(-1.22)	(-1.37)	(-1.19)
Sex	0.112	0.120	0.114	0.120
	(0.40)	(0.43)	(0.40)	(0.42)
Black	-0.228	-0.210	-0.224	-0.205
	(-1.03)	(-0.94)	(-0.99)	(-0.89)
Other Races	-0.268	-0.249	-0.267	-0.247
	(-0.66)	(-0.62)	(-0.65)	(-0.61)
American Natives	0.434	0.446	0.427	-0.205
	(1.07)	(1.09)	(1.05)	(-0.89)
Family Income	0.001	0.001	0.001	0.001
	(0.36)	(0.25)	(0.38)	(0.28)
Number of Years of Formal Education	-0.024	----	-0.023	----
No Formal Education	(-1.11)	----	(-1.07)	----
	----	0.718	----	0.720
	----	(1.54)	----	(1.52)
Less than Grade	----	-0.047	-----	-0.056
School Education	----	(-0.20)	----	(-0.23)
Grade School	----	-0.144	----	-0.148
Education	----	(-0.97)	----	(-0.94)
Some High School	----	-0.149	----	-0.159
Education	----	(-0.78)	----	(-0.84)
College	----	-0.232	----	-0.220
	----	(-0.98)	----	(-0.95)
Active	----	----	0.106	0.101
	----	----	(0.61)	(0.58)
Exercise	----	----	-0.090	-0.097
	----	----	(-0.80)	(-0.84)
Intercept	-0.637	-0.779	-0.656	-0.769
	(-1.16)	(-1.29)	(-1.08)	(-1.20)
R ²	0.333	0.353	0.344	0.364
F	547.95	457.43	498.38	431.10

* See note to Table 8-1.

Table 8-9*
TSLS Estimates of Cigarette Demand Equation
No Assumed Rate of Depreciation, Border Price

Variable	(9-1)	(9-2)	(9-3)	(9-4)
Past Cigarette	7.335	5.983	7.406	6.030
Price, Border	(1.10)	(0.94)	(1.11)	(0.94)
Current Cigarette	-12.419	-11.022	-12.606	-11.160
Price, Border	(-1.64)	(-1.52)	(-1.66)	(-1.54)
Future Cigarette	3.401	3.435	3.548	3.546
Price, Border	(0.80)	(0.83)	(0.84)	(0.86)
Past Consumption	0.586	0.560	0.580	0.556
	(3.15)	(2.98)	(3.13)	(2.97)
Future Consumption	0.186	0.255	0.188	0.56
	(0.66)	(0.90)	(0.67)	(0.91)
Age	0.112	0.083	0.113	0.084
	(1.65)	(1.34)	(1.66)	(1.33)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.43)	(-1.10)	(-1.44)	(-1.10)
Sex	0.140	0.071	0.181	0.101
	(0.47)	(0.25)	(0.57)	(0.33)
Black	-0.272	-0.185	-0.292	-0.198
	(-1.09)	(-0.80)	(-1.11)	(-0.81)
Other Races	-0.372	-0.235	-0.409	-0.260
	(-0.79)	(-0.55)	(-0.83)	(-0.59)
American Natives	0.551	0.476	0.566	0.485
	(1.19)	(1.07)	(1.20)	(1.07)
Family Income	0.001	0.001	0.001	0.001
	(0.78)	(0.69)	(0.73)	(0.67)
Number of Years of Formal Education	-0.040	----	-0.039	----
	(-1.36)	----	(-1.38)	----
No Formal Education	----	0.686	----	0.677
	----	(1.40)	----	(1.34)
Less than Grade	----	-0.125	----	-0.132
School Education	----	(-0.53)	----	(-0.56)
Grade School	----	-0.133	----	-0.143
Education	----	(-0.89)	----	(-0.90)
Some High School	----	-0.158	----	-0.156
Education	----	(-0.77)	----	(-0.75)
College	----	-0.319	----	-0.320
	----	(-1.11)	----	(-1.09)
Active	----	----	0.105	0.118
	----	----	(0.61)	(0.68)
Exercise	----	----	-0.141	-0.113
	----	----	(-1.00)	(-0.83)
Intercept	-0.886	-0.975	-0.866	-0.979
	(-1.67)	(-1.70)	(-1.57)	(-1.77)
R ²	0.303	0.336	0.313	0.348
F	477.98	426.11	433.52	400.44

Table 8-9 (continued)
 TSLS Estimates of Cigarette Demand Equation
 No Assumed Rate of Depreciation, Border Price

Variable	(9-5)	(9-6)	(9-7)	(9-8)
Past Cigarette	7.682	6.748	7.755	6.871
Price, Border	(1.21)	(1.09)	(1.22)	(1.11)
Current Cigarette	-12.872	-11.966	-13.018	-12.157
Price, Border	(-1.77)	(-1.68)	(-1.79)	(-1.70)
Future Cigarette	3.500	3.579	3.587	3.649
Price, Border	(0.84)	(0.87)	(0.86)	(0.89)
Past Consumption	0.584	0.565	0.584	0.567
	(4.12)	(3.90)	(4.10)	(3.90)
Future Consumption	0.176	0.221	0.172	0.213
	(0.81)	(0.98)	(0.79)	(0.94)
Age	0.121	0.102	0.121	0.103
	(2.22)	(1.92)	(2.25)	(1.95)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.97)	(-1.66)	(-1.99)	(-1.68)
Sex	0.184	0.157	0.214	0.189
	(0.78)	(0.68)	(0.87)	(0.77)
Black	-0.304	-0.245	-0.317	-0.260
	(-1.42)	(-1.19)	(-1.44)	(-1.22)
Other Races	-0.421	-0.320	-0.449	-0.350
	(-0.98)	(-0.79)	(-1.02)	(-0.84)
American Natives	0.586	0.548	0.597	0.562
	(1.33)	(1.27)	(1.34)	(1.28)
Family Income	0.001	0.001	0.001	0.001
	(0.84)	(0.69)	(0.83)	(0.69)
Number of Years of Formal Education	-0.043	----	-0.041	----
No Formal Education	----	0.640	----	0.617
	----	(1.30)	----	(1.23)
Less than Grade	----	-0.137	----	-0.157
School Education	----	(-0.61)	----	(-0.68)
Grade School	----	-0.148	----	-0.164
Education	----	(-1.01)	----	(-1.07)
Some High School	----	-0.114	----	-0.113
Education	----	(-0.59)	----	(-0.59)
College	----	-0.393	----	-0.401
	----	(-1.58)	----	(-1.59)
Active	----	----	0.096	0.087
	----	----	(-0.61)	(0.55)
Exercise	----	----	-0.152	-0.144
	----	----	(-1.22)	(-1.22)
Intercept	-0.898	-1.061	-0.864	-1.013
	(-1.73)	(-1.95)	(-1.61)	(-1.90)
R ²	0.304	0.334	0.313	0.343
F	480.67	420.89	433.72	392.08

* See note to Table 8-1.

Table 8-10*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=100%, Weighted Price

Variable	(10-1)	(10-2)	(10-3)	(10-4)
Past Cigarette Price, Weighted	-----	-----	-----	-----
Current Cigarette Price, Weighted	-1.895 (-1.51)	-1.861 (-1.48)	-1.871 (-1.50)	-1.846 (-1.48)
Future Cigarette Price, Weighted	-----	-----	-----	-----
Past Consumption	0.536 (2.85)	0.539 (2.76)	0.533 (2.82)	0.537 (2.75)
Future Consumption	0.265 (1.00)	0.284 (1.01)	0.269 (1.03)	0.287 (1.03)
Age	0.101 (1.44)	0.081 (1.19)	0.099 (1.43)	0.079 (1.16)
Age Squared	-0.001 (-1.23)	-0.001 (-0.96)	-0.001 (-1.21)	-0.001 (-0.93)
Sex	0.137 (0.38)	0.077 (0.22)	0.156 (0.42)	0.093 (0.25)
Black	-0.265 (-0.95)	-0.190 (-0.71)	-0.270 (-0.93)	-0.194 (-0.68)
Other Races	-0.276 (-0.58)	-0.169 (-0.38)	-0.287 (-0.59)	-0.178 (-0.39)
American Natives	0.503 (1.09)	0.459 (1.01)	0.503 (1.07)	0.458 (0.99)
Family Income	0.001 (0.64)	0.001 (0.62)	0.001 (0.63)	0.001 (0.62)
Number of Years of Formal Education	-0.036 (-1.24)	-----	-0.034 (-1.25)	-----
No Formal Education	-----	0.698 (1.42)	-----	0.696 (1.36)
Less than Grade School Education	-----	-0.105 (-0.46)	-----	-0.111 (-0.48)
Grade School Education	-----	-0.130 (-0.84)	-----	-0.137 (-0.81)
Some High School Education	-----	-0.156 (-0.69)	-----	-0.160 (-0.71)
College	-----	-0.307 (-1.02)	-----	-0.298 (-0.98)
Active	-----	-----	0.103 (0.56)	0.177 (0.61)
Exercise	-----	-----	-0.122 (-0.85)	-0.107 (-0.74)
Intercept	-0.734 (-1.39)	-0.880 (-1.49)	-0.724 (-1.29)	-0.879 (-1.55)
R ²	0.312	0.337	0.323	0.349
F	590.10	484.18	525.09	450.41

Table 8-10 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=100%, Weighted Price

Variable	(10-5)	(10-6)	(10-7)	(10-8)
Past Cigarette Price, Weighted	----	----	----	----
Current Cigarette Price, Weighted	-1.724 (-1.46)	-1.700 (-1.44)	-1.712 (-1.45)	-1.693 (-1.43)
Future Cigarette Price, Weighted	----	----	----	----
Past Consumption	0.479 (3.47)	0.479 (3.32)	0.479 (3.44)	0.479 (3.31)
Future Consumption	0.348 (1.80)	0.354 (1.69)	0.348 (1.79)	0.352 (1.68)
Age	0.092 (1.97)	0.085 (1.76)	0.090 (1.98)	0.084 (1.76)
Age Squared	-0.001 (-1.68)	-0.001 (-1.48)	-0.001 (-1.68)	-0.001 (-1.47)
Sex	0.159 (0.67)	0.162 (0.67)	0.172 (0.71)	0.178 (0.71)
Black	-0.271 (-1.31)	-0.245 (-1.19)	-0.274 (-1.30)	-0.249 (-1.18)
Other Races	-0.260 (-0.67)	-0.222 (-0.59)	-0.269 (-0.69)	-0.234 (-0.61)
American Natives	0.481 (1.17)	0.485 (1.17)	0.481 (1.16)	0.668 (1.39)
Family Income	0.001 (0.56)	0.001 (0.42)	0.001 (0.57)	0.001 (0.43)
Number of Years of Formal Education	-0.031 (-1.42)	----	-0.029 (-1.40)	----
No Formal Education	----	0.680 (1.44)	----	0.668 (1.39)
Less than Grade School Education	----	-0.075 (-0.35)	----	-0.089 (-0.41)
Grade School Education	----	-0.151 (-1.05)	----	-0.162 (-1.08)
Some High School Education	----	-0.124 (-0.66)	----	-0.129 (-0.69)
College	----	-0.301 (-1.33)	----	-0.296 (-1.32)
Active	----	----	0.089 (0.58)	0.079 (0.50)
Exercise	----	----	-0.144 (-0.99)	-0.121 (-1.02)
Intercept	-0.681 (-1.35)	-0.849 (-1.61)	-0.667 (-1.26)	-0.802 (-1.53)
R ²	0.326	0.348	0.337	0.359
F	629.56	507.42	558.49	470.58

* See note to Table 8-1.

Table 8-11*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=100%, Own Price

Variable	(11-1)	(11-2)	(11-3)	(11-4)
Past Cigarette Price, Own	-----	-----	-----	-----
Current Cigarette Price, Own	-1.603 (-1.35)	-1.552 (-1.31)	-1.597 (-1.34)	-1.555 (-1.31)
Future Cigarette Price, Own	-----	-----	-----	-----
Past Consumption	0.450 (1.92)	0.459 (1.90)	0.454 (1.94)	0.462 (1.92)
Future Consumption	0.380 (1.27)	0.389 (1.21)	0.381 (1.28)	0.391 (1.23)
Age	0.095 (1.26)	0.078 (0.99)	0.088 (1.22)	0.072 (0.94)
Age Squared	-0.001 (-1.06)	-0.001 (-0.81)	-0.001 (-1.01)	-0.001 (-0.74)
Sex	0.202 (0.46)	0.146 (0.32)	0.190 (0.42)	0.133 (0.28)
Black	-0.294 (-0.89)	-0.228 (-0.69)	-0.278 (-0.83)	-0.212 (-0.62)
Other Races	-0.295 (-0.57)	-0.204 (-0.42)	-0.278 (-0.53)	-0.189 (-0.38)
American Natives	0.501 (1.06)	0.464 (0.98)	0.483 (1.01)	0.445 (0.92)
Family Income	0.001 (0.24)	0.001 (0.23)	0.001 (0.29)	0.001 (0.28)
Number of Years of Formal Education	-0.031 (-1.06)	-----	-0.028 (-1.03)	-----
No Formal Education	-----	0.697 (1.41)	-----	0.705 (1.35)
Less than Grade School Education	-----	-0.056 (-0.24)	-----	-0.064 (-0.27)
Grade School Education	-----	-0.147 (-0.89)	-----	-0.149 (-0.81)
Some High School Education	-----	-0.134 (-0.53)	-----	-0.151 (-0.61)
College	-----	-0.266 (-0.81)	-----	-0.243 (-0.74)
Active	-----	-----	0.080 (0.38)	0.095 (0.42)
Exercise	-----	-----	-0.115 (-0.76)	-0.103 (-0.65)
Intercept	-0.665 (-1.21)	-0.817 (-1.27)	-0.638 (-1.04)	-0.782 (-1.24)
R ²	0.321	0.344	0.333	0.357
F	614.45	500.08	548.15	466.35

Table 8-11 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=100%, Own Price

Variable	(11-5)	(11-6)	(11-7)	(11-8)
Past Cigarette Price, Own	-----	-----	-----	-----
Current Cigarette Price, Own	-1.517 (-1.32)	-1.467 (-1.28)	-1.514 (-1.32)	-1.469 (-1.27)
Future Cigarette Price, Own	-----	-----	-----	-----
Past Consumption	0.420 (2.25)	0.413 (2.15)	0.421 (2.24)	0.415 (2.15)
Future Consumption	0.462 (1.92)	0.476 (1.87)	0.462 (1.91)	0.475 (1.87)
Age	0.063 (1.51)	0.058 (1.31)	0.061 (1.51)	0.055 (1.30)
Age Squared	-0.001 (-1.19)	-0.001 (-1.00)	-0.001 (-1.17)	-0.001 (-0.97)
Sex	0.090 (0.33)	0.093 (0.34)	0.096 (0.35)	0.096 (-0.34)
Black	-0.207 (-0.95)	-0.188 (-0.85)	-0.205 (-0.92)	-0.185 (-0.82)
Other Races	-0.149 (-0.39)	-0.134 (-0.36)	-0.149 (-0.39)	-0.134 (-0.35)
American Natives	0.387 (0.96)	0.392 (0.97)	0.382 (0.95)	0.386 (0.95)
Family Income	0.001 (0.37)	0.0005 (0.24)	0.001 (0.39)	0.0005 (0.25)
Number of Years of Formal Education	-0.019 (-0.95)	-----	-0.018 (-0.93)	-----
No Formal Education	-----	0.744 (1.60)	-----	0.749 (1.58)
Less than Grade School Education	-----	-0.023 (-0.10)	-----	-0.027 (-0.12)
Grade School Education	-----	-0.141 (-0.96)	-----	-0.144 (-0.93)
Some High School Education	-----	-0.169 (-0.89)	-----	-0.176 (-0.94)
College	-----	-0.168 (-0.80)	-----	-0.159 (-0.77)
Active	-----	-----	0.103 (0.62)	0.103 (0.61)
Exercise	-----	-----	-0.076 (-0.68)	-0.080 (-0.70)
Intercept	-0.581 (-1.11)	-0.669 (-1.23)	-0.608 (-1.07)	-0.680 (-1.18)
R ²	0.334	0.354	0.345	0.366
F	651.39	521.09	578.42	484.29

* See note to Table 8-1.

Table 8-12*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=100%, Border Price

Variable	(12-1)	(12-2)	(12-3)	(12-4)
Past Cigarette	----	----	----	----
Price, Border	----	----	----	----
Current Cigarette	-1.666	-1.626	-1.647	-1.610
Price, Border	(-1.44)	(-1.41)	(-1.43)	(-1.40)
Future Cigarette	----	----	----	----
Price, Border	----	----	----	----
Past Consumption	0.548	0.533	0.543	0.530
	(3.44)	(3.26)	(3.41)	(3.25)
Future Consumption	0.289	0.330	0.292	0.333
	(1.24)	(1.38)	(1.26)	(1.39)
Age	0.073	0.054	0.073	0.054
	(1.26)	(0.99)	(1.26)	(0.98)
Age Squared	-0.001	-0.0005	-0.001	-0.0005
	(-1.00)	(-0.72)	(-1.00)	(-0.70)
Sex	0.001	-0.043	0.022	-0.030
	(0.01)	(-0.16)	(0.08)	(-0.10)
Black	-0.169	-0.109	-0.176	-0.112
	(-0.73)	(-0.49)	(-0.73)	(-0.48)
Other Races	-0.123	-0.044	-0.135	-0.051
	(-0.29)	(-0.11)	(-0.31)	(-0.13)
American Natives	0.394	0.357	0.395	0.354
	(0.91)	(0.84)	(0.90)	(0.82)
Family Income	0.002	0.002	0.002	0.001
	(0.98)	(0.88)	(0.95)	(0.86)
Number of Years of	-0.026	----	-0.025	----
Formal Education	(-1.02)	----	(-1.04)	----
No Formal Education	----	0.757	----	0.771
	----	(1.59)	----	(1.58)
Less than Grade	----	-0.095	----	-0.089
School Education	----	(-0.43)	----	(-0.39)
Grade School	----	-0.112	----	-0.111
Education	----	(-0.77)	----	(-0.72)
Some High School	----	-0.219	----	-0.220
Education	----	(-1.11)	----	(-1.11)
College	----	-0.201	----	-0.195
	----	(-0.80)	----	(-0.76)
Active	----	----	0.148	0.161
	----	----	(0.91)	(0.97)
Exercise	----	----	-0.080	-0.065
	----	----	(-0.63)	(-0.51)
Intercept	-0.775	-0.819	-0.839	-0.906
	(-1.58)	(-1.57)	(-1.62)	(-1.76)
R ²	0.320	0.345	0.330	0.357
F	610.42	502.29	541.54	466.03

Table 8-12 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=100%, Border Price

Variable	(12-5)	(12-6)	(12-7)	(12-8)
Past Cigarette Price, Border	-----	-----	-----	-----
Current Cigarette Price, Border	-1.732 (-1.54)	-1.686 (-1.50)	-1.725 (-1.53)	-1.687 (-1.50)
Future Cigarette Price, Border	-----	-----	-----	-----
Past Consumption	0.552 (4.34)	0.536 (4.11)	0.552 (4.32)	0.538 (4.11)
Future Consumption	0.255 (1.33)	0.292 (1.47)	0.251 (1.31)	0.285 (1.43)
Age	0.094 (1.93)	0.079 (1.64)	0.094 (1.96)	0.079 (1.66)
Age Squared	-0.001 (-1.64)	-0.001 (-1.33)	-0.001 (-1.66)	-0.001 (-1.36)
Sex	0.092 (0.42)	0.071 (0.32)	0.115 (0.50)	0.095 (0.41)
Black	-0.237 (-1.17)	-0.189 (-0.96)	-0.246 (-1.19)	-0.199 (-0.98)
Other Races	-0.227 (-0.58)	-0.153 (-0.41)	-0.246 (-0.61)	-0.172 (-0.45)
American Natives	0.472 (1.12)	0.448 (1.08)	0.478 (1.13)	0.456 (1.08)
Family Income	0.001 (0.99)	0.001 (0.83)	0.001 (0.98)	0.001 (0.83)
Number of Years of Formal Education	-0.033 (-1.46)	-----	-0.032 (-1.49)	-----
No Formal Education	-----	0.698 (1.46)	-----	0.690 (1.42)
Less than Grade School Education	-----	-0.108 (-0.50)	-----	-0.117 (-0.53)
Grade School Education	-----	-0.133 (-0.93)	-----	-0.141 (-0.95)
Some High School Education	-----	-0.161 (-0.87)	-----	-0.161 (-0.87)
College	-----	-0.295 (-1.31)	-----	-0.299 (-1.31)
Active	-----	-----	0.120 (0.80)	0.116 (0.76)
Exercise	-----	-----	-0.112 (-0.95)	-0.107 (-0.90)
Intercept	-0.806 (-1.65)	-0.922 (-1.82)	-0.824 (-1.61)	-0.935 (-1.86)
R ²	0.319	0.345	0.328	0.355
F	607.50	501.30	536.05	462.22

* See note to Table 8-1.

Table 8-13*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=80%, Weighted Price

Variable	(13-1)	(13-2)	(13-3)	(13-4)
Current Cigarette	-5.562	-5.325	-5.634	-5.384
Price, Weighted	(-1.33)	(-1.29)	(-1.35)	(-1.31)
Future Cigarette	3.841	3.684	3.941	3.757
Price, Weighted	(0.93)	(0.90)	(0.95)	(0.981)
Addictive Stock	0.312	0.357	0.358	0.355
	(2.34)	(2.22)	(2.30)	(2.21)
Future Consumption	0.361	0.402	0.365	0.402
	(1.36)	(1.43)	(1.38)	(1.44)
Age	0.092	0.066	0.091	0.065
	(1.33)	(1.00)	(1.33)	(0.98)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.18)	(-0.83)	(-1.17)	(-0.82)
Sex	0.231	0.150	0.261	0.174
	(0.63)	(0.42)	(0.67)	(0.45)
Black	-0.330	-0.242	-0.344	-0.252
	(-1.17)	(-0.89)	(-1.16)	(-0.88)
Other Races	-0.440	-0.299	-0.468	-0.320
	(-0.88)	(-0.65)	(-0.90)	(-0.66)
American Natives	0.528	0.456	0.539	0.463
	(1.15)	(1.02)	(1.15)	(1.01)
Family Income	0.0003	0.0003	0.0004	0.0004
	(0.18)	(0.17)	(0.17)	(0.17)
Number of Years of	-0.035	----	-0.033	----
Formal Education	(-1.25)	----	(-1.24)	----
No Formal Education	----	0.590	----	0.572
	----	(1.21)	----	(1.13)
Less than Grade	----	-0.077	----	-0.092
School Education	----	(-0.33)	----	(-0.39)
Grade School	----	-0.150	----	-0.164
Education	----	(-0.97)	----	(-0.97)
Some High School	----	-0.150	----	-0.107
Education	----	(-0.47)	----	(-0.48)
College	----	-0.283	----	-0.282
	----	(-0.96)	----	(-0.94)
Active	----	----	0.049	0.068
	----	----	(0.26)	(0.35)
Exercise	----	----	-0.150	-0.124
	----	----	(-1.05)	(-0.87)
Intercept	-0.300	-0.424	-0.227	-0.366
	(-0.60)	(-0.79)	(-0.44)	(-0.73)
R ²	0.318	0.345	0.329	0.357
F	556.26	471.05	499.56	440.30

Table 8-13 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=80%, Weighted Price

Variable	(13-5)	(13-6)	(13-7)	(13-8)
Current Cigarette	-5.480	-5.421	-5.517	-5.459
Price, Weighted	(-1.34)	(-1.34)	(-1.35)	(-1.35)
Future Cigarette	3.815	3.804	3.866	3.849
Price, Weighted	(0.96)	(0.96)	(0.97)	(0.97)
Addictive Stock	0.353	0.348	0.353	0.349
	(3.14)	(2.97)	(3.11)	(2.96)
Future Consumption	0.392	0.408	0.392	0.405
	(2.00)	(1.93)	(2.00)	(1.92)
Age	0.080	0.071	0.078	0.070
	(1.73)	(1.51)	(1.74)	(1.51)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.52)	(-1.29)	(-1.52)	(-1.29)
Sex	0.189	0.186	0.205	0.204
	(0.78)	(0.75)	(0.82)	(0.80)
Black	-0.297	-0.266	-0.301	-0.273
	(-1.43)	(-1.28)	(-1.42)	(-1.28)
Other Races	-0.384	-0.331	-0.397	-0.348
	(-0.94)	(-0.83)	(-0.96)	(-0.86)
American Natives	0.485	0.478	0.487	0.482
	(1.18)	(1.16)	(1.18)	(1.16)
Family Income	0.0004	0.0002	0.0005	0.0002
	(0.26)	(0.13)	(0.28)	(0.14)
Number of Years of	-0.031	----	-0.029	----
Formal Education	(-1.41)	----	(-1.38)	----
No Formal Education	----	0.578	----	0.559
	----	(1.22)	----	(1.16)
Less than Grade	----	-0.073	----	-0.092
School Education	----	(-0.33)	----	(-0.42)
Grade School	----	-0.158	----	-0.172
Education	----	(-1.09)	----	(-1.14)
Some High School	----	-0.090	----	-0.095
Education	----	(-0.48)	----	(-0.51)
College	----	-0.298	----	-0.296
	----	(-1.32)	----	(-1.31)
Active	----	----	0.066	0.056
	----	----	(0.43)	(0.35)
Exercise	----	----	-0.130	-0.132
	----	----	(-1.13)	(-1.12)
Intercept	-0.284	-0.445	-0.238	-0.364
	(-0.58)	(-0.89)	(-0.47)	(-0.74)
R ²	0.327	0.349	0.338	0.361
F	579.28	478.86	520.51	447.32

* See note to Table 8-1.

Table 8-14*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=80%, Own Price

Variable	(14-1)	(14-2)	(14-3)	(14-4)
Current Cigarette	-5.205	-4.994	-5.173	-4.967
Price, Own	(-1.24)	(-1.20)	(-1.24)	(-1.20)
Future Cigarette	3.843	3.721	3.821	3.688
Price, Own	(0.91)	(0.88)	(0.91)	(0.88)
Addictive Stock	0.247	0.245	0.252	0.251
	(1.20)	(1.15)	(1.23)	(1.19)
Future Consumption	0.539	0.572	0.537	0.569
	(1.68)	(1.67)	(1.69)	(1.68)
Age	0.097	0.074	0.089	0.067
	(1.21)	(0.90)	(1.17)	(0.84)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.08)	(-0.77)	(-1.03)	(-0.71)
Sex	0.391	0.315	0.380	0.302
	(0.80)	(0.63)	(0.77)	(0.59)
Black	-0.418	-0.341	-0.405	-0.327
	(-1.19)	(-0.96)	(-1.13)	(-0.89)
Other Races	-0.522	-0.399	-0.511	-0.388
	(-0.92)	(-0.73)	(-0.88)	(-0.69)
American Natives	0.566	0.602	0.553	0.485
	(1.15)	(1.19)	(1.12)	(0.97)
Family Income	-0.001	-0.001	-0.001	-0.001
	(-0.31)	(-0.31)	(-0.25)	(-0.26)
Number of Years of	-0.031	----	-0.027	----
Formal Education	(-1.04)	----	(-0.97)	----
No Formal Education	----	0.602	----	0.585
	----	(1.19)	----	(1.11)
Less than Grade	----	0.010	----	-0.016
School Education	----	(0.04)	----	(-0.06)
Grade School	----	-0.190	----	-0.202
Education	----	(-1.09)	----	(-1.03)
Some High School	----	-0.056	----	-0.075
Education	----	(-0.21)	----	(-0.29)
College	----	-0.238	----	-0.220
	----	(-0.71)	----	(-0.66)
Active	----	----	-0.010	0.009
	----	----	(-0.04)	(0.04)
Exercise	----	----	-0.155	-0.133
	----	----	(-0.99)	(-0.81)
Intercept	-0.287	-0.416	-0.149	-0.270
	(-0.55)	(-0.69)	(-0.27)	(-0.50)
R ²	0.312	0.335	0.325	0.349
F	540.42	450.76	490.28	425.33

Table 8-14 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=80%, Own Price

Variable	(14-5)	(14-6)	(14-7)	(14-8)
Current Cigarette	-4.768	-4.736	-4.794	-4.756
Price, Own	(-1.19)	(-1.18)	(-1.20)	(-1.18)
Future Cigarette	3.365	3.404	3.397	3.423
Price, Own	(0.85)	(0.85)	(0.85)	(0.86)
Addictive Stock	0.278	0.267	0.279	0.269
	(1.79)	(1.66)	(1.79)	(1.66)
Future Consumption	0.550	0.576	0.549	0.574
	(2.21)	(2.18)	(2.20)	(2.18)
Age	0.053	0.046	0.051	0.044
	(1.24)	(1.04)	(1.23)	(1.01)
Age Squared	-0.001	-0.0005	-0.001	-0.0004
	(-1.01)	(-0.81)	(-0.99)	(-0.78)
Sex	0.155	0.156	0.162	0.160
	(0.54)	(0.54)	(0.55)	(0.54)
Black	-0.251	-0.233	-0.251	-0.231
	(-1.12)	(-1.02)	(-1.10)	(-0.99)
Other Races	-0.274	-0.254	-0.278	-0.256
	(-0.67)	(-0.62)	(-0.67)	(-0.62)
American Natives	0.396	0.392	0.393	0.388
	(0.97)	(0.95)	(0.96)	(0.94)
Family Income	0.00001	-0.0003	0.00004	-0.0002
	(0.01)	(-0.14)	(0.02)	(-0.11)
Number of Years of Formal Education	-0.018	----	-0.016	----
No Formal Education	(-0.87)	----	(-0.81)	----
	----	0.665	----	0.659
	----	(1.40)	----	(1.37)
Less than Grade	----	0.005	----	-0.006
School Education	----	(0.02)	----	(-0.02)
Grade School	----	-0.159	----	-0.165
Education	----	(-1.05)	----	(-1.04)
Some High School	----	-0.129	----	-0.136
Education	----	(-0.67)	----	(-0.72)
College	----	-0.147	----	-0.139
	----	(-0.68)	----	(-0.66)
Active	----	----	0.065	0.063
	----	----	(0.38)	(0.37)
Exercise	----	----	-0.092	-0.093
	----	----	(-0.81)	(-0.80)
Intercept	-0.219	-0.298	-0.201	-0.258
	(-0.44)	(-0.59)	(-0.38)	(-0.50)
R ²	0.329	0.347	0.340	0.359
F	584.79	474.79	526.20	445.04

* See note to Table 8-1.

Table 8-15*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=80%, Border Price

Variable	(15-1)	(15-2)	(15-3)	(15-4)
Current Cigarette	-5.096	-5.023	-5.201	-5.102
Price, Border	(-1.26)	(-1.25)	(-1.29)	(-1.27)
Future Cigarette	3.607	3.614	3.732	3.706
Price, Border	(0.89)	(0.90)	(0.92)	(0.92)
Addictive Stock	0.389	0.371	0.385	0.369
	(2.98)	(2.77)	(2.95)	(2.76)
Future Consumption	0.365	0.421	0.367	0.421
	(1.56)	(1.75)	(1.57)	(1.76)
Age	0.058	0.036	0.059	0.037
	(1.03)	(0.69)	(1.05)	(0.69)
Age Squared	-0.001	-0.0003	-0.001	-0.0003
	(-0.83)	(-0.48)	(-0.86)	(-0.48)
Sex	0.044	-0.009	0.075	0.011
	(0.16)	(-0.03)	(0.25)	(0.04)
Black	-0.201	-0.135	-0.215	-0.143
	(-0.87)	(-0.61)	(-0.89)	(-0.61)
Other Races	-0.239	-0.146	-0.266	-0.162
	(-0.54)	(-0.35)	(-0.58)	(-0.38)
American Natives	0.391	0.340	0.402	0.343
	(0.92)	(0.81)	(0.92)	(0.81)
Family Income	0.001	0.001	0.001	0.001
	(0.58)	(0.48)	(0.54)	(0.46)
Number of Years of	-0.024	----	-0.024	----
Formal Education	(-0.97)	----	(-0.99)	----
No Formal Education	----	0.653	----	0.656
	----	(1.38)	----	(1.35)
Less than Grade	----	-0.081	----	-0.080
School Education	----	(-0.36)	----	(-0.36)
Grade School	----	-0.124	----	-0.127
Education	----	(-0.85)	----	(-0.82)
Some High School	----	-0.183	----	-0.181
Education	----	(-0.94)	----	(-0.92)
College	----	-0.178	----	-0.176
	----	(-0.71)	----	(-0.70)
Active	----	----	0.113	0.129
	----	----	(0.70)	(0.77)
Exercise	----	----	-0.097	-0.076
	----	----	(-0.77)	(-0.60)
Intercept	-0.344	-0.377	-0.369	-0.429
	(-0.73)	(-0.78)	(-0.76)	(-0.92)
R ²	0.326	0.351	0.336	0.363
F	576.58	483.50	517.03	451.35

Table 8-15 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=80%, Border Price

Variable	(15-5)	(15-6)	(15-7)	(15-8)
Current Cigarette	-5.195	-5.181	-5.272	-5.253
Price, Border	(-1.28)	(-1.29)	(-1.29)	(-1.31)
Future Cigarette	3.544	3.607	3.630	3.677
Price, Border	(0.88)	(0.91)	(0.90)	(0.93)
Addictive Stock	0.418	0.400	0.418	0.402
	(4.04)	(3.79)	(4.02)	(3.79)
Future Consumption	0.291	0.339	0.286	0.331
	(1.51)	(1.70)	(1.49)	(1.66)
Age	0.077	0.060	0.078	0.061
	(1.64)	(1.31)	(1.67)	(1.34)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-1.42)	(-1.08)	(-1.45)	(-1.11)
Sex	0.099	0.073	0.126	0.100
	(0.44)	(0.33)	(0.54)	(0.42)
Black	-0.249	-0.196	-0.261	-0.209
	(-1.23)	(-1.00)	(-1.26)	(-1.02)
Other Races	-0.326	-0.239	-0.351	-0.264
	(-0.80)	(-0.61)	(-0.84)	(-0.66)
American Natives	0.461	0.426	0.471	0.437
	(1.10)	(1.04)	(1.12)	(1.05)
Family Income	0.001	0.001	0.001	0.001
	(0.72)	(0.57)	(0.71)	(0.56)
Number of Years of	-0.033	----	-0.032	----
Formal Education	(-1.44)	----	(-1.46)	----
No Formal Education	----	0.587	----	0.573
	----	(1.24)	----	(1.18)
Less than Grade	----	-0.114	----	-0.127
School Education	----	(-0.52)	----	(-0.58)
Grade School	----	-0.135	----	-0.146
Education	----	(-0.95)	----	(-0.99)
Some High School	----	-0.132	----	-0.131
Education	----	(-0.72)	----	(-0.71)
College	----	-0.289	----	-0.295
	----	(-1.29)	----	(-1.30)
Active	----	----	0.103	0.100
	----	----	(0.69)	(0.66)
Exercise	----	----	-0.125	-0.115
	----	----	(-1.06)	(-0.98)
Intercept	-0.368	-0.481	-0.361	-0.471
	(-0.77)	(-1.01)	(-0.74)	(-1.00)
R ²	0.322	0.349	0.331	0.359
F	565.50	478.73	505.22	444.69

* See note to Table 8-1.

Table 8-16*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=60%, Weighted Price

Variable	(16-1)	(16-2)	(16-3)	(16-4)
Current Cigarette	-5.226	-5.018	-5.300	-5.066
Price, Weighted	(-1.23)	(-1.19)	(-1.25)	(-1.21)
Future Cigarette	3.655	3.567	3.754	3.623
Price, Weighted	(0.86)	(0.84)	(0.88)	(0.86)
Addictive Stock	0.240	0.229	0.238	0.229
	(2.04)	(1.88)	(2.00)	(1.88)
Future Consumption	0.433	0.495	0.435	0.492
	(1.63)	(1.77)	(1.64)	(1.77)
Age	0.065	0.037	0.065	0.036
	(0.93)	(0.55)	(0.92)	(0.53)
Age Squared	-0.001	-0.0004	-0.001	-0.0004
	(-0.87)	(-0.47)	(-0.87)	(-0.46)
Sex	0.224	0.136	0.256	0.157
	(0.58)	(0.36)	(0.63)	(0.39)
Black	-0.340	-0.247	-0.355	-0.256
	(-1.19)	(-0.89)	(-1.18)	(-0.87)
Other Races	-0.434	-0.282	-0.463	-0.301
	(-0.86)	(-0.60)	(-0.88)	(-0.61)
American Natives	0.499	0.412	0.512	0.419
	(1.08)	(0.91)	(1.08)	(0.91)
Family Income	-0.00004	-0.0001	-0.0001	-0.0001
	(-0.02)	(-0.04)	(-0.03)	(-0.04)
Number of Years of	-0.033	----	-0.030	----
Formal Education	(-1.15)	----	(-1.13)	----
No Formal Education	----	0.534	----	0.515
	----	(1.08)	----	(1.01)
Less than Grade	----	-0.056	----	-0.072
School Education	----	(-0.23)	----	(-0.30)
Grade School	----	-0.156	----	-0.170
Education	----	(-0.99)	----	(-0.99)
Some High School	----	-0.094	----	-0.097
Education	----	(-0.42)	----	(-0.43)
College	----	-0.242	----	-0.242
	----	(-0.82)	----	(-0.81)
Active	----	----	0.037	0.059
	----	----	(0.19)	(0.30)
Exercise	----	----	-0.156	-0.123
	----	----	(-1.09)	(-0.85)
Intercept	0.247	0.139	0.330	0.203
	(0.43)	(0.24)	(0.61)	(0.41)
R ²	0.317	0.343	0.327	0.355
F	553.43	466.29	496.41	435.95

Table 8-16 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=60%, Weighted Price

Variable	(16-5)	(16-6)	(16-7)	(16-8)
Current Cigarette	-4.981	-4.928	-5.014	-4.961
Price, Weighted	(-1.21)	(-1.20)	(-1.22)	(-1.21)
Future Cigarette	3.365	3.376	3.412	3.413
Price, Weighted	(0.83)	(0.83)	(0.84)	(0.84)
Addictive Stock	0.255	0.249	0.255	0.250
	(3.02)	(2.83)	(3.00)	(2.83)
Future Consumption	0.419	0.442	0.418	0.439
	(2.16)	(2.12)	(2.15)	(2.11)
Age	0.052	0.042	0.050	0.041
	(1.13)	(0.90)	(1.10)	(0.88)
Age Squared	-0.001	-0.0005	-0.001	-0.0005
	(-1.04)	(-0.81)	(-1.03)	(-0.79)
Sex	0.146	0.139	0.162	0.156
	(0.58)	(0.54)	(0.62)	(0.59)
Black	-0.289	-0.255	-0.292	-0.261
	(-1.37)	(-1.21)	(-1.36)	(-1.21)
Other Races	-0.359	-0.300	-0.372	-0.313
	(-0.87)	(-0.74)	(-0.89)	(-0.77)
American Natives	0.451	0.436	0.452	0.439
	(0.58)	(1.05)	(1.09)	(1.05)
Family Income	0.0003	0.0001	0.0003	0.0001
	(0.18)	(0.05)	(0.20)	(0.07)
Number of Years of	-0.030	----	-0.027	----
Formal Education	(-1.36)	----	(-1.32)	----
No Formal Education	----	0.502	----	0.483
	----	(1.05)	----	(0.99)
Less than Grade	----	-0.080	----	-0.099
School Education	----	(-0.43)	----	(-0.44)
Grade School	----	-0.154	----	-0.167
Education	----	(-1.06)	----	(-1.10)
Some High School	----	-0.080	----	-0.086
Education	----	(-0.43)	----	(-0.46)
College	----	-0.291	----	-0.288
	----	(-1.27)	----	(-1.27)
Active	----	----	0.071	0.062
	----	----	(0.46)	(0.39)
Exercise	----	----	-0.134	-0.133
	----	----	(-1.16)	(-1.12)
Intercept	0.295	0.141	0.341	0.220
	(0.56)	(0.27)	(0.65)	(0.45)
R ²	0.325	0.347	0.335	0.358
F	572.87	474.08	514.78	442.97

* See note to Table 8-1.

Table 8-17*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=60%, Own Price

Variable	(17-1)	(17-2)	(17-3)	(17-4)
Current Cigarette	-5.454	-5.323	-5.396	-5.256
Price, Own	(-1.20)	(-1.16)	(-1.20)	(-1.16)
Future Cigarette	4.327	4.325	4.282	4.250
Price, Own	(0.93)	(0.92)	(0.93)	(0.91)
Addictive Stock	0.112	0.100	0.116	0.106
	(0.68)	(0.58)	(0.70)	(0.61)
Future Consumption	0.687	0.748	0.684	0.740
	(2.02)	(2.05)	(2.02)	(2.05)
Age	0.093	0.068	0.085	0.060
	(1.02)	(0.72)	(0.96)	(0.65)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-0.96)	(-0.65)	(-0.90)	(-0.58)
Sex	0.522	0.442	0.512	0.427
	(0.95)	(0.77)	(0.91)	(0.72)
Black	-0.504	-0.427	-0.493	-0.414
	(-1.31)	(-1.07)	(-1.26)	(-1.01)
Other Races	-0.612	-0.483	-0.604	-0.473
	(-0.99)	(-0.80)	(-0.96)	(-0.76)
American Natives	0.598	0.514	0.589	0.503
	(1.13)	(0.96)	(1.10)	(0.92)
Family Income	-0.002	-0.002	-0.002	-0.002
	(-0.66)	(-0.67)	(-0.61)	(-0.62)
Number of Years of	-0.029	----	-0.023	----
Formal Education	(-0.90)	----	(-0.80)	----
No Formal Education	----	0.585	----	0.550
	----	(1.07)	----	(0.97)
Less than Grade	----	0.082	----	0.045
School Education	----	(0.29)	----	(0.16)
Grade School	----	-0.228	----	-0.246
Education	----	(-1.18)	----	(-1.14)
Some High School	----	-0.012	----	-0.033
Education	----	(-0.04)	----	(-0.12)
College	----	-0.185	----	-0.171
	----	(-0.52)	----	(-0.48)
Active	----	----	-0.073	-0.053
	----	----	(-0.30)	(-0.20)
Exercise	----	----	-0.176	-0.148
	----	----	(-1.07)	(-0.84)
Intercept	-0.017	-0.140	0.201	0.093
	(-0.02)	(-0.19)	(0.35)	(0.17)
R ²	0.288	0.305	0.301	0.319
F	482.67	392.11	439.22	372.43

Table 8-17 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=60%, Own Price

Variable	(17-5)	(17-6)	(17-7)	(17-8)
Current Cigarette	-4.559	-4.571	-4.576	-4.578
Price, Own	(-1.10)	(-1.09)	(-1.11)	(-1.10)
Future Cigarette	3.241	3.334	3.264	3.338
Price, Own	(0.78)	(0.80)	(0.79)	(0.80)
Addictive Stock	0.179	0.167	0.180	0.170
	(1.52)	(1.37)	(1.52)	(1.38)
Future Consumption	0.616	0.651	0.614	0.647
	(2.48)	(2.47)	(2.46)	(2.45)
Age	0.035	0.028	0.032	0.025
	(0.73)	(0.57)	(0.69)	(0.52)
Age Squared	-0.0004	-0.0003	-0.0003	-0.0002
	(-0.63)	(-0.45)	(-0.59)	(-0.41)
Sex	0.166	0.166	0.172	0.168
	(0.53)	(0.52)	(0.54)	(0.52)
Black	-0.269	-0.251	-0.268	-0.248
	(-1.15)	(-1.05)	(-1.12)	(-1.02)
Other Races	-0.280	-0.257	-0.284	-0.259
	(-0.66)	(-0.61)	(-0.66)	(-0.60)
American Natives	0.380	0.370	0.378	0.366
	(0.91)	(0.88)	(0.90)	(0.86)
Family Income	-0.0004	-0.001	-0.0004	-0.001
	(-0.20)	(-0.34)	(-0.18)	(-0.31)
Number of Years of	-0.016	----	-0.014	----
Formal Education	(-0.75)	----	(-0.69)	----
No Formal Education	----	0.620	----	0.610
	----	(1.27)	----	(1.24)
Less than Grade	----	0.024	----	0.010
School Education	----	(0.10)	----	(0.04)
Grade School	----	-0.167	----	-0.175
Education	----	(-1.07)	----	(-1.06)
Some High School	----	-0.112	----	-0.120
Education	----	(-0.58)	----	(-0.63)
College	----	-0.122	----	-0.116
	----	(-0.56)	----	(-0.53)
Active	----	----	0.050	0.049
	----	----	(0.28)	(0.27)
Exercise	----	----	-0.098	-0.096
	----	----	(-0.86)	(-0.81)
Intercept	0.202	0.120	0.241	0.182
	(0.36)	(0.22)	(0.45)	(0.36)
R ²	0.321	0.337	0.332	0.349
F	562.82	453.07	506.78	425.32

* See note to Table 8-1.

Table 8-18*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=60%, Border Price

Variable	(18-1)	(18-2)	(18-3)	(18-4)
Current Cigarette	-4.605	-4.561	-4.715	-4.636
Price, Border	(-1.12)	(-1.12)	(-1.15)	(-1.14)
Future Cigarette	3.217	3.282	3.344	3.367
Price, Border	(0.78)	(0.80)	(0.81)	(0.82)
Addictive Stock	0.277	0.259	0.275	0.259
	(2.78)	(2.54)	(2.76)	(2.54)
Future Consumption	0.404	0.472	0.405	0.472
	(1.72)	(1.97)	(1.72)	(1.97)
Age	0.026	0.004	0.027	0.004
	(0.46)	(0.08)	(0.49)	(0.08)
Age Squared	-0.0003	0.00001	-0.0003	0.000002
	(-0.39)	(0.02)	(-0.42)	(0.002)
Sex	-0.004	-0.059	0.027	-0.040
	(-0.01)	(-0.20)	(0.09)	(-0.13)
Black	-0.189	-0.121	-0.203	-0.127
	(-0.81)	(-0.53)	(-0.83)	(-0.53)
Other Races	-0.349	-0.108	-0.236	-0.123
	(-0.47)	(-0.26)	(-0.51)	(-0.28)
American Natives	0.349	0.289	0.360	0.292
	(0.81)	(0.69)	(0.82)	(0.68)
Family Income	0.001	0.001	0.001	0.001
	(0.47)	(0.37)	(0.43)	(0.35)
Number of Years of Formal Education	-0.022	----	-0.022	----
	(-0.88)	----	(-0.90)	----
No Formal Education	----	0.581	----	0.586
	----	(1.21)	----	(1.19)
Less than Grade School Education	----	-0.080	----	-0.079
	----	(-0.35)	----	(-0.34)
Grade School Education	----	-0.120	----	-0.122
	----	(-0.81)	----	(-0.78)
Some High School Education	----	-0.176	----	-0.175
	----	(-0.90)	----	(-0.89)
College	----	-0.156	----	-0.155
	----	(-0.62)	----	(-0.61)
Active	----	----	0.118	0.135
	----	----	(0.71)	(0.80)
Exercise	----	----	-0.100	-0.074
	----	----	(-0.79)	(-0.58)
Intercept	0.283	0.238	0.251	0.177
	(0.55)	(0.47)	(0.49)	(0.38)
R ²	0.325	0.349	0.335	0.360
F	573.18	478.64	513.75	446.77

Table 8-18 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=60%, Border Price

Variable	(18-5)	(18-6)	(18-7)	(18-8)
Current Cigarette	-4.586	-4.589	-4.662	-4.655
Price, Border	(-1.11)	(-1.13)	(-1.13)	(-1.15)
Future Cigarette	2.988	3.089	3.071	3.153
Price, Border	(0.73)	(0.77)	(0.75)	(0.78)
Addictive Stock	0.308	0.292	0.308	0.294
	(3.93)	(3.66)	(3.91)	(3.67)
Future Consumption	0.309	0.367	0.304	0.359
	(1.60)	(1.85)	(1.58)	(1.81)
Age	0.043	0.026	0.044	0.026
	(0.94)	(0.58)	(0.96)	(0.59)
Age Squared	-0.001	-0.0003	-0.001	-0.0003
	(-0.87)	(-0.49)	(-0.89)	(-0.51)
Sex	0.035	0.007	0.062	0.032
	(0.15)	(0.03)	(0.26)	(0.13)
Black	-0.231	-0.175	-0.242	-0.186
	(-1.14)	(-0.89)	(-1.16)	(-0.91)
Other Races	-0.289	-0.194	-0.314	-0.216
	(-0.70)	(-0.49)	(-0.75)	(-0.54)
American Natives	0.417	0.375	0.426	0.384
	(0.99)	(0.91)	(1.01)	(0.92)
Family Income	0.001	0.001	0.001	0.001
	(0.67)	(0.52)	(0.66)	(0.52)
Number of Years of	-0.032	----	-0.031	----
Formal Education	(-1.40)	----	(-1.41)	----
No Formal Education	----	0.496	----	0.484
	----	(1.03)	----	(0.99)
Less than Grade	----	-0.128	----	-0.140
School Education	----	(-0.58)	----	(-0.62)
Grade School	----	-0.127	----	-0.137
Education	----	(-0.89)	----	(-0.92)
Some High School	----	-0.125	----	-0.124
Education	----	(-0.67)	----	(-0.67)
College	----	-0.284	----	-0.290
	----	(-1.25)	----	(-1.27)
Active	----	----	0.062	0.112
	----	----	(0.76)	(0.73)
Exercise	----	----	-0.129	-0.115
	----	----	(-1.09)	(-0.97)
Intercept	0.328	0.200	0.328	0.203
	(0.65)	(0.41)	(0.64)	(0.43)
R ²	0.320	0.347	0.329	0.358
F	559.80	475.29	500.03	441.63

* See note to Table 8-1.

Table 8-19*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=40%, Weighted Price

Variable	(19-1)	(19-2)	(19-3)	(19-4)
Current Cigarette Price, Weighted	-4.996 (-1.12)	-4.880 (-1.09)	-5.067 (-1.13)	-4.906 (-1.10)
Future Cigarette Price, Weighted	3.746 (0.83)	3.778 (0.83)	3.840 (0.85)	3.807 (0.84)
Addictive Stock	0.125 (1.59)	0.114 (1.39)	0.124 (1.55)	0.114 (1.38)
Future Consumption	0.554 (2.12)	0.633 (2.29)	0.555 (2.12)	0.628 (2.28)
Age	0.030 (0.38)	0.003 (0.04)	0.030 (0.37)	0.002 (0.03)
Age Squared	-0.0004 (-0.44)	-0.0001 (-0.08)	-0.0004 (-0.44)	-0.0001 (-0.07)
Sex	0.228 (0.53)	0.141 (0.33)	0.261 (0.57)	0.159 (0.35)
Black	-0.368 (-1.23)	-0.275 (-0.94)	-0.383 (-1.22)	-0.283 (-0.90)
Other Races	-0.453 (-0.87)	-0.300 (-0.61)	-0.483 (-0.89)	-0.317 (-0.61)
American Natives	0.486 (1.02)	0.386 (0.83)	0.500 (1.02)	0.393 (0.82)
Family Income	-0.001 (-0.38)	-0.001 (-0.40)	-0.001 (-0.38)	-0.001 (-0.38)
Number of Years of Formal Education	-0.029 (-0.99)	----	-0.026 (-0.96)	----
No Formal Education	----	0.527 (1.02)	----	0.505 (0.95)
Less than Grade School Education	----	0.003 (0.01)	----	-0.016 (-0.07)
Grade School Education	----	-0.173 (-1.05)	----	-0.187 (-1.03)
Some High School Education	----	-0.084 (-0.37)	----	-0.088 (-0.38)
College	----	-0.189 (-0.62)	----	-0.190 (-0.61)
Active	----	----	0.015 (0.08)	0.040 (0.19)
Exercise	----	----	-0.159 (-1.08)	-0.119 (-0.80)
Intercept	-0.986 (-1.03)	0.826 (0.85)	1.081 (1.23)	0.913 (1.06)
R ²	0.308	0.328	0.317	0.340
F	529.58	436.34	474.66	408.76

Table 8-19 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=40%, Weighted Price

Variable	(19-5)	(19-6)	(19-7)	(19-8)
Current Cigarette	-4.313	-4.280	-4.336	-4.300
Price, Weighted	(-1.02)	(-1.01)	(-1.02)	(-1.02)
Future Cigarette	2.892	2.928	2.926	2.952
Price, Weighted	(0.69)	(0.70)	(0.70)	(0.71)
Addictive Stock	0.155	0.150	0.156	0.151
	(2.84)	(2.65)	(2.81)	(2.65)
Future Consumption	0.478	0.506	0.476	0.502
	(2.57)	(2.54)	(2.55)	(2.53)
Age	0.003	-0.007	0.0005	-0.010
	(0.07)	(-0.13)	(0.01)	(-0.18)
Age Squared	-0.0001	0.00001	-0.0001	0.00003
	(-0.21)	(0.02)	(-0.16)	(0.05)
Sex	0.067	0.055	0.079	0.068
	(0.24)	(0.20)	(0.28)	(0.23)
Black	-0.279	-0.242	-0.281	-0.245
	(-1.29)	(-1.12)	(-1.27)	(-1.10)
Other Races	-0.334	-0.266	-0.344	-0.277
	(-0.80)	(-0.65)	(-0.81)	(-0.66)
American Natives	0.414	0.389	0.413	0.390
	(0.98)	(0.93)	(0.98)	(0.92)
Family Income	-0.00004	-0.0002	-0.000002	-0.0002
	(-0.026)	(-0.12)	(-0.001)	(-0.10)
Number of Years of	-0.028	----	-0.026	----
Formal Education	(-1.26)	----	(-1.22)	----
No Formal Education	----	0.453	----	0.438
	----	(0.92)	----	(0.88)
Less than Grade	----	-0.063	----	-0.079
School Education	----	(-0.28)	----	(-0.35)
Grade School	----	-0.152	----	-0.163
Education	----	(-1.02)	----	(-1.05)
Some High School	----	-0.083	----	-0.089
Education	----	(-0.43)	----	(-0.47)
College	----	-0.276	----	-0.272
	----	(-1.19)	----	(-1.18)
Active	----	----	0.082	0.076
	----	----	(0.51)	(0.46)
Exercise	----	----	-0.132	-0.126
	----	----	(-1.12)	(-1.04)
Intercept	1.309	1.151	1.351	1.219
	(1.75)	(1.58)	(1.89)	(1.79)
R ²	0.319	0.340	0.329	0.351
F	556.57	459.89	500.32	430.05

* See note to Table 8-1.

Table 8-20*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=40%, Own Price

Variable	(20-1)	(20-2)	(20-3)	(20-4)
Current Cigarette	-6.364	-6.374	-6.305	-6.292
Price, Own	(-1.19)	(-1.16)	(-1.18)	(-1.15)
Future Cigarette	5.597	5.766	5.568	5.691
Price, Own	(1.02)	(1.01)	(1.02)	(1.00)
Addictive Stock	0.005	-0.008	0.006	-0.005
	(0.05)	(-0.06)	(0.05)	(-0.04)
Future Consumption	0.890	0.968	0.890	0.962
	(2.48)	(2.51)	(2.48)	(2.50)
Age	0.117	0.095	0.109	0.088
	(0.93)	(0.71)	(0.87)	(0.66)
Age Squared	-0.001	-0.001	-0.001	-0.001
	(-0.92)	(-0.68)	(-0.87)	(-0.63)
Sex	0.772	0.703	0.774	0.700
	(1.12)	(0.95)	(1.09)	(0.91)
Black	-0.649	-0.581	-0.647	-0.578
	(-1.46)	(-1.22)	(-1.41)	(-1.16)
Other Races	-0.783	-0.664	-0.789	-0.667
	(-1.10)	(-0.92)	(-1.08)	(-0.89)
American Natives	0.687	0.596	0.689	0.597
	(1.13)	(0.95)	(1.12)	(0.93)
Family Income	-0.004	-0.004	-0.003	-0.004
	(-1.09)	(-1.07)	(-1.05)	(-1.02)
Number of Years of	-0.026	----	-0.019	----
Formal Education	(-0.72)	----	(-0.59)	----
No Formal Education	----	0.634	----	0.569
	----	(1.00)	----	(0.88)
Less than Grade	----	0.197	----	0.144
School Education	----	(0.61)	----	(0.46)
Grade School	----	-0.293	----	-0.324
Education	----	(-1.30)	----	(-1.26)
Some High School	----	0.052	----	0.033
Education	----	(0.16)	----	(0.10)
College	----	-0.127	----	-0.119
	----	(-0.31)	----	(-0.30)
Active	----	----	-0.183	-0.166
	----	----	(-0.62)	(-0.51)
Exercise	----	----	-0.208	-0.178
	----	----	(-1.10)	(-0.86)
Intercept	-0.205	-0.426	0.130	-0.047
	(-0.15)	(-0.28)	(0.11)	(-0.04)
R ²	0.242	0.251	0.252	0.263
F	380.47	298.78	344.38	283.12

Table 8-20 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=40%, Own Price

Variable	(20-5)	(20-6)	(20-7)	(20-8)
Current Cigarette	-4.459	-4.528	-4.467	-4.519
Price, Own	(-1.01)	(-1.01)	(-1.01)	(-1.01)
Future Cigarette	3.340	3.487	3.356	3.476
Price, Own	(0.75)	(0.77)	(0.76)	(0.77)
Addictive Stock	0.088	0.080	0.089	0.082
	(1.15)	(1.01)	(1.14)	(1.02)
Future Consumption	0.719	0.757	0.718	0.753
	(3.02)	(3.01)	(2.99)	(2.99)
Age	0.012	0.007	0.009	0.003
	(0.20)	(0.10)	(0.15)	(0.05)
Age Squared	-0.0002	-0.0001	-0.0001	-0.00003
	(-0.22)	(-0.09)	(-0.18)	(-0.05)
Sex	0.193	0.189	0.199	0.190
	(0.53)	(0.51)	(0.53)	(0.50)
Black	-0.303	-0.283	-0.303	-0.281
	(-1.22)	(-1.11)	(-1.20)	(-1.08)
Other Races	-0.307	-0.283	-0.313	-0.285
	(-0.69)	(-0.63)	(-0.69)	(-0.62)
American Natives	0.379	0.360	0.378	0.358
	(0.86)	(0.81)	(0.85)	(0.80)
Family Income	-0.001	-0.001	-0.001	-0.001
	(-0.53)	(-0.64)	(-0.51)	(-0.61)
Number of Years of	-0.013	----	-0.011	----
Formal Education	(-0.59)	----	(-0.51)	----
No Formal Education	----	0.614	----	0.599
	----	(1.19)	----	(1.15)
Less than Grade	----	0.070	----	0.053
School Education	----	(0.28)	----	(0.21)
Grade School	----	-0.184	----	-0.194
Education	----	(-1.12)	----	(-1.11)
Some High School	----	-0.099	----	-0.108
Education	----	(-0.49)	----	(-0.53)
College	----	-0.087	----	-0.082
	----	(-0.38)	----	(-0.36)
Active	----	----	0.024	0.027
	----	----	(0.13)	(0.13)
Exercise	----	----	-0.103	-0.097
	----	----	(-0.86)	(-0.78)
Intercept	0.720	0.607	0.788	0.702
	(0.78)	(0.65)	(0.93)	(0.85)
R ²	0.303	0.316	0.314	0.329
F	517.59	413.17	466.14	388.29

* See note to Table 8-1.

Table 8-21*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=40%, Border Price

Variable	(21-1)	(21-2)	(21-3)	(21-4)
Current Cigarette	-3.974	-4.005	-4.075	-4.060
Price, Border	(-0.94)	(-0.94)	(-0.96)	(-0.96)
Future Cigarette	2.799	2.960	2.913	3.020
Price, Border	(0.65)	(0.69)	(0.68)	(0.70)
Addictive Stock	0.170	0.156	0.169	0.156
	(2.50)	(2.23)	(2.47)	(2.23)
Future Consumption	0.464	0.543	0.463	0.541
	(1.95)	(2.25)	(1.96)	(2.24)
Age	-0.028	-0.047	-0.026	-0.047
	(-0.45)	(-0.78)	(-0.42)	(-0.77)
Age Squared	0.0002	0.001	0.0002	0.001
	(0.33)	(0.71)	(0.30)	(0.69)
Sex	-0.093	-0.140	-0.065	-0.128
	(-0.29)	(-0.43)	(-0.19)	(-0.37)
Black	-0.177	-0.110	-0.188	-0.113
	(-0.73)	(-0.47)	(-0.74)	(-0.45)
Other Races	-0.186	-0.083	-0.208	-0.092
	(-0.41)	(-0.19)	(-0.45)	(-0.21)
American Natives	0.310	0.244	0.318	0.242
	(0.71)	(0.57)	(0.72)	(0.55)
Family Income	0.001	0.0003	0.0005	0.0003
	(0.28)	(0.18)	(0.25)	(0.17)
Number of Years of	-0.020	----	-0.020	----
Formal Education	(-0.80)	----	(-0.82)	----
No Formal Education	----	0.531	----	0.541
	----	(1.07)	----	(1.07)
Less than Grade	----	-0.059	----	-0.057
School Education	----	(-0.25)	----	(-0.24)
Grade School	----	-0.118	----	-0.118
Education	----	(-0.78)	----	(-0.73)
Some High School	----	-0.176	----	-0.177
Education	----	(-0.88)	----	(-0.88)
College	----	-0.141	----	-0.138
	----	(-0.54)	----	(-0.52)
Active	----	----	0.132	0.148
	----	----	(0.76)	(0.83)
Exercise	----	----	-0.098	-0.067
	----	----	(-0.76)	(-0.52)
Intercept	1.401	1.274	1.351	1.201
	(1.67)	(1.55)	(1.70)	(1.59)
R ²	0.319	0.341	0.329	0.352
F	557.50	461.77	499.69	431.15

Table 8-21 (continued)
TSLS Estimates of Cigarette Demand Equation
Depreciation Rate=40%, Border Price

Variable	(21-5)	(21-6)	(21-7)	(21-8)
Current Cigarette	-3.754	-3.790	-3.819	-3.842
Price, Border	(-0.89)	(-0.91)	(-0.81)	(-0.92)
Future Cigarette	2.341	2.486	2.412	2.534
Price, Border	(0.56)	(0.60)	(0.58)	(0.61)
Addictive Stock	0.196	0.184	0.197	0.186
	(3.76)	(3.49)	(3.75)	(3.50)
Future Consumption	0.353	0.416	0.348	0.408
	(1.86)	(2.15)	(1.83)	(2.10)
Age	-0.019	-0.035	-0.019	-0.035
	(-0.39)	(-0.75)	(-0.40)	(-0.75)
Age Squared	0.0001	0.0003	0.0001	0.0003
	(0.17)	(0.57)	(0.16)	(0.55)
Sex	-0.086	-0.113	-0.063	-0.094
	(-0.34)	(-0.46)	(-0.24)	(-0.36)
Black	-0.209	-0.151	-0.217	-0.158
	(-1.01)	(-0.75)	(-1.02)	(-0.76)
Other Races	-0.254	-0.150	-0.274	-0.167
	(-0.61)	(-0.37)	(-0.64)	(-0.41)
American Natives	0.370	0.319	0.375	0.324
	(0.87)	(0.77)	(0.88)	(0.77)
Family Income	0.001	0.001	0.001	0.001
	(0.51)	(0.41)	(0.51)	(0.40)
Number of Years of	-0.031	----	-0.030	----
Formal Education	(-1.34)	----	(-1.35)	----
No Formal Education	----	0.425	----	0.419
	----	(0.86)	----	(0.84)
Less than Grade	----	-0.120	----	-0.129
School Education	----	(-0.54)	----	(-0.57)
Grade School	----	-0.119	----	-0.125
Education	----	(-0.82)	----	(-0.82)
Some High School	----	-0.128	----	-0.128
Education	----	(-0.68)	----	(-0.68)
College	----	-0.284	----	-0.287
	----	(-1.22)	----	(-1.23)
Active	----	----	0.140	0.137
	----	----	(0.89)	(0.87)
Exercise	----	----	-0.127	-0.107
	----	----	(-1.06)	(-0.90)
Intercept	1.641	1.455	1.626	1.440
	(2.30)	(2.17)	(2.33)	(2.23)
R ²	0.314	0.341	0.323	0.352
F	545.58	462.80	487.45	430.37

* See note to Table 8-1.

Table 8-22*
TSLS Estimates of Cigarette Demand Equation
Depreciation Rate=20%, Weighted Price

Variable	(22-1)	(22-2)	(22-3)	(22-4)
Current Cigarette Price, Weighted	-4.881 (-1.00)	-4.862 (-0.99)	-4.960 (-1.01)	-4.876 (-0.99)
Future Cigarette Price, Weighted	3.958 (0.81)	4.079 (0.82)	4.062 (0.82)	4.098 (0.82)
Addictive Stock	0.044 (1.22)	0.039 (1.01)	0.044 (1.16)	0.039 (1.00)
Future Consumption	0.676 (2.81)	0.753 (2.93)	0.678 (2.81)	0.749 (2.92)
Age	-0.009 (-0.08)	-0.029 (-0.26)	-0.008 (-0.07)	-0.031 (-0.26)
Age Squared	-0.0001 (-0.09)	0.0002 (0.16)	-0.0001 (-0.10)	0.0002 (0.16)
Sex	0.218 (0.43)	0.143 (0.28)	0.253 (0.47)	0.160 (0.29)
Black	-0.418 (-1.35)	-0.328 (-1.07)	-0.433 (-1.32)	-0.336 (-0.72)
Other Races	-0.525 (-0.97)	-0.373 (-0.72)	-0.556 (-0.98)	-0.390 (-0.72)
American Natives	0.541 (1.09)	0.431 (0.88)	0.555 (1.09)	0.439 (0.87)
Family Income	-0.002 (-0.99)	-0.002 (-0.94)	-0.002 (-0.98)	-0.002 (-0.92)
Number of Years of Formal Education	-0.027 (-0.88)	----	-0.024 (-0.84)	----
No Formal Education	----	0.538 (0.97)	----	0.511 (0.90)
Less than Grade School Education	----	0.069 (0.27)	----	0.048 (0.19)
Grade School Education	----	-0.195 (-1.12)	----	-0.210 (-1.09)
Some High School Education	----	-0.073 (-0.30)	----	-0.077 (-0.32)
College	----	-0.170 (-0.51)	----	-0.171 (-0.51)
Active	----	----	-0.009 (-0.04)	0.016 (0.07)
Exercise	----	----	-0.161 (-1.32)	-0.120 (-1.02)
Intercept	2.050 (1.02)	1.728 (0.83)	2.141 (1.11)	1.849 (0.94)
R ²	0.287	0.304	0.296	0.315
F	478.25	389.78	428.47	365.26

Table 8-22 (continued)
TSLS Estimates of Cigarette Demand Equation
Depreciation Rate=20%, Weighted Price

Variable	(22-5)	(22-6)	(22-7)	(22-8)
Current Cigarette	-3.640	-3.614	-3.655	-3.625
Price, Weighted	(-0.81)	(-0.81)	(-0.81)	(-0.81)
Future Cigarette	2.529	2.568	2.556	2.584
Price, Weighted	(0.57)	(0.58)	(0.58)	(0.58)
Addictive Stock	0.064	0.063	0.065	0.063
	(2.63)	(2.46)	(2.60)	(2.46)
Future Consumption	0.577	0.603	0.575	0.600
	(3.50)	(3.42)	(3.48)	(3.41)
Age	-0.068	-0.079	-0.072	-0.082
	(-0.96)	(-1.10)	(-1.00)	(-1.13)
Age Squared	0.0005	0.001	0.001	0.001
	(0.63)	(0.83)	(0.68)	(0.86)
Sex	-0.049	-0.067	-0.040	-0.059
	(-0.15)	(-0.21)	(-0.12)	(-0.17)
Black	-0.303	-0.263	-0.303	-0.264
	(-1.36)	(-1.18)	(1.33)	(-1.15)
Other Races	-0.381	-0.303	-0.388	-0.312
	(-0.87)	(-0.71)	(-0.88)	(-0.72)
American Natives	0.463	0.424	0.461	0.419
	(1.06)	(0.84)	(1.05)	(0.81)
Family Income	-0.001	-0.001	-0.001	-0.001
	(-0.71)	(-0.72)	(-0.69)	(-0.70)
Number of Years of	-0.027	----	-0.025	----
Formal Education	(-1.18)	----	(-1.14)	----
No Formal Education	----	0.430	----	0.419
	----	(0.84)	----	(0.81)
Less than Grade	----	-0.009	----	-0.023
School Education	----	(-0.04)	----	(-0.10)
Grade School	----	-0.158	----	-0.166
Education	----	(-1.02)	----	(-1.03)
Some High School	----	-0.088	----	-0.095
Education	----	(-0.44)	----	(-0.48)
College	----	-0.282	----	-0.276
	----	(-1.15)	----	(-1.14)
Active	----	----	0.088	0.085
	----	----	(0.52)	(0.49)
Exercise	----	----	-0.127	-0.117
	----	----	(-1.04)	(-0.93)
Intercept	3.117	2.933	3.161	3.000
	(2.25)	(2.11)	(2.35)	(2.24)
R ²	0.301	0.322	0.312	0.333
F	513.56	423.83	461.85	396.52

* See note to Table 8-1.

Table 8-23*
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=20%, Own Price

Variable	(23-1)	(23-2)	(23-3)	(23-4)
Current Cigarette	-7.263	-7.308	-7.307	-7.318
Price, Own	(-1.21)	(-1.19)	(-1.20)	(-1.18)
Future Cigarette	6.626	6.815	6.722	6.858
Price, Own	(1.09)	(1.09)	(-1.09)	(1.08)
Addictive Stock	-0.014	-0.019	-0.015	-0.020
	(-0.26)	(-0.33)	(-0.27)	(-0.33)
Future Consumption	0.976	1.045	0.986	1.049
	(3.17)	(3.13)	(3.14)	(3.12)
Age	0.160	0.144	0.158	0.142
	(0.87)	(0.74)	(0.84)	(0.71)
Age Squared	-0.002	-0.002	-0.002	-0.002
	(-0.91)	(-0.75)	(-0.88)	(-0.72)
Sex	0.974	0.906	1.008	0.935
	(1.18)	(1.04)	(1.15)	(1.00)
Black	-0.737	-0.663	-0.752	-0.680
	(-1.58)	(-1.34)	(-1.53)	(-1.29)
Other Races	-0.888	-0.763	-0.918	-0.791
	(-1.19)	(-1.02)	(-1.17)	(-1.00)
American Natives	0.743	0.643	0.761	0.662
	(1.17)	(0.98)	(1.16)	(0.86)
Family Income	-0.004	-0.004	-0.004	-0.004
	(-1.50)	(-1.42)	(-1.46)	(-1.38)
Number of Years of	-0.025	----	-0.018	----
Formal Education	(-0.66)	----	(-0.52)	----
No Formal Education	----	0.677	----	0.594
	----	(1.00)	----	(0.86)
Less than Grade	----	0.241	----	0.182
School Education	----	(0.78)	----	(0.59)
Grade School	----	-0.328	----	-0.374
Education	----	(-1.38)	----	(-1.36)
Some High School	----	0.091	----	0.079
Education	----	(0.26)	----	(0.22)
College	----	-0.098	----	-0.095
	----	(-0.23)	----	(-0.22)
Active	----	----	-0.263	-0.243
	----	----	(-0.80)	(-0.67)
Exercise	----	----	-0.232	-0.203
	----	----	(-1.13)	(-0.90)
Intercept	-0.988	-1.355	-0.664	-0.959
	(-0.34)	(-0.43)	(-0.24)	(-0.33)
R ²	0.221	0.230	0.227	0.239
F	337.09	267.11	300.12	248.88

Table 8-23 (continued)
TSLS Estimates of Cigarette Demand Equation
Depreciation Rate=20%, Own Price

Variable	(23-5)	(23-6)	(23-7)	(23-8)
Current Cigarette	-4.412	-4.495	-4.426	-4.487
Price, Own	(-0.93)	(-0.93)	(-0.92)	(-0.93)
Future Cigarette	3.482	3.625	3.509	3.621
Price, Own	(0.74)	(0.76)	(0.74)	(0.75)
Addictive Stock	0.030	0.027	0.030	0.028
	(0.93)	(0.82)	(0.91)	(0.82)
Future Consumption	0.812	0.843	0.813	0.841
	(4.16)	(4.10)	(4.13)	(4.08)
Age	-0.012	-0.017	-0.015	-0.020
	(-0.13)	(-0.17)	(-0.16)	(-0.21)
Age Squared	0.00004	0.0001	0.0001	0.0002
	(0.04)	(0.12)	(0.06)	(0.15)
Sex	0.201	0.189	0.210	0.192
	(0.48)	(0.44)	(0.48)	(0.43)
Black	-0.345	-0.321	-0.347	-0.320
	(-1.38)	(-1.25)	(-1.35)	(-1.21)
Other Races	-0.362	-0.331	-0.370	-0.335
	(-0.78)	(-0.71)	(-0.79)	(-0.71)
American Natives	0.420	0.390	0.421	0.390
	(0.92)	(0.84)	(0.91)	(0.83)
Family Income	-0.002	-0.002	-0.002	-0.002
	(-1.09)	(-1.13)	(-1.07)	(-1.11)
Number of Years of	-0.011	----	-0.009	----
Formal Education	(-0.50)	----	(-0.41)	----
No Formal Education	----	0.623	----	0.605
	----	(1.14)	----	(1.10)
Less than Grade	----	0.116	----	0.098
School Education	----	(0.47)	----	(0.40)
Grade School	----	-0.199	----	-0.211
Education	----	(-1.17)	----	(-1.17)
Some High School	----	-0.093	----	-0.100
Education	----	(-0.43)	----	(-0.47)
College	----	-0.072	----	-0.067
	----	(-0.30)	----	(-0.28)
Active	----	----	0.001	0.009
	----	----	(0.01)	(0.04)
Exercise	----	----	-0.106	-0.097
	----	----	(-0.84)	(-0.74)
Intercept	1.416	1.255	1.500	1.374
	(0.79)	(0.69)	(0.88)	(0.80)
R ²	0.282	0.300	0.291	0.307
F	466.70	374.51	419.65	351.29

* See note to Table 8-1.

Table 8-24*
TSLS Estimates of Cigarette Demand Equation
Depreciation Rate=20%, Border Price

Variable	(24-1)	(24-2)	(24-3)	(24-4)
Current Cigarette	-3.352	-3.488	-3.420	-3.500
Price, Border	(-0.73)	(-0.76)	(-0.75)	(-0.76)
Future Cigarette	2.500	2.763	2.573	2.775
Price, Border	(0.54)	(0.59)	(0.56)	(-0.60)
Addictive Stock	0.072	0.065	0.072	0.066
	(2.15)	(1.87)	(2.13)	(1.88)
Future Consumption	0.560	0.639	0.557	0.634
	(2.15)	(2.71)	(2.42)	(2.69)
Age	-0.109	-0.119	-0.109	-0.122
	(-1.24)	(-1.33)	(-1.20)	(-1.31)
Age Squared	0.001	0.001	0.001	0.001
	(1.01)	(-1.33)	(0.97)	(1.18)
Sex	-0.232	-0.258	-0.214	-0.257
	(-0.58)	(-0.64)	(-0.51)	(-0.60)
Black	-0.201	-0.138	-0.207	-0.135
	(-0.81)	(-0.56)	(-0.79)	(-0.52)
Other Races	-0.245	-0.138	-0.260	-0.140
	(-0.53)	(-0.31)	(-0.54)	(-0.30)
American Natives	0.369	0.290	0.371	0.284
	(0.82)	(0.65)	(0.81)	(0.63)
Family Income	-0.001	-0.001	-0.001	-0.001
	(-0.34)	(-0.36)	(-0.35)	(-0.35)
Number of Years of Formal Education	-0.021	----	-0.020	----
	(-0.77)	----	(-0.78)	----
No Formal Education	----	0.501	----	0.513
	----	(0.95)	----	(0.96)
Less than Grade	----	-0.004	----	-0.001
School Education	----	(-0.02)	----	(-0.01)
Grade School	----	-0.126	----	-0.122
Education	----	(-0.79)	----	(-0.72)
Some High School	----	-0.177	----	-0.179
Education	----	(-0.85)	----	(-0.86)
College	----	-0.156	----	-0.153
	----	(-0.54)	----	(-0.53)
Active	----	----	0.145	0.157
	----	----	(0.77)	(0.81)
Exercise	----	----	-0.093	-0.060
	----	----	(-0.70)	(-0.45)
Intercept	3.480	3.120	3.431	3.070
	(1.89)	(1.69)	(1.93)	(1.73)
R ²	0.302	0.322	0.312	0.333
F	515.44	424.87	462.07	396.98

Table 8-24 (continued)
 TSLS Estimates of Cigarette Demand Equation
 Depreciation Rate=20%, Border Price

Variable	(24-5)	(24-6)	(24-7)	(24-8)
Current Cigarette	-2.903	-2.967	-2.953	-3.001
Price, Border	(-0.66)	(-0.68)	(-0.67)	(-0.69)
Future Cigarette	1.846	2.018	1.902	2.050
Price, Border	(0.42)	(0.46)	(0.43)	(0.47)
Addictive Stock	0.085	0.080	0.086	0.081
	(3.49)	(3.23)	(3.48)	(3.23)
Future Consumption	0.457	0.518	0.452	0.512
	(2.61)	(2.90)	(2.58)	(2.86)
Age	-0.119	-0.132	-0.121	-0.133
	(-1.85)	(-2.05)	(-1.85)	(-2.04)
Age Squared	0.001	0.001	0.001	0.001
	(1.40)	(1.71)	(1.39)	(1.69)
Sex	-0.277	-0.300	-0.261	-0.289
	(-0.95)	(-1.03)	(-0.85)	(-0.95)
Black	-0.221	-0.160	-0.226	-0.163
	(-1.03)	(-0.77)	(-1.03)	(-0.75)
Other Races	-0.300	-0.183	-0.315	-0.195
	(-0.70)	(-0.44)	(-0.72)	(-0.46)
American Natives	0.424	0.355	0.426	0.355
	(0.97)	(0.82)	(0.96)	(0.81)
Family Income	-0.0003	-0.0004	-0.0003	-0.0004
	(-0.24)	(-0.25)	(-0.24)	(-0.25)
Number of Years of Formal Education	-0.031	----	-0.030	----
	(-1.28)	----	(-1.30)	----
No Formal Education	----	0.388	----	0.391
	----	(0.76)	----	(0.75)
Less than Grade School Education	----	-0.062	----	-0.065
	----	(-0.27)	----	(-0.28)
Grade School Education	----	-0.119	----	-0.120
	----	(-0.78)	----	(-0.76)
Some High School Education	----	-0.142	----	-0.143
	----	(-0.73)	----	(-0.73)
College	----	-0.298	----	-0.298
	----	(-1.21)	----	(-1.20)
Active	----	----	0.163	0.162
	----	----	(0.99)	(0.98)
Exercise	----	----	-0.117	-0.092
	----	----	(-0.95)	(-0.75)
Intercept	4.130	3.804	4.107	3.778
	(3.01)	(2.85)	(3.06)	(2.91)
R ²	0.300	0.325	0.309	0.336
F	510.32	430.70	456.37	401.03

* See note to Table 8-1.

few exceptions, are identical to those obtained in the non-addictive models. Briefly, these results are that: men smoke less, on average, than women; blacks and other races smoke less than whites; American Natives smoke more than others; and older individuals smoke more than younger individuals, with the difference diminishing with age.

Once cigarette smoking is modelled as an addictive behavior, however, it appears that smoking is a weakly superior behavior in an economic sense. That is, increases in income lead to increases in consumption. However, this effect is relatively small, with the estimated income elasticities of demand in the range from 0.003 to 0.009.

Most of the earlier findings concerning the impact of education on cigarette smoking remain unchanged. As before, cigarette smoking decreases as the number of years of formal education increases. Individuals with some post-high school education smoke less than those whose formal education concluded with their high school graduation. Now, however, there appears to be little difference in cigarette demand by those individuals who completed high school and those individuals who dropped out of high school. As before, those whose formal education stopped after eight years of school or less smoke somewhat less than high school graduates. Finally, those individuals with no formal education are found to smoke more than high school graduates.

As in the non-addictive models presented above, individuals whose recreational activities provide much or

moderate exercise smoke less than those individuals who do little or no exercise. This is consistent with the expectation that these individuals are more health conscious and are, therefore, less likely to engage in an unhealthy activity such as cigarette smoking. However, when cigarette demand is estimated in the addictive framework, the opposite is found for individuals who describe their normal day as very or moderately active. Now, cigarette smoking is positively related to activity. This would be expected if the activity variable is an indicator of the daily stress the individual suffers. As discussed above, one of the major reinforcement aspects of addictive consumption in general and cigarette smoking in particular is to relieve stress. Modelling consumption as non-addictive would, therefore, be a misspecification which could lead to incorrect conclusions being made based on the estimates obtained, particularly for those variables most sensitive to the distinction between addictive and non-addictive consumption.

Before discussing the results obtained for the key variables - cigarette prices, future consumption, and past consumption or the addictive stock - a brief review of the implications of the model of rational addictive behavior is in order. Firstly, in every model, current cigarette consumption should be inversely related to the current price of cigarettes. When they are included, past and future prices should positively affect current consumption. In the

model with no assumed rate of depreciation on the addictive stock, the effect of the future price on current consumption should be less than the effect of the past price on current consumption by a factor of $(1+\sigma)$. The absolute value of the effect of current price on consumption, in this model, should be larger than the combined effects of past and future price on current consumption, holding past and future consumption constant. The comparable expectation in the stock models is that the absolute value of the effect of future price on current consumption will be less than the impact of current price on current consumption by the term $(1-\delta)/(1+\sigma)$.

Adjacent complementarity, one of Becker and Murphy's requirements for addiction, implies that a positive relationship would exist between consumption in consecutive periods. Hence, future consumption and, when it enters, past consumption should exert a positive influence on current consumption. On the other hand, in the models which include the stock of past consumption, no a priori predictions can be made concerning the direction of the relationship between the stock and current consumption due to the offsetting effects of reinforcement in consumption and the full price of cigarette smoking being captured by the addictive stock. As with future and past prices, when both future and past consumption enter, the effect of past consumption on current consumption is expected to be larger than that of future consumption by the factor $(1+\sigma)$. For

stability of the second order difference equations given as the cigarette demand equations, the sum of the effects of past and future consumption on current consumption should be less than one. The comparable condition for the stock models is that the sum of the coefficient on future consumption plus the coefficient on the stock divided by the assumed rate of depreciation on the stock should be less than unity.

All of these predictions are confirmed by the estimates presented above. In every model, regardless of the measure of price employed, current cigarette consumption is negatively related to the current price of cigarettes. Similarly, in the first set of results - the models with no assumed rate of depreciation - the coefficients on both lagged cigarette price and led cigarette price are positive, with the coefficient on lagged price larger in each case. The sum of the coefficients on past, current, and future price in these models is less than zero, confirming the prediction that the negative effect of current price would be larger than the combined positive effects of past and future prices. Similarly, the coefficients on prices in the stock models are also as expected, with current price having a negative effect on current consumption larger in absolute value than the positive effect of future price on current consumption.

Comparing the alternative measures of price employed in the estimation of these demand equations, one sees that the

use of the weighted price appears to perform somewhat better than either the own-price or the border-price, as expected. In all models, the coefficients on the weighted price measure are slightly more significant than those on either of the other two measures. The remainder of the discussion will focus on the results obtained when the weighted average of the own-price and border-price is used as the appropriate measure of price.

In the models with no assumed rate of depreciation on the addictive stock, the estimated coefficients on the current price of cigarettes are significant at at least the five percent level, while the coefficients on past price are significant, in at least some cases, at the ten percent level or better. However, the coefficients on future price in these models never achieve statistical significance at conventional levels. In the models where the rate of depreciation on the addictive stock is assumed to be one hundred percent, the coefficients on current price are significant at about the seven percent level, in general. Finally, in the stock models, the coefficients on current price are significant at about the ten percent level when the assumed rate of depreciation is relatively high (eighty percent). However, as lower depreciation rates are assumed, the statistical significance of the estimated coefficients on current price falls. As in the other models, the coefficients on future prices in these models never achieve statistical significance at much more than the seventeen

percent level.

It is not surprising that the coefficients on price fail to achieve statistical significance at higher levels given the high correlation between prices in consecutive periods and the use of the cigarette prices as instruments for past and future consumption. The combination of these factors is likely to result in substantial multicollinearity between the cigarette prices and the measures of past and future consumption, a problem which leads to inflated standard errors for the coefficients on these variables and, hence, to less statistically significant results.

As with the cigarette prices, all of the predictions concerning the magnitudes and directions of the effects of past and future consumption on current consumption are supported by the estimates presented above. As noted earlier, the Becker-Grossman-Murphy test for addiction, in at least an economic sense, is that past consumption has a significant positive effect on current consumption. In each of the models estimated including past consumption as a determinant of current consumption, positive coefficients significant at at least the one percent level are obtained on past consumption.

Similarly, one of the basic tests for rational addictive behavior depended on the sign and significance of the estimated coefficient on future consumption. In all of the models estimated, a positive coefficient is obtained for future consumption. The statistical significance of these

coefficients depends, however, on the set of instruments used for future consumption. When the set of instruments comprised of the exogenous determinants of demand and a set of further leads and lags of cigarette prices is used, the estimated coefficients on future consumption are, for the most part, statistically insignificant. However, when a set of leads and lags of excise taxes are included in the set of instruments for future consumption, the estimated coefficients are significant at conventional levels. In the model with no assumed rate of depreciation, the estimated coefficients are significant at the ten percent level. In the models assuming a one hundred percent rate of depreciation on the addictive stock, the estimates are significant at the five percent level. Finally, in the various stock models, the estimated coefficients on future consumption are significant at at least the five percent level, with the statistical significance of the estimates increasing as lower rates of depreciation are assumed on the addictive stock.

The results indicate that the use of a set of cigarette excise taxes in addition to the set of cigarette prices and other exogenous determinants of demand as instruments for past and future consumption performs better than the set of instruments excluding taxes. The choice of instruments has little impact both on the estimates obtained on prices and the estimates obtained on past consumption, but it does have a noticeable impact on the estimated coefficients on future

consumption. This may be because individuals are able to predict future cigarette excise taxes better than they can predict future cigarette prices and, hence, base their expectations concerning future consumption more heavily on tax rates. Finally, the inclusion of excise taxes may also be helping to reduce the collinearity problems which plague the demand equations.

In all of the stock models estimated using the weighted price as the relevant measure of price, positive and significant estimates are obtained for the coefficient on the addictive stock. These estimates imply that the reinforcement effect associated with cigarette addiction plays a larger role in affecting current cigarette consumption than does the shadow price of the addictive stock.

The stock models were estimated assuming a variety of depreciation rates ranging from ten to ninety percent with the results of the models estimated using rates of twenty, forty, sixty, and eighty percent presented above. As noted earlier, assuming a relatively high rate of depreciation appears to be more appropriate than assuming a relatively low rate of depreciation, in the context of this work. The reasons behind this were that a relatively short period of withdrawal is associated with cigarette smoking and the fact that many of the health problems associated with cigarette smoking disappear within a short time after smoking cessation. In fact, a few years after cessation, former smokers are almost indistinguishable from non-smokers with respect

to many of the smoking-linked health problems. However, there are some respiratory problems caused by cigarette smoking which will never disappear, implying that the depreciation rate should not be assumed to be one hundred percent.

For these reasons, among the stock models, the focus will be on those models where the rate of depreciation is relatively high - either eighty or sixty percent. As the assumed rate is reduced, the estimated coefficients on both current and future price fall somewhat in absolute value and become less statistically significant. At the same time, the estimated coefficients on future consumption increase and become more significant. The estimated coefficients on the stock, however, decrease and become less statistically significant. Finally, as the assumed rate of depreciation is reduced, some of the coefficients on the exogenous determinants of demand change signs. In particular, the relationship between age and cigarette smoking is changed so that smoking appears to be negatively related to age. Similarly, the finding in all other models that men smoke more than women is reversed, as is the finding that income has positive effect on cigarette smoking. The inconsistency between these estimates and those obtained in the less restrictive models of addictive cigarette demand strengthen the conclusion that relatively low assumed rates of depreciation on the addictive stock are inappropriate.

Thus far, the results appear to support the assumption

that cigarette smoking is, in fact, an addictive behavior. Less clear is the support for either the hypothesis that cigarette smoking is a rational addictive behavior or the alternative hypothesis that cigarette smoking is an addictive behavior but that individuals behave myopically. The positive and significant estimates obtained for the coefficients on future consumption in most models support the former hypothesis, that of rational behavior. Weaker support is found from the positive but insignificant estimates for the coefficients on the future price of cigarettes in those models in which it is included.

An examination of the estimates of the various price elasticities of demand and the roots of the difference equations presented in Chapter Six may help in deciding between the competing hypotheses of rational addictive behavior and myopic addictive behavior. These estimates are presented in the tables which follow.

Table 8-25 contains the estimated own-price elasticities of demand for the models estimated under the assumption of non-addictive behavior. Tables 8-26, 8-27, and 8-28 contain the estimates of the two roots of the second order difference equation represented by the cigarette demand equation estimated with no assumed rate of depreciation on the addictive stock, followed by the estimates of the long and short run price elasticities of demand, as well as the estimated response to temporary changes in current, past, and future prices. The estimated short run price elasticity

and the estimated responses to temporary price changes are presented for both anticipated and unanticipated changes in prices. The estimated roots and price elasticities for the other models are contained in Tables 8-29 through 8-43, as follows: Tables 8-29, 8-30, and 8-31 for the models assuming a one hundred percent rate of depreciation; Tables 8-32, 8-33, and 8-34 for the models assuming an eighty percent rate of depreciation; Tables 8-35, 8-36, and 8-37 for models assuming a sixty percent rate of depreciation; Tables 8-38, 8-39, and 8-40 for the models assuming a forty percent rate of depreciation; and Tables 8-41, 8-42, and 8-43 for the models assuming a twenty percent rate of depreciation. The first table in each set contains the estimates corresponding to the models which use the weighted average of the own-price and border-price of cigarettes as the relevant price of cigarettes, with the second containing the estimates for the own-price models and the third containing the estimates for the border-price models.

For reasons mentioned above, the discussion that follows focuses on the models estimated using the weighted average of own-price and border-price as the relevant measure of price. Similarly, the results obtained from the models which include cigarette excise taxes as part of the set of instruments for future consumption and past consumption or the addictive stock will be emphasized (Models 5 through 8 in the tables).

The estimated own-price elasticities of demand for

Table 8-25

Price Elasticities of Demand
Non-Addictive Models

Model:	(1-1)	(1-2)	(1-3)	(1-4)
	-0.032	-0.012	-0.027	-0.008

Model:	(2-1)	(2-2)	(2-3)	(2-4)
	-0.065	-0.044	-0.059	-0.039

Model:	(3-1)	(3-2)	(3-3)	(3-4)
	-0.012	0.014	-0.005	0.019

Model:	(4-1)	(4-2)	(4-3)	(4-4)
	-0.051	-0.024	-0.044	-0.018

Model:	(5-1)	(5-2)	(5-3)	(5-4)
	-0.046	-0.032	-0.042	-0.030

Model:	(6-1)	(6-2)	(6-3)	(6-4)
	-0.066	-0.054	-0.062	-0.051

Table 8-26

Price Elasticities of Demand
Models with No Assumed Rate of Depreciation, Weighted Price

Model:	(7-1)	(7-2)	(7-3)	(7-4)
ϕ_1	0.029	0.037	0.043	0.043
ϕ_2	1.539	1.487	1.552	1.498
Long Run:	-0.219	-0.234	-0.215	-0.229
Short Run:				
Anticipated:	-0.390	-0.366	-0.387	-0.363
Unanticipated:	-0.469	-0.439	-0.466	-0.438
Current Price:				
Anticipated:	-0.512	-0.475	-0.510	-0.475
Unanticipated:	-0.589	-0.546	-0.586	-0.547
Past Price:				
Anticipated:	0.060	0.043	0.061	0.044
Unanticipated:	0.010	-0.004	0.012	-0.003
Future Price:				
Anticipated:	0.119	0.105	0.118	0.107
Unanticipated:	0.117	0.103	0.114	0.104
Model:	(7-5)	(7-6)	(7-7)	(7-8)
ϕ_1	0.338	0.321	0.340	0.321
ϕ_2	1.630	1.613	1.629	1.613
Long Run:	-0.283	-0.278	-0.281	-0.275
Short Run:				
Anticipated:	-0.376	-0.369	-0.371	-0.365
Unanticipated:	-0.403	-0.400	-0.401	-0.397
Current Price:				
Anticipated:	-0.421	-0.418	-0.419	-0.417
Unanticipated:	-0.438	-0.439	-0.438	-0.439
Past Price:				
Anticipated:	0.036	0.035	0.035	0.034
Unanticipated:	0.025	0.022	0.023	0.020
Future Price:				
Anticipated:	0.029	0.033	0.031	0.036
Unanticipated:	0.023	0.026	0.025	0.029

Table 8-27

Price Elasticities of Demand
Models with No Assumed Rate of Depreciation, Own Price

Model:	(8-1)	(8-2)	(8-3)	(8-4)
ϕ_1	0.095	-0.044	0.118	-0.005
ϕ_2	1.580	1.491	1.562	1.486
Long Run:	-0.200	-0.177	-0.209	-0.187
Short Run:				
Anticipated:	-0.375	-0.360	-0.364	-0.352
Unanticipated:	-0.432	-0.437	-0.418	-0.422
Current Price:				
Anticipated:	-0.464	-0.474	-0.448	-0.456
Unanticipated:	-0.515	-0.553	-0.495	-0.526
Past Price:				
Anticipated:	0.064	0.060	0.056	0.054
Unanticipated:	0.032	0.007	0.026	0.007
Future Price:				
Anticipated:	0.081	0.118	0.074	0.105
Unanticipated:	0.076	0.122	0.068	0.105

Model:	(8-5)	(8-6)	(8-7)	(8-8)
ϕ_1	0.540	0.544	0.538	0.542
ϕ_2	1.687	1.678	1.675	1.665
Long Run:	-0.376	-0.371	-0.378	-0.375
Short Run:				
Anticipated:	-0.377	-0.383	-0.375	-0.381
Unanticipated:	-0.351	-0.353	-0.351	-0.353
Current Price:				
Anticipated:	-0.334	-0.333	-0.335	-0.335
Unanticipated:	-0.322	-0.320	-0.324	-0.322
Past Price:				
Anticipated:	0.001	0.005	-0.001	0.003
Unanticipated:	0.008	0.013	0.006	0.010
Future Price:				
Anticipated:	-0.020	-0.023	-0.018	-0.021
Unanticipated:	-0.014	-0.015	-0.013	-0.014

Table 8-28

Price Elasticities of Demand
Models with No Assumed Rate of Depreciation, Border Price

Model:	(9-1)	(9-2)	(9-3)	(9-4)
ϕ_1	0.212	0.308	0.215	---
ϕ_2	1.494	1.478	1.509	---
Steady State:	-0.269	-0.316	-0.260	---
Short Run:				
Anticipated:	-0.350	-0.333	-0.348	---
Unanticipated:	-0.395	-0.366	-0.396	---
Current Price:				
Anticipated:	-0.417	-0.382	-0.421	---
Unanticipated:	-0.453	-0.405	-0.459	---
Past Price:				
Anticipated:	0.027	0.005	0.030	---
Unanticipated:	0.003	-0.010	0.004	---
Future Price:				
Anticipated:	0.053	0.034	0.057	---
Unanticipated:	0.046	0.027	0.049	---

Model:	(9-5)	(9-6)	(9-7)	(9-8)
ϕ_1	0.199	0.259	0.194	0.248
ϕ_2	1.513	1.511	1.518	1.516
Long Run: :	-0.257	-0.279	-0.251	-0.271
Short Run:				
Anticipated:	-0.356	-0.340	-0.352	-0.337
Unanticipated:	-0.404	-0.383	-0.405	-0.384
Current Price:				
Anticipated:	-0.429	-0.405	-0.432	-0.408
Unanticipated:	-0.468	-0.437	-0.474	-0.444
Past Price:				
Anticipated:	0.033	0.020	0.035	0.022
Unanticipated:	0.008	-0.001	0.007	-0.001
Future Price:				
Anticipated:	0.059	0.048	0.064	0.054
Unanticipated:	0.051	0.040	0.056	0.045

Table 8-29

Price Elasticities of Demand
Depreciation Rate=100%, Weighted Price

Model:	(10-1)	(10-2)	(10-3)	(10-4)
ϕ_1	0.320	0.350	0.325	0.354
ϕ_2	1.546	1.505	1.551	1.508
Long Run:	-0.347	-0.384	-0.345	-0.383
Short Run:				
Anticipated:	-0.155	-0.168	-0.155	-0.168
Unanticipated:	-0.123	-0.129	-0.122	-0.129
Current Price:				
Anticipated:	-0.105	-0.109	-0.105	-0.109
Unanticipated:	-0.083	-0.084	-0.083	-0.083
Past Price:				
Anticipated:	-0.068	-0.072	-0.067	-0.072
Unanticipated:	-0.054	-0.056	-0.053	-0.055
Future Price:				
Anticipated:	-0.034	-0.038	-0.034	-0.039
Unanticipated:	-0.027	-0.029	-0.027	-0.029
Model:	(10-5)	(10-6)	(10-7)	(10-8)
ϕ_1	0.441	0.452	0.441	0.448
ϕ_2	1.646	1.636	1.646	1.639
Long Run:	-0.364	-0.371	-0.361	-0.366
Short Run:				
Anticipated:	-0.195	-0.199	-0.194	-0.196
Unanticipated:	-0.143	-0.144	-0.142	-0.143
Current Price:				
Anticipated:	-0.109	-0.109	-0.108	-0.108
Unanticipated:	-0.080	-0.079	-0.079	-0.079
Past Price:				
Anticipated:	-0.066	-0.067	-0.066	-0.066
Unanticipated:	-0.048	-0.048	-0.048	-0.048
Future Price:				
Anticipated:	-0.048	-0.049	-0.048	-0.049
Unanticipated:	-0.035	-0.036	-0.035	-0.035

Table 8-30

Price Elasticities of Demand
Depreciation Rate=100%, Own Price

Model:	(11-1)	(11-2)	(11-3)	(11-4)
ϕ_1	0.487	0.507	0.490	0.512
ϕ_2	1.736	1.672	1.713	1.652
Long Run:	-0.344	-0.373	-0.353	-0.386
Short Run:				
Anticipated:	-0.203	-0.215	-0.206	-0.221
Unanticipated:	-0.146	-0.150	-0.147	-0.152
Current Price:				
Anticipated:	-0.104	-0.106	-0.105	-0.108
Unanticipated:	-0.075	-0.074	-0.075	-0.074
Past Price:				
Anticipated:	-0.060	-0.063	-0.061	-0.065
Unanticipated:	-0.043	-0.044	-0.044	-0.045
Future Price:				
Anticipated:	-0.051	-0.054	-0.051	-0.055
Unanticipated:	-0.036	-0.037	-0.037	-0.038
Model:	(11-5)	(11-6)	(11-7)	(11-8)
ϕ_1	0.627	0.651	0.628	0.651
ϕ_2	1.754	1.770	1.747	1.759
Long Run:	-0.469	-0.482	-0.472	-0.487
Short Run:				
Anticipated:	-0.314	-0.332	-0.315	-0.334
Unanticipated:	-0.202	-0.210	-0.202	-0.210
Current Price:				
Anticipated:	-0.117	-0.116	-0.117	-0.117
Unanticipated:	-0.075	-0.073	-0.075	-0.073
Past Price:				
Anticipated:	-0.067	-0.065	-0.067	-0.066
Unanticipated:	-0.043	-0.041	-0.043	-0.042
Future Price:				
Anticipated:	-0.073	-0.075	-0.074	-0.076
Unanticipated:	-0.047	-0.048	-0.047	-0.048

Table 8-31

Price Elasticities of Demand
Depreciation Rate=100%, Border Price

Model:	(12-1)	(12-2)	(12-3)	(12-4)
ϕ	0.360	0.427	0.364	0.432
ϕ_2	1.465	1.449	1.478	1.455
Long Run:	-0.373	-0.433	-0.364	-0.429
Short Run:				
Anticipated:	-0.157	-0.190	-0.156	-0.191
Unanticipated:	-0.118	-0.134	-0.118	-0.134
Current Price:				
Anticipated:	-0.100	-0.109	-0.099	-0.108
Unanticipated:	-0.076	-0.077	-0.075	-0.076
Past Price:				
Anticipated:	-0.069	-0.075	-0.067	-0.074
Unanticipated:	-0.052	-0.053	-0.051	-0.052
Future Price:				
Anticipated:	-0.036	-0.047	-0.036	-0.047
Unanticipated:	-0.027	-0.033	-0.027	-0.033
Model:	(12-5)	(12-6)	(12-7)	(12-8)
ϕ_1	0.307	0.362	0.301	0.351
ϕ_2	1.505	1.503	1.511	1.507
Long Run:	-0.327	-0.358	-0.319	-0.348
Short Run:				
Anticipated:	-0.138	-0.158	-0.135	-0.153
Unanticipated:	-0.110	-0.120	-0.108	-0.117
Current Price:				
Anticipated:	-0.096	-0.101	-0.094	-0.099
Unanticipated:	-0.076	-0.076	-0.075	-0.076
Past Price:				
Anticipated:	-0.064	-0.067	-0.062	-0.066
Unanticipated:	-0.051	-0.051	-0.050	-0.050
Future Price:				
Anticipated:	-0.029	-0.036	-0.028	-0.035
Unanticipated:	-0.023	-0.028	-0.023	-0.027

Table 8-32

Price Elasticities of Demand
Depreciation Rate=80%, Weighted Price

Model:	(13-1)	(13-2)	(13-3)	(13-4)
ϕ	0.435	0.525	0.459	0.524
ϕ_2	2.129	1.716	1.775	1.730
Long Run:	-0.252	-0.395	-0.329	-0.385
Short Run:				
Anticipated:	-0.068	-0.090	-0.057	-0.085
Unanticipated:	-0.134	-0.165	-0.144	-0.162
Current Price:				
Anticipated:	-0.207	-0.218	-0.212	-0.219
Unanticipated:	-0.244	-0.254	-0.259	-0.256
Past Price:				
Anticipated:	-0.097	-0.127	-0.119	-0.127
Unanticipated:	-0.115	-0.148	-0.146	-0.148
Future Price:				
Anticipated:	0.079	0.061	0.084	0.064
Unanticipated:	0.063	0.042	0.062	0.045
Model:	(13-5)	(13-6)	(13-7)	(13-8)
ϕ_1	0.504	0.530	0.504	0.525
ϕ_2	1.762	1.768	1.762	1.767
Long Run:	-0.364	-0.376	-0.361	-0.370
Short Run:				
Anticipated:	-0.078	-0.088	-0.075	-0.082
Unanticipated:	-0.158	-0.163	-0.156	-0.161
Current Price:				
Anticipated:	-0.218	-0.222	-0.218	-0.221
Unanticipated:	-0.257	-0.257	-0.259	-0.258
Past Price:				
Anticipated:	-0.124	-0.125	-0.124	-0.125
Unanticipated:	-0.146	-0.145	-0.147	-0.146
Future Price:				
Anticipated:	0.069	0.063	0.071	0.066
Unanticipated:	0.049	0.044	0.051	0.046

Table 8-33

Price Elasticities of Demand
Depreciation Rate=80%, Own Price

Model:	(14-1)	(14-2)	(14-3)	(14-4)
ϕ_1	0.683	0.739	0.685	0.742
ϕ_2	2.556	2.526	2.490	2.446
Long Run:	-0.326	-0.382	-0.333	-0.398
Short Run:				
Anticipated:	-0.176	-0.228	-0.177	-0.235
Unanticipated:	-0.199	-0.230	-0.199	-0.235
Current Price:				
Anticipated:	-0.234	-0.235	-0.233	-0.236
Unanticipated:	-0.241	-0.236	-0.241	-0.236
Past Price:				
Anticipated:	-0.091	-0.093	-0.094	-0.097
Unanticipated:	-0.094	-0.093	-0.097	-0.097
Future Price:				
Anticipated:	0.018	0.002	0.018	0.000
Unanticipated:	0.013	0.001	0.013	0.000
Model:	(14-5)	(14-6)	(14-7)	(14-8)
ϕ_1	0.741	0.778	0.740	0.777
ϕ_2	2.137	2.218	2.127	2.197
Long Run:	-0.499	-0.539	-0.499	-0.542
Short Run:				
Anticipated:	-0.288	-0.339	-0.285	-0.338
Unanticipated:	-0.266	-0.296	-0.264	-0.295
Current Price:				
Anticipated:	-0.240	-0.243	-0.241	-0.244
Unanticipated:	-0.234	-0.233	-0.236	-0.235
Past Price:				
Anticipated:	-0.112	-0.110	-0.113	-0.111
Unanticipated:	-0.110	-0.105	-0.111	-0.107
Future Price:				
Anticipated:	-0.012	-0.021	-0.011	-0.021
Unanticipated:	-0.008	-0.014	-0.007	-0.013

Table 8-34

Price Elasticities of Demand
Depreciation Rate=80%, Border Price

Model:	(15-1)	(15-2)	(15-3)	(15-4)
ϕ_1	0.474	0.574	0.476	0.572
ϕ_2	1.582	1.583	1.602	1.596
Long Run:	-0.365	-0.446	-0.353	-0.433
Short Run:				
Anticipated:	-0.037	-0.080	-0.032	-0.072
Unanticipated:	-0.134	-0.164	-0.133	-0.162
Current Price:				
Anticipated:	-0.191	-0.214	-0.193	-0.215
Unanticipated:	-0.242	-0.250	-0.246	-0.253
Past Price:				
Anticipated:	-0.121	-0.135	-0.121	-0.135
Unanticipated:	-0.153	-0.158	-0.154	-0.158
Future Price:				
Anticipated:	0.081	0.057	0.085	0.061
Unanticipated:	0.056	0.036	0.059	0.039

Model:	(15-5)	(15-6)	(15-7)	(15-8)
ϕ_1	0.358	0.433	0.350	0.419
ϕ_2	1.556	1.567	1.564	1.571
Long Run:	-0.323	-0.357	-0.313	-0.345
Short Run:				
Anticipated:	-0.017	-0.030	-0.012	-0.024
Unanticipated:	-0.115	-0.129	-0.113	-0.125
Current Price:				
Anticipated:	-0.170	-0.185	-0.170	-0.184
Unanticipated:	-0.233	-0.241	-0.235	-0.243
Past Price:				
Anticipated:	-0.109	-0.118	-0.109	-0.117
Unanticipated:	-0.150	-0.154	-0.151	-0.155
Future Price:				
Anticipated:	0.098	0.088	0.103	0.093
Unanticipated:	0.076	0.064	0.080	0.068

Table 8-35

Price Elasticities of Demand
Depreciation Rate=60%, Weighted Price

Model:	(16-1)	(16-2)	(16-3)	(16-4)
ϕ_1	0.557	0.663	0.559	0.656
ϕ_2	1.943	1.958	1.962	1.964
Long Run:	-0.343	-0.429	-0.335	-0.417
Short Run:				
Anticipated:	-0.110	-0.183	-0.104	-0.172
Unanticipated:	-0.167	-0.210	-0.164	-0.205
Current Price:				
Anticipated:	-0.220	-0.236	-0.222	-0.236
Unanticipated:	-0.245	-0.245	-0.248	-0.247
Past Price:				
Anticipated:	-0.113	-0.121	-0.113	-0.120
Unanticipated:	-0.126	-0.125	-0.127	-0.126
Future Price:				
Anticipated:	0.049	0.018	0.052	0.022
Unanticipated:	0.035	0.012	0.037	0.014

Model:	(16-5)	(16-6)	(16-7)	(16-8)
ϕ_1	0.545	0.583	0.544	0.578
ϕ_2	1.808	1.827	1.809	1.822
Long Run:	-0.378	-0.396	-0.372	-0.391
Short Run:				
Anticipated:	-0.115	-0.133	-0.110	-0.127
Unanticipated:	-0.169	-0.179	-0.167	-0.177
Current Price:				
Anticipated:	-0.212	-0.218	-0.212	-0.217
Unanticipated:	-0.237	-0.237	-0.238	-0.238
Past Price:				
Anticipated:	-0.117	-0.119	-0.117	-0.119
Unanticipated:	-0.131	-0.130	-0.131	-0.131
Future Price:				
Anticipated:	0.044	0.036	0.047	0.038
Unanticipated:	0.031	0.024	0.033	0.026

Table 8-36

Price Elasticities of Demand
Depreciation Rate=60%, Own Price

Model:	(17-1)	(17-2)	(17-3)	(17-4)
ϕ_1	0.809	0.876	0.811	0.875
ϕ_2	4.548	5.124	4.361	4.785
Long Run:	-0.325	-0.427	-0.331	-0.440
Short Run:				
Anticipated:	-0.259	-0.371	-0.262	-0.380
Unanticipated:	-0.254	-0.343	-0.255	-0.348
Current Price:				
Anticipated:	-0.235	-0.231	-0.235	-0.231
Unanticipated:	-0.234	-0.227	-0.234	-0.227
Past Price:				
Anticipated:	-0.052	-0.045	-0.054	-0.048
Unanticipated:	-0.052	-0.044	-0.054	-0.047
Future Price:				
Anticipated:	-0.005	-0.017	-0.005	-0.019
Unanticipated:	-0.004	-0.014	-0.004	-0.015

Model:	(17-5)	(17-6)	(17-7)	(17-8)
ϕ_1	0.813	0.854	0.812	0.853
ϕ_2	2.539	2.739	2.522	2.676
Long Run:	-0.561	-0.639	-0.557	-0.649
Short Run:				
Anticipated:	-0.410	-0.505	-0.403	-0.509
Unanticipated:	-0.340	-0.405	-0.336	-0.407
Current Price:				
Anticipated:	-0.233	-0.233	-0.233	-0.235
Unanticipated:	-0.220	-0.219	-0.221	-0.220
Past Price:				
Anticipated:	-0.092	-0.085	-0.093	-0.088
Unanticipated:	-0.087	-0.080	-0.088	-0.082
Future Price:				
Anticipated:	-0.033	-0.040	-0.032	-0.040
Unanticipated:	-0.023	-0.027	-0.022	-0.027

Table 8-37

Price Elasticities of Demand
Depreciation Rate=60%, Border Price

Model:	(18-1)	(18-2)	(18-3)	(18-4)
ϕ_1	0.537	0.660	0.537	0.660
ϕ_2	1.629	1.657	1.644	1.657
Long Run:	-0.377	-0.484	-0.366	-0.481
Short Run:				
Anticipated:	-0.074	-0.151	-0.067	-0.144
Unanticipated:	-0.146	-0.192	-0.143	-0.190
Current Price:				
Anticipated:	-0.190	-0.219	-0.193	-0.221
Unanticipated:	-0.223	-0.233	-0.228	-0.237
Past Price:				
Anticipated:	-0.117	-0.132	-0.117	-0.133
Unanticipated:	-0.137	-0.140	-0.139	-0.143
Future Price:				
Anticipated:	0.054	0.023	0.058	0.026
Unanticipated:	0.036	0.014	0.039	0.016
Model:	(18-5)	(18-6)	(18-7)	(18-8)
ϕ_1	0.385	0.478	0.377	0.465
ϕ_2	1.563	1.576	1.571	1.576
Long Run:	-0.328	-0.374	-0.318	-0.363
Short Run:				
Anticipated:	-0.041	-0.063	-0.036	-0.054
Unanticipated:	-0.118	-0.137	-0.116	-0.133
Current Price:				
Anticipated:	-0.161	-0.180	-0.161	-0.178
Unanticipated:	-0.209	-0.218	-0.211	-0.220
Past Price:				
Anticipated:	-0.103	-0.114	-0.103	-0.113
Unanticipated:	-0.133	-0.138	-0.134	-0.140
Future Price:				
Anticipated:	0.074	0.061	0.078	0.066
Unanticipated:	0.056	0.043	0.059	0.047

Table 8-38

Price Elasticities of Demand
Depreciation Rate=40%, Weighted Price

Model:	(19-1)	(19-2)	(19-3)	(19-4)
ϕ_1	0.713	0.829	0.712	0.819
ϕ_2	2.487	2.680	2.514	2.689
Long Run:	-0.342	-0.490	-0.332	-0.461
Short Run:				
Anticipated:	-0.187	-0.348	-0.179	-0.319
Unanticipated:	-0.204	-0.307	-0.200	-0.290
Current Price:				
Anticipated:	-0.230	-0.240	-0.231	-0.239
Unanticipated:	-0.235	-0.233	-0.237	-0.234
Past Price:				
Anticipated:	-0.092	-0.090	-0.092	-0.089
Unanticipated:	-0.094	-0.087	-0.094	-0.087
Future Price:				
Anticipated:	0.012	-0.018	0.015	-0.015
Unanticipated:	0.009	-0.013	0.011	-0.010
Model:	(19-5)	(19-6)	(19-7)	(19-8)
ϕ_1	0.634	0.679	0.632	0.673
ϕ_2	1.947	1.988	1.933	1.976
Long Run:	-0.385	-0.415	-0.384	-0.408
Short Run:				
Anticipated:	-0.171	-0.203	-0.166	-0.195
Unanticipated:	-0.188	-0.206	-0.185	-0.202
Current Price:				
Anticipated:	-0.203	-0.209	-0.203	-0.208
Unanticipated:	-0.209	-0.209	-0.210	-0.210
Past Price:				
Anticipated:	-0.104	-0.105	-0.105	-0.105
Unanticipated:	-0.107	-0.105	-0.109	-0.106
Future Price:				
Anticipated:	0.011	0.002	0.013	0.004
Unanticipated:	0.008	0.001	0.009	0.003

Table 8-39

Price Elasticities of Demand
Depreciation Rate=40%, Own Price

Model:	(20-1)	(20-2)	(20-3)	(20-4)
ϕ_1	0.900	0.950	0.902	0.951
ϕ_2	79.100	-50.950	65.764	-80.951
Long Run:	-0.287	-0.427	-0.283	-0.434
Short Run:				
Anticipated:	-0.284	-0.431	-0.279	-0.437
Unanticipated:	-0.283	-0.435	-0.279	-0.440
Current Price:				
Anticipated:	-0.235	-0.228	-0.233	-0.227
Unanticipated:	-0.235	-0.228	-0.233	-0.227
Past Price:				
Anticipated:	-0.003	0.004	-0.004	0.003
Unanticipated:	-0.003	0.004	-0.004	0.003
Future Price:				
Anticipated:	-0.005	-0.010	-0.005	-0.010
Unanticipated:	-0.005	-0.010	-0.004	-0.010
Model:	(20-5)	(20-6)	(20-7)	(20-8)
ϕ_1	0.895	0.930	0.897	0.930
ϕ_2	3.650	4.070	3.597	3.948
Long Run:	-0.669	-0.883	-0.681	-0.906
Short Run:				
Anticipated:	-0.589	-0.814	-0.599	-0.833
Unanticipated:	-0.486	-0.666	-0.492	-0.677
Current Price:				
Anticipated:	-0.213	-0.213	-0.215	-0.215
Unanticipated:	-0.203	-0.203	-0.204	-0.204
Past Price:				
Anticipated:	-0.058	-0.052	-0.060	-0.054
Unanticipated:	-0.056	-0.050	-0.057	-0.052
Future Price:				
Anticipated:	-0.039	-0.042	-0.040	-0.043
Unanticipated:	-0.030	-0.032	-0.030	-0.033

Table 8-40

Price Elasticities of Demand
Depreciation Rate=40%, Border Price

Model:	(21-1)	(21-2)	(21-3)	(21-4)
ϕ_1	0.636	0.781	0.631	0.776
ϕ_2	1.717	1.783	1.735	1.788
Long Run:	-0.386	-0.569	-0.370	-0.550
Short Run:				
Anticipated:	-0.127	-0.290	-0.115	-0.272
Unanticipated:	-0.161	-0.250	-0.157	-0.242
Current Price:				
Anticipated:	-0.186	-0.219	-0.187	-0.219
Unanticipated:	-0.199	-0.210	-0.203	-0.212
Past Price:				
Anticipated:	-0.108	-0.123	-0.108	-0.122
Unanticipated:	-0.116	-0.118	-0.117	-0.119
Future Price:				
Anticipated:	0.022	-0.016	0.027	-0.012
Unanticipated:	0.014	-0.009	0.017	-0.007
Model:	(21-5)	(21-6)	(21-7)	(21-8)
ϕ_1	0.454	0.561	0.446	0.547
ϕ_2	1.587	1.613	1.585	1.603
Long Run:	-0.328	-0.384	-0.322	-0.376
Short Run:				
Anticipated:	-0.073	-0.107	-0.066	-0.097
Unanticipated:	-0.121	-0.146	-0.119	-0.141
Current Price:				
Anticipated:	-0.150	-0.169	-0.149	-0.168
Unanticipated:	-0.176	-0.186	-0.179	-0.188
Past Price:				
Anticipated:	-0.094	-0.105	-0.094	-0.105
Unanticipated:	-0.111	-0.115	-0.113	-0.117
Future Price:				
Anticipated:	0.042	0.027	0.046	0.032
Unanticipated:	0.030	0.018	0.033	0.021

Table 8-41

Price Elasticities of Demand
Depreciation Rate=20%, Weighted Price

Model:	(22-1)	(22-2)	(22-3)	(22-4)
ϕ_1	0.826	0.917	0.829	0.911
ϕ_2	3.719	4.211	3.716	4.217
Long Run:	-0.324	-0.549	-0.321	-0.507
Short Run:				
Anticipated:	-0.243	-0.481	-0.239	-0.438
Unanticipated:	-0.237	-0.419	-0.235	-0.387
Current Price:				
Anticipated:	-0.219	-0.221	-0.222	-0.221
Unanticipated:	-0.218	-0.216	-0.221	-0.216
Past Price:				
Anticipated:	-0.059	-0.053	-0.060	-0.052
Unanticipated:	-0.059	-0.051	-0.060	-0.051
Future Price:				
Anticipated:	-0.004	-0.022	-0.003	-0.019
Unanticipated:	-0.003	-0.017	-0.002	-0.015
Model:	(22-5)	(22-6)	(22-7)	(22-8)
ϕ_1	0.764	0.809	0.765	0.803
ϕ_2	2.361	2.365	2.312	2.371
Long Run:	-0.394	-0.465	-0.401	-0.447
Short Run:				
Anticipated:	-0.259	-0.328	-0.260	-0.310
Unanticipated:	-0.227	-0.269	-0.228	-0.258
Current Price:				
Anticipated:	-0.183	-0.188	-0.185	-0.187
Unanticipated:	-0.176	-0.177	-0.178	-0.177
Past Price:				
Anticipated:	-0.078	-0.080	-0.080	-0.079
Unanticipated:	-0.074	-0.075	-0.077	-0.075
Future Price:				
Anticipated:	-0.018	-0.027	-0.018	-0.024
Unanticipated:	-0.012	-0.017	-0.012	-0.016

Table 8-42

Price Elasticities of Demand
Depreciation Rate=20%, Own Price

Model:	(23-1)	(23-2)	(23-3)	(23-4)
ϕ_1	0.917	0.958	0.922	0.957
ϕ_2	-15.203	-11.484	-14.256	-10.957
Long Run:	-0.247	-0.360	-0.240	-0.329
Short Run:				
Anticipated:	-0.263	-0.379	-0.256	-0.349
Unanticipated:	-0.264	-0.391	-0.257	-0.359
Current Price:				
Anticipated:	-0.249	-0.244	-0.249	-0.243
Unanticipated:	-0.249	-0.244	-0.249	-0.244
Past Price:				
Anticipated:	0.016	0.021	0.017	0.022
Unanticipated:	0.016	0.021	0.017	0.022
Future Price:				
Anticipated:	-0.001	-0.006	-0.001	-0.005
Unanticipated:	-0.001	-0.006	-0.001	-0.005
Model:	(23-5)	(23-6)	(23-7)	(23-8)
ϕ_1	0.946	0.970	0.948	0.974
ϕ_2	5.720	6.437	5.719	6.169
Long Run:	-0.893	-1.443	-0.904	-1.663
Short Run:				
Anticipated:	-0.852	-01.407	-0.863	-01.625
Unanticipated:	-0.737	-01.219	-0.746	-01.393
Current Price:				
Anticipated:	-0.194	-0.194	-0.194	-0.196
Unanticipated:	-0.188	-0.189	-0.188	-0.190
Past Price:				
Anticipated:	-0.034	-0.030	-0.034	-0.032
Unanticipated:	-0.033	-0.029	-0.033	-0.031
Future Price:				
Anticipated:	-0.035	-0.036	-0.035	-0.038
Unanticipated:	-0.029	-0.031	-0.029	-0.032

Table 8-43

Price Elasticities of Demand
Depreciation Rate=20%, Border Price

Model:	(24-1)	(24-2)	(24-3)	(24-4)
ϕ_1	0.778	0.905	0.771	0.903
ϕ_2	2.000	2.171	2.007	2.127
Long Run:	-0.389	-0.735	-0.372	-0.735
Short Run:				
Anticipated:	-0.214	-0.567	-0.198	-0.559
Unanticipated:	-0.194	-0.396	-0.187	-0.389
Current Price:				
Anticipated:	-0.174	-0.196	-0.175	-0.198
Unanticipated:	-0.170	-0.180	-0.173	-0.182
Past Price:				
Anticipated:	-0.087	-0.090	-0.087	-0.093
Unanticipated:	-0.085	-0.083	-0.086	-0.086
Future Price:				
Anticipated:	-0.009	-0.035	-0.005	-0.035
Unanticipated:	-0.005	-0.020	-0.003	-0.020
Model:	(24-5)	(24-6)	(24-7)	(24-8)
ϕ_1	0.621	0.733	0.614	0.725
ϕ_2	1.732	1.767	1.711	1.744
Long Run:	-0.327	-0.422	-0.325	-0.418
Short Run:				
Anticipated:	-0.133	-0.212	-0.125	-0.201
Unanticipated:	-0.138	-0.183	-0.135	-0.178
Current Price:				
Anticipated:	-0.142	-0.161	-0.142	-0.161
Unanticipated:	-0.144	-0.153	-0.146	-0.155
Past Price:				
Anticipated:	-0.082	-0.091	-0.083	-0.092
Unanticipated:	-0.083	-0.087	-0.086	-0.089
Future Price:				
Anticipated:	0.003	-0.014	0.007	-0.011
Unanticipated:	0.002	-0.008	0.004	-0.006

models estimated under the assumption of non-addictive behavior fall in the range from -0.032 to -0.008 when current consumption, as reported in the survey, is the dependent variable, and in the range from -0.051 to -0.018 when lagged consumption, as reported in the survey, is the dependent variable. These estimates are low relative to the short and long run price elasticities of demand obtained from the cigarette demand equations estimated within the addictive framework, implying that ignoring the addictive aspects of consumption leads to a misstatement of the effect of changes in prices on consumption. In particular, the estimates obtained from the non-addictive models would lead one to conclude that increases in cigarette prices resulting from increases in cigarette excise taxes would be relatively ineffective in reducing cigarette smoking.

Before examining the estimated price elasticities obtained from the models of cigarette demand as a rational addictive behavior, some discussion of the expected signs and magnitudes of the estimates is in order. As described in Chapter 6, if consumption is addictive, then both roots of the second order difference equations represented by the demand equations will be real and both will be positive. As Becker, Grossman, and Murphy note, the roots of the difference equations describe the dynamic response of current cigarette consumption to shocks to past and future cigarette consumption (page 22). The smaller of the two roots, ϕ_1 , gives the change in current consumption which results from a

shock to future consumption, while the inverse of the larger root, ϕ_2 , gives the effect on current consumption of a shock to past consumption. The shocks to past and/or future consumption can be the result of a change in any of the factors which affect the demand for cigarettes including, for example a change in the past and/or future price of cigarettes.

Becker, Grossman, and Murphy distinguish between several types of price changes. Temporary, one period, increases in price are expected to reduce consumption in all periods if the price change was expected. However, if the price change was unexpected, then consumption in periods prior to the change would not be affected, while consumption in all other periods would be affected. Similarly, permanent price increases are expected to lead to reductions in consumption, beginning in the current period if the change is unanticipated, and in each period if the change was anticipated. The effect of a permanent increase in price in the current period on current consumption, the "short-run" effect of Becker, Grossman, and Murphy, is expected to be smaller in absolute value than the effect of a permanent increase in price in all periods on current consumption, their "long-run" price effect. Additionally, the effect on current consumption of an anticipated permanent change in price beginning in the current period is expected to be larger in magnitude than the comparable effect of an equivalent unanticipated permanent change in price.

Finally, the effect on current consumption of a temporary change in current price is expected to be smaller in absolute value than the effect of a permanent change in price beginning in the current period.

The estimates obtained provide, at best, mixed support for the hypothesis that cigarette smoking is a rational addictive behavior, while providing a fairly strong defence for the hypothesis that cigarette smoking is an addictive behavior. Many of the predictions of the model concerning the response of consumption to various changes in price are supported by the estimates while some of the other predictions are contradicted by the estimates from the demand equations.

For each of the models presented using the weighted price as the relevant price, both of the roots of the difference equation are real and positive, indicating that increases in either past or future consumption will lead to increases in current consumption. Stated differently, these results imply that cigarette consumption exhibits adjacent complementarity. This implies that factors which lead to changes in past consumption, such as changes in past price, will not only affect past consumption but will also have an impact on current consumption, and similarly for factors affecting current consumption.

The roots from the models estimated with no assumed rate of depreciation suggest that a 10 percent rise in past consumption would result in approximately a 6.1 to 6.2

percent increase in current consumption. Similarly, an increase of 10 percent in future consumption would lead to an increase of from 3.2 to 3.4 percent in current consumption.

The roots obtained when the depreciation rate on the addictive stock is assumed to be one hundred percent suggest a slightly larger impact on current consumption of a change in future consumption. These estimates suggest that an increase of ten percent in future consumption would result in an increase of between 4.4 and 4.5 percent in current consumption. The predicted effect on current consumption of a 10 percent rise in past consumption is 6.1 percent, identical to that of the first model.

Finally, an increase of 10 percent in future consumption, based on the roots from the stock model with an assumed rate of depreciation of eighty percent, is expected to result in an increase in current consumption in the range from 5 to 5.3 percent. The comparable effect of a 10 percent increase in past consumption is an increase of 5.7 percent in current consumption. As the assumed rate of depreciation is reduced, the impact on current consumption of changes in future consumption becomes larger, while the impact of changes in past consumption falls.

Turning now to an examination of the effects of price changes on consumption, the best support for the model of cigarette smoking as a rational addictive behavior is found in the models estimated under the assumption that the rate

of depreciation on the addictive stock is one hundred percent.

In these models, a temporary increase in past, current, or future price results in a fall in current consumption, with the fall larger for anticipated price increases than for unanticipated increases. A temporary increase of 10 percent in the current price would lead to a fall of 1.1 percent in current consumption if the price change was anticipated, and a fall of 0.8 percent if the price change was unanticipated. Similarly, an anticipated rise of 10 percent in last period's cigarette price would reduce consumption this period by 0.7 percent, with a fall of 0.5 percent for the comparable unanticipated increase in price. Finally, an increase of 10 percent in next period's price of cigarettes would lead to a drop of 0.5 percent in current cigarette consumption if the increase was anticipated, or 0.35 percent if the increase was unexpected. As expected, the magnitude of the effect on current consumption of a change in current price is larger than that of a change in the price in the previous period, with the effect on current cigarette consumption of a change in next period's cigarette price being the smallest of the three. In each case, the effect on consumption of an anticipated price change is greater than the effect of an unanticipated price change.

The response of current consumption to a permanent change in price, in these models, is larger than the response to temporary changes in price, as predicted. A

permanent increase of 10 percent in the price of cigarettes beginning in the current period would result in a fall of 1.9 to 2.0 percent in current consumption, if the increase was anticipated. If the 10 percent rise in price was unexpected, then current consumption would fall by only 1.4 percent. Finally, an increase of 10 percent in cigarette prices in every period would result in a fall in current consumption in the range from 3.6 to 3.7 percent.

For the models estimated assuming that the rate of depreciation on the addictive stock was one hundred percent, all of the predictions of the model of cigarette smoking as a rational addictive behavior are confirmed by the estimates. To summarize, current cigarette consumption is inversely related to temporary changes in cigarette prices in all periods. The response to permanent price changes is larger than the response to temporary price changes, with the longer run response larger than the short run response. Finally, if the price change was anticipated, then the resulting change in current consumption will be greater in magnitude than if the price change was unanticipated.

The results obtained from the estimation of the remaining models are somewhat disappointing, particularly those from the most general model, that in which no assumption is made concerning the rate of depreciation on the addictive stock. In this model, current cigarette consumption is found to be positively related to changes in past or future cigarette prices. A 10 percent, temporary increase

in the price of cigarettes last period results in an increase of 0.35 percent in current consumption, if anticipated, or an increase of 0.23 percent, if unanticipated. A comparable rise in the price of cigarettes next period would lead to increases in current consumption of 0.33 percent and 0.26 percent, on average, for anticipated and unanticipated changes, respectively.

A temporary increase in the current cigarette price, however, does result in a decrease in current consumption. Based on the results from this model, a temporary, anticipated increase of 10 percent in the current price results in a drop of about 4.2 percent in current consumption. If this increase in price was unanticipated, current consumption would fall by 4.4 percent, contrary to the prediction that the response of consumption to an anticipated price change would be larger than to an unanticipated change.

Somewhat more surprising are the effects on current consumption of permanent changes in price implied by these estimates. These results suggest that an unanticipated, permanent increase in cigarette prices of 10 percent beginning in the current period would induce a fall of 4 percent in current cigarette consumption, while the same increase would reduce consumption by 3.7 percent if it was anticipated. Finally, a permanent 10 percent increase in cigarette prices in all periods is estimated to lead to a fall in current consumption of 2.8 percent. These findings

are counter to the predictions of the model, which predicts that the long run response will be larger than the short run response, with a temporary price change having a smaller impact than a comparable permanent price change.

Somewhat more support for the model of cigarette smoking as a rational addictive behavior is found in the estimates obtained from the models which include a measure of the addictive stock as a determinant of current cigarette demand.

In those models estimated using the weighted price of cigarettes as the relevant price and assuming an eighty percent rate of depreciation on the addictive stock, a negative relationship is obtained between past cigarette prices and current cigarette consumption. For example, a temporary 10 percent increase in last period's cigarette price, if anticipated, would lead to a fall of 1.2 percent in current cigarette consumption, with a corresponding fall of 1.5 percent if the increase was unanticipated.

Similarly, a temporary increase of 10 percent in the current price of cigarettes results in a drop of 2.2 percent in current cigarette consumption if anticipated, or of 2.6 percent if unanticipated.

Increases in future prices, however, lead to increases in current cigarette consumption, based on these results. For example, an increase of 10 percent in the price of cigarettes next period results in an increase of 0.7 percent in current consumption, if anticipated. The comparable

increase associated with an unanticipated price rise is 0.5 percent.

A permanent, anticipated 10 percent increase in the price of cigarettes beginning in the current period results in a fall of about 0.8 percent in current cigarette consumption. If the 10 percent, permanent increase was unexpected, current consumption would fall by 1.6 percent, based on these estimates.

Finally, an increase of 10 percent in cigarette prices in all periods will decrease current cigarette consumption by 3.6 to 3.8 percent.

When a sixty percent rate of depreciation is assumed, the qualitative results are essentially unchanged. Temporary increases in the price of cigarettes in the current period or the previous period will lead to lower current cigarette consumption, with unanticipated changes having a greater effect than anticipated changes. However, a temporary increase in the price next period will lead to an increase in current consumption, with consumption increasing more if the price increase was anticipated. A permanent, anticipated increase of 10 percent in price beginning in the current period will reduce current consumption in these models by approximately 1.1 to 1.3 percent. If the price increase was unanticipated, the estimated fall in consumption would be between 1.7 and 1.8 percent. Finally, a permanent 10 percent increase in price in every period is expected to reduce consumption by 3.7 to 3.9 percent,

comparable to the estimates discussed above.

As the assumed rate of depreciation is reduced, the estimated price elasticities of demand become more consistent with the predictions of the model. In fact, when the rate of depreciation on the addictive stock is assumed to be twenty percent, all of the predictions of the model of rational addictive behavior are supported by the estimated price elasticities of demand.

Conclusions

The results from the estimation of the various demand equations developed in Chapter Six, along with the estimated price elasticities of demand for each of these equations were presented in this chapter. In addition to these equations, a set of demand equations was estimated under the assumption that cigarette smoking is a non-addictive behavior. All equations were estimated using three alternative measures of the price of cigarettes: the own-price of cigarettes, the border-price of cigarettes, and an equally weighted average of the own-price and the border-price.

As expected, the weighted average of the two price performed better than either of the other two measures. This is due, most likely, to the fact that this measure of price is not going to either consistently overstate or understate the true price of cigarettes the individual faces.

Similarly, the estimates from demand equations which included the addictive stock, presented for assumed rates of depreciation of eighty, sixty, forty, and twenty percent on the stock, support the contention that relatively high rates of depreciation on the stock of past cigarette smoking are more appropriate than relatively low rates.

The results obtained from the estimation of the demand equations provide relatively strong support for the hypothesis that cigarette smoking is an addictive behavior, while somewhat less support is obtained for the hypothesis that this behavior is rational. The signs and relative magnitudes of the estimated coefficients on the cigarette prices and past and future cigarette consumption are consistent in every estimated equation with the predictions of the model of cigarette smoking as a rational addictive behavior. However, the predictions concerning the various price elasticities of demand are somewhat less supportive. In all models estimated, support for the hypothesis that cigarette consumption exhibits adjacent complementarity is found. This is the main test for whether or not consumption is addictive.

The positive and significant coefficients on past consumption and the real, positive roots obtained from the second order difference equations suggest that anything which affects either past or future cigarette consumption will affect current consumption in the same direction. Ignoring the intertemporal linkages for cigarette consump-

tion (i.e. ignoring the addictive nature of consumption) leads to estimated long run price elasticities of demand one-tenth to one-sixth the estimated long run price elasticities of demand obtained when the addictive aspects of consumption are accounted for. Thus, ignoring addiction would lead one to conclude that the use of cigarette excise tax policy is an ineffective means of reducing cigarette smoking and the public health problems associated with smoking. Long run price elasticities of demand in the range from -0.40 to -0.28 are obtained from the estimation of the demand equations developed within the rational addiction framework. Thus, the doubling of the Federal cigarette excise tax rate from sixteen cents per pack to thirty-two cents per pack (approximately a thirteen percent increase in price) which has been discussed recently in Congress would reduce cigarette consumption by 3.2 to 5.6 percent.

The estimates obtained for the demand equations derived assuming the rate of depreciation on the addictive stock is one hundred percent are consistent in every way with the model of rational addictive behavior. Current cigarette consumption is inversely related to the price of cigarettes in every period, permanent price changes affect consumption more than temporary price changes, anticipated price changes have a larger impact than comparable unanticipated price changes, and long run price elasticities of demand exceed short run price elasticities of demand. These estimates are potentially more reliable than the estimates obtained from

the other two demand equations as they are less taxing on the data.

The estimates from the stock equations provide strong support for the assumption that cigarette smoking is an addictive behavior, but provide only mixed support for the rationality assumption. Temporary increases in current and past cigarette prices lead to reductions in current cigarette consumption, but temporary increases in future prices lead to increased consumption, contrary to the hypothesis that smoking is a rational behavior. Also contrary to the predictions of the model is that the estimated short run effect on current cigarette consumption of a permanent increase in the price of cigarettes is smaller than the estimated effect of a temporary price increase. However, the long run effect of a comparable permanent price increase is larger than either the short run effect of a permanent price increase or the effect of a temporary price increase, as the model predicts.

Finally, the estimates obtained from the most general model, that which makes no assumption concerning that rate of depreciation on the addictive stock and, hence, includes lagged, current, and led cigarette prices in addition to instruments for lagged and led cigarette consumption, are mostly inconsistent with the model of cigarette smoking as a rational addictive behavior. These estimates, however, can be considered the least reliable as they are the most taxing on the data, but do provide at least some support for the

model. All estimated coefficients in these models are consistent with the predictions of the model of rational addiction. Similarly, the roots from the second order difference equation imply significant intertemporal linkages for cigarette consumption and, therefore, addiction. While most of the estimated price elasticities obtained from these models are inconsistent with expectations, the estimated long run price elasticities of demand implied by the results are about the same order of magnitude as those obtained from the alternative models.

Chapter Nine

Clean Indoor Air Laws and Cigarette Smoking

This chapter contains the estimates obtained for a subset of the cigarette demand equations presented in Chapter 8 when a dichotomous variable indicating that the individual resided in a state which had a clean indoor air law, as defined by the Public Health Service in their annual publication entitled State Legislation on Smoking and Health, in place at the time the individual was surveyed is included in the demand equations as an additional regressor.

As discussed much earlier, the effect on cigarette smoking of a clean indoor air law may arise from several different sources. Since the laws restrict cigarette smoking in various public places (including elevators, theaters, sports arenas, schools, drugstores, supermarkets, department stores, hospitals, public transportation, government buildings, and, in some states, private workplaces) and/or require nonsmoking sections in restaurants, they may reduce smoking by simply allowing a smoker fewer opportunities to smoke. Additionally, U.S. Surgeon General C. Everett Koop suggests that the laws can create "an environment where a smoker is provided with the support and reinforcement needed to overcome the addiction" to cigarettes.

Throughout this research, the assumption has been made that individuals have perfect foresight. This is, at best,

an imperfect description of the real world. Hence, cigarette smokers may incorrectly evaluate the true risks to their health from cigarette smoking. This brings up the final way in which clean indoor air laws may serve to reduce cigarette smoking. A substantial amount of newspaper, television, and radio publicity surrounds both the consideration and enactment of a clean indoor air law. Much of this publicity is likely to concern the effects of cigarette smoking on health, the major reason for the enactment of these laws, as discussed in Chapter Two. If this information leads individuals to revise upwards their expectations concerning the health consequences of cigarette smoking, then the "full price" of cigarette smoking (the sum of the money price of cigarettes and the appropriately discounted sum of negative future utility effects) for these individuals will increase. The increase in the full price will serve, therefore, to reduce cigarette smoking, according to the model of cigarette smoking as a rational addictive behavior.

Only a subset of the models presented in the last chapter were reestimated including a variable indicating the presence of a clean indoor air law in the state in which the individual resides. All models estimated include the dichotomous variables indicating the individuals daily activity level and exercise habits. In all models, the relevant price of cigarettes is assumed to be the equally weighted average of the own-price of cigarettes and the

border-price of cigarettes. The set of instruments including cigarette excise taxes in addition to cigarette prices and other exogenous determinants of demand is used for future consumption and past consumption or the addictive stock. Finally, only the results from models assuming relatively high rates of depreciation on the addictive stock are presented.

Before discussing the results obtained for models which include the clean indoor air law indicator, one point should be kept in mind concerning the effectiveness of these laws in reducing cigarette smoking. As Warner (1981a) notes, it may be the case that laws which restrict cigarette smoking in public places with the stated intent to reduce smoking (the clean indoor air laws) are passed in states where there is a significant amount of anti-smoking sentiment. Both smoking participation rates and average cigarette smoking in states with a large degree of anti-smoking sentiment are likely to be lower than in states where there is little widespread anti-smoking sentiment. Hence, the laws may be passed only in places where cigarette smoking is relatively low to begin with and may be the result of and not the cause of lower average cigarette consumption. Work in progress by Chaloupka and Saffer (1988) is using a pooled time-series of state cross-sections to examine the potential endogeneity of the clean indoor air laws more closely. The use of micro-level data in this dissertation should alleviate much of the problem of the potential endogeneity of these laws.

Models estimated under the assumption that cigarette smoking is a non-addictive behavior are presented in Table 9-1 in order to assess the consequences of ignoring the addictive aspects of consumption. Models 1-1 and 1-2 of Table 9-1 contain the estimates using current cigarette consumption as the dependent variable, while Models 1-3 and 1-4 use lagged cigarette consumption as the dependent variable. The price of cigarettes which enters each equation pertains to the same period as the dependent variable. Table 9-2 contains the estimates for the various cigarette demand equations developed within the rational addictive framework. Models 2-1 and 2-2 contain the estimates from equations which make no assumption concerning the rate of depreciation on the addictive stock. Models 2-3 and 2-4 contain the results obtained from equations where the rate of depreciation on the stock is assumed to be one hundred percent. Finally, Models 2-5 and 2-6, and Models 2-7 and 2-8 contain the results for models where the rate of depreciation is assumed to be eighty percent and sixty percent, respectively.

The own-price elasticities of demand from the non-addictive models, and the roots of the second order difference equations represented by the demand equations developed within the rational addiction framework, along with the various price elasticities of demand pertaining to this framework, are presented in Table 9-3 for each of the equations presented in this Chapter.

Table 9-1*
OLS Estimates of Non-Addictive Demand Equation
Current, Lagged Cigarette Consumption, Weighted Price

Variable	(1-1)	(1-2)	(1-3)	(1-4)
Clean Indoor Air Law	-0.051 (-0.24)	-0.133 (-0.62)	-0.212 (-0.92)	-0.295 (-1.29)
Current Cigarette Price, Weighted	-0.640 (-0.25)	-0.080 (-0.03)	-1.292 (-0.46)	-0.638 (-0.23)
Age	0.715 (17.91)	0.694 (17.35)	0.747 (17.90)	0.726 (17.39)
Age Squared	-0.009 (-20.64)	-0.009 (-19.96)	-0.010 (-20.48)	-0.009 (-19.82)
Sex	3.355 (16.71)	3.488 (17.39)	3.852 (17.98)	3.989 (18.63)
Black	-2.460 (-7.59)	-2.409 (-7.48)	-2.891 (-8.35)	-2.843 (-8.26)
Other Races	-3.750 (-4.96)	-3.274 (-4.34)	-4.031 (-5.00)	-3.563 (-4.43)
American Natives	2.787 (3.13)	2.715 (3.06)	3.207 (3.38)	3.140 (3.32)
Family Income	-0.008 (-3.24)	-0.008 (-3.37)	-0.011 (-4.08)	-0.011 (-4.29)
Number of Years of Formal Education	-0.219 (-6.66)	----	-0.217 (-6.17)	----
No Formal Education	----	-2.199 (-2.04)	----	-1.528 (-1.33)
Less than Grade School Education	----	-0.666 (-1.43)	----	-0.521 (-1.05)
Grade School Education	----	-0.864 (-2.71)	----	-1.148 (-3.37)
Some High School Education	----	1.620 (4.44)	----	1.564 (4.02)
College	----	-2.685 (-10.99)	----	-2.700 (-10.23)
Active	-1.066 (-3.61)	-1.290 (-4.39)	-1.166 (-3.70)	-1.386 (-4.41)
Exercise	-1.101 (-4.95)	-1.131 (-5.11)	-1.208 (-5.09)	-1.245 (-5.27)
Intercept	-0.166 (-0.14)	-1.510 (-1.36)	0.552 (0.44)	-0.809 (-0.68)
R ²	0.072	0.081	0.072	0.80
F	92.37	78.43	92.52	77.34

*Asymptotic t-ratios are shown in parentheses. The critical asymptotic t-ratios are: 1.28 for a one-tailed test and 1.64 for a two-tailed test at the 10 percent level; 1.64 for a one-tailed test and 1.96 for a two-tailed test at the 5 percent level; and 2.33 for a one-tailed test and 2.58 for a two-tailed test at the 1 percent level. The F statistic for each equation is significant at the one percent level.

Table 9-2*
 TSLS Estimates of Cigarette Demand Equations

Variable	(2-1)	(2-2)	(2-3)	(2-4)
Clean Indoor Air Law	-0.141 (-1.53)	-0.149 (-1.62)	-0.154 (-1.70)	-0.161 (-1.77)
Past Cigarette Price, Weighted	4.566 (0.77)	4.743 (0.79)	-----	-----
Current Cigarette Price, Weighted	-9.303 (-1.34)	-9.398 (-1.34)	-1.332 (-1.14)	-1.329 (-1.13)
Future Cigarette Price, Weighted	3.464 (0.87)	3.382 (0.85)	-----	-----
Past Consumption	0.449 (3.04)	0.459 (2.95)	0.436 (3.20)	0.439 (3.11)
Future Consumption	0.388 (1.87)	0.373 (1.64)	0.425 (2.28)	0.420 (2.10)
Age	0.088 (1.90)	0.087 (1.78)	0.074 (1.70)	0.072 (1.58)
Age Squared	-0.001 (-1.61)	-0.001 (-1.50)	-0.001 (-1.39)	-0.001 (-1.27)
Sex	0.195 (0.80)	0.216 (0.85)	0.140 (0.59)	0.155 (0.63)
Black	-0.273 (-1.30)	-0.261 (-1.23)	-0.231 (-1.12)	-0.218 (-1.05)
Other Races	-0.309 (-0.75)	-0.291 (-0.72)	-0.158 (-0.41)	-0.147 (-0.39)
American Natives	0.483 (1.17)	0.506 (1.21)	0.417 (1.03)	0.435 (1.06)
Family Income	0.001 (0.33)	0.0004 (0.21)	0.001 (0.43)	0.0005 (0.29)
Number of Years of Formal Education	-0.026 (-1.23)	-----	-0.021 (-1.07)	-----
No Formal Education	-----	0.646 (1.34)	-----	0.691 (1.46)
Less than Grade School Education	-----	-0.100 (-0.45)	-----	-0.077 (-0.36)
Grade School Education	-----	-0.181 (-1.20)	-----	-0.166 (-1.12)
Some High School Education	-----	-0.117 (-0.62)	-----	-0.147 (-0.80)
College	-----	-0.299 (-1.28)	-----	-0.232 (-1.08)
Active	0.077 (0.51)	0.064 (0.40)	0.091 (0.60)	0.082 (0.53)
Exercise	-0.113 (-0.98)	-0.127 (-1.06)	-0.091 (-0.81)	-0.102 (-0.88)
Intercept	-0.681 (-1.26)	-0.813 (-1.48)	-0.667 (-1.28)	-0.758 (-1.46)
R ²	0.340	0.361	0.343	0.364
F	460.63	402.78	532.71	454.59

Table 9-2 (continued)
TOLS Estimates of Cigarette Demand Equations

Variable	(2-5)	(2-6)	(2-7)	(2-8)
Clean Indoor Air Law	-0.163 (-1.79)	-0.170 (-1.85)	-0.187 (-2.02)	-0.194 (-2.08)
Current Cigarette Price, Weighted	-4.465 (-1.09)	-4.397 (-1.08)	-3.785 (-0.91)	-3.701 (-0.89)
Future Cigarette Price, Weighted	3.186 (0.80)	3.131 (0.80)	2.555 (0.63)	2.484 (0.61)
Addictive Stock	0.326 (2.95)	0.328 (2.85)	0.243 (2.92)	0.244 (2.84)
Future Consumption	0.458 (2.44)	0.457 (2.26)	0.469 (2.52)	0.468 (2.34)
Age	0.062 (1.43)	0.058 (1.30)	0.034 (0.77)	0.030 (0.66)
Age Squared	-0.001 (-1.20)	-0.001 (-1.07)	-0.0004 (-0.68)	-0.0003 (-0.56)
Sex	0.158 (0.64)	0.065 (0.42)	0.100 (0.39)	0.107 (0.40)
Black	-0.249 (-1.19)	-0.232 (-1.10)	-0.228 (-1.07)	-0.210 (-0.98)
Other Races	-0.255 (-0.62)	-0.231 (-0.58)	-0.209 (-0.50)	-0.179 (-0.44)
American Natives	0.416 (1.02)	0.426 (1.04)	0.375 (0.91)	0.382 (0.92)
Family Income	0.0003 (0.20)	0.0001 (0.08)	0.0003 (0.19)	0.0001 (0.08)
Number of Years of Formal Education	-0.021 (-1.04)	----	-0.020 (-0.99)	----
No Formal Education	----	0.591 (1.24)	----	0.513 (1.06)
Less than Grade School Education	----	-0.085 (-0.39)	----	-0.105 (-0.47)
Grade School Education	----	-0.172 (-1.15)	----	-0.164 (-1.08)
Some High School Education	----	-0.119 (-0.65)	----	-0.113 (-0.61)
College	----	-0.235 (-1.09)	----	-0.237 (-1.09)
Active	0.074 (0.49)	0.065 (0.42)	0.086 (0.56)	0.077 (0.49)
Exercise	-0.103 (-0.91)	-0.111 (-0.95)	-0.105 (-0.92)	-0.111 (-0.95)
Intercept	-0.285 (-0.57)	-0.367 (-0.75)	0.253 (0.49)	0.188 (0.39)
R ²	0.342	0.364	0.340	0.361
F	495.48	429.68	489.55	424.62

* See note to Table 9-1.

Table 9-3
Price Elasticities of Demand

Non Addictive Models:	(1-1)	(1-2)	(1-3)	(1-4)
	-0.025	-0.003	-0.047	-0.023
Addictive Models:	(2-1)	(2-2)	(2-3)	(2-4)
ϕ_1	0.500	0.478	0.563	0.555
ϕ_2	1.727	1.701	1.730	1.722
Long Run:	-0.285	-0.276	-0.350	-0.344
Short Run:				
Anticipated:	-0.339	-0.337	-0.219	-0.213
Unanticipated:	-0.335	-0.336	-0.148	-0.144
Current Price:				
Anticipated:	-0.332	-0.334	-0.096	-0.095
Unanticipated:	-0.330	-0.333	-0.064	-0.064
Past Price:				
Anticipated:	0.023	0.025	-0.055	-0.055
Unanticipated:	0.024	0.026	-0.037	-0.037
Future Price:				
Anticipated:	-0.003	-0.002	-0.054	-0.053
Unanticipated:	-0.002	-0.001	-0.036	-0.036
	(2-5)	(2-6)	(2-7)	(2-8)
ϕ_1	0.609	0.609	0.634	0.578
ϕ_2	1.845	1.830	1.805	1.822
Long Run:	-0.347	-0.347	-0.371	-0.354
Short Run:				
Anticipated:	-0.112	-0.111	-0.147	-0.143
Unanticipated:	-0.159	-0.158	-0.165	-0.161
Current Price:				
Anticipated:	-0.198	-0.196	-0.180	-0.175
Unanticipated:	-0.217	-0.214	-0.187	-0.181
Past Price:				
Anticipated:	-0.108	-0.107	-0.100	-0.096
Unanticipated:	-0.117	-0.117	-0.103	-0.099
Future Price:				
Anticipated:	0.034	0.033	0.012	0.012
Unanticipated:	0.023	0.022	0.008	0.008

The inclusion of the dummy indicating the presence of a clean indoor air law as an independent variable in the cigarette demand equations has little effect on the estimated coefficients of the other regressors. The signs and magnitudes of these coefficients are almost identical to those estimated in equations excluding the clean indoor air law. Hence, only a brief summary of these estimates will follow.

As in the basic models presented in the previous chapter, men are found to smoke more, on average, than women. Similarly, whites are found to smoke greater average quantities of cigarettes than either blacks or individuals of other races. As before, the coefficient on the dummy variable indicating American Natives is positive, indicating that these individuals smoke more than others, possibly due to the lower price on cigarettes that they may face resulting from the tax exempt status of cigarette sales on Indian reservations. Again, older individuals smoke more than younger individuals, on average, with the difference diminishing with age.

Cigarettes, as before, are found to be an economically inferior good when cigarette demand is estimated in a non-addictive framework, with the negative and statistically significant coefficient on income implying an income elasticity of demand in the range from -0.099 to -0.078 . However, estimating cigarette demand in the rational addiction framework leads to the conclusion that cigarettes

are a weakly superior good in an economic sense, with an implied income elasticity of demand in the range from 0.004 to 0.009.

Individuals who are more health conscious, as measured by the indicator of the exercise provided by their recreational activities, smoke less than more sedentary individuals. On the other hand, those describing their average day, apart from recreational activities, as fairly active smoke more than less active individuals. The first of these findings is obtained regardless of the framework in which cigarette demand is estimated, while the second is the result of modelling smoking as an addictive behavior.

More educated individuals smoke less, on average, than those with fewer years of education, with some interesting differences found for the smoking behavior of individuals with different levels of educational attainment. Those who have no formal education smoke substantially more, on average, than individuals whose education consists of a high school degree. Individuals with some formal education beyond high school, however, smoke significantly less than those whose formal education stopped at their high school graduation. Little difference is found in the average cigarette consumption of individuals with less than a grade school education, a grade school education, some high school education, and a high school education, with high school graduates smoking slightly more, on average, than the others.

Turning now to the estimates on the variables of interest, one sees that the estimated coefficients on past and future cigarette consumption and the various sets of cigarette prices included in the alternative demand specifications are somewhat different in the models which include the clean indoor air law indicator from those which do not include it. However, the signs and relative magnitudes of these coefficients remain consistent with the predictions of the model of rational addiction (i.e. current cigarette consumption is inversely related to the current price of cigarettes but positively related to past and future cigarette prices, when included, with the magnitude of the effect of the past price on current consumption larger than that of the current price; and current cigarette consumption is positively related to both past and future cigarette consumption, indicating adjacent complementarity, with the effect of past consumption on current consumption larger in magnitude than the effect of future consumption on current consumption). As before, when it enters, the estimated coefficients on the addictive stock are positive and significant, indicating that the reinforcement effects of addictive consumption represented by the stock outweigh the effects of increases in the full price of cigarette smoking associated with increases in the stock of past cigarette consumption.

A comparison of the coefficients on these variables obtained from the demand equations including the dichotomous

indicator of a clean indoor air law to those obtained from equations which exclude the indicator yields some interesting observations.

The estimated coefficients on each of the included cigarette prices are smaller in absolute value, and slightly less statistically significant in the models which include the law variable than those estimated in equations excluding the law variable. One possible explanation for this is that states which are actively involved in the anti-smoking campaign are both raising state cigarette excise taxes (and, hence, cigarette prices in the state) and enacting laws prohibiting smoking in public places, the two main policy options for discouraging cigarette smoking available to state governments. Evidence of this is the relatively high simple correlation between cigarette excise tax rates and the clean indoor air law indicator. Thus, when the clean indoor air law indicator is left out of the demand equation, the cigarette prices may be capturing, in part, the degree of state activity in the anti-smoking campaign including the use of laws prohibiting smoking in various places, and, hence, the effects of prices on demand may be somewhat overstated.

When the clean indoor air law indicator is included in the demand equations, the estimated coefficients on the measure of past consumption (either lagged consumption or the addictive stock) fall slightly, but remain statistically significant, while the coefficients on future consumption

become somewhat larger, as compared to the estimates obtained from equations excluding the law variable. In those models containing both lagged and future consumption, the coefficient on lagged consumption continues to be larger than that on future consumption. These results appear to support the hypothesis that the passage of the clean indoor air law is surrounded by publicity on the negative health consequences of cigarette smoking which leads smokers to reassess the risks they face from cigarette smoking. The result is that future cigarette consumption plays a relatively larger role in determining current cigarette consumption, or, stated differently, that the individual behaves somewhat more rationally.

This hypothesis is also supported by the results for the clean indoor air law variable itself. When cigarette demand is estimated in the non-addictive framework, all reinforcement effects and most of the full price effects of the law described above are ignored. Rather, only the prohibitional nature of the law and some immediate publicity effects are captured. The estimates obtained from these equations would appear to suggest that the clean indoor air laws have a small, insignificantly negative effect on cigarette smoking. When modelled in the addictive framework, however, the coefficient on the law increases in absolute value and becomes statistically significant, at the five percent level. The relative importance of a clean indoor air law as a determinant of cigarette demand when

modelled in the rational addiction framework suggests that the effects of this law associated with the addictive aspects of consumption are particularly relevant. As noted earlier, these include the creation of an atmosphere providing the positive reinforcement necessary to overcome the addiction to cigarettes and the better assessment of the health risks associated with cigarette smoking resulting from the publicity on the health consequences of smoking which surrounds the passage of these laws.

Although the resulting coefficients on price and consumption are somewhat different in models containing the clean indoor air law variable from those obtained in models which exclude this variable, the various estimates of the price elasticity of demand and the roots of the second order difference equations represented by the demand equations are approximately the same for both sets of equations.

In all models containing the clean indoor air law indicator variable as a regressor, the estimated roots of the second order difference equations are larger than those obtained from the comparable models which exclude the law variable. These estimates indicate that factors which would lead to an increase of ten percent in future consumption would result in an increase in current consumption in the range from 4.8 percent to 6.3 percent. Alternatively, changes in factors affecting past cigarette demand which result in an increase in past consumption of ten percent will lead to increases of between 5.6 and 5.9 percent in

current cigarette consumption. These estimates support the hypothesis that there are important intertemporal links in cigarette consumption, or that cigarette consumption is an addictive behavior.

As before, the best support for the model of rational addiction is found in the models estimated assuming a one hundred percent rate of depreciation on the addictive stock. In these models, current cigarette consumption is found to be negatively related to temporary changes in past, current, and future cigarette prices with the effect on consumption of an anticipated price change being larger than the effect of an unanticipated price change. Permanent price increases are also found to reduce current consumption, with the fall resulting from an anticipated price increase exceeding that associated with the comparable unanticipated price increase. Also, the impact on current consumption of a permanent price increase exceeds that of a temporary price increase. Finally, a permanent increase in price in all periods results in a larger drop in current consumption than a permanent increase in price beginning in the current period (i.e. the long run effect of a price change is greater than the short run effect of a comparable price change), as expected.

The results from the most general model (and, unfortunately, the model most taxing on the data) are somewhat more consistent with the model of rational addiction when the clean indoor air law variable is included as a deter-

minant of demand. As before, current consumption is found to be positively affected by a temporary change in last period's price of cigarettes and is negatively affected by a temporary change in the current price of cigarettes. Now, however, a temporary change in the price of cigarettes next period is found to reduce current cigarette consumption. Also, the effect of a permanent price change beginning in the current period is found to be larger than that of a temporary price change in the current period, unlike before. However, the effect of a long run price change on current consumption remains smaller than that of the comparable short run price change.

Finally, there are no qualitative differences between the various estimated price elasticities of demand for the models containing the addictive stock variable when the clean indoor air variable is included in the demand equations and when it is excluded from the equations.

The estimates from the alternative models of cigarette demand developed under the assumption that cigarette smoking is a rational addictive behavior continue to support the hypothesis that increases in cigarette prices brought on by increases in cigarette excise tax rates will reduce cigarette consumption. The estimated long run price elasticities of demand obtained from these models suggest that a ten percent, permanent increase in the price of cigarettes will result in a fall in consumption in the range from 2.8 to 3.7 percent. This fall in consumption associated with a per-

manent increase in price is substantially larger than that predicted based on the results from demand equations estimated assuming that cigarette smoking is a non-addictive behavior. In these models, a ten percent increase in price will result in a fall in cigarette consumption in the range from 0.2 to 0.5 percent.

Conclusions

Estimates of cigarette demand equations including a dichotomous indicator of a state clean indoor air law derived under the alternative assumptions of non-addictive and addictive behavior were presented in this chapter. The inclusion of the clean indoor air law variable had little quantitative or qualitative impact on the estimated coefficients of the other regressors. Similarly, the basic conclusions concerning the various price elasticities of demand and the intertemporal linkages between consumption were almost unchanged by the inclusion of the clean indoor air law variable as an exogenous determinant of cigarette demand. In particular, strong support continues to be found for the hypothesis that cigarette smoking is an addictive behavior, with somewhat weaker support for the hypothesis that smokers are behaving rationally.

Clean indoor air laws at the state level are found to have a negative impact on cigarette smoking whether smoking is modelled as either a non-addictive behavior or an

addictive behavior. However, this effect is statistically significant in the models derived under the assumption of addictive behavior and is not significant in those developed ignoring the addictive aspects of cigarette consumption. This suggests that the impact of the laws on consumption comes primarily through the reinforcement factors and publicity effects associated with the laws rather than through the simple prohibition of cigarette smoking.

These estimates suggest that the stated intent of reducing cigarette smoking associated with the laws described as comprehensive clean indoor air laws can also be accomplished through the dissemination of information on the health consequences cigarette smoking and the creation of an environment encouraging smokers to quit smoking.

Chapter Ten

Stressful Life Cycle Events and Cigarette Smoking

The Becker-Murphy model of rational addiction allows for stressful life-cycle events to play a major role in the determination of addictive consumption. Many researchers (including Pomerleau, 1986; Shiffman, 1986; Wills, 1985; Kandel, 1980; and Kozlowski, 1979) have found that the consumption of addictive substances is positively related to these events, which can include peer pressure during youth, periods of unemployment, the death of a loved one, and divorce or separation. This chapter will present an abbreviated version of the Becker-Murphy model of rational addiction which incorporates stressful events, followed by a discussion of the demand equations implied by this model. Finally, the results from the estimation of these demand equations will be presented and discussed.

Becker and Murphy introduce the occurrence of stressful events into their model of rational addictive behavior by assuming that the occurrence of the event at time t reduces the individual's utility at time t but at the same time raises the marginal utility of the addictive good (page 33). More formally, the instantaneous utility at time t is given as:

$$(11-1) \quad u(t) = u[C(t), A(t), Y(t), E(t)]$$

with:

$$(11-2) \quad u_E < 0$$

$$(11-3) \quad u_{CE} > 0$$

and:

$$(11-4) \quad u_{YE} = u_{AE} = 0$$

where $E(t)$ represents the occurrence of the stressful event. Equation (11-2) represents the negative impact on utility of the stressful event, while (11-3) captures the positive effect of the event on the marginal utility of the addictive good. Equation (11-4) indicates that the stressful event has no effect on the marginal utilities of the composite good or the addictive stock.

Becker and Murphy use this model to argue that persons who are identical with respect to tastes, productive ability, and wealth and who face the same set of prices may differ in their consumption of addictive goods if they have had or expect to have different experiences. Alternatively, all individuals who experience the stressful events at some point in their life are not going to react identically. That is, all individuals who are divorced or unemployed are not going to either become smokers or, if already smoking, increase their consumption of cigarettes. Again, even if identical in all other respects, differences in other life-

cycle events, either past or anticipated, can lead to different reactions to the same stressful event.

Following the same strategy employed in Chapter Six to develop the cigarette demand equations, a set of demand equations can be derived which include indicators of stressful events. The occurrence of a stressful event is expected to lead to increased consumption of the addictive good in that period. However, as shown earlier with prices, factors which lead to increases in cigarette consumption in one period are also expected to result in increases in cigarette consumption in all other periods. Thus the expectation that a stressful event will occur in the future may lead to increased cigarette consumption today. Similarly, a stressful event in the past may have led an individual to either begin smoking or to increase cigarette consumption in the past, either of which will result in increases in current cigarette consumption, as a result of the increase in past consumption the event induced.

In an attempt to capture the effects of stressful life cycle events on cigarette smoking within the rational addictive framework, alternative sets of dichotomous variables are included as additional regressors in the cigarette demand equations.

Some discussion of stressful situations has been presented in the earlier chapters. It was argued above that the positive relationship found between average daily cigarette consumption and the dichotomous variable indicat-

ing the daily activity level of the individual may have been capturing the daily stress the individual was under.

Similarly, for the equations estimated using a set of dummy variables indicating various levels of educational achievement, it was argued that some of the results obtained may have been capturing not only the effect of additional years of formal education on cigarette smoking but also the effect of peer pressure on cigarette smoking behavior. Recall that individuals with less than a high school education (excepting those with no formal education) were, in general, found to smoke less than those whose education ended with their high school graduation, in the demand equations developed from the addictive model. One possible explanation for this seemingly counterintuitive result was that these individuals were either not exposed to or were exposed for a shorter time to the peer pressure to smoke generally found in high school. Peer pressure to smoke is generally at it strongest during high school (illustrated by the large fraction of smokers whose addiction was initiated during high school (see Kandel, 1980 and Wills, 1985)).

In addition to these variables, sets of variables indicating marital status and labor force status were included in the cigarette demand equations. The set of variables indicating marital status is comprised of dichotomous variables indicating divorced, married but separated, widowed, and single individuals, with the excluded category being married individuals. The labor force status in-

dicators are two dichotomous variables indicating individuals who are nonparticipants and unemployed participants, with the excluded category being individuals who are employed participants.

Of the various indicators of marital status, the death of a spouse indicated by the widowed variable, and the either permanent or temporary separation from one's spouse indicated by the divorced and separated variables are assumed to represent stressful events. Thus, the demand for cigarettes is expected to be positively related to these variables. There is no a priori expectation about the smoking behavior of single individuals.

One of the largest sources of stress for individuals is their job. For this reason, individuals who are nonparticipants in the labor force are expected to smoke less than those who are employed participants, as they are subject to less stress, all other factors constant. On the other hand, unemployment is likely to be a quite stressful situation which may result in the initiation of cigarette smoking or increased cigarette consumption by those already smoking. Thus, a positive relationship is expected between cigarette smoking and the variable indicating unemployed participants in the labor force.

The results from the estimation of the cigarette demand equations including the variables indicating stressful events are contained in Tables 10-1 and 10-2. Table 10-1 contains the estimates obtained for demand equations which

are estimated under the assumption of non-addictive behavior. Models 1-1 and 1-2 use current cigarette consumption, as reported in the NHANES2 survey, as the dependent variable, while Models 1-3 and 1-4 use lagged cigarette consumption. Table 10-2 contains the estimates from the cigarette demand equations developed within the Becker-Murphy framework of rational addictive behavior. Models 2-1 and 2-2 of Table 10-2 are the models which make no assumption concerning the rate of depreciation on the addictive stock, while Models 2-3 and 2-4, Models 2-5 and 2-6, and Models 2-7 and 2-8 assume rates of depreciation on the addictive stock of one hundred percent, eighty percent, and sixty percent, respectively.

All equations presented use the equally weighted average of the own-price of cigarettes and the border price of cigarettes as the relevant price. The set of instruments which contains leads and lags of the cigarette excise tax in addition to the leads and lags of cigarette prices and the other exogenous determinants of demand is used for future consumption, past consumption, and the addictive stock, in each of the equations in which they appear.

The own-price elasticities of demand from the non-addictive models, and the roots of the second order difference equations represented by the addictive demand equations along with the various price elasticities of demand pertaining to these equations are presented in Table 10-3.

Table 10-1*

OLS Estimates of Non-Addictive Demand Equation
Current, Lagged Cigarette Consumption, Weighted Price

Variable	(1-1)	(1-2)	(1-3)	(1-4)
Clean Indoor Air Law	-0.069 (-0.32)	-0.149 (-0.70)	-0.227 (-1.00)	-0.308 (-1.35)
Current Cigarette Price, Weighted	-2.147 (-0.86)	-1.606 (-0.64)	-2.639 (-0.94)	-1.988 (-0.71)
Age	0.590 (13.02)	0.591 (13.08)	0.619 (13.08)	0.620 (13.12)
Age Squared	-0.008 (-15.83)	-0.008 (-15.75)	-0.008 (-15.78)	-0.008 (-15.67)
Sex	3.591 (16.54)	3.766 (17.33)	4.095 (17.66)	4.272 (18.40)
Black	-2.779 (-8.51)	-2.750 (-8.47)	-3.178 (-9.11)	-3.152 (-9.09)
Other Races	-3.533 (-4.70)	-3.079 (-4.11)	-3.845 (-4.79)	-3.401 (-4.25)
American Natives	2.516 (2.84)	2.481 (2.81)	2.933 (3.10)	2.901 (3.08)
Family Income	-0.003 (-1.16)	-0.003 (-1.06)	-0.006 (-2.19)	-0.006 (-2.19)
Number of Years of Formal Education	-0.216 (-6.56)	-----	-0.213 (-6.06)	-----
No Formal Education	-----	-2.235 (-2.08)	-----	-1.554 (-1.35)
Less than Grade School Education	-----	-0.739 (-1.59)	-----	-0.584 (-1.18)
Grade School Education	-----	-0.834 (-2.62)	-----	-1.117 (-3.29)
Some High School Education	-----	1.511 (4.16)	-----	1.458 (3.76)
College	-----	-2.689 (-10.98)	-----	-2.661 (-10.17)
Active	-1.022 (-3.46)	-1.216 (-4.13)	-1.135 (-3.60)	-1.325 (-4.21)
Exercise	-1.113 (-5.03)	-1.153 (-5.23)	-1.217 (-5.15)	-1.264 (-5.37)
Not in the Labor Force	-0.135 (-0.57)	-0.023 (-0.10)	-0.157 (-0.62)	-0.048 (-0.19)
Unemployed	3.796 (3.45)	3.498 (3.19)	3.685 (3.14)	3.386 (2.89)
Widowed	1.568 (4.22)	1.701 (4.60)	1.663 (4.19)	1.785 (4.51)
Single	-1.218 (-3.72)	-0.892 (-2.72)	-1.331 (-3.80)	-1.023 (-2.92)
Divorced	4.312 (9.54)	4.388 (9.75)	4.329 (8.97)	4.391 (9.13)
Separated	3.210 (5.24)	3.422 (5.60)	2.799 (4.28)	3.000 (4.60)
Intercept	2.310 (1.76)	0.353 (0.28)	3.036 (2.17)	1.110 (0.83)
R ²	0.083	0.091	0.081	0.089
F	71.44	65.01	70.33	63.17

*Asymptotic t-ratios are shown in parentheses. The critical asymptotic t-ratios are: 1.28 for a one-tailed test and 1.64 for a two-tailed test at the 10 percent level; 1.64 for a one-tailed test and 1.96 for a two-tailed test at the 5 percent level; and 2.33 for a one-tailed test and 2.58 for a two tailed test at the 1 percent level. The F statistic for each equation is significant at the one percent level.

Table 10-2*

TSLS Estimates of Cigarette Demand Equations

Variable	(2-1)	(2-2)	(2-3)	(2-4)
Clean Indoor Air Law	-0.143 (-1.55)	-0.151 (-1.63)	-0.156 (-1.72)	-0.173 (-1.79)
Past Cigarette Price, Weighted	4.703 (0.80)	4.941 (0.82)	-----	-----
Current Cigarette Price, Weighted	-9.650 (-1.39)	-9.779 (-1.40)	-1.263 (-1.08)	-1.261 (-1.07)
Future Cigarette Price, Weighted	3.724 (0.94)	3.613 (0.91)	-----	-----
Past Consumption	0.460 (3.08)	0.471 (2.97)	0.446 (3.24)	0.450 (3.15)
Future Consumption	0.376 (1.78)	0.358 (1.53)	0.412 (2.18)	0.406 (1.99)
Age	0.084 (2.03)	0.086 (1.85)	0.073 (1.88)	0.073 (1.72)
Age Squared	-0.001 (-1.65)	-0.001 (-1.52)	-0.001 (-1.46)	-0.001 (-1.33)
Sex	0.119 (0.44)	0.148 (0.52)	0.067 (0.25)	0.089 (0.332)
Black	-0.244 (-1.08)	-0.237 (-1.02)	-0.201 (-0.91)	-0.191 (-0.84)
Other Races	-0.296 (-0.73)	-0.282 (-0.71)	-0.146 (-0.38)	-0.139 (-0.37)
American Natives	0.486 (1.19)	0.514 (1.24)	0.427 (1.06)	0.448 (1.10)
Family Income	0.00003 (0.18)	0.0001 (0.09)	0.0003 (0.23)	0.0001 (0.09)
Number of Years of Formal Education	-0.029 (-1.33)	-----	-0.024 (-1.19)	-----
No Formal Education	-----	0.668 (1.38)	-----	0.711 (1.49)
Less than Grade School Education	-----	-0.073 (-0.33)	-----	-0.049 (-0.23)
Grade School Education	-----	-0.161 (-1.06)	-----	-0.149 (-0.99)
Some High School Education	-----	-0.104 (-0.51)	-----	-0.132 (-0.72)
College	-----	-0.305 (-1.25)	-----	-0.240 (-1.08)
Active	0.056 (0.37)	0.044 (0.28)	0.067 (0.45)	0.060 (0.39)
Exercise	-0.108 (-0.93)	-0.124 (-1.01)	-0.087 (-0.77)	-0.100 (-0.84)
Not in the Labor Force	-0.194 (-1.69)	-0.182 (-1.59)	-0.186 (-1.65)	-0.173 (-1.56)
Unemployed	0.053 (0.10)	0.056 (0.11)	-0.001 (-0.02)	-0.010 (-0.02)
Widowed	0.016 (0.08)	0.030 (0.16)	-0.007 (-0.04)	0.001 (0.01)
Single	0.063 (0.37)	0.078 (0.47)	0.081 (0.48)	0.089 (0.54)
Divorced	0.053 (0.16)	0.072 (0.20)	-0.024 (-0.08)	-0.019 (-0.06)
Separated	-0.482 (-1.47)	-0.449 (-1.29)	-0.525 (-1.63)	-0.504 (-1.49)
Intercept	-0.519 (-0.84)	-0.733 (-1.19)	-0.550 (-0.90)	-0.712 (-1.20)
R ²	0.366	0.384	0.369	0.388
F	375.25	341.61	417.97	376.59

Table 10-2 (continued)

TSLS Estimates of Cigarette Demand Equations

Variable	(2-5)	(2-6)	(2-7)	(2-8)
Clean Indoor Air Law	-0.165 (-1.81)	-0.172 (-1.87)	-0.190 (-2.05)	-0.197 (-2.10)
Current Cigarette Price, Weighted	-4.668 (-1.15)	-4.601 (-1.13)	-3.957 (-0.97)	-3.862 (-0.93)
Future Cigarette Price, Weighted	3.458 (0.87)	3.400 (0.86)	2.789 (0.69)	2.716 (0.67)
Addictive Stock	0.334 (3.00)	0.335 (2.89)	0.249 (2.99)	0.250 (2.88)
Future Consumption	0.447 (2.35)	0.447 (2.16)	0.454 (2.40)	0.454 (2.22)
Age	0.061 (1.58)	0.059 (1.41)	0.035 (0.91)	0.033 (0.81)
Age Squared	-0.001 (-1.24)	-0.001 (-1.10)	-0.0004 (-0.72)	-0.0003 (-0.62)
Sex	0.083 (0.30)	0.098 (0.35)	0.022 (0.08)	0.036 (0.12)
Black	-0.219 (-0.98)	-0.204 (-0.89)	-0.208 (-0.92)	-0.192 (-0.83)
Other Races	-0.246 (-0.61)	-0.225 (-0.57)	-0.206 (-0.51)	-0.179 (-0.45)
American Natives	0.422 (1.05)	0.435 (1.07)	0.389 (0.96)	0.399 (0.98)
Family Income	0.00001 (0.04)	-0.00001 (-0.09)	0.00001 (0.04)	-0.00001 (-0.06)
Number of Years of Formal Education	-0.024 (-1.16)	----	-0.024 (-1.15)	----
No Formal Education	----	0.610 (1.27)	----	0.521 (1.07)
Less than Grade School Education	----	-0.057 (-0.26)	----	-0.077 (-0.35)
Grade School Education	----	-0.154 (-1.02)	----	-0.145 (-0.95)
Some High School Education	----	-0.106 (-0.59)	----	-0.096 (-0.53)
College	----	-0.239 (-1.06)	----	-0.252 (-1.11)
Active	0.053 (0.35)	0.046 (0.30)	0.064 (0.42)	0.056 (0.36)
Exercise	-0.098 (-0.86)	-0.108 (-0.91)	-0.103 (-0.89)	-0.111 (-0.93)
Not in the Labor Force	-0.183 (-1.61)	-0.169 (-1.51)	-0.201 (-1.71)	-0.187 (-1.62)
Unemployed	0.066 (0.13)	0.053 (0.10)	0.155 (0.30)	0.139 (0.26)
Widowed	0.007 (0.04)	0.014 (0.07)	0.011 (0.05)	0.017 (0.09)
Single	0.091 (0.53)	0.103 (0.61)	0.135 (0.75)	0.152 (0.85)
Divorced	0.012 (0.04)	0.008 (0.02)	0.029 (0.09)	0.025 (0.07)
Separated	-0.505 (-1.57)	-0.491 (-1.46)	-0.483 (-1.49)	-0.468 (-1.38)
Intercept	-0.174 (-0.29)	-0.332 (-0.59)	0.341 (0.57)	0.183 (0.34)
R ²	0.369	0.388	0.366	0.385
F	397.53	361.61	392.40	356.98

* See note to Table 10-1.

Table 10-3
Price Elasticities of Demand

Non Addictive Models:	(1-1)	(1-2)	(1-3)	(1-4)
	-0.083	-0.062	-0.096	-0.073
Addictive Models:	(2-1)	(2-2)	(2-3)	(2-4)
ϕ_1	0.484	0.456	0.544	0.555
ϕ_2	1.690	1.667	1.698	1.722
Long Run:	-0.272	-0.261	-0.325	-0.320
Short Run:				
Anticipated:	-0.320	-0.321	-0.196	-0.191
Unanticipated:	-0.332	-0.334	-0.133	-0.130
Current Price:				
Anticipated:	-0.340	-0.343	-0.090	-0.089
Unanticipated:	-0.346	-0.350	-0.061	-0.061
Past Price:				
Anticipated:	0.020	0.024	-0.053	-0.053
Unanticipated:	0.016	0.020	-0.036	-0.036
Future Price:				
Anticipated:	0.010	0.012	-0.049	-0.047
Unanticipated:	0.007	0.008	-0.033	-0.032
	(2-5)	(2-6)	(2-7)	(2-8)
ϕ_1	0.595	0.595	0.607	0.608
ϕ_2	1.801	1.793	1.803	1.792
Long Run:	-0.329	-0.326	-0.325	-0.323
Short Run:				
Anticipated:	-0.079	-0.078	-0.105	-0.104
Unanticipated:	-0.146	-0.144	-0.145	-0.143
Current Price:				
Anticipated:	-0.200	-0.197	-0.177	-0.174
Unanticipated:	-0.227	-0.224	-0.193	-0.189
Past Price:				
Anticipated:	-0.111	-0.110	-0.098	-0.097
Unanticipated:	-0.126	-0.125	-0.107	-0.105
Future Price:				
Anticipated:	0.049	0.048	0.029	0.027
Unanticipated:	0.033	0.032	0.019	0.018

The inclusion of the variables capturing stressful life cycle events - the marital status and employment status variables - in the cigarette demand equations has little effect on the estimated coefficients of the other explanatory variables. In particular, the findings that men smoke more, on average, than women, that whites smoke more, on average, than blacks and individuals of other races, and that American Natives smoke more than other individuals are unchanged. Similarly, the positive but diminishing relationship obtained between cigarette consumption and age persists, as does the positive relationship between consumption and real family income. Finally, individuals whose recreational activities provide much or moderate exercise smoke less than others.

The presence of a state law restricting smoking in public places, the clean indoor air law, is found to significantly reduce average cigarette consumption in the addictive framework. Again, this may be due to the atmosphere encouraging individuals to stop smoking or refrain from starting smoking created by the passage of the law and/or the information provided on the negative health consequences of cigarette smoking publicized during the consideration and enactment of these laws.

The findings concerning the role of education in cigarette demand are also unchanged by the inclusion of the variables indicating stressful events. As before, individuals with a greater number of years of formal education

completed smoke less, on average, than those with fewer years completed. Similarly, individuals who completed one or more years of formal education beyond high school are found to smoke significantly less than those whose education ended with their high school graduation, while those who had no formal education smoke significantly more than high school graduates. The differences between the cigarette smoking behaviors of other groups are, as before, less pronounced, with high school graduates generally smoking slightly more than those with some grade school education, a grade school education, or some high school education. Again, this is likely to be due to the longer period of peer pressure to which these individuals were exposed, supporting the hypothesis that stressful situations lead to either smoking initiation or the increased consumption of cigarettes.

Similarly, individuals describing a typical day, apart from recreational activities, as moderately or very active are found to smoke greater quantities of cigarettes, on average, than their less active counterparts. Again, this finding may be the result of the activity variable being a measure of daily stress, to which addictive consumption is expected to be positively related.

The results for the variables indicating labor force status are, in most models, consistent with expectations, while those for the marital status variables are somewhat more disappointing.

As expected, individuals who are not participants in the labor force are found to smoke significantly less than employed individuals, likely due to the fact that non-participants are subject to less stress, *ceteris paribus*, than their employed counterparts. This finding holds up in all variations of the addictive demand equations estimated, but is not observed in the equations estimated under the assumption that cigarette smoking is a non-addictive behavior.

On the other hand, unemployed individuals are found to smoke significantly more, on average, than employed individuals in the non-addictive cigarette demand equations. However, only an insignificant positive relationship is found between unemployment and cigarette demand in the addictive demand equations, with a negative relationship between the two observed for the models assuming a one hundred percent rate of depreciation on the stock of past cigarette consumption.

In the non-addictive demand equations, the marital status variables perform as expected. In these equations, positive and significant coefficients are estimated on the dummy variables indicating widowed, divorced, and separated individuals. Also, single individuals are found to smoke significantly less than married individuals, in the non-addictive framework. However, these variables perform less well in the models of addictive demand. In these equations, positive but insignificant coefficients are obtained, in

general, on the variables indicating widowed and divorced individuals, but negative coefficients are estimated on the variable indicating individuals who are married but separated from their spouse, contrary to expectations. Finally, single individuals are found to smoke slightly more, on average, than married individuals, in the addictive framework.

The mixed results estimated for the variables indicating stressful life cycle events may be attributable to the imperfect data used to capture these events. In general, the variables indicating employment status are likely to be more closely related to the cigarette consumption data provided by the survey due to their accuracy at the time of the survey. However, little is known about the timing of the events represented by the set of marital status dummy variables. In particular, the event in question - the death of a loved one, divorce, or separation - may have taken place long before the survey was conducted. As Becker and Murphy note, the role played by stressful events in the determination of the demand for addictive goods is similar to the role played by the past and future prices of these goods. Thus, in the demand equations developed within the addictive framework, only events occurring in the periods immediately preceding and following the period in question are relevant. Events taking place earlier are being captured by past consumption and are, hence, irrelevant as determinants of current consumption.

An examination of the results obtained for the effects of cigarette prices and past and future cigarette consumption on current cigarette demand yields the same conclusions as before. The signs and relative magnitudes of the coefficients on prices and the measures of cigarette consumption are consistent with the predictions of the Becker-Murphy model of rational addictive behavior. As before, however, somewhat less support is found in the various estimated price elasticities of demand.

As expected, positive relationships are estimated between current cigarette consumption and, when included, past and future cigarette prices and past and future cigarette consumption, with the estimated coefficients on past price and past consumption exceeding those on future price and future consumption. Similarly, in all equations, current cigarette demand is inversely related to the current price of cigarettes.

The estimated roots of the second order difference equations represented by the addictive demand equations are real and positive in all cases, and are similar in magnitude to the roots estimated based on the results presented in the previous two chapters.

As before, the strongest support for the model of cigarette smoking as a rational addictive behavior is found in the demand equations estimated under the assumption that the rate of depreciation on the addictive stock is one hundred percent. Each of the price elasticities of demand

estimated using the results from these equations is consistent with the model of rational addictive behavior. In particular, temporary increases in past, current, or future cigarettes prices are found to reduce current cigarette consumption, with anticipated increases leading to larger reductions than unanticipated increases. Similarly, permanent increases in price are found to reduce current consumption, with the effect of a "long run" increase exceeding that of a comparable "short run" increase. Finally, an anticipated permanent short run price change has a larger impact on current consumption than either the comparable unanticipated price change or a temporary change in the current price, as expected.

The estimated price elasticities of demand from the other models of cigarette demand derived from the model of rational addiction provide mixed support for the model, as before, with the estimates from the stock models slightly more consistent with the predictions of the model.

The estimated long run price elasticities of demand obtained from each of the models estimated under the assumption of addictive behavior continue to be significantly greater than the estimated price elasticities obtained using the result from the non-addictive demand equations. For example, the long run price elasticities implied by the estimates obtained in the addictive models suggest that a permanent increase of ten percent in the price of cigarettes in all periods would result in a fall in cigarette consump-

tion in the range from 2.6 to 3.3 percent. This same increase in price would result in a drop in consumption of only 0.8 percent, on average, using the estimates obtained from the non-addictive models of cigarette demand. These results continue to support the claim that ignoring the addictive nature of cigarette consumption leads to misleading conclusions concerning the response of cigarette smokers to changes in cigarette prices and, hence, the use of cigarette excise taxes to discourage cigarette smoking.

Conclusions

A brief discussion of the role of stressful life cycle events in cigarette smoking behavior, as discussed in the Becker-Murphy theoretical model of rational addiction, was presented in this chapter. This was followed by the presentation and discussion of the results obtained from cigarette demand equations estimated including a set of variables indicating various stressful events and situations.

The inclusion in the cigarette demand equations of the variables indicating stressful events had little discernible impact on the estimates pertaining to the other determinants of demand. Many of the predictions of the Becker-Murphy model of rational addiction continued to be supported by the estimates obtained for the addictive demand equations. In particular, significant intertemporal linkages continue to

be found in cigarette consumption. Also, the results continue to indicate that increases in cigarette prices would lead to reductions in cigarette demand.

The estimated effects of life cycle events on cigarette smoking, however, are somewhat less conclusive. While the labor force status indicators perform as expected, in general, the marital status indicators do less well. Individuals facing less work-related stress, those who are not participating in the labor force, are found to smoke less than employed individuals, while unemployed individuals, assumed to be under greater stress, are found to smoke more than employed individuals. Stressful events such as widowhood, divorce, or separation were expected to lead to increased cigarette consumption, on average. However, only a weak positive relationship was obtained between the indicators of widowhood and divorce and cigarette smoking, with a somewhat stronger negative relationship obtained between separation and smoking.

The use of better data on stressful life cycle events, in particular more information on the timing of such events, would likely clarify the role these phenomena play in the determination of cigarette consumption.

Chapter Eleven

Differences in Cigarette Smoking

This chapter explores the observed differences in cigarette smoking behavior between men and women, whites and blacks, and individuals of different ages and educational attainment within the rational addiction framework. Moreover, the Becker-Murphy model of rational addiction allows for differences in behavior through differences in rates of time preference. Many argue that more educated and/or older individuals discount the future less than their less educated and/or younger counterparts.

To examine these differences, separate sets of demand equations are estimated for males and females, for blacks and whites, for individuals ages seventeen years to twenty four years, twenty five years to sixty four years, and ages sixty five years to seventy three years, and for individuals with less than a high school education and for those with at least a high school education. The results for the variables of particular interest in this work, prices, clean air laws, and past and future consumption, are presented for each of the equations together with the sample means and standard deviations of these variables. Finally, the various price elasticities of demand are presented. The results associated with the other determinants of demand will also be discussed below, particularly where they differ across samples.

Differences in the Cigarette Smoking Behavior of Men and Women

Significant differences between the smoking patterns of men and women have been observed since the introduction of tobacco to Western civilizations. Historically, men have always smoked at much higher rates than women, with the differences between the two becoming more dramatic with the advent of the anti-smoking campaign in the mid-1960's. At the time of the release of the first U.S. Surgeon General's report on the health consequences of cigarette smoking, the U.S. Department of Health and Human Services estimates that 52.9 percent of men were smokers, while only 34.1 percent of women were smokers.¹ However, during the years that followed, significant progress was made in reducing smoking participation among men, with only limited progress made in reducing the fraction of women who smoked. By 1985, the male smoking participation rate had fallen to 33 percent while the comparable female rate had fallen to only 28 percent. Moreover, surveys show that fewer men are initiating smoking today than there were twenty years ago, while the fraction of women initiating smoking today is identical to that in 1970.²

In addition to the observed differences in the historical smoking patterns of men and women, several psychological

¹ U.S. Department of Health and Human Services, 1986b.

² U.S. Department of Health and Human Services, 1986b.

and physiological differences have been observed in cigarette smoking and its effects across the sexes. As discussed in Chapter Four, women face additional health risks from cigarette smoking, which are complicated by pregnancy and the use of oral contraceptives. Similarly, the Surgeon General notes that "women may not start smoking, continue to smoke, quit smoking, or fail to quit smoking for precisely the same reasons as men."³ For example, women smokers have been much less successful in smoking cessation than their male counterparts, with women in organized cessation programs experiencing more severe withdrawal symptoms than men.⁴ Also, women tend to smoke "low tar and nicotine cigarettes, smoke fewer cigarettes per day, and inhale less deeply than do men."⁵ Also, differences in nicotine metabolism between men and women have been suggested.⁶ Analogously, women appear to smoke more in stressful situations (to relax themselves) than in situations where they are bored (to stimulate themselves) while the opposite is observed for men.⁷ Finally, in those studies by economists which considered the demand for cigarettes by men and women

³ U.S. Department of Health and Human Services, 1980.

⁴ Ashton and Stepney, 1982, page 172, and U.S. Department of Health and Human Services, 1980, page 347.

⁵ U.S. Department of Health and Human Services, 1980, page 346.

⁶ U.S. Department of Health and Human Services, 1980, page 300.

⁷ U.S. Department of Health and Human Services, 1980, page 301.

separately, significant, but conflicting, differences in the responses to price and income changes have been estimated. For example, Atkinson and Skegg (1973) find that men are unresponsive to changes in cigarette prices but do respond to the negative publicity on cigarette smoking, while Mullahy (1985) finds, in every equation he estimates, that men are more responsive to changes in price than women. Mullahy also observes that cigarette smoking is an economically superior behavior for men while it is an economically inferior behavior for women.

To examine the potential differences in smoking behavior between men and women in the rational addiction framework, a subset of the cigarette demand equations were estimated separately for men and women. The means and standard deviations of the key variables for the two samples are presented in Table 11-1, along with smoking participation rates. As expected, the smoking participation rate for males is greater (by ten percentage points) than that for females, consistent with the observed rates during the period covered by NHANES2.

The estimated coefficients on the dichotomous clean indoor air law indicator, cigarette prices, and future cigarette consumption and past cigarette consumption or the stock of past cigarette consumption are presented in Table 11-2. Panel A of Table 11-2 contains the results for males while Panel B contains the results for females. Models 2-1 and 2-2 of Table 11-2 contain the results obtained from the

Table 11-1*

Means and Standard Deviations of Key Variables, by Sex

Variable	Men	Women
Clean Indoor	0.316	0.313
Air Law	(0.465)	(0.464)
Past Cigarette	0.287	0.286
Price, Weighted	(0.038)	(0.038)
Current Cigarette	0.285	0.285
Price, Weighted	(0.038)	(0.038)
Future Cigarette	0.279	0.279
Price, Weighted	(0.040)	(0.040)
Past Cigarette	12.942	7.793
Consumption	(17.913)	(13.664)
Current Cigarette	9.865	6.067
Consumption	(14.654)	(11.256)
Future Cigarette	8.995	5.668
Consumption	(13.723)	(10.587)
Addictive Stock,	16.236	9.739
$\delta=80\%$	(22.256)	(16.981)
Addictive Stock,	21.771	12.946
$\delta=60\%$	(29.443)	(22.459)
Smoking Participation	41.21	31.08
Rate		
N	6569	7736

* Standard deviations in parentheses below means. The "current" period is the year prior to the individuals survey as part of NHANES2, as discussed in Chapter Seven, where the complete definitions of the variables can be found.

estimation of the demand equation which makes no assumption concerning the rate of depreciation on the stock of past consumption, with Model 2-1 employing the continuous measure of education and Model 2-2 employing the set of indicators of educational attainment for education. Models 2-3 and 2-4 are the comparable equations estimated assuming the rate of depreciation on the addictive stock is one hundred percent. Models 2-5 and 2-6, and Models 2-7 and 2-8 contain the results for equations estimated assuming eighty and sixty percent rates of depreciation, respectively.

All models were estimated using instrumental variables for future cigarette consumption and past cigarette consumption or the addictive stock, where the set of instruments included, in addition to the exogenous determinants of demand, further leads and lags of both cigarette prices and cigarette excise tax rates. The measure of cigarette prices (and cigarette excise taxes) employed in all equations is the equally weighted average of the own-price and border-price of cigarettes.

All equations include variables measuring the individual's age, age squared, and real family income, as well as the dichotomous variables indicating blacks, individuals of other races, American natives, exercise, activity, marital status, and labor force status.

The estimated price elasticities of demand based on the results presented in Table 11-2 are contained in Table 11-3.

Before turning to the variables of interest, a brief discussion of the estimates obtained for the other variables is in order. White men are found to smoke significantly more than black men, as well as more than men of other races in every equation estimated, while the opposite relationships are found among women. American natives, both male and female, are found to smoke more than other individuals, with the effect for males statistically significant and larger in magnitude than for females.

Men who describe their recreational activities as providing much or moderate exercise smoke significantly less

Table 11-2"

Price, Consumption, and Clean Indoor Air Law Coefficients
from TSLS Estimation of Cigarette Demand Equations
Differences by Sex

Panel A: Men

Model	(2-1)	(2-2)	(2-3)	(2-4)
Clean Indoor Air Law	-0.291 (-1.62)	-0.293 (-1.62)	-0.294 (-1.68)	-0.294 (-1.66)
Past Cigarette Price, Weighted	9.811 (0.94)	9.203 (0.90)	----- -----	----- -----
Current Cigarette Price, Weighted	-17.217 (-1.41)	-16.473 (-1.37)	-4.499 (-2.07)	-4.447 (-2.05)
Future Cigarette Price, Weighted	3.039 (0.42)	2.962 (0.41)	----- -----	----- -----
Past Consumption	0.522 (3.54)	0.527 (3.58)	0.515 (3.61)	0.521 (3.66)
Future Consumption	0.227 (1.09)	0.238 (1.12)	0.263 (1.36)	0.272 (1.37)
R ²	0.289	0.307	0.296	0.314
F	126.45	116.09	144.83	129.99

Model	(2-5)	(2-6)	(2-7)	(2-8)
Clean Indoor Air Law	-0.303 (-1.73)	-0.304 (-1.72)	-0.326 (-1.86)	-0.328 (-1.84)
Current Cigarette Price, Weighted	-7.391 (-1.01)	-7.238 (-1.00)	-6.365 (-0.86)	-6.212 (-0.84)
Future Cigarette Price, Weighted	3.071 (0.43)	2.976 (0.42)	2.279 (0.31)	2.179 (0.30)
Addictive Stock	0.400 (3.50)	0.404 (3.53)	0.297 (3.44)	0.301 (3.48)
Future Consumption	0.286 (1.46)	0.295 (1.47)	0.297 (1.52)	0.305 (1.52)
R ²	0.297	0.315	0.293	0.310
F	138.11	125.14	135.59	122.72

Table 11-2 (continued)

Panel B: Women

Model	(2-1)	(2-2)	(2-3)	(2-4)
Clean Indoor Air Law	-0.082 (-0.78)	-0.080 (-0.77)	-0.090 (-0.87)	-0.089 (-0.87)
Past Cigarette Price, Weighted	0.909 (0.15)	1.044 (0.17)	----- -----	----- -----
Current Cigarette Price, Weighted	-1.576 (-0.21)	-1.908 (-0.26)	1.102 (0.90)	1.069 (0.87)
Future Cigarette Price, Weighted	1.783 (0.41)	1.953 (0.45)	----- -----	----- -----
Past Consumption	0.467 (3.30)	0.470 (3.33)	0.470 (3.45)	0.472 (3.48)
Future Consumption	0.466 (2.50)	0.464 (2.44)	0.469 (2.64)	0.468 (2.59)
R ²	0.360	0.400	0.359	0.396
F	206.49	202.65	227.53	219.54

Model	(2-5)	(2-6)	(2-7)	(2-8)
Clean Indoor Air Law	-0.107 (-1.02)	-0.107 (-1.02)	-0.142 (-1.32)	-0.143 (-1.33)
Current Cigarette Price, Weighted	-0.166 (-0.04)	-0.351 (-0.08)	0.516 (0.11)	0.346 (0.08)
Future Cigarette Price, Weighted	1.163 (0.26)	1.324 (0.30)	0.403 (0.09)	0.559 (0.13)
Addictive Stock	0.379 (3.46)	0.379 (3.48)	0.290 (3.54)	0.289 (3.55)
Future Consumption	0.459 (2.58)	0.460 (2.54)	0.449 (2.54)	0.451 (2.50)
R ²	0.361	0.398	0.360	0.397
F	218.11	212.38	216.97	211.38

*Asymptotic t-ratios are shown in parentheses. The critical asymptotic t-ratios are: 1.28 for a one-tailed test and 1.64 for a two-tailed test at the 10 percent level; 1.64 for a one-tailed test and 1.96 for a two-tailed test at the 5 percent level; and 2.33 for a one-tailed test and 2.58 for a two-tailed test at the 1 percent level. The F statistic for each equation is significant at the one percent level.

Table 11-3

Price Elasticities of Demand, Sex Differences

Panel A: Men

Models:	(2-1)	(2-2)	(2-3)	(2-4)
ϕ_1	0.263	0.279	0.314	0.328
ϕ_2	1.653	1.619	1.628	1.591
Long Run:	-0.503	-0.530	-0.585	-0.621
Short Run:				
Anticipated:	-0.554	-0.546	-0.280	-0.291
Unanticipated:	-0.527	-0.514	-0.226	-0.231
Current Price:				
Anticipated:	-0.510	-0.494	-0.192	-0.195
Unanticipated:	-0.490	-0.471	-0.155	-0.155
Past Price:				
Anticipated:	0.020	0.006	-0.118	-0.123
Unanticipated:	0.032	0.021	-0.095	-0.097
Future Price:				
Anticipated:	-0.032	-0.038	-0.060	-0.064
Unanticipated:	-0.027	-0.031	-0.049	-0.051
	(2-5)	(2-6)	(2-7)	(2-8)
ϕ_1	0.346	0.361	0.362	0.376
ϕ_2	1.654	1.619	1.658	1.617
Long Run:	-0.583	-0.616	-0.568	-0.603
Short Run:				
Anticipated:	-0.210	-0.219	-0.226	-0.237
Unanticipated:	-0.231	-0.235	-0.225	-0.230
Current Price:				
Anticipated:	-0.244	-0.245	-0.225	-0.226
Unanticipated:	-0.258	-0.256	-0.224	-0.221
Past Price:				
Anticipated:	-0.148	-0.152	-0.135	-0.140
Unanticipated:	-0.156	-0.158	-0.135	-0.137
Future Price:				
Anticipated:	0.023	0.017	-0.007	-0.007
Unanticipated:	0.018	0.013	-0.006	-0.006

Table 11-3 (continued)

Panel B: Women

Models:	(2-1)	(2-2)	(2-3)	(2-4)
ϕ_1	0.685	0.684	0.698	0.698
ϕ_2	1.456	1.444	1.430	1.421
Long Run:	0.782	0.775	0.849	0.837
Short Run:				
Anticipated:	0.504	0.493	0.498	0.487
Unanticipated:	0.182	0.166	0.255	0.248
Current Price:				
Anticipated:	0.035	0.021	0.151	0.147
Unanticipated:	-0.066	-0.083	0.077	0.075
Past Price:				
Anticipated:	0.087	0.087	0.105	0.104
Unanticipated:	0.018	0.015	0.054	0.053
Future Price:				
Anticipated:	0.147	0.149	0.105	0.103
Unanticipated:	0.078	0.079	0.054	0.052
	(2-5)	(2-6)	(2-7)	(2-8)
ϕ_1	0.675	0.677	0.659	0.662
ϕ_2	1.436	1.433	1.410	1.414
Long Run:	0.696	0.690	0.638	0.631
Short Run:				
Anticipated:	0.504	0.517	0.385	0.399
Unanticipated:	0.212	0.209	0.186	0.185
Current Price:				
Anticipated:	0.084	0.075	0.104	0.096
Unanticipated:	-0.011	-0.024	0.036	-0.024
Past Price:				
Anticipated:	0.058	0.052	0.074	0.068
Unanticipated:	-0.008	-0.017	0.025	0.017
Future Price:				
Anticipated:	0.137	0.142	0.096	0.102
Unanticipated:	0.073	0.075	0.051	0.054

than their more sedentary counterparts, while no difference is observed among the two groups for women. On the other hand, women who describe their typical day as very or moderately active smoke significantly more than less active women, with no differences in smoking behavior observed between fairly active and inactive men. This is likely to be the result of the differences in smoking behavior as a response to stress noted above.

Both older men and older women smoke more than younger men and younger women, with the difference declining with age for both sexes. However, the age differences are more pronounced and statistically significant for men, while generally insignificant for women.

A positive relationship is found between income and average cigarette consumption in every equation estimated for men, while a negative relationship is obtained in each of the demand equations estimated for women, albeit never significant. The income elasticities of demand implied by these estimates center on 0.015 for men and -0.011 for women.

For both men and women, the estimates show that individuals with more years of formal education smoke less than those with fewer years of formal education, with more educated men smoking significantly less than less educated men, while the differences for women are statistically insignificant. There are few differences in smoking behavior of men and women with different levels of educa-

tional attainment. In both cases, those with no formal education smoke more than high school graduates, while those who dropped out of high school and those who had some education beyond high school smoking less, on average than high school graduates. The results for the other indicators are inconsistent across the various estimated equations, suggesting little difference between individuals with eight years of less of formal education and high school graduates.

Few differences are observed between men and women with respect to the effects of stressful life cycle events on average cigarette consumption, as captured by the dichotomous indicators of labor force status and marital status. Both male and female nonparticipants smoke significantly less than their employed counterparts, while unemployed men and women smoke somewhat more than employed men and women, as expected.

However, the marital status indicators continue to fall short of expectations. Divorced, separated, and widowed women all smoke less, sometimes significantly less, than married women, contrary to expectations, while single women smoke slightly more than married women. Similar findings are obtained for separated and single men. However, widowed or divorced men smoke more than married men, although never significantly.

Turning now to the estimated effects of clean indoor air laws and cigarette prices on male and female cigarette demand, one sees that male cigarette demand is much more

responsive to both the laws and to prices.

In all estimated equations for both men and women, average cigarette consumption is found to be negatively related to the variable indicating the presence of a clean indoor air law in the state in which the individual resides. However, the estimated coefficients on the law variable in the male demand equations are approximately three times those in the female demand equations, and are statistically significant at at least the five percent level in the male demand equations, while they are generally less significant in the female demand equations. These results may indicate that men are much more responsive than women to the publicity on the negative health effects of cigarette smoking surrounding the passage of these laws.

In each of the cigarette demand equations estimated for men, the estimated coefficients on cigarette prices are of the expected signs and magnitudes, with many of the coefficients on current price statistically significant at better than the ten percent level, with the others generally less significant. The comparable estimates from the female cigarette demand equations are generally inconsistent with the predictions of the models, and are generally not statistically different from zero. These results appear to be consistent with the estimates Mullahy obtains using data collected at about the same time. That is, men appear to be much more responsive to changes in the price of cigarettes than do women. Moreover, when cigarette demand is modelled

in the rational addiction framework of Becker and Murphy, it appears that women are completely unresponsive to changes in the price of cigarettes.

The various estimated price elasticities of demand tend to support this conclusion. Almost all of the estimated price elasticities of demand for women are inconsistent with expectations, while those obtained for men are much more consistent with the predictions of the model. As before, the estimates obtained from the models which are least taxing on the data, those which assume the rate of depreciation on the stock is one hundred percent, perform the best, with the others performing less consistently. However, the estimated long run price elasticities of demand for men are fairly consistent across specifications. These estimates imply that a permanent ten percent increase in the price of cigarettes in all periods would lead to a fall in average cigarette consumption of between 5.0 and 6.2 percent, with the impact of a comparable price increase beginning in the current period about one-third to one-half that, in general.

These estimates imply that increases in cigarette prices induced by increased excise taxation, increased publicity concerning the harmful effects of cigarette smoking, and/or the passage of clean indoor air laws are all effective policies in reducing cigarette smoking among men. However, the estimates imply that price changes will have no impact on cigarette smoking by women, while the other policies will be much less effective among women.

The estimated roots of the second order difference equations implied by the cigarette demand equations, based on the estimated coefficients on future consumption and past consumption or the addictive stock, suggest strong intertemporal linkages in cigarette consumption for both men and women, with some interesting differences between the sexes.

In all equations for both men and women, the estimated coefficients on future cigarette consumption, past cigarette consumption, and the stock of past consumption are positive and statistically significant at the one percent level, with the exception the coefficients on future consumption in the male cigarette demand equations, which are positive but less significant.

Comparing the coefficients on past and future consumption obtained from the estimation of separate demand equations for men and women, one can see that the coefficients on past consumption are larger in all equations for men than those on past consumption for women. On the other hand, the estimated coefficients on future consumption obtained from the male demand equations are much smaller than those obtained from the female demand equations. These estimates imply that men are behaving more myopically than women, or that they are discounting the future more heavily than women. The discount rates implied by these estimates suggest that men discount the future at about a one hundred percent rate, while women do not appear to discount the future at all.

The estimates imply that factors which lead to an increase in lagged cigarette consumption of ten percent will lead to about a six percent increase in current cigarette consumption by men and about a seven percent increase for women. However, while factors which lead to an increase of ten percent in future cigarette consumption are predicted to have only a slightly smaller effect on current consumption, in general, by women as factors leading to a ten percent increase in past consumption, men are expected to increase current consumption by between 2.6 and 3.8 percent, about half their response to comparable past effects.

Summary

To summarize, dramatic differences are observed between the smoking behaviors of men and women when cigarette smoking is modelled in the Becker-Murphy rational addiction framework. In particular, men are found to be much more responsive to changes in the price of cigarettes than are women, for whom there appears to be no response. Both men and women exhibit strong intertemporal bonds between cigarette consumption, with women appearing to behave "more rationally" (much less myopically) than men. Both men and women residing in states with clean indoor air laws smoke less than their counterparts in states without such laws, with the differences more pronounced among men than among women.

Differences in Cigarette Smoking Behavior

By Race

While less attention has been paid to the differences in the cigarette smoking pattern of whites and blacks than has been paid to the smoking patterns of men and women, some differences have been observed. As the U.S. Department of Health and Human Services notes, the smoking participation rates of blacks have historically been and continue to be higher than the smoking participation rates of whites.^a While both black and white men smoke more than black and white women, the differences in the smoking patterns of white and black women are less pronounced than the differences between white and black men. Finally, the anti-smoking campaign appears to have been successful in reducing smoking among both black and white males, with participation rates falling from 51.3 percent in 1965 to 34.7 percent in 1983 for white males and from 59.6 percent in 1965 to 42.6 percent in 1983 for black males. However, women appear to have been much less affected, with the smoking participation rates of white women falling from 34.5 percent in 1965 to 29.8 percent in 1983, while the smoking participation rates of black women were almost unchanged over this period (at 32.7 percent in 1965 and 32.5 percent in 1983).^a

^a U.S. Department of Health and Human Services, 1986b, page 23.

^a U.S. Department of Health and Human Services, 1986b, page 23.

While smoking participation rates are higher for blacks, the average cigarette consumption of black smokers has been less than the average cigarette consumption of white smokers, with blacks much less likely to be heavy smokers than whites, while blacks generally have lower quit rates than do whites.¹⁰ Finally, there have been no studies of differences between blacks and whites in the physiological and psychological factors associated with cigarette smoking.

Ideally, separate cigarette demand equations could have been estimated for white men, white women, black men, and black women. However, due to the severe collinearity problems encountered in estimating separate demand equations for black men and women, separate equations for each race-sex group were not estimated. Instead, separate equations were estimated for whites and blacks only. As will be discussed below, serious problems remain in the estimation of separate demand equations for blacks.

The means and standard deviations of the key variables for the white and black samples are presented in Table 11-4, along with smoking participation rates. As expected, the smoking participation rate of blacks exceeds that of whites, while whites have greater average past, current, and future cigarette consumption.

The coefficients on the clean indoor air law indicator,

¹⁰ U.S. Department of Health and Human Services, 1985, pages 50-53.

Table 11-4*

Means and Standard Deviations of Key Variables, by Race

Variable	Whites	Blacks
Clean Indoor	0.303	0.362
Air Law	(0.460)	(0.481)
Past Cigarette	0.288	0.279
Price, Weighted	(0.036)	(0.047)
Current Cigarette	0.286	0.277
Price, Weighted	(0.037)	(0.049)
Future Cigarette	0.280	0.270
Price, Weighted	(0.038)	(0.050)
Past Cigarette	10.537	7.755
Consumption	(16.395)	(12.397)
Current Cigarette	8.114	5.882
Consumption	(13.445)	(9.888)
Future Cigarette	7.450	5.610
Consumption	(12.602)	(9.249)
Addictive Stock,	13.202	9.688
$\delta=80\%$	(20.378)	(15.414)
Addictive Stock,	17.646	12.887
$\delta=60\%$	(26.972)	(20.415)
Smoking Participation	35.53	38.11
Rate		
N	12476	1577

* See note to Table 11-1.

cigarette prices, future cigarette consumption, and past cigarette consumption or the addictive stock are presented in Table 11-5. The results from the demand equations for whites are contained in Panel A of Table 11-5 while those for blacks are contained in Panel B of Table 11-5. Models 5-1 and 5-2 of Table 11-5 contain the results obtained from the estimation of the demand equation which makes no assumption concerning the rate of depreciation on the stock of past consumption, with Model 5-1 employing the continuous measure of education and Model 5-2 employing the set of indicators of educational attainment for education. Models

5-3 and 5-4 are the comparable equations estimated assuming the rate of depreciation on the addictive stock is one hundred percent. Models 5-5 and 5-6, and Models 5-7 and 5-8 contain the results for equations estimated assuming eighty and sixty percent rates of depreciation, respectively.

All models were estimated using instrumental variables for future cigarette consumption and past cigarette consumption or the addictive stock, where the set of instruments included, in addition to the exogenous determinants of demand, further leads and lags of both cigarette prices and cigarette excise tax rates. The measure of cigarette prices (and cigarette excise taxes) employed in all equations is the equally weighted average of the own-price and border-price of cigarettes.

All equations include variables measuring the individual's age, age squared, and real family income, as well as the dichotomous variables indicating males, American natives, exercise, activity, marital status, and labor force status. Individuals of other races were excluded from the demand equations.

Finally, the estimated price elasticities of demand are contained in Table 11-6.

Before examining the results obtained for the clean indoor air laws, cigarette prices, and past and future cigarette consumption, a synopsis of the results for the other determinants of demand will be presented.

As expected, men of either race smoke more than women

Table 11-5*

Price, Consumption, and Clean Indoor Air Law Coefficients
from TSLS Estimation of Cigarette Demand Equations
Differences by Race

Panel A: Whites

Model	(5-1)	(5-2)	(5-3)	(5-4)
Clean Indoor Air Law	-0.227 (-2.21)	-0.234 (-2.27)	-0.251 (-2.48)	-0.256 (-2.53)
Past Cigarette Price, Weighted	5.909 (0.94)	5.884 (0.93)	----- -----	----- -----
Current Cigarette Price, Weighted	-13.167 (-1.73)	-13.138 (-1.72)	-1.267 (-0.97)	-1.216 (-0.93)
Future Cigarette Price, Weighted	5.996 (1.33)	6.036 (1.33)	----- -----	----- -----
Past Consumption	0.465 (3.66)	0.464 (3.60)	0.456 (3.76)	0.452 (3.70)
Future Consumption	0.382 (2.16)	0.385 (2.09)	0.417 (2.53)	0.427 (2.50)
R ²	0.370	0.391	0.373	0.394
F	366.40	333.63	411.59	368.17
Model	(5-5)	(5-6)	(5-7)	(5-8)
Clean Indoor Air Law	-0.254 (-2.48)	-0.260 (-2.53)	-0.288 (-2.76)	-0.294 (-2.80)
Current Cigarette Price, Weighted	-6.835 (-1.44)	-6.824 (-1.44)	-5.810 (-1.21)	-5.817 (-1.21)
Future Cigarette Price, Weighted	5.480 (1.21)	5.519 (1.22)	4.452 (0.96)	4.505 (0.97)
Addictive Stock	0.357 (3.61)	0.354 (3.54)	0.277 (3.65)	0.275 (3.58)
Future Consumption	0.423 (2.53)	0.432 (2.50)	0.408 (2.41)	0.416 (2.37)
R ²	0.372	0.394	0.368	0.389
F	388.96	351.27	381.89	345.07

Table 11-5 (continued)

Panel B: Blacks

Model	(5-1)	(5-2)	(5-3)	(5-4)
Clean Indoor Air Law	0.314 (1.25)	0.264 (1.05)	0.377 (1.49)	0.327 (1.28)
Past Cigarette Price, Weighted	-3.390 (-0.21)	-3.985 (-0.25)	-----	-----
Current Cigarette Price, Weighted	32.563 (1.73)	32.955 (1.73)	2.153 (0.82)	2.280 (0.87)
Future Cigarette Price, Weighted	-27.565 (-2.04)	-27.282 (-2.02)	-----	-----
Past Consumption	0.211 (1.16)	0.215 (1.14)	0.172 (0.94)	0.165 (0.86)
Future Consumption	0.573 (2.04)	0.557 (1.91)	0.637 (2.26)	0.636 (2.19)
R ²	0.311	0.328	0.303	0.318
F	35.18	31.58	37.69	32.93
Model	(5-5)	(5-6)	(5-7)	(5-8)
Clean Indoor Air Law	0.315 (1.24)	0.265 (1.05)	0.306 (1.20)	0.256 (1.00)
Current Cigarette Price, Weighted	29.892 (2.21)	29.724 (2.19)	29.962 (2.19)	29.714 (2.16)
Future Cigarette Price, Weighted	-27.915 (-2.08)	-27.631 (-2.04)	-27.758 (-2.05)	-27.375 (-2.00)
Addictive Stock	0.153 (1.07)	0.151 (1.01)	0.101 (0.98)	0.096 (0.89)
Future Consumption	0.607 (2.21)	0.602 (2.12)	0.642 (2.43)	0.644 (2.35)
R ²	0.309	0.325	0.304	0.319
F	36.62	32.47	35.79	31.56

* See note to Table 11-2.

Table 11-6
Price Elasticities of Demand, Race Differences

Panel A: Whites

Models:	(5-1)	(5-2)	(5-3)	(5-4)
ϕ_1	0.497	0.502	0.560	0.578
ϕ_2	1.654	1.653	1.633	1.634
Long Run:	-0.291	-0.284	-0.352	-0.354
Short Run:				
Anticipated:	-0.314	-0.309	-0.207	-0.213
Unanticipated:	-0.386	-0.383	-0.136	-0.137
Current Price:				
Anticipated:	-0.433	-0.431	-0.091	-0.090
Unanticipated:	-0.469	-0.468	-0.060	-0.058
Past Price:				
Anticipated:	0.009	0.010	-0.056	-0.055
Unanticipated:	-0.013	-0.013	-0.037	-0.035
Future Price:				
Anticipated:	0.060	0.061	-0.051	-0.052
Unanticipated:	0.042	0.042	-0.034	-0.034
	(5-5)	(5-6)	(5-7)	(5-8)
ϕ_1	0.566	0.582	0.545	0.559
ϕ_2	1.675	1.678	1.621	1.622
Long Run:	-0.365	-0.367	-0.367	-0.368
Short Run:				
Anticipated:	0.011	0.012	-0.017	-0.015
Unanticipated:	-0.147	-0.148	-0.141	-0.141
Current Price:				
Anticipated:	-0.254	-0.257	-0.217	-0.220
Unanticipated:	-0.322	-0.324	-0.274	-0.276
Past Price:				
Anticipated:	-0.152	-0.153	-0.134	-0.136
Unanticipated:	-0.192	-0.193	-0.169	-0.170
Future Price:				
Anticipated:	0.115	0.113	0.091	0.090
Unanticipated:	0.076	0.074	0.060	0.059

Table 11-6 (continued)

Panel B: Blacks

Models:	(5-1)	(5-2)	(5-3)	(5-4)
ϕ_1	0.671	0.647	0.728	0.722
ϕ_2	4.068	4.004	5.086	5.339
Long Run:	0.356	0.349	0.531	0.540
Short Run:				
Anticipated:	0.099	0.127	0.498	0.507
Unanticipated:	0.454	0.480	0.426	0.438
Current Price:				
Anticipated:	1.545	1.537	0.135	0.141
Unanticipated:	1.662	1.662	0.116	0.122
Past Price:				
Anticipated:	0.194	0.166	0.027	0.026
Unanticipated:	0.222	0.197	0.023	0.023
Future Price:				
Anticipated:	-0.476	-0.498	0.099	0.102
Unanticipated:	-0.397	-0.417	0.084	0.088
	(5-5)	(5-6)	(5-7)	(5-8)
ϕ_1	0.701	0.693	0.732	0.729
ϕ_2	4.528	4.605	5.208	5.521
Long Run:	0.461	0.471	0.547	0.562
Short Run:				
Anticipated:	0.029	0.051	0.181	0.226
Unanticipated:	0.360	0.369	0.442	0.460
Current Price:				
Anticipated:	1.527	1.513	1.540	1.521
Unanticipated:	1.626	1.610	1.609	1.584
Past Price:				
Anticipated:	0.337	0.328	0.296	0.275
Unanticipated:	0.359	0.350	0.309	0.287
Future Price:				
Anticipated:	-0.448	-0.449	-0.364	-0.351
Unanticipated:	-0.379	-0.382	-0.313	-0.305

of either race. Similarly, a significant positive but diminishing relationship is observed between age and average cigarette consumption, with the relationship more pronounced among blacks than among whites.

As with men and women, different conclusions are implied for the impact of family income on cigarette smoking. For whites, a positive relationship is observed between income and average cigarette consumption, suggesting that cigarette smoking is an economically superior behavior among whites, with the income elasticity of demand implied by these estimates centering on 0.05. For blacks, however, a negative relationship is estimated in each equation between income and average cigarette consumption, suggesting that, for blacks, cigarette smoking is an economically inferior behavior. The income elasticity of demand for blacks implied by the estimates falls in the range from -0.06 to -0.05.

Substantial differences are found in the relationships between education and cigarette smoking for whites and blacks. In particular, whites with more completed years of formal education are found to smoke significantly less than whites with fewer years of formal education, while more educated blacks are found to smoke more, on average, than less educated blacks. While this relationship is never statistically significant for blacks, the estimated coefficient changes little across the various specifications. Moreover, this finding is supported by the results obtained

for the various dichotomous indicators of educational attainment. Blacks with no formal education, or only a grade school education or less are found to smoke less than high school graduates, while blacks attending college smoke significantly more, on average, than those whose formal education ended with their high school graduation. Blacks who attended high school, but did not graduate, smoke slightly more than their graduating counterparts. The results associated with the set of dichotomous attainment indicators for whites continue to exhibit less uniform differences in smoking among individuals with differing levels of education. Generally, whites with no formal education smoke significantly more than those with a high school degree, while whites attending college smoke significantly less than white high school graduates. However, there is no apparent difference between the average cigarette consumption of whites with less than a grade school education and high school graduates, while whites with a grade school education or some high school smoke less than their counterparts who complete high school.

The relationships between cigarette demand and labor force status are also suprisingly different for whites and blacks. Black nonparticipants and unemployed participants are found to smoke more than employed black participants, in every equation. Again, although these findings are never statistically significant, the estimated coefficients are quite similar across specifications, suggesting that this is

a fairly robust result. Perhaps the finding for nonparticipants is the result of the "discouraged worker" effect (Killingsworth, 1983). That is, many black nonparticipants may have been actively seeking work earlier, but became discouraged as a result of their inability to find an appropriate job, and subsequently dropped out of the labor force. This is suggested by the much higher nonparticipation rates of black men as compared to white men. If this is the case, then nonparticipation may be the result of a stressful event (the search for employment and subsequent exit from the labor market due to the inability to obtain employment) and the hypothesis that stressful events encourage addictive consumption is supported.

On the other hand, the expected difference between the average cigarette consumption of employed whites and unemployed whites is not found, while nonparticipating whites are found to smoke significantly less than employed white participants, as expected.

The results obtained for the marital status indicators are somewhat different across races. Single, divorced, and widowed whites do not smoke consistently more or less, on average, than their married counterparts, while separated whites smoke significantly less, contrary to expectations. Single and widowed blacks, however, are consistently found to smoke more than married blacks, with divorced blacks smoking less than married blacks. No difference is observed between the average cigarette consumption of married blacks

and separated blacks, however. Again, the failure of these variables may be due to the lack of information concerning the timing of these events.

An examination of the results obtained for the variables of interest leads to several relatively clear conclusions for whites, while the conclusions which can be drawn for blacks are somewhat less definitive. The major problem with the estimation of the various demand equations for blacks is the multicollinearity between cigarette prices. This problem, present in all equations, is exacerbated in the black sample due to the relatively small number of blacks surveyed, and their concentration in only a few of the primary sampling units. Thus, the discussion which follows for blacks will focus on the estimates obtained from the demand equation which assumes the rate of depreciation on the addictive stock is one hundred percent, as only the current price of cigarettes enters this equation.

In each of the cigarette demand equations estimated for whites, the coefficient estimated on the clean indoor air law indicator is negative and statistically significant, indicating that these laws are effective in reducing average cigarette consumption among whites, either the result of fewer opportunities to smoke or the result of a reevaluation of the health risk associated with smoking (part of the "full price" of cigarette smoking) resulting from the publicity on the health consequences of smoking associated with the passage of these laws. These same effects are not

observed for blacks. In the equations estimated for blacks, positive and insignificant coefficients are estimated for the clean indoor air laws, suggesting that neither the law nor the publicity accompanying it is effective in reducing cigarette smoking.

In all equations estimated for whites, the coefficients obtained on cigarette prices are of the expected signs and, generally, of the expected relative magnitudes. In some of the equations, the estimated coefficients on the current price are statistically significant, while the others are less significant, with future prices performing somewhat better than past prices. However, the estimated coefficients on cigarette prices for the black sample are not consistent with the predictions of the model, and are not significantly different from zero.

The price elasticities of demand obtained for whites are mostly consistent with the predictions of the Becker-Murphy model of rational addictive behavior, with the estimates obtained from the model assuming the one hundred percent rate of depreciation on the addictive stock completely consistent with expectations. The estimated long run price elasticities of cigarette demand for whites obtained from the various specifications are quite similar, falling in the range from -0.37 to -0.28 . These estimates imply that permanent increases in cigarette prices will lead to reductions in average cigarette consumption among whites.

These estimates suggest that cigarette excise tax

increases, the passage of clean indoor air laws, and/or increased dissemination of information on the health consequences of cigarette smoking will all be effective policies in reducing average cigarette consumption among whites. However, these policies appear to have no discernible impact on the smoking behavior of blacks.

In all equations estimated for both whites and blacks, positive coefficients are obtained on past cigarette consumption, future cigarette consumption, and the addictive stock variables. For whites, the relative magnitudes of these coefficients are consistent with the predictions of the model, and all of the coefficients are statistically significant at the one percent level, with the exception of the coefficients on future consumption in the most general model, which are only slightly less significant. For blacks, however, the relative magnitudes of the coefficients on past and future consumption are inconsistent with the theoretical model, with the coefficients on past consumption generally statistically insignificant at conventional levels.

These estimates imply that there are strong relationships between cigarette consumption over time for whites. For example, factors which increase lagged cigarette consumption by ten percent are expected to result in an increase in current cigarette consumption of about six percent, on average. Similarly, increases of ten percent in future consumption, brought on, perhaps, by reductions in

future cigarette prices, will result in increases in current consumption in the range from 5.0 percent to 5.8 percent. While the results for blacks suggest strong intertemporal bonds between cigarette consumption, the relative effects of future shocks on current consumption are predicted to be substantially larger than those of past shocks on current consumption, contrary to expectations.

Summary

Interesting differences are observed between the effects of various exogenous factors on the demand for cigarettes by whites and blacks, including the effects of the passage of a clean indoor air law. Less clear are the differences in their reactions to changes in cigarette prices, as well as the relative strengths of the intertemporal linkages in consumption. While the estimates for whites are generally consistent with the predictions of the Becker-Murphy model of rational addiction, those for blacks are not consistent. Much of the difficulty in determining the effects of prices and past and future cigarette consumption on current cigarette consumption in the black sample is attributable to the severe collinearity problems resulting from the relatively small sample size drawn largely from only a few primary sampling units. More light could be shed on racial differences in cigarette smoking behavior through the use of a larger, more diverse sample of blacks.

Differences in Cigarette Smoking Behavior by Age

The cigarette demand equations developed from the Becker-Murphy model of rational addictive behavior suggest that separate demand equations should be estimated for individuals with different rates of time preference. In particular, the relative magnitudes of the coefficients on past and future cigarette consumption and past and future cigarette prices will differ across groups of individuals whose rates of time preference differ. The relative response to changes in future factors (consumption and prices) should be smaller for individuals who discount the future more heavily than for those who discount the future less heavily.

One possible source of differences in rates of time preference is differences in ages. Fisher (1961) identifies several factors which would result in different discounting of the future including difference in income and foresight. Each of these factors, in some way, can be captured by differences in age. Fisher states that individuals with a relatively low current income level who expect higher future income levels will be more "impatient" or will have a greater preference for the present, suggesting that younger individuals whose income is likely to increase with age will have a greater rate of time preference than older individuals whose earnings may not increase as much over the

remainder of their life-cycle. Likewise, Fisher suggests that younger individuals have less foresight and, therefore, are more "impatient" than older individuals, and that the degree of impatience is lowered by experience. Finally, Peltzman (1975) suggests that younger individuals have a greater demand for risky behaviors, such as reckless or drunken driving, implying that they place a greater value on the present, or that they discount the future more heavily.

An examination of cigarette smoking differences by age is confounded, however, by the different events to which individuals of different age cohorts were exposed. Examining the smoking participation rates within different age cohorts, one can see that those individuals who were born further in the past are more likely to have smoked and are more likely to be current smokers, although this does not hold for older cohorts. Among older cohorts, current smoking participation rates are much lower than among younger cohorts, due to the high incidence of smoking related deaths among individuals of these cohorts.

To examine differences in cigarette smoking by age in the rational addiction framework, separate sets of cigarette demand equations are estimated for three age groups: individuals ages seventeen through twenty four years one year prior to their survey; individuals ages twenty five through sixty four years one year prior to their survey; and individuals ages sixty five through seventy three one year prior to their survey.

The means and standard deviations of the key variables for the three age samples are presented in Table 11-7, along with smoking participation rates. While the participation rates among the youngest group are little different from those among the middle group, the participation rates among the oldest group are significantly lower. Again, this is likely to be due to the incidence of cigarette smoking related diseases among individuals of this age cohort which eventually caused their deaths.

The estimated coefficients on the clean indoor air law indicator, cigarette prices, future cigarette consumption, and past cigarette consumption or the addictive stock are presented in Table 11-8. Panel A of Table 11-8 contains the estimates for individuals ages seventeen to twenty four years, Panel B contains the estimates for individuals ages twenty five to sixty four years, and Panel C contains the estimates for individuals ages sixty five years and older. Models 8-1 and 8-2 of Table 11-8 contain the results obtained from the estimation of the demand equation which makes no assumption concerning the rate of depreciation on the addictive stock, with Model 8-1 employing the continuous measure of education and Model 8-2 employing the set of dichotomous indicators of educational attainment for education. Models 8-3 and 8-4 are the results from the comparable equations estimated imposing the assumption that the rate of depreciation on the addictive stock is one hundred percent. Finally, Models 8-5 and 8-6 and Models 8-7

Table 11-7*

Means and Standard Deviations of Key Variables, by Age

Variable	Age<25	25≤Age<65	Age≥65
Clean Indoor	0.296	0.314	0.333
Air Law	(0.456)	(0.464)	(0.471)
Past Cigarette	0.286	0.286	0.287
Price, Weighted	(0.037)	(0.038)	(0.039)
Current Cigarette	0.285	0.284	0.286
Price, Weighted	(0.037)	(0.038)	(0.040)
Future Cigarette	0.279	0.279	0.280
Price, Weighted	(0.039)	(0.040)	(0.041)
Past Cigarette	9.846	11.745	5.226
Consumption	(14.857)	(17.026)	(11.805)
Current Cigarette	7.062	9.165	4.060
Consumption	(11.271)	(14.155)	(9.674)
Future Cigarette	6.607	8.496	3.470
Consumption	(10.454)	(13.358)	(8.612)
Addictive Stock,	12.030	14.776	6.618
δ=80%	(18.157)	(21.220)	(14.737)
Addictive Stock,	15.338	19.896	9.025
δ=60%	(23.350)	(28.206)	(19.653)
Smoking Participation	39.11	39.50	20.12
Rate			
N	2575	8997	2733

* See note to Table 11-1.

and 8-8 are the comparable models estimated assuming that the rate of depreciation on the addictive stock is eighty percent and sixty percent, respectively.

All models were estimated using instrumental variables for future cigarette consumption and past cigarette consumption or the addictive stock, where the set of instruments included, in addition to the exogenous determinants of demand, further leads and lags of cigarette prices and cigarette excise tax rates. The measures of cigarette prices and excise tax rates employed in the estimation is the equally weighted average of the own-price and the

border-price for cigarettes.

All estimated equations include variables measuring the individual's age, age squared, and real family income, as well as dichotomous variables indicating males, race, American Natives, exercise, daily activity, marital status, and labor force status.

Finally, the various estimated price elasticities of demand are contained in Table 11-9.

Before examining the results presented in the tables, a brief discussion of the effects of the other independent variables on demand is in order.

In each of the three age groups, as expected, men smoke more than women. In the youngest and oldest age groups, blacks are found to smoke less than whites. However, in the middle age group, no differences are found between the average cigarette consumption of blacks and that of whites. In all age groups, members of other races are found to smoke less than whites. Finally, American Natives in all three age groups smoke less than others, with the strongest finding for the young group.

Individuals of both the younger age group and the middle age group appear to treat smoking as an economically superior behavior, given the consistently positive estimates of the coefficients on income obtained from the demand equations for these groups. In fact, the estimated coefficients on income for the middle age group are statistically significant at close to normal levels. However, this

Table 11-8*

Price, Consumption, and Clean Indoor Air Law Coefficients
from TSLS Estimation of Cigarette Demand Equations
Differences by Age

Panel A: Less Than 25 Years Old

Model	(8-1)	(8-2)	(8-3)	(8-4)
Clean Indoor Air Law	-0.198 (-0.84)	-0.206 (-0.87)	-0.219 (-0.90)	-0.227 (-0.93)
Past Cigarette Price, Weighted	4.451 (0.36)	3.402 (0.27)	----- -----	----- -----
Current Cigarette Price, Weighted	-14.515 (-1.02)	-14.136 (-1.00)	0.519 (0.17)	0.557 (0.18)
Future Cigarette Price, Weighted	10.793 (1.02)	11.473 (1.07)	----- -----	----- -----
Past Consumption	0.611 (3.34)	0.603 (3.29)	0.646 (3.83)	0.648 (3.86)
Future Consumption	0.091 (0.36)	0.095 (0.38)	0.036 (0.16)	0.025 (0.11)
R ²	0.319	0.346	0.308	0.331
F	54.36	51.83	56.75	52.60
Model	(1-5)	(1-6)	(1-7)	(1-8)
Clean Indoor Air Law	-0.240 (-1.03)	-0.250 (-1.07)	-0.307 (-1.31)	-0.319 (-1.35)
Current Cigarette Price, Weighted	-10.092 (-0.96)	-10.392 (-0.98)	-9.087 (-0.86)	-9.333 (-0.87)
Future Cigarette Price, Weighted	10.237 (1.00)	10.571 (1.02)	8.909 (0.86)	9.190 (0.87)
Addictive Stock	0.472 (3.45)	0.472 (3.43)	0.346 (3.34)	0.347 (3.31)
Future Consumption	0.142 (0.63)	0.134 (0.59)	0.190 (0.86)	0.181 (0.82)
R ²	0.328	0.353	0.328	0.353
F	59.36	55.65	59.39	55.70

Table 11-8 (continued)

Panel B: 25 Years Old to Less Than 65 Years Old

Model	(8-1)	(8-2)	(8-3)	(8-4)
Clean Indoor Air Law	-0.206 (-1.59)	-0.220 (-1.66)	-0.209 (-1.66)	-0.217 (-1.70)
Past Cigarette	10.206	10.829	-----	-----
Price, Weighted	(1.24)	(1.27)	-----	-----
Current Cigarette	-14.109	-14.633	-2.487	-2.494
Price, Weighted	(-1.39)	(-1.42)	(-1.60)	(-1.61)
Future Cigarette	1.558	1.480	-----	-----
Price, Weighted	(0.28)	(0.27)	-----	-----
Past Consumption	0.478 (2.84)	0.494 (2.83)	0.462 (2.82)	0.469 (2.81)
Future Consumption	0.307 (1.38)	0.279 (1.17)	0.365 (1.72)	0.358 (1.61)
R ²	0.322	0.333	0.332	0.347
F	193.79	171.97	223.19	198.57
Model	(8-5)	(8-6)	(8-7)	(8-8)
Clean Indoor Air Law	-0.217 (-1.72)	-0.225 (-1.74)	-0.229 (-1.79)	-0.235 (-1.81)
Current Cigarette	-3.368	-3.296	-2.868	-2.780
Price, Weighted	(-0.60)	(-0.59)	(-0.51)	(-0.50)
Future Cigarette	0.938	0.867	0.570	0.487
Price, Weighted	(0.18)	(0.16)	(0.11)	(0.09)
Addictive Stock	0.356 (2.75)	0.362 (2.74)	0.255 (2.68)	0.260 (2.68)
Future Consumption	0.387 (1.85)	0.380 (1.73)	0.416 (2.05)	0.409 (1.91)
R ²	0.332	0.347	0.330	0.345
F	212.52	190.68	210.86	189.27

Table 11-8 (continued)

Panel C: 65 Years or Older

Model	(8-1)	(8-2)	(8-3)	(8-4)
Clean Indoor Air Law	-0.004 (-0.03)	-0.006 (-0.04)	-0.001 (-0.01)	-0.004 (-0.03)
Past Cigarette Price, Weighted	-3.663 (-0.40)	-2.780 (-0.30)	-----	-----
Current Cigarette Price, Weighted	1.129 (0.10)	0.650 (0.06)	0.061 (0.03)	-0.087 (-0.05)
Future Cigarette Price, Weighted	2.527 (0.39)	1.995 (0.31)	-----	-----
Past Consumption	0.415 (3.92)	0.412 (3.90)	0.418 (3.97)	0.415 (3.94)
Future Consumption	0.458 (3.46)	0.450 (3.41)	0.448 (3.43)	0.442 (3.40)
R ²	0.331	0.340	0.330	0.339
F	60.83	53.62	66.66	57.90
Model	(8-5)	(8-6)	(8-7)	(8-8)
Clean Indoor Air Law	-0.016 (-0.10)	-0.021 (-0.14)	-0.051 (-0.32)	-0.057 (-0.36)
Current Cigarette Price, Weighted	-2.222 (-0.33)	-1.846 (-0.27)	-1.623 (-0.24)	-1.278 (-0.19)
Future Cigarette Price, Weighted	2.393 (0.37)	1.861 (0.28)	1.981 (0.30)	1.472 (0.22)
Addictive Stock	0.339 (4.06)	0.336 (4.03)	0.252 (4.05)	0.251 (4.04)
Future Consumption	0.442 (3.39)	0.436 (3.35)	0.448 (3.45)	0.441 (3.41)
R ²	0.328	0.338	0.324	0.333
F	63.12	55.26	61.84	54.16

* See note to Table 11-2.

Table 11-9

Price Elasticities of Demand, Age Differences

Panel A: Less Than 25 Years Old

Models:	(8-1)	(8-2)	(8-3)	(8-4)
ϕ_1	0.097	0.101	0.037	0.025
ϕ_2	1.540	1.557	1.511	1.518
Long Run:	0.099	0.099	0.066	0.069
Short Run:				
Anticipated:	0.154	0.220	0.023	0.024
Unanticipated:	-0.156	-0.111	0.022	0.023
Current Price:				
Anticipated:	-0.324	-0.295	0.022	0.023
Unanticipated:	-0.604	-0.593	0.021	0.023
Past Price:				
Anticipated:	-0.019	-0.043	0.015	0.015
Unanticipated:	-0.201	-0.234	0.014	0.015
Future Price:				
Anticipated:	0.432	0.463	0.001	0.001
Unanticipated:	0.405	0.433	0.001	0.001
	(8-5)	(8-6)	(8-7)	(8-8)
ϕ_1	0.156	0.147	0.217	0.205
ϕ_2	1.538	1.548	1.517	1.524
Long Run:	0.022	0.026	-0.031	-0.024
Short Run:				
Anticipated:	0.338	0.343	0.304	0.310
Unanticipated:	0.008	0.009	-0.010	-0.008
Current Price:				
Anticipated:	-0.170	-0.174	-0.173	-0.175
Unanticipated:	-0.449	-0.459	-0.419	-0.427
Past Price:				
Anticipated:	-0.111	-0.112	-0.114	-0.115
Unanticipated:	-0.292	-0.297	-0.276	-0.281
Future Price:				
Anticipated:	0.429	0.442	0.373	0.385
Unanticipated:	0.385	0.400	0.320	0.333

Table 11-9 (continued)

Panel B: 25 Years Old to Less Than 65 Years Old

Models:	(8-1)	(8-2)	(8-3)	(8-4)
ϕ_1	0.374	0.334	0.465	0.455
ϕ_2	1.718	1.690	1.700	1.677
Long Run:	-0.338	-0.317	-0.445	-0.447
Short Run:				
Anticipated:	-0.629	-0.622	-0.252	-0.248
Unanticipated:	-0.526	-0.531	-0.183	-0.180
Current Price:				
Anticipated:	-0.453	-0.469	-0.135	-0.135
Unanticipated:	-0.388	-0.409	-0.098	-0.098
Past Price:				
Anticipated:	0.122	0.124	-0.079	-0.080
Unanticipated:	0.159	0.160	-0.058	-0.059
Future Price:				
Anticipated:	-0.110	-0.102	-0.063	-0.061
Unanticipated:	-0.086	-0.082	-0.046	-0.045
	(8-5)	(8-6)	(8-7)	(8-8)
ϕ_1	0.497	0.488	0.540	0.531
ϕ_2	1.750	1.722	1.813	1.776
Long Run:	-0.448	-0.449	-0.448	-0.451
Short Run:				
Anticipated:	-0.239	-0.235	-0.268	-0.265
Unanticipated:	-0.192	-0.188	-0.201	-0.197
Current Price:				
Anticipated:	-0.157	-0.155	-0.146	-0.144
Unanticipated:	-0.134	-0.131	-0.115	-0.112
Past Price:				
Anticipated:	-0.090	-0.090	-0.081	-0.081
Unanticipated:	-0.077	-0.076	-0.064	-0.063
Future Price:				
Anticipated:	-0.041	-0.041	-0.056	-0.057
Unanticipated:	-0.029	-0.029	-0.039	-0.040

Table 11-9 (continued)

Panel C: 65 Years or Older

Models:	(8-1)	(8-2)	(8-3)	(8-4)
ϕ_1	0.615	0.597	0.597	0.583
ϕ_2	1.795	1.830	1.795	1.827
Long Run:	-0.004	-0.069	0.032	-0.043
Short Run:				
Anticipated:	0.727	0.490	0.021	-0.028
Unanticipated:	0.345	0.228	0.014	-0.019
Current Price:				
Anticipated:	0.041	0.011	0.009	-0.012
Unanticipated:	-0.106	-0.094	0.006	-0.008
Past Price:				
Anticipated:	-0.324	-0.254	0.005	-0.007
Unanticipated:	-0.406	-0.311	0.003	-0.004
Future Price:				
Anticipated:	0.264	0.193	0.005	-0.007
Unanticipated:	0.174	0.130	0.003	-0.005
	(8-5)	(8-6)	(8-7)	(8-8)
ϕ_1	0.589	0.575	0.598	0.583
ϕ_2	1.771	1.806	1.783	1.807
Long Run:	0.090	0.007	0.191	0.097
Short Run:				
Anticipated:	0.249	0.145	0.284	0.176
Unanticipated:	0.039	0.003	0.084	0.043
Current Price:				
Anticipated:	-0.122	-0.111	-0.072	-0.064
Unanticipated:	-0.209	-0.171	-0.153	-0.119
Past Price:				
Anticipated:	-0.069	-0.062	-0.041	-0.035
Unanticipated:	-0.118	-0.095	-0.086	-0.066
Future Price:				
Anticipated:	0.153	0.109	0.143	0.100
Unanticipated:	0.102	0.074	0.095	0.068

coefficient is consistently negative for the older group suggesting that older individuals view smoking as an inferior behavior, in an economic sense.

A positive but diminishing relationship between age and average cigarette consumption is observed for all three age groups. However, this relationship is statistically significant for the middle age group only, and is less strong in each of the other two groups.

Within the younger and middle age groups, individuals whose recreational activities provide much or moderate exercise are found to smoke substantially less than those engaging in little or no exercise. Among the older age group, however, there appear to be no differences in the smoking behavior of those who exercise and those who do not. The reverse holds for active individuals in the three age groups. Those who describe their typical day as active are little different than those who are inactive among the young and middle age groups, with these individuals smoking only slightly greater average quantities. Among the older age group, however, active individuals are found to smoke somewhat less, on average, than less active individuals.

Individuals of all ages who have completed more years of formal education smoke less than those completing fewer years of formal education, with significant differences for individuals in the younger and middle age groups. Individuals attending college smoke less than high school graduates in all three groups, with the most significant

differences occurring in the oldest age group. There appears to be no difference between the smoking behavior of individuals with no formal education and those with a high school education in either the young or old age groups. However, among the middle age group, those individuals with no formal education are found to smoke significantly more, on average, than those with a high school education. For the older age group, individuals with some formal grade school education, but no high school education, are found to smoke significantly less than high school graduates. The remainder of the results show little difference between individuals of these education levels and high school graduates, in all age groups.

Individuals of different age groups exhibit differing responses to the labor force participation indicators. Unemployed youths smoke significantly more, on average, than their employed counterparts, while the average cigarette consumption of nonparticipants differs little from that of employed participants. On the other hand, nonparticipants in the middle age group smoke significantly less than the employed participants in this group, with unemployed participants smoking about the same as employed participants. Finally, labor force status appears to have no impact on the cigarette smoking behavior of individuals ages sixty five years or greater.

Marital status appears to be unimportant in determining average cigarette consumption among younger individuals,

while playing only a slightly more important role in the determination of consumption among older individuals. Among the individuals of the oldest age group, married individuals are found to smoke less than single, widowed, divorced, and separated individuals, but, although consistent across specifications, the differences are never statistically significant. Likewise, for individuals in the middle age category, married persons are found to smoke less than divorced and widowed persons, but more than separated and single persons.

Turning to the results presented in Tables 11-8 and 11-9, several interesting conclusions can be drawn concerning the response to price changes and clean indoor air laws for individuals of different age groups.

The estimated coefficients on variable indicating the existence of a clean indoor air law in the state in which an individual resides are negative and statistically significant in the equations estimated for the middle age group. Although less significantly, these laws also have a negative impact on the smoking behavior of younger individuals, while they appear to have no effect on average cigarette consumption among individuals in the oldest age group. The less significant impact of these laws on cigarette demand among younger individuals may be the result of the greater preference for the present suggested for these individuals. If the laws are capturing the impact of negative publicity concerning cigarette smoking and health,

then it is not suprising that the response of youths is less significant than that of the individuals in the middle age group. Finally, the lack of an effect of these laws among older individuals is not suprising given that smokers of this age are likely to be well informed about the effects of smoking on health, both from their own experience and the experience of their peers.

With respect to the impact of cigarette prices on demand, the estimates obtained for the middle age group are generally consistent with the predictions of the model of rational addictive behavior. That is, current cigarette prices enter negatively in all specifications, while past and future prices, when included, enter positively, with the relative magnitudes of these estimates as expected. In at least some of the specifications, the coefficient on the current cigarette price achieves statistical significance at conventional levels.

For the youngest age group, the results are somewhat mixed. In the most general model, the signs of the estimated coefficients are as expected, but the relative magnitudes of the estimates are inconsistent with the predictions of the model. In the model least taxing on the data, that which assumes that the rate of depreciation on the addictive stock is one hundred percent, the estimated coefficients on the current cigarette price are positive, but not significantly different from zero. Finally, in the two stock models, the estimates on prices are of the

expected signs, but are little different, suggesting that prices have little impact on demand.

Finally, individuals in the oldest age group show no response to changes in the price of cigarettes, with each of the estimated coefficients on the various cigarette prices not statistically different from zero.

The price elasticities of demand estimated using these results suggest that individuals in the youngest and oldest age groups are unresponsive to changes in the price of cigarettes. However, the elasticities calculated for individuals in the middle age group suggest that increases in cigarette prices will lead to reductions in average cigarette consumption. With the exception of the most general model, all of the estimated price elasticities of demand for this group are consistent with the prediction of the Becker-Murphy model of rational addictive behavior. That is, both permanent and temporary increases in cigarette prices in all periods will lower current cigarette consumption, with anticipated price changes inducing larger falls in consumption than unanticipated price changes. Similarly, a temporary increase in the current cigarette price will have less of an effect than a permanent increase of the same magnitude beginning in the current period, with the largest effect coming from a comparable permanent increase in price in every period. These results suggest that a ten percent permanent increase in cigarette prices in all periods would reduce current cigarette consumption by approximately 4.5

percent individuals ages twenty five to sixty four years, but would have no impact on the cigarette consumption of younger and older individuals.

In all of the demand equations estimated for each of the three age groups, positive coefficients are obtained on past cigarette consumption, future cigarette consumption, and the addictive stock measures. For the youngest age group, the estimated coefficients on past consumption or the addictive stock are statistically significant at the one percent level, while the estimates for future consumption are not statistically different from zero. For the middle age group, the coefficients on past consumption and the measures of the addictive stock are significant at the one percent level, while the estimates for future consumption are generally significant at better than the five percent level. Finally, all estimated coefficients on the various measure of consumption are significant at the one percent level in the demand equations estimated for the oldest age group. This finding, that future consumption is a more important determinant of demand among individuals of older age groups, is consistent with the a priori expectation that younger individuals will discount the future more than older individuals. In particular, based on the estimates, it appears that persons ages seventeen to twenty four years discount the future very heavily, while those ages sixty five years or older do not discount the future at all.

The relative effects of future and past factors on

current average cigarette consumption can be seen most clearly from the estimated roots of the difference equation. Recall that the smaller of the two roots, ϕ_1 , is an estimate of the effect on current consumption of changes in future consumption, while the inverse of the larger root, ϕ_2 , gives the impact on current consumption of a change in last period's consumption. Factors which induce a ten percent increase in lagged consumption (lower past cigarette prices, for example) lead to increases in current cigarette consumption of 6.5 percent, 5.8 percent, and 5.6 percent, on average, for seventeen to twenty four year olds, twenty five to sixty four years olds, and sixty five to seventy three year olds, respectively. A comparable increase in future consumption leads to the opposite ordering. That is, a ten percent increase in future consumption will lead to increases in current consumption of 1.2 percent, 4.6 percent, and 5.9 percent, on average, for seventeen to twenty four year olds, twenty five to sixty four years olds, and sixty five to seventy three year olds, respectively.

That is, the youngest age group exhibits the greatest response to the past while showing almost no response to the future. Alternatively, the oldest age group exhibits a significant response to both past and future factors, with their response to past factors smaller than those of the other two groups, while their response to future factors is larger than those of the two younger groups. Finally, persons ages twenty five through sixty four years exhibit a

significant response to both past and future factors.

Summary

To summarize, differences in cigarette smoking are found across age groups within the rational addiction framework. The most interesting findings concerned the response to price changes of the different age groups and the relative impact of future and past shocks on current consumption.

Somewhat suprisingly, given the findings of others,¹¹ younger individuals are found to be unresponsive to changes in cigarette prices. Less suprising is the finding that elderly individuals are virtually unresponsive to price changes. Finally, individuals in the middle age group were found to be somewhat responsive to changes in prices, with the relative responses to various price changes generally consistent with the predictions of the Becker-Murphy model of rational addiction.

Less suprising were the relative importance of past and future events in the determination of current consumption across age groups. The expectation that younger individuals behave more myopically than older individuals was supported by the estimates which suggest that changes in past consumption are very important determinants of current consumption,

¹¹ For example, Lewit and Coate, 1982, and Lewit, Coate, and Grossman, 1983.

while changes in future consumption play a relatively unimportant role. For individuals of the middle age group, past shocks have less of an effect, although this effect continues to be important and larger than the effect of future shocks, which are also quite important. Finally, for persons in the oldest age group, shocks to both past and future consumption are found to be significant determinants of current consumption, with the relative impacts of past and future shocks approximately identical.

Differences in Cigarette Smoking Behavior by Education

The last section discussed the potential, within the Becker-Murphy model of rational addiction, for differing responses to price changes and to shocks to past and future consumption by individuals with different rates of time preference. Many suggest either that differences in education are a source of differences in time preference, while others suggest that individuals with different rates of time preference will choose different levels of formal education or will choose different levels of investment in other forms of human capital.¹² Whatever the source of the differences in discount rates, the consensus is that individuals with different levels of formal education

¹² See, for example, Michael, 1972 and 1975; Grossman, 1975; Solmon, 1975; and Fuchs, 1982.

exhibit different rates of time preference, with those completing more years of formal education having lower rates of time preference than those with fewer years of formal education completed.

To examine potential differences arising from different rates of time preference, separate sets of cigarette demand equations are estimated for individuals with different levels of formal education. Specifically, the sample is divided into two groups: individuals with less than a high school education and individuals with at least a high school education. The means and standard deviations of the key variables for each of these samples are presented in Table 11-10, together with their smoking participation rates. At first glance, it would appear that the two groups are no different given the similarity between their smoking participation rates, past, current, and future consumption, and the measures of the addictive stock.

The estimated coefficients on the clean indoor air law indicator, cigarette prices, future cigarette consumption, and past cigarette consumption or the addictive stock are presented in Table 11-11. The estimates for those with at least a high school education appear in Panel A of Table 11-11, while the estimates for those with less than a high school education appear in Panel B of this table. Models 11-1 and 11-2 of Table 11-11 contain the estimates for the demand equation which imposes no assumption concerning the rate of depreciation on the stock of past consumption.

Table 11-10*

Means and Standard Deviations of Key Variables, by Education

Variable	High School Graduates	Less Than High School Education
Clean Indoor	0.320	0.302
Air Law	(0.467)	(0.459)
Past Cigarette	0.287	0.285
Price, Weighted	(0.037)	(0.040)
Current Cigarette	0.285	0.283
Price, Weighted	(0.037)	(0.041)
Future Cigarette	0.280	0.277
Price, Weighted	(0.039)	(0.042)
Past Cigarette	10.170	10.128
Consumption	(15.925)	(16.062)
Current Cigarette	7.809	7.816
Consumption	(13.074)	(13.046)
Future Cigarette	7.198	7.191
Consumption	(12.244)	(12.233)
Addictive Stock,	12.728	12.711
$\delta=80\%$	(19.793)	(19.972)
Addictive Stock,	16.975	17.053
$\delta=60\%$	(26.187)	(26.470)
Smoking Participation	35.75	35.67
Rate		
N	10030	4275

* See note to Table 11-1.

Model 11-1 includes the number of formal years of education completed as a regressor, while Model 11-2 employs the relevant dichotomous indicators of education (the college indicator in Panel A, and the indicators of no formal education, less than eight years of formal education, and eight years of formal education in Panel B - the omitted categories are no college in Panel A and some high school in Panel B). Models 11-3 and 11-4 are the comparable models which impose the assumption that the rate of depreciation on the addictive stock is one hundred percent, while Models 11-5 and 11-6 assume an eighty percent rate of depreciation,

Table 11-11

Price, Consumption, and Clean Indoor Air Law Coefficients
from TSLS Estimation of Cigarette Demand Equations
Differences by Educational Attainment

Panel A: At Least a High School Education

Model	(11-1)	(11-2)	(11-3)	(11-4)
Clean Indoor Air Law	-0.120 (-1.06)	-0.125 (-1.11)	-0.134 (-1.20)	-0.137 (-1.23)
Past Cigarette	-2.762	-1.906	----	----
Price, Weighted	(-0.38)	(-0.26)	----	----
Current Cigarette	-1.903	-2.731	-1.157	-1.131
Price, Weighted	(-0.23)	(-0.32)	(-0.84)	(-0.82)
Future Cigarette	3.429	3.435	----	----
Price, Weighted	(0.74)	(0.75)	----	----
Past Consumption	0.411 (2.57)	0.426 (2.73)	0.455 (3.23)	0.461 (3.36)
Future Consumption	0.546 (2.35)	0.514 (2.27)	0.482 (2.44)	0.466 (2.46)
R ²	0.348	0.313	0.350	0.314
F	242.50	217.03	269.85	240.97
Model	(11-5)	(11-6)	(11-7)	(11-8)
Clean Indoor Air Law	-0.144 (-1.27)	-0.147 (-1.30)	-0.171 (-1.46)	-0.172 (-1.49)
Current Cigarette	-3.998	-4.043	-3.236	-3.278
Price, Weighted	(-0.83)	(-0.84)	(-0.66)	(-0.67)
Future Cigarette	2.823	2.897	2.167	2.236
Price, Weighted	(0.61)	(0.63)	(0.46)	(0.48)
Addictive Stock	0.351 (3.08)	0.354 (3.20)	0.265 (3.12)	0.265 (3.22)
Future Consumption	0.504 (2.55)	0.490 (2.61)	0.508 (2.61)	0.500 (2.72)
R ²	0.351	0.314	0.348	0.311
F	257.21	229.15	254.33	226.26

Table 11-11 (continued)

Panel B: Less Than a High School Education

Model	(11-1)	(11-2)	(11-3)	(11-4)
Clean Indoor Air Law	-0.119 (-0.59)	-0.127 (-0.63)	-0.138 (-0.67)	-0.145 (-0.71)
Past Cigarette Price, Weighted	12.394 (1.08)	12.829 (1.12)	-----	-----
Current Cigarette Price, Weighted	-16.098 (-1.13)	-16.467 (-1.15)	-2.994 (-1.14)	-3.010 (-1.13)
Future Cigarette Price, Weighted	1.328 (0.16)	1.282 (0.15)	-----	-----
Past Consumption	0.492 (2.55)	0.468 (2.39)	0.512 (2.65)	0.491 (2.51)
Future Consumption	0.239 (0.87)	0.258 (0.93)	0.207 (0.76)	0.222 (0.82)
R ²	0.478	0.478	0.472	0.471
F	177.22	162.07	189.93	172.24
Model	(11-5)	(11-6)	(11-7)	(11-8)
Clean Indoor Air Law	-0.148 (-0.71)	-0.155 (-0.75)	-0.175 (-0.83)	-0.181 (-0.86)
Current Cigarette Price, Weighted	-2.328 (-0.26)	-2.277 (-0.26)	-0.721 (-0.08)	-0.682 (-0.07)
Future Cigarette Price, Weighted	-1.006 (-0.11)	-1.096 (-0.12)	-3.022 (-0.32)	-3.128 (-0.33)
Addictive Stock	0.429 (2.56)	0.415 (2.43)	0.336 (2.46)	0.327 (2.35)
Future Consumption	0.165 (0.54)	0.177 (0.58)	0.122 (0.37)	0.131 (0.39)
R ²	0.460	0.459	0.441	0.441
F	172.29	156.93	159.94	145.62

* See Note to Table 11-2.

Table 11-12

Price Elasticities of Demand, Education Differences

Panel A: At Least a High School Education

Models:	(11-1)	(11-2)	(11-3)	(11-4)
ϕ_1	0.827	0.760	0.714	0.678
ϕ_2	1.606	1.587	1.484	1.491
Long Run:	-1.049	-0.731	-0.670	-0.565
Short Run:				
Anticipated:	-0.258	-0.097	-0.421	-0.342
Unanticipated:	-0.243	-0.167	-0.219	-0.186
Current Price:				
Anticipated:	-0.234	-0.209	-0.121	-0.110
Unanticipated:	-0.232	-0.226	-0.063	-0.060
Past Price:				
Anticipated:	-0.299	-0.234	-0.081	-0.074
Unanticipated:	-0.297	-0.245	-0.042	-0.040
Future Price:				
Anticipated:	-0.004	0.027	-0.086	-0.075
Unanticipated:	-0.002	0.014	-0.045	-0.041
	(11-5)	(11-6)	(11-7)	(11-8)
ϕ_1	0.752	0.718	0.770	0.745
ϕ_2	1.527	1.542	1.495	1.519
Long Run:	-0.749	-0.620	-0.775	-0.652
Short Run:				
Anticipated:	-0.311	-0.219	-0.364	-0.280
Unanticipated:	-0.258	-0.218	-0.256	-0.223
Current Price:				
Anticipated:	-0.231	-0.217	-0.204	-0.193
Unanticipated:	-0.218	-0.216	-0.179	-0.178
Past Price:				
Anticipated:	-0.151	-0.141	-0.136	-0.127
Unanticipated:	-0.143	-0.140	-0.120	-0.117
Future Price:				
Anticipated:	-0.020	-0.001	-0.037	-0.022
Unanticipated:	-0.010	-0.000	-0.018	-0.011

Table 11-12 (continued)

Panel B: Less Than a High School Education

Models:	(11-1)	(11-2)	(11-3)	(11-4)
ϕ_1	0.277	0.300	0.235	0.254
ϕ_2	1.756	1.837	1.718	1.783
Long Run:	-0.320	-0.311	-0.386	-0.380
Short Run:				
Anticipated:	-0.742	-0.780	-0.187	-0.194
Unanticipated:	-0.657	-0.657	-0.161	-0.167
Current Price:				
Anticipated:	-0.593	-0.600	-0.143	-0.145
Unanticipated:	-0.531	-0.531	-0.123	-0.124
Past Price:				
Anticipated:	0.182	0.214	-0.083	-0.081
Unanticipated:	0.217	0.251	-0.072	-0.070
Future Price:				
Anticipated:	-0.108	-0.126	-0.034	-0.037
Unanticipated:	-0.091	-0.106	-0.029	-0.032
	(11-5)	(11-6)	(11-7)	(11-8)
ϕ_1	0.183	0.197	0.132	0.142
ϕ_2	1.682	1.731	1.654	1.693
Long Run:	-0.404	-0.401	-0.426	-0.426
Short Run:				
Anticipated:	-0.211	-0.220	-0.261	-0.269
Unanticipated:	-0.164	-0.169	-0.169	-0.174
Current Price:				
Anticipated:	-0.132	-0.132	-0.108	-0.108
Unanticipated:	-0.093	-0.092	-0.028	-0.027
Past Price:				
Anticipated:	-0.078	-0.077	-0.065	-0.064
Unanticipated:	-0.056	-0.053	-0.017	-0.016
Future Price:				
Anticipated:	-0.065	-0.070	-0.132	-0.138
Unanticipated:	-0.057	-0.062	-0.122	-0.127

and Models 11-7 and 11-8 assume a sixty percent rate of depreciation.

All models were estimated using instrumental variables for future cigarette consumption and past cigarette consumption or the addictive stock, where the set of instruments included, in addition to the exogenous determinants of demand, further leads and lags of cigarette prices and cigarette excise tax rates. The measures of cigarette prices and excise tax rates employed in the estimation is the equally weighted average of the own-price and the border-price for cigarettes.

All estimated equations include variables measuring the individual's age, age squared, and real family income, as well as dichotomous variables indicating males, race, American Natives, exercise, daily activity, marital status, and labor force status.

Finally, the various estimated price elasticities of demand are contained in Table 11-12.

Several interesting differences are observed across the education groups for the variables which are not reported in the tables. Before turning to the results reported above, these differences will be noted.

Males with less than a high school education smoke significantly more than their female counterparts. However, this difference between sexes is reversed for those with at least a high school education. In this group, men smoke less than women, albeit not significantly.

Blacks and members of other races with less than a high school education smoke less than whites with similar educations. However, there are no differences in smoking between the races for individuals with at least a high school education. Similarly, American Natives with less than a high school education smoke significantly more than other persons with less than a high school education, but those with at least a high school education are no different than other persons with at least a high school education.

A significant, positive but diminishing relationship is observed between average cigarette consumption and age for individuals with less than a high school education. However, no relationship is observed between average cigarette consumption and age for individuals with at least a high school education.

High school graduates who engage in recreational activities which provide at least moderate exercise smoke less than their more sedentary counterparts, while there are no differences between persons with less than a high school degree who exercise and those who do not exercise. Similarly, more active high school graduates smoke more than their less active peers, while no difference is observed between active and inactive individuals with less than a high school education.

Income, while never significant, enters negatively in all equations for the group with less than a high school education, but enters positively in all equations for the

group with at least a high school education. This suggests that less educated individuals view smoking as an inferior behavior in an economic sense, while more educated individuals view it as a superior behavior.

In general, labor force status appears to be an unimportant determinant of average cigarette consumption by individuals with less than a high school education. For individuals with at least a high school education, however, labor force status has some impact on consumption. In particular, nonparticipants, in this group, are found to smoke less than employed participants, while unemployed participants smoke more than employed participants, as expected (given the discussion in Chapter 10).

The results for the indicators of marital status continue to perform disappointingly. In both groups, separated individuals are found to smoke less, sometimes significantly less, than married individuals. Among individuals with less than a high school education, single and widowed individuals are also found to smoke less than married individuals, while divorced persons are found to smoke more, although the differences are never significant. Among those with at least a high school education, married persons are observed to smoke more than divorced persons, but less than single or widowed persons, with these differences never significant.

Finally, more educated individuals in both groups are found to smoke less than less educated individuals. In the

less educated group, this difference appears to be largely due to greater average consumption by individuals with no formal education.

Examining the estimated coefficients on the clean indoor air law indicator variable, one sees that the estimated coefficients are approximately the same for the two education groups, while achieving statistical significance only in the equations estimated for individuals with at least a high school education.

With the exception of the most general model, the estimated coefficients on cigarette prices are of the expected signs and relative magnitudes for the sample with at least a high school education, though they never achieve statistical significance at conventional levels. For the sample with less than a high school education, the support for the model from the estimated coefficients on cigarette prices is somewhat weaker, with the estimates from the stock models inconsistent with expectations, while the others are as expected.

Focusing on the models which impose an assumed rate of depreciation on the addictive stock estimated for individuals with at least a high school education, one sees that the various estimated price elasticities of demand are consistent with the predictions of the Becker-Murphy model of rational addiction. In each of these models, the response of current consumption to permanent price changes exceeds the response to comparable temporary price changes.

Similarly, an anticipated price change, permanent or temporary, leads to a larger change in current consumption than does the comparable unanticipated price change. Finally, a permanent change in the price of cigarettes in all periods has a larger impact on current consumption than either temporary price changes or a permanent price change which begins in the current period. These estimates suggest that a ten percent permanent price increase in all periods would reduce current consumption by about seven percent, on average.

Focusing on the results from Models 11-3 and 11-4 for individuals with less than a high school education, one sees that the results are consistent with the Becker-Murphy model of rational addiction outlined above. These estimates imply that a ten percent increase in the price of cigarettes in all periods would reduce average consumption by approximately 3.8 percent, substantially less than the comparable reduction among more educated individuals.

Mixed support for the model is found from the estimated coefficients on past and future cigarette consumption. In all equations for both education groups, the estimated coefficients on future consumption and past consumption or the addictive stock are positive. In the equations estimated for those with at least a high school education, each of these coefficients is statistically significant at the one percent level. However, contrary to expectations, the estimated coefficient on future consumption is slightly

larger in magnitude than that on past consumption, for this group. In the equations estimated for persons with less than a high school education, the relative magnitudes of the coefficients on past and future consumption are as expected. However, the estimated coefficients on future consumption for this group are not significantly different from zero, although they are relatively consistent across specifications. The estimated coefficients on past consumption and the measures of the addictive stock for this group are statistically significant at at least the one percent level.

These estimates suggest that there are strong intertemporal linkages between cigarette consumption for both educational groups. As expected, the effect on current cigarette consumption of future shocks to consumption is much stronger among more educated individuals than it is among less educated individuals. Similarly, the finding that past shocks have larger effects on current consumption among less educated individuals than among more educated individuals is also consistent with the expectation that less educated persons behave more myopically or less rationally than more educated individuals.

Summary

Some differences are found in the cigarette smoking behavior of individuals with less than a high school education and those with at least a high school education,

when cigarette smoking is modelled in the Becker-Murphy rational addiction framework.

Clean indoor air laws appear to reduce the cigarette consumption of both educational groups, while having a somewhat less significant impact on the cigarette smoking behavior of individuals with less than a high school education than they do on the average cigarette consumption of more educated individuals.

The effects of prices on consumption are somewhat muddled, with the estimated coefficients on prices inconsistent, in some specifications, with the predictions of the model. Using the estimates which are consistent with expectations, more educated individuals are found to be somewhat more responsive to changes in prices than are less educated individuals.

As expected, individuals with at least a high school education behave more rationally, or less myopically, than individuals with less than a high school education. This is consistent with the assumption that individuals with fewer years of formal education discount the future more heavily than those with a greater number of years of formal education completed.

Conclusions

This chapter examined, within the rational addiction framework, the differences in cigarette smoking between males and females and blacks and whites which have been observed historically. Additionally, differences in cigarette demand between individuals of different ages and between individuals with different levels of educational attainment were explored, with an eye towards differences in rates of time preference.

Men are found to be much more responsive to price than are women, who exhibit no significant response to price changes. Men also respond more significantly to clean indoor air laws and/or the publicity surrounding the passage of these laws, although women do exhibit some response. Significant intertemporal linkages are found in cigarette consumption for both men and women. However, the estimates suggest that men behave less rationally, or more myopically, than do women.

Some difficulty was encountered in attempting to examine the differences between the smoking behaviors of whites and blacks, due primarily to severe collinearity problems in the black sample. However, the estimates obtained for the white sample were, by and large, consistent with the predictions of the Becker-Murphy model. That is, whites exhibit strong intertemporal linkages in cigarette consumption and are relatively responsive to price changes.

While whites were found to significantly reduce average cigarette consumption in response to the passage of a clean indoor air law and/or the publicity accompanying the law, no effect was found among blacks.

With respect to individuals of different ages, the most interesting result concerned the relative magnitudes of the responses of young, middle age, and elderly individuals to shocks to past and future cigarette consumption. As expected, significant intertemporal linkages were found between cigarette consumption for all three groups. However, young persons (those ages seventeen to twenty four years) were found to behave myopically, discounting the future heavily. Elderly individuals (ages sixty five to seventy three years) exhibited approximately the same response to both past and future shocks, suggesting little or no discount of the future. Middle age individuals (ages twenty five through sixty four years) responded significantly to changes in both past and future factors, with the response to a past shock somewhat larger than the response to a comparable future shock. Among the three age groups, only the middle group was found to show any response to changes in cigarette prices, with the younger and older groups essentially unresponsive to price changes. Finally, clean indoor air laws were found to reduce consumption among individuals of the young and middle age groups, while having no effect on average cigarette consumption among older persons.

Similar findings were obtained when subsamples were taken on the basis of educational attainment. As expected, individuals with fewer years of formal education (less than a high school education) reacted strongly to past events but responded less dramatically to future events. Alternatively, more educated individuals (those with at least a high school education) reacted both to future and past shocks, with the magnitude of the response to future shocks generally exceeding that to past shocks. Similarly, more educated individuals appear to be slightly more responsive to both price changes and clean indoor air laws than are less educated individuals, although the estimated price effects were somewhat unstable across specifications.

Chapter Twelve

Summary

This dissertation applied the model of rational addictive behavior behavior being developed by Gary Becker and Kevin Murphy to cigarette smoking. After a brief introduction, a short history of the Federal and state governments' roles in the anti-smoking campaign was presented in Chapter Two with particular emphasis on two policies: increased cigarette excise taxation and restrictions on cigarette smoking in public places. Increased cigarette excise taxation was emphasized due to the interest in examining price responsiveness when cigarette smoking was analyzed in the rational addictive framework. It was noted that the relative stability of the Federal and state cigarette excise taxes resulted in a substantial drop in the real price of cigarettes over time, a policy inconsistent with the stated goals of the anti-smoking campaign. The laws restricting cigarette smoking in public places were emphasized due to the enactment of several of these laws at the state level during the mid to late 1970's, the period covered by the data employed, and due to the increased use of these restrictions in the 1980's by all levels of government.

Chapter Three reviewed the extensive body of economics' literature on cigarette smoking, emphasizing the findings of others concerning the price elasticity of cigarette demand

and the response to the various other policies used in the anti-smoking campaign.

To provide some support for many of the assumptions made in the exposition of the theoretical model of cigarette smoking as a rational addictive behavior, the physiological and psychological mechanisms involved in cigarette smoking were reviewed in Chapter Four. In particular, a discussion of the mechanisms through which cigarette smoking produced increments to utility was presented, with the basic conclusion that smoking is an effective way to modify an individual's psychological state. An addictive behavior was then defined by the presence of acquired tolerance, reinforcement factors in consumption, and withdrawal symptoms associated with the cessation of consumption. Each of these factors was discussed in the context of cigarette smoking, and the conclusion that cigarette smoking is an addictive behavior, most likely due to the presence of nicotine, was made. This was followed by a short discussion of the well documented health consequences of cigarette smoking, particularly cancers, cardiovascular disease, and chronic obstructive lung disease. Differences were noted for women and the synergistic effects of cigarette smoking and various workplace pollutants were discussed. Finally, rational behavior was characterized as consistent behavior. In particular, consistency or rationality implied that individuals were aware of the interdependence between past, current, and future addictive consumption decision in

addition to the future consequences of their addiction and that these factors were accounted for when making consumption decisions.

Chapter Five began with a discussion of the alternative models of habitual and/or addictive behavior suggested by various economists, noting that there seemed to be two essential distinctions among the various models. The first distinction is endogenous versus exogenous tastes, while the second is rational versus myopic behavior by individuals. The Becker-Murphy theoretical model of rational addictive behavior was then applied to cigarette smoking, recalling the discussion of Chapter Four to justify various assumptions.

Chapter Six used the theoretical model presented in Chapter Five to construct alternative cigarette demand equations which explicitly accounted for the addictive aspects of cigarette consumption. In addition, cigarette demand equations were derived under the competing hypotheses that cigarette smoking is a non-addictive behavior and that cigarette smoking is an addictive behavior, but that individuals behave myopically. These various demand equations were compared in order to discuss the manner in which the hypothesis that cigarette smoking is a rational addictive behavior could be tested. This was followed by the derivation of a variety of price elasticities of demand, together with a discussion concerning the expected relative magnitudes of these elasticities.

Chapter Seven contained a description of the primary data set employed in the estimation of the cigarette demand equations, the Second National Health and Nutrition Examination Survey. Additionally, the manner in which the data set was augmented with cigarette prices and excise taxes was recounted. This was followed by a discussion of the problems associated with the price variable and the alternative measures of price employed in the estimated demand equations. Finally, some attention was given to the use of the survey data in the construction of the variables entering the demand equations. In particular, the use of the data in constructing lagged, current, and future cigarette consumption, and the stock of past cigarette consumption was outlined.

The four chapters which followed contained a variety of results from the estimation of the alternative cigarette demand equations.

Chapter Eight contained the results from several basic models. In addition to the results from the estimation of demand equations derived under the assumption of non-addictive behavior, the results from each of the three alternative addictive demand equations were presented. Additionally, each of the equations was estimated using three alternative measures of the price of cigarettes. Finally, the results from the addictive models which included the stock of past cigarette consumption were presented for four alternative assumed rates of depreciation

on the addictive stock.

Chapter Nine examined the effectiveness of state level clean indoor air laws in reducing cigarette smoking in both the non-addictive and addictive frameworks. A subset of the results from the estimation of the non-addictive and addictive demand equations was presented.

Chapter Ten, after a brief theoretical discussion, examined the impact of stressful life cycle events on cigarette smoking. In particular, the effects on average cigarette consumption of labor force status and marital status were examined within the rational addiction framework.

Finally, Chapter Eleven considered differences in cigarette smoking by sex, race, age, and educational attainment within the rational addiction framework. Some discussion of the observed differences in behavior among these groups was presented, followed by the results from the estimation of the addictive demand equations for the various groups.

The mass of results presented in these four chapters can be summarized briefly, as follows:

- 1) In general, the estimated coefficients on cigarette prices, future cigarette consumption, and past consumption or the stock of past consumption, are consistent with the predictions of the model of rational addictive behavior. That is, average current cigarette consumption is inversely related to the current price of cigarettes, holding past and

future cigarette consumption constant. Current cigarette consumption is positively related to lagged and future cigarette prices, when included, holding past and future consumption constant. Similarly, current cigarette consumption is positively related to past and future cigarette consumption, holding current cigarette price, and, in some cases, past and future cigarette prices constant. In each case, the effect of past consumption or past price is larger in magnitude than the effect of future consumption or future price. Finally, the estimated coefficients on the stock of past consumption are, in all models, positive, suggesting that the reinforcement factors associated with past consumption, represented by the stock, outweigh the increase in the "full price" of cigarette smoking associated with an increase in the stock.

2) An equally weighted average of the local or own-price of cigarettes and the lowest price within twenty five miles of the individuals county of residence, the border-price, generally performed better than either the own-price or the border-price, and had fewer measurement problems associated with it. For this reason, only the results from the average price models were presented in the later chapters.

3) Similarly, the models estimated assuming relatively high rates of depreciation on the stock of past consumption were, generally, more consistent with expectations and could be justified on a theoretical basis. For this reason, only

the results from the models assuming higher rates of depreciation were presented in later chapters.

4) The results from all of the models estimated support the contention that cigarette smoking is an addictive behavior. In every model, strong intertemporal linkages between consumption were found, evidence that cigarette consumption exhibits adjacent complementarity, the Becker-Murphy criterion for addictive behavior, in an economic sense. That is, factors which affect consumption in any single period will have similar effects on consumption in all other periods. Ignoring these linkages (i.e. assuming that cigarette smoking is non-addictive) leads to a substantial underestimate of the long run response to changes in cigarette prices.

5) Somewhat weaker support is found for the assumption that cigarette smoking is a rational addictive behavior. In general, the various estimated price elasticities of demand provide mixed support for the hypothesis that individuals behave rationally. However, the importance of future effects, particularly future consumption, implies that individuals are not behaving myopically. In general, the estimates from the models least taxing on the data provide the strongest support for the Becker-Murphy model of rational addiction.

6) Estimated long run price elasticities of demand based on the results from the demand equations derived under the assumption of rational addictive behavior, for the full

sample, fell in the range from -0.26 to -0.40. These estimates suggested a substantially larger response to changes in price than did the estimates obtained from comparable equations estimated under the assumption of non-addictive behavior, implying that ignoring the addictive aspects of consumption led to erroneous conclusion concerning the effectiveness of excise tax policy in reducing cigarette smoking. In particular, the estimates obtained from the addictive demand equations imply that the doubling of the Federal excise tax rate on cigarettes from sixteen cents per pack to thirty two cents per pack (approximately a thirteen percent increase in price, if fully passed on to consumers) currently under consideration by Congress would reduce cigarette consumption by between 3.2 percent and 5.6 percent. Ignoring the addictive aspects of consumption would lead to the conclusion that the proposed increase in the Federal tax would lower consumption by less than one percent.

7) The existence of a clean indoor air law in the state in which an individual resides was associated with significantly lower cigarette consumption. However, the mechanisms through which these laws reduce cigarette consumption are unclear. The law may reduce cigarette smoking solely through its prohibition of smoking in various public place, thus reducing the opportunities an individual has to smoke. Alternatively, the enactment of a clean indoor air law is likely to be surrounded by a significant

amount of publicity, particularly concerning the negative health effects of cigarette smoking. This information may lead individuals to revise upwards their expectations concerning the impact of smoking on their health and, thus, their estimates of the "full price" of cigarette smoking. The increase in the full price of smoking could account for the observed reduction induced by the laws, and implies that the continued dissemination of information on the health consequences of cigarette smoking is an effective policy tool in the anti-smoking campaign. Finally, the laws themselves may be passed in areas where anti-smoking sentiment is high and, therefore, where fewer individuals smoke. Thus, the possibility of reverse causality between average cigarette consumption (specifically, smoking participation) and clean indoor air laws could account for this finding. However, the lack of a significant effect associated with the laws estimated in the non-addictive demand equations appears to support the contention that the endogeneity of the laws is not responsible for these findings.

8) Stressful life cycle events, such as unemployment, the death of a loved one, and separation or divorce from one's spouse, were expected to result in either the initiation of addictive consumption or the increased consumption of the addictive good. However, the estimated effects of stressful events on smoking were somewhat disappointing. In general, variables indicating labor force status performed

as expected, with the average cigarette consumption employed participants found to exceed the average consumption of non-participants while falling short of that of unemployed participants. This is consistent with the arguments that an individual's job is a significant source of daily stress (thus, non-participants should be under less stress), and that unemployment is a stressful situation. Variables indicating marital status (in particular, single, widowed, divorced, and separated individuals) fell short of expectations. Divorce or separation from one's spouse or the death of a loved one were assumed to be stressful events which should induce addictive consumption. However, only a weak positive relationship was estimated between the indicators of widowhood and divorce, while a somewhat stronger negative relationship was observed between separation and average cigarette consumption. Part of the failure of these variables was attributed to a lack of information concerning the timing of these events.

9) Interesting differences were observed in the response of various groups of individuals to cigarette prices and clean indoor air laws within the addictive framework. Men were found to be significantly more responsive to changes in cigarette prices, with estimated long run price elasticities of demand centered on -0.55 , while women were observed to be virtually unresponsive to changes in price. Similarly, men also exhibited a greater response to the passage of a clean indoor air law and/or the publicity

accompanying the law than did women. However, men were observed to behave more myopically, or less rationally, than women, placing a greater weight on the past while discounting the future more heavily. Less clearcut were racial differences in cigarette smoking, due primarily to problems with the data for blacks. However, whites were found to exhibit strong intertemporal linkages in cigarette consumption, to be relatively responsive to price changes, and to reduce consumption in response to the passage of a clean indoor air law, while blacks showed little response to the laws and/or the publicity surrounding their passage. Older and/or more educated individuals were found to behave more rationally (less myopically) than did younger and/or less educated individuals. Similarly, older individuals (with the exception of the elderly) and/or more educated individuals were found to be relatively responsive to changes in cigarette prices, while younger and/or less individuals showed little response to price changes.

As I conclude this dissertation, it should be noted that the Federal, state, and local governments continue to be active in the anti-smoking campaign, but continue to ignore the use of increased excise taxation to reduce cigarette smoking. The major policy tool in the anti-smoking campaign of the late 1980's continues to be the prohibition of cigarette smoking in public places, evidenced by the ban on smoking on domestic airline flights of two hours or less and the prohibition of smoking on commuter

railroads imposed by Congress, the various workplace no smoking policies being implemented by numerous businesses and the prohibition of cigarette smoking on all it's flights put in place by Northwest Airlines, and the recently enacted laws extending the places in which smoking is prohibited in Connecticut and New York City. A better understanding of the mechanisms through which these laws reduce cigarette smoking is needed. Otherwise, current trends suggest that the mistakes of the early Nineteenth century with respect to alcohol and Prohibition may be repeated.

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