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Cost-Benefit Analysis Involving Addictive Goods: Using Contingent Valuation to Estimate Willingness to Pay to Eliminate Addiction

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Abstract

The appropriate valuation of changes in consumption of addictive goods resulting from policy interventions poses a challenge for cost-benefit analysts. Consumer surplus losses from reduced consumption of addictive goods measured relative to market demand schedules overestimate social cost. Consumer surplus losses measured using the non-addicted demand schedule provide a more appropriate assessment of social cost. Willingness-to-pay to avoid addiction estimated from a contingent valuation survey of current smokers allows for the positioning of the non-addicted demand schedule relative to the market demand schedule for cigarettes. This exercise suggests that, as a rule-of-thumb, only about 70 percent of the loss of the conventionally measured consumer surplus should be counted as social cost in assessing policies that reduce the consumption of cigarettes.

Keywords: cost-benefit analysis, addiction, smoking, contingent valuation

Introduction

As the range of application of cost-benefit analysis (CBA) has expanded from infrastructure projects to environmental policy to social programs, so too have the complexities of estimating benefits. The guiding principle of benefit measurement, the willingness of people to pay for policy changes, can often be applied directly through the estimation of changes in consumer surplus when policies affect quantities or prices in markets with well-defined demand schedules. However, in situations involving compulsive behavior, ranging from physical addiction to habituation, analysts should have concerns about interpreting demand schedules as representing peoples' true marginal valuations of goods and hence about interpreting changes in consumer surplus as willingness to pay. How should cost-benefit analysts take account of addiction?

Governments in Western democracies are increasingly mandating the application of CBA to a wide range of potential policy interventions. The U.S. federal government, for example, now requires CBA or closely related procedures in many policy arenas (Hahn et al., 2000; Hahn and Sunstein, 2002). Many states have initiated similar mandates (Zerbe, 1998). A noticeable feature of the recent growth in CBA is its wider application to social policy areas such as drug addiction (e.g., Egerton, Fox and Leshner, 1997; Cartwright, 1998; Cartwright, 2000; French et al., 2002) and family welfare issues (e.g., Plotnick and Deppman, 1999; Shanahan and Donato, 2000; Robertson, Grimes and Rogers, 2001). Just as valuing changes in public goods presented a challenge to the use of CBA in environmental policy, the assumption of consumer sovereignty presents a challenge to social policy analysts in appropriately valuing changes in the consumption of private goods that involve addiction.

The measurement of social benefits as the aggregation of individuals' willingness to pay is inherent to the neoclassical premise of individual rationality — people know what is best for themselves and act rationally when choosing goods and services. This premise is questionable for goods that, to a lesser or greater degree, are "addictive." These goods range from physically addictive goods, such as cocaine, heroin, nicotine, and alcohol to psychologically addictive goods, such as gambling. Should CBA treat consumption of these addictive goods differently? Furthermore, should the assessment of welfare changes resulting from changes in consumption of these goods vary depending on the nature and degree of their addictiveness? The nicotine in tobacco, for example, is now recognized as one of the most addictive substances known to science (Hogg and Bertrand, 2004; Tapper et al., 2004). There is less evidence and consensus on the addictive power of psychologically addictive goods, such as gambling, especially as only some people appear susceptible to them.

The appropriate methodological treatment of addictive goods in CBA is an important practical question because legislators and analysts in a wide variety of jurisdictions are assessing current policies and considering new policy interventions— whether through taxes, quantity restrictions, treatments, or criminal proscriptions— that seek to alter the consumption of these goods. Although MacCoun (2003) and other scholars have questioned whether the concept of addiction is relevant to the assessment of public policies, policy analysts have increasingly begun to consider addictive goods, and government interventions relating to their consumption, to be appropriately guided by a social efficiency and CBA framework (e.g., Grossman and Saffer, 1987; Australian Productivity Commission, 1999; Evans, Ringel, and Stech, 1999; Suranovic, Goldfarb, and Leonard, 1999; Chaloupka and Warner, 2000; Laux, 2000; Gruber and

Koszegi, 2001; Glied, 2002). As we discuss in detail below, however, addictive goods represent a practical challenge to the application of CBA to social policy. While social policy analysts are embracing CBA in principle and in many aspects of practice, their emerging practice often ignores the issue of changes in consumer surplus. For example, Ettner et al. (2006) in their CBA of drug abuse treatment programs in California ignore any lost consumer surplus from drug use when considering the net benefits of the treatment programs. In doing so, they argue that they are following "best practice" in the drug abuse treatment field, which does not treat reduced usage as a loss of consumer surplus (see French et al., 2002). Although a case can be made for ignoring consumer surplus losses from reductions in consumption of illegal goods (Zerbe, 1998), it is not so for legal goods that may happen to be addictive.

Analysts have taken a number of approaches to dealing with market goods for which persons may be psychologically or physically addicted. These range from treating them as if they were non-addictive to treating them as intrapersonal externalities. If one adopts the former stance and ignores the addictive quality of the good and assumes that consumers are fully informed of the goods' qualities including any risks to health, then benefits would be measured in the standard way as changes in consumer surplus — the difference between the maximum amount the consumer would be willing to pay for some quantity of the good as revealed by the consumers' marginal valuation (demand) schedules less the amount they actually have to pay. Based on a simple model of consumer choice, we propose an adjustment to consumer surplus based on the willingness of individuals to pay to eliminate their addiction. Empirically, we estimate the magnitude of this adjustment for smokers using a contingent valuation (CV) survey. Our estimates of the willingness-to-pay to avoid addiction are between about $240 and $335.

Adopting such an approach suggests that only between about 65 percent of the consumer surplus in the cigarette market should be counted as actual value for consumers. Further, only approximately 70 percent of the loss in consumer surplus from a one dollar increase in price should be counted in cost-benefit analysis.

The Standard Approach

The core axiom of neoclassical economics is that individuals have coherent preferences characterized by transitivity, completeness, and time consistency. If we treat these axioms seriously, when consumption of some addictive good, such as tobacco, falls because of some government policy intervention (such as an increase in cigarette taxes), then the reduced consumption results in a consumer surplus reduction. This reduced consumer surplus would count as a *cost* of the policy intervention. Embedded in this conventional treatment of consumer surplus change is the assumption that individuals can make rational tradeoffs concerning consumption over time. For example, people recognize that smoking provides them with utility (benefits) in the current time period, but that they will experience some disutility (such as impaired health) in some future time periods (Gruber, 2002/3).

The case can be made that, as long as it is fully anticipated, addiction need not interfere with this rationality. Economic models of addictive goods assume that the amount demanded at any time depends on the amount of previous consumption. Addiction is rational when consumers fully take account of the future effects of their current consumption (Becker and Murphy, 1988). Beginning with Becker, Grossman, and Murphy (1994), a number of empirical studies based on aggregate consumption data provide evidence apparently consistent with smoking as a rational addiction. However, Auld and Grootendorst (2004) demonstrate that autocorrelation, the common tendency of random shocks to consumption to persist over time, in aggregate consumption of any good, including milk, will tend to make its consumption appear consistent with rational addiction.

Intrapersonal Externalities: Consumption under Addiction

If current consumption is myopic or fails to take account of future risks, then addiction is not rational. For example, some children may fail to anticipate the consequences of tobacco addiction during their future adulthood or some adults may fail to anticipate the risk that their casual gambling may become a disruptive compulsion. From a welfare economics perspective, such cases can be interpreted as *negative intrapersonal externalities,* harm imposed by current consumers on their future selves. Behavioral scientists have identified a number of biases that arise from the heuristics that individuals commonly employ when they face situations involving uncertainty (Kahneman and Tversky, 2000) that help explain such behavior. Juveniles, for example, may be overconfident concerning their ability to avoid addiction (Taylor and Brown, 1988). Because of biases emanating from a number of different sources, individuals may well underestimate the risks and misperceive the real costs of smoking (Russo and Shoemaker, 1989). In the case of a good like cigarettes, where over 80 percent of current adult smokers report that they began smoking regularly before the age of 21 (CDC, 2004), the relevant group in terms of understanding of risks, costs, and addictiveness is juveniles rather than adults.

The negative intrapersonal externalities approach brings into question the appropriateness of using changes in consumer surplus measured under market demand schedules as the basis for assessing the net benefits of alternative policies. The demand schedule reveals the marginal willingness of the market to pay for additional units of the good. Yet, the satisfaction from addictive consumption may not actually make consumers better off; it avoids the pain of abstinence but does not provide as much happiness as would alternative consumption in a non-addicted state. The claimed desire and costly efforts made by many adult smokers to quit smoking suggest that they perceive benefits from ending their addiction. In other words, they wish they had not been addicted by their younger selves.

What is a plausible approach to measuring consumer surplus in the presence of undesirable addiction? It involves assessing consumer surplus using some form of non-addicted demand schedules (Australian Productivity Commission, 1999, Appendix C, 11-13.; Laux, 2000). Figure 1 illustrates the approach for addicted, or so-called problem gamblers. It shows two demand schedules: D_A, the demand schedule for gambling in the presence of the addiction, and D_R, the demand schedule for the same group of gamblers if they were instead like recreational gamblers who enjoy gambling but do not have a strong compulsion to gamble that leads them to regret their gambling behaviors. The quantity of gambling demanded by these gamblers at price P_C is Q_A. If they were not addicted, however, they would only consume Q_R at that price. Q_A minus Q_R is the excess consumption due to the addiction. Consumption up to level Q_R involves a positive consumer surplus of $P_R aP_C$. The consumption from Q_A to Q_R involves expenditures of Q_RabQ_A but consumer value only equal to Q_RacQ_A as measured under their recreational demand schedule, resulting in a loss equal to area *abc*. Overall, addicted gamblers receive consumer surplus equal to P_RaP_C - *abc*. If a policy resulted in these addicted gamblers becoming non-addicted recreational gamblers, then a surplus gain of *abc* would result.

The Australian Productivity Commission (1999) applied this approach to estimate the consumer surplus losses and gains from the Australian gambling industry. It estimated a consumer surplus gain for the 97.9 percent of recreational gamblers to be between AU$2.7 billion to AU$4.5 billion annually but a consumer surplus loss of almost AU$2.7 billion annually for the 2.1 percent of problem gamblers.

We apply the general approach of the Australian Productivity Commission to smoking. First, we develop a simple model of addiction that permits an estimate of the smoker's compensating variation for the elimination of addiction. Second, we employ a contingent valuation survey to estimate the willingness of smokers to pay for a treatment that would eliminate addiction. Third, we use the estimate of willingness to pay calculate the fraction of consumer surplus as measured relative to the market demand schedule that should be viewed as consumer value. The end result of the exercise is a rule of thumb for counting changes in consumer surplus in the cigarette market.

A Simple Model of Addiciton

The intrapersonal externality framework requires a model of consumption that allows one to distinguish between addicted and non-addicted demand. As a simple model of addiction, consider a person who chooses the level of smoking in two periods, the juvenile period (J) and the adult period (A). As in models of rational addiction, the choice of smoking level in J, quantity S, plays the role of a stock, or cumulative prior consumption, that affects the utility of smoking level c in A. Rather than maximizing the present value of expected consumption relative to some lifetime budget constraint, however, we assume that the person faces a budget constraint of B_J in J and B_A in A. This is consistent with observation that juveniles cannot typically borrow against their future income. Indeed, they may be constrained by an allowance.

Let V(x, S) be the utility of the person in J and U(x,c|S) be the utility of the person in A assuming no mortality or morbidity risk, where x represents all non-smoking consumption. Assume that in A, the person maximizes expected utility, which can be written as a function of S as W*(S). The problem facing the person in J is to choose S and x to maximize the present value of expected utility. The problem can be written as maximizing the following Lagrangian:

$$L_J = V(x_J,S) + \tau W^*(S) + \lambda_J[B_J - p_{xJ}x_J - p_S S]$$

where p_{xJ} and p_S are the prices of other goods and cigarettes, respectively, τ is a discount factor ranging between 0 and 1, and λ_J is the marginal utility of income. If τ equals 0, then the juvenile is completely myopic and does not consider the impact of current consumption on future utility.

Our analysis concerns choices in A. Assume that there is some probability, w(c), that the person enjoys perfect health such that the derivative of the probability of perfect health with respect to consumption is negative ($dw/dc \leq 0$). If the person does not enjoy perfect health, then assume that he or she receives utility U_0. To simplify, the parameters of U can be set so that U_0 is equal to zero without loss of generality. The problem for the adult is to maximize

$$L = w(c)U(x,c|S) + \lambda[B_A - p_x x - p_c c]$$

The first-order conditions imply the following:

$$\frac{(\partial \mathbf{U}/\partial \mathbf{c})}{(\partial \mathbf{U}/\partial \mathbf{x})} + \left[\frac{(dw/dc)}{w}\right]\left[\frac{\mathbf{U}}{(\partial \mathbf{U}/\partial \mathbf{x})}\right] = \frac{\mathbf{p_c}}{\mathbf{p_x}}$$

Note that because U is a function of S, in general the values of x and c that maximize utility in A will be a function of S. If U is a decreasing function of S, then we can think of S as an addiction index. The compensating variation for the elimination of addiction is then the amount of the budget that could be taken away from the person after removal of the addiction so that he or she has the same utility as he or she had with the addiction.

As a simple example, assume that the probability of health does not depend on the level of smoking in A, w(c)=1, and that the utility can be written as follows:

$$U = x + \alpha c - \rho(c-S)^2$$

where α and ρ are non-zero parameters. Solving the first order conditions for x and c and substituting them into the above, yields the following expression for the maximum utility, W*:

$$W^* = \left[\frac{B_A - p_c S}{p_x}\right] - \left[\frac{\alpha p_c}{2\rho p_x}\right] + \left[\frac{p_c^2}{2\rho p_x^2}\right] + \rho\left[\frac{\alpha}{2\rho} - \frac{p_c}{2\rho p_x}\right]^2$$

In this simple case, it is easy to see by inspection that if S were set to 0, then decreasing B_A by an amount $p_c S$ would leave the utility unchanged. Therefore, $p_c S$ is the compensating variation for the elimination of the addiction. Letting p_x =\$1 the optimal level of c is linear in p_c as follows

$$c = \frac{\alpha}{2\rho} + S - \frac{p_c}{2\rho}$$

where the slope is -1/2ρ. Setting p_c =0 allows one to find the points of intersection of each of the addicted and non-addicted demand schedules with the quantity axis. This difference, S, can then be used to find the difference in the choke prices for the two demand schedules. Appendix A uses simple geometry to derive an expression for the ratio of the correct consumer surplus, CS_U, and the market demand consumer surplus, CS_U, at price p_c:

$$\frac{CS_U}{CS_A} = 1 - \frac{2S}{c_A} = 1 - \frac{2WTP / p_c}{c_A}$$

where c_A is the quantity demanded in the market based on the addicted demand schedule.

As also derived in Appendix A, the ratio of consumer surplus losses for a price increase of Δp is given by

$$\Delta CS_U / \Delta CS_A = \frac{c_A \Delta p - e\, c_A (\Delta p)^2 / 2p_c - WTP\Delta p / p_c}{c_A \Delta p - e\, c_A (\Delta p)^2 / 2p_c}$$

where e is the absolute value of the price elasticity of demand. Although these expressions are based on a particular, and simple, model of addiction, they provide a basis for deriving rough rules of thumb for the fraction of consumer surplus change measured in the market for the addicted good that should be treated as actual welfare change in the presence of addiction.

Contingent Valuation Survey

Although contingent valuation (CV) is being used increasingly to assess willingness to pay for medical treatments, we were able to locate only one published CV of treatments for addiction (Busch et al., 2004). That study used a two-part elicitation with a first question to determine if the respondent were willing to pay more for a more effective smoking cessation product followed by a question with an open-ended response of the amount more. We also found a related CV survey that estimated the willingness of smokers to pay for safe cigarettes (Hammer and Johansson-Stenman, 2004). Like that study, we employ the dichotomous choice elicitation format, which is generally viewed as the most reliable elicitation method.

Elicitation Format. Specifically, in addition to questions to ascertain demographic information and smoking behavior, we asked smokers the following basic elicitation question:

> Next, we would like you to consider the concept for a new drug. Developed by medical researchers, this new drug would completely block your craving for cigarettes. The drug, which would be administered by injection, is completely effective in eliminating the physical compulsion to smoke and has no known side effects. It would be effective for one year and could be readministered in subsequent years. Your own out-of-pocket costs for the annual dose of the drug would be X and the money you pay for the drug would not be available for you to spend on other things such as household expenses or recreation and would not be reimbursed by insurance. Would you purchase this new drug for X?

Where X, the bid, is equally likely to take the following values: $50, $100, $250, $500, $750, $1000, $1500, $2000, $2500, $3000, $4000, $5000.

In addition to the basic elicitation question, we used two alternative formats as well. One alternative format, which we label, “Would Block Pleasure,” adds the following phrase to the end of the second sentence: “as well as block any pleasure you obtain from smoking.” The other alternative format, which we label, “Would Not Be Unpleasant,” adds the following phrase to the end of the second sentence: “though it would not make smoking unpleasant for you.” Respondents were randomly assigned one of the three formats.

Immediately following the elicitation question, respondents were asked about how certain they were of their responses. For example, those who answered yes to the elicitation question were asked, “How certain are you that you would purchase the drug at a price of X?” (Although not reported here, half of the respondents in the full study were randomly assigned an elicitation question with the following alternative last sentence: “How likely would you be to purchase this new drug for X?” Possible responses were: Not at all likely, Somewhat likely, Likely, Very likely, and Absolutely certain I would.) Although we use the entire sample to estimate the demand for cigarettes, we limit our estimation of willingness to pay to smokers who were asked the traditional dichotomous choice question so as to avoid any confounding from the different formats. With appropriate adjustments to models to accommodate the different elicitation format, estimations are qualitatively similar to those reported for the dichotomous choice format.

General Willingness-to-Pay Model. The most general WTP model that we employ has three components. First, following Werner (1999), it specifies a relationship between respondent characteristics and the probability of having zero demand at any non-zero price. Second, it specifies a relationship between respondent characteristics and willingness to pay for those who demand the good at some non-negative price. Third, it specifies a relationship between respondent certainty in the elicitation response and the variance in the random utility of bid acceptance.

As some people may be unwilling to purchase the treatment to eliminate addiction at any non-negative price, we specify the probability of zero demand for person j as $q_j = \Phi(V_j\delta)$ where $\Phi(.)$ is the cumulative normal distribution, V_j is a vector of respondent characteristics, and δ is a vector of parameters. Because respondents who do not believe they are addicted to cigarettes are likely to have zero demand, V_j is based on self-assessments of physical and psychological addiction.

Assuming positive demand at non-zero price, we specify the willingness of person j to pay for the treatment to eliminate addiction as

$$WTP_j = f(X_j, \beta, \sigma, \varepsilon) = e^{X_j\beta + \sigma\varepsilon_j}$$

where $\ln(\sigma) = Z_j\theta$, X_j and Z_j are vectors of characteristics of the person; β and θ are unobserved vectors of parameters; and ϵ_j is a standard normal random variable. X_j includes income and other factors likely to affect demand; Z_j is the self-reported certainty in the elicitation response.

Neither q_j nor WTP_j are observed. Rather, we observe the response to the elicitation question with bid price t_j, Y_j, where $Y_j=1$ indicates an acceptance and $Y_j=0$ indicates a rejection. Person j will accept the bid if his or her willingness to pay exceeds t_j. That is, $Y_j = 1$ if $WTP_j > t_j$ or equivalently, if $\ln(WTP_j) > \ln(t_j)$. Because ϵ_j is assumed to be normally distributed, for those with non-zero demand, the probability that $\ln(WTP_j) > \ln(t_j)$ is

$$\Phi\left(\frac{(\ln WTP_j - \ln(t_j))}{\sigma}\right)$$

where $\Phi(.)$ is the cumulative normal density function. Noting that Y_j=0 if either $WTP_j < t_j$ or respondent j has zero demand, the probabilities of bid responses can be written as:

$$\Pr(Y_j = 1) = [1 - \Phi(V_j\delta)]\Phi((X_j\beta - \ln(t_j)) / e^{Z_j\theta})$$

$$\Pr(Y_j = 0) = \Phi(V_j\delta) + [1 - \Phi(V_j\delta)]\Phi((\ln(t_j) - X_j\beta) / e^{Z_j\theta})$$

Assuming q_j equals zero for all respondents and all the elements of θ equal zero, the formulation is similar to a probit model except that t_j allows for the identification of σ (Cameron and James, 1987). Assuming that the elements of θ other than the constant are not all zero, the model is similar to a heteroscedastistic probit model. When q_j is not assumed equal to zero for all respondents, the model is similar to a heterogenous probit mixture model.

We use maximum likelihood estimation to find b, c, and d, the estimates of β, θ, and δ, respectively. These estimates, in turn, allow for the prediction of a WTP_j for each respondent. The mean willingness-to-pay for the sample can be calculated by simply averaging the WTP_j. The median willingness-to-pay, a more conservative estimate, can be found as the middle value of the ordered WTP_j.

Survey Sample. We administered a web-based survey to a sample of U.S. residents who were 18 years of age or older. Respondents were sampled from the Harris Interactive panel (HarrisPollOnline.com). The Harris Interactive panel has approximately 7 million individual members (with about 5 million in the United States) who have been recruited through various websites and various online panel enrollment campaigns. In a number of studies, this panel has provided data that are comparable to data that have been obtained from random samples of general populations when sampling and weighting have been done appropriately (Berrens et al., 2003; Krosnick, Nie, and Rivers, 2005; Taylor et al., 2001; Thomas, Krane, and Taylor, 2004). Between November 2005 to March 2006, potential respondents were randomly selected from the Harris Interactive panel within the strata of sex, age group, region of country, and ethnic group, and then sent an email invitation to respond to a web-based survey: 292,000 invitations were sent and 33,052 respondents started the survey representing an 11.3 percent response rate. Of this number, 30,527 completed the survey while 2,525 discontinued their participation at some point within the survey, representing a 7.6 suspend rate, or a 92.4 completion rate.

The prevalence rate of smokers in the full sample is 23.7, comparable to NHANES 1999-2002 self-reported smoking rate of 24.9 percent of the U.S. population 18 years or older and a 23 percent prevalence reported by the CDC (2004: 24) for the period 1999-2001. Of respondents who were smokers (N=7,239), the distribution of cigarettes consumed per day is similar to that reported by the CDC (2004: 30): less than 15, 50.8 percent CDC versus 49.7 percent sample; 15 to 24, 38.1 percent CDC versus 35.2 percent sample; 25 to 34, 6.8 percent CDC versus 8.6 percent sample; and 35 or more, 4.3 percent CDC versus 6.5 percent sample.

As might be expected from a survey of only Internet users, the sample over-represents those with high levels of education (graduate degrees) and under-represents those with low levels of education (high school diploma or less as highest level of education). Columns one and two of Appendix B compare the characteristics of the raw sample to those of the U.S. smoking population 18 years or older estimated using smoking rates for demographic groups from CDC (2005) and group sizes based on data from the 2000 Census. Column three shows the percentages based on “raking” weights derived to match these characteristics of the sample more closely to those of the smoking population. As the weights were bounded to fall between 0.2 and 5, the marginals for the weighted data do not exactly correspond to the estimated marginals in the population.

Survey Design. The data collection was part of a larger study that Harris Interactive conducts continuously to screen respondents for a variety of valued characteristics including several that are health and business-related. Upon entry into the survey, respondents completed basic questions on their demographic characteristics, including age, sex, and country of residence. They were then asked a series of questions about their health with some specific questions focusing on any chronic illnesses or conditions they might experience. Additional demographic questions (e.g. education, income, etc.) were completed at the end of the survey following the experimental section detailed below.

Experimental Section. In the experimental section of the survey (following the health section), we asked about respondents' cigarette smoking (whether the respondent was a current smoker, a former smoker, or never smoked), including questions on the level of consumption and age at which smoking first began. Next was a series of questions about attitudes and affective reactions concerning smoking (including enjoyment and self-rated addiction). We then asked respondents about their reasons for smoking along with any negative reactions they have from smoking, and their sense of the likelihood of dying prematurely as a result of smoking. Following those questions we asked a series of questions on how changes in the price of cigarettes would influence their consumption. As noted previously, the CV experiment presented one of three scenarios through which smokers were exposed to the possibility of a drug administered by injection that would block their cravings to smoke cigarette

Variables Used in the Analysis. Table 1 summarizes the values of the various variables used in estimating the demand for cigarettes and the WTP to eliminate addiction. The first column of statistics is based on the 3,138 smokers who received the standard dichotomous elicitation question upon which the WTP analysis is based and for whom all items were complete. Column two is based on all 6,303 smokers for whom all items were complete. As expected, random assignment yields nearly identical summary statistics. Note that among all smokers the average consumption of cigarettes is 268.8 packs per year at an average price of $4.32 per pack.

Estimation of Demand for Cigarettes. It is possible that the intensity of smoking affects respondents' WTPs for the elimination of addiction. However, there are likely to be unobserved variables that affect both the intensity of smoking and WTP. These unobserved variables would potentially introduce an endogeniety basis. Consequently, the first step in the analysis involves estimating a demand equation with packs consumed per year as the dependent variable with price, income, and other variables as independent variables. Variation in price arises because smokers living in different states face different sales tax rates. The retail price per pack seen by respondents ranges form $3.33 to $6.46 (Lindblom, 2005). Price plays the role of instrumental variable in the demand equations.

The regressions in Table 2 are based on the full set of smokers. Packs-consumed-per-year is the dependent variable in model M1; the natural logarithm of packs-per-year is the dependent variable in models M2 through M5. In all the models, both price and income consistently have negative and statistically significant coefficients. The negative coefficient of price is as expected. The negative coefficient of income implies that smoking is an inferior good.

The implied price elasticities of demand for a smoker with the mean level of consumption at the mean sample price range valued at the point estimate and plus or minus one standard deviation are -0.15 (-0.09, -0.22) for M1, -0.16 (-.09, -.22) for M3 and M4, and -0.26 (-.19, -.34) for M2 and M4. The empirical literature generally reports price elasticities in the range of -0.3 to -0.5 (Sloan, Smith, and Taylor, 2003: 193-194). Models M2 and M4, which do not control for self-reported levels of addiction appear most consistent with this range.

In the analysis of WTP that follows, we use M5, which includes the full set of independent variables, as the basis for deriving instrumented values for consumption. Specifically, as equation M5 estimates the natural logarithm of consumption as the dependent variable, the instrumented values of consumption are calculated by raising the natural base to a power equal to the predicted value of the dependent variable plus one-half times the standard error of the prediction.

Estimation of Willingness-to-Pay. The analyses that follow estimate models for current smokers who received the standard dichotomous choice question — a yes or no response to the elicitation followed by a response to a question about the certainty of the elicitation response. Table 3 displays the bid responses for each of the three elicitation formats; the last column shows the response pooled over the three formats. The acceptance rates show a steep gradient over the lower bid range with a flatter tail for higher bids. The similar overall acceptance rates for the three elicitation formats suggest that respondents did not put great weight on whether the treatment would block or allow pleasure from smoking once the craving was removed. Indeed, rather than present estimates of models separately for each of the question formats, we present estimates using the pooled data with indicator variables to pick up any average differences across the three formats. In no case are these indicators either large or statistically significant. (Estimating the models on each of the formats separately yields similar results.) Thus, the format variations used in the elicitation question were not sufficiently different to produce meaningful differences.

In the following analyses, estimations are based on unweighted data. Subsequently, when translating WTP estimates for individual smokers into changes in social surplus, we employ weights to make these assessments more representative of the population of smokers.

Table 4 presents six models that range from the simplest plausible specification to the full model presented in the previous section. Model WPT1 estimates the simplest choice model (incorporation of neither zero demand nor heteroscedasticity) with the direct inclusion of consumption (Packspy). As is the case in all the specifications, WTP increases with income. The level of consumption also has a positive effect on WTP. The other variables include basic demographic variables (age, race/ethnicity, sex, and education) and an indicator of early smoking. Among these, only age and the square-of-age are statistically significant, indicating that WTP peaks at about age 46 years. The estimated mean and median WTP are $307 and $152, respectively, indicating a substantial skew in the distribution of WTP within the sample.

Model WPT2 includes the same set of regressors as WPT1 in the WPT equation but allows for heteroscedasticity as a function of the respondent's certainty of response to the dichotomous elicitation question. As expected, the estimated variance was inversely related to the degree of certainty — the estimate of sigma was 1.4 for those extremely certain (Extreme_cer), 2.2 for those very certain (Very_cer), and 5.5 for others. (There results were closely replicated in the remaining specifications.) Although the coefficients in the WTP equation remained statistically unchanged, the allowance for heteroscedasticity reduced the estimated mean WTP to $248 but raised the estimated median WTP to $161.

Model WPT3 replaces consumption (Packspy) with its instrumented value (Pred_packspy) to take account of the possibility of endogeniety between consumption and WTP. The instrumenting substantially increased the magnitudes of the effects of income and consumption, approximately tripling each relative to models WTP1 and WTP2. It also resulted in statistically significant positive coefficients several demographic characteristics (Black, Hispanic, and College_grad). Relative to other race/ethnicity groups, Blacks and Hispanics are willing to pay more; relative to those with a high school degree but no college degree, those with a college degree are willing to pay more. These differences in the WTP equation relative to model WTP2 yield approximately the same estimated mean WTP ($246) but a substantially reduced estimated median WTP ($124). Among the six models, WTP3 reports the smallest estimates of WTP.

The next three models in Table 4 implement the zero demand specification. In each model a variable is included in the equation for the probability of zero demand to indicate respondents who report that they are neither physically nor psychologically addicted to cigarettes (No_addiction). In model WTP4, this variable has the expected statistically significant positive coefficient. That is, those who do not believe that they have any addiction are much more likely to have zero WTP for the elimination of addiction at any non-negative price. However, in models WTP5 and WTP6, which include levels of addiction in the WTP equation, the variable is not statistically significant. In these models, the reported mean and median WTP are calculated by multiplying the WTP estimated from the WTP equation by the probability of non-zero demand ($1-q_i$).

Model WTP4 also adds several attitudinal and behavioral variables that may be related to WTP. Those who reported that smoking aggravated an illness (Illness), affirmed that smoking was becoming more inconvenient (Inconven), and believed that smoking shortens one's life (Life_shorter) all had higher WTP. Compared to those who never tried to quit, those who have tried to quit have higher WTP; from one attempt (Quit_once) through twenty attempts (Quit_2to5, Quit_6to10, Quit_11to20), WTP appears to be higher for more attempts. Respondents who reported enjoying smoking extremely or very much (Enjoy_much) do not appear to have a different WTP than those who claim less enjoyment. The combination of the implementation of zero demand and the inclusion of these additional attitudinal and behavioral variables results in an estimated mean WTP of $316 and an estimated median WTP of $201.

Model WTP5 drops the attitudinal and behavioral variables used in equation WTP4 and adds respondents self-assessments of their levels of physical and psychological addiction. These variables show the expected pattern of higher levels of perceived addiction leading to greater WTP. For example, relative to no physical addiction, the coefficient of some physical addition (Some_phyad) is about one-half the coefficient of very strong physical addiction (Vstrong_phyad). The switch from the attitudinal and behavioral variables in model WTP4 to the variables differentiating levels of addiction increases the estimated mean WTP to $324 but leaves the estimated median WTP effectively unchanged at $202.

Model WTP6 includes both the attitudinal and behavioral variables from model WTP4 and the addiction indicators from model WTP5. The attitudinal and behavioral variables have very similar effects as in model WTP4. The physical addiction indicators have effects similar to those in model WTP5, but among the psychological indicators, only very strong addiction (Vstrong_psyad) has a statistically significant coefficient. The estimated mean WTP based on model WTP6 is $335, the largest among all the models. The estimated median WTP of $199 is virtually the same as that for models WTP4 and WTP5.

Which models are most appropriate. In view of the likely endogeniety of consumption, models WTP3 through WTP6, which instrument consumption, seem more appropriate than models WTP1 and WTP2, which do not. Among models WTP3 through WTP6, the three taking account of zero demand seem more appropriate conceptually, even though in the zero-demand equation the independent variable does not have a statistically significant coefficient due to the inclusion of the addiction variables in the WTP equation. These considerations lead us to prefer model WTP4. Nonetheless, in the consumer surplus analysis that follows, we present results for models WTP3 through WTP6.

Caveats. The experimental design employed varied the extent to which the addiction treatment would affect the receipt of pleasure for those who choose to smoke when not addicted. As noted above, this variation did not affect estimates of WTP. The experimental design did not vary the mode of administration of the addiction treatment—only injection was offered. It is possible that some respondents rejected the treatment out of an aversion to injection. A study of reasons why healthcare workers declined vaccination against influenza suggests that this percentage could be larger than 15 percent (Steiner, 2002). It would be useful to vary administration mode in future studies to assess the extent to which injections deter demand.

There is also a possibility that some smokers may not easily recall the amount they spend on cigarettes in a year so that they do not make appropriate financial assessments of the cost of an annual treatment. It may be desirable in future studies to prime respondents with an estimate of the amount they spend on cigarettes based on their responses to questions about how many packs they purchase per day or month or a question asking them to make such an estimate themselves.

Estimating the Fraction of Consumer Surplus in the Cigarette Market that Should Count

The estimates of WTP for individuals in the various models provide a basis for estimating the fraction of consumer surplus changes based on the market demand schedule that should be counted as consumer welfare. Table 5 implements the formulas derived in Appendix A for the ratios of total consumer surplus and changes in consumer surplus. The first two columns show the ratio of the total consumer surplus based on the non-addicted demand schedule to the addicted demand schedule. The unweighed ratios range from 55 to 61 percent over the four models. The weighted ratios, which provide a better prediction for the U.S. population of smokers, are somewhat higher, ranging from 61 to 65 percent.

In applying CBA, a rule-of-thumb for adjusting consumer surplus changes in the cigarette market resulting from small increases in price, such as would result from an increase in the excise tax, is of more immediate value. The second two columns show ratios for changes in consumer surplus for a 25 percent price increase (approximately $1 per pack). These ratios are somewhat larger than the ratios of total surplus, with the ratios of the unweighted surplus changes ranging from 64 to 69 percent and the ratios of the weighted surplus changes ranging from 68 to 71 percent. Although these estimates depend on the assumed elasticity, the relationship is very weak with a doubling or tripling of elasticity changing these percentages by only a few points. These estimates suggest that a reasonable rule-of-thumb is to *consider only 70 percent of the loss in consumer surplus as measured by the market demand for cigarettes as actual welfare loss in cost-benefit analysis*.

Frank Sloan and colleagues (2004: 257) estimate the total cost of smoking taking account of the private costs to smokers, the external costs borne by family members (quasi-external costs in their terminology), and external costs to estimate total social cost of a pack of cigarettes of about $40. We cannot directly integrate our estimate of the magnitude of the intrapersonal externality into their calculation, which is based on lifetime costs to a 24 year old smoker. Nonetheless, the differences between the addicted and non-addicted demand schedules that we estimate suggest a noticeable upward adjustment would be warranted. That is, the social cost of smoking is probably considerably higher than their estimate of $40 per pack.

Conclusion

Goods with addictive qualities pose a substantial challenge for CBA methodology, which assumes consumer sovereignty and rationality. Measuring changes in social welfare in terms of the observed market demand schedule results in an overestimation of the costs of policy alternatives that reduce the level of consumption of the addictive good; ignoring the surplus loss to those addicted to the good results in an underestimation. We argue that the correct measurement of changes in individual welfare should be based on the non-addicted demand schedule rather than the market schedule, which includes addicted demand. This could significantly alter the estimation of net benefits for programs and policies that attempt to reduce the consumption of addictive goods. It is likely to increase estimates of net benefits for CBAs that have treated all lost consumer surplus as a cost of an intervention, but it would likely decrease net benefits of programs that have simply ignored the loss of consumer surplus. In order to aid CBA practitioners, we demonstrate how CV surveys can be used to relate these two demand schedules for cigarettes, a particularly addictive good. Our analysis suggests that a significant fraction of the consumer surplus losses measured relative to the demand schedule should not be counted as losses in welfare. Rather, they should be treated as reductions in an intrapersonal externality.

We suggest that it is inappropriate for addiction reduction-focused studies that claim to use CBA to ignore the issue of forgone consumer surplus. At the very least, the issue should be treated through sensitivity analysis— perhaps with one scenario following current practice, but with at least one other another using the adjusted consumer surplus approach described here.

The analysis presented here extends to other legal goods that are addictive to a sufficient fraction of consumers such that there is likely to be substantial divergence between the market demand schedule and the non-addicted demand schedule. For example, those who havean "alcohol problem" may account for a sufficient amount of demand for these goods as to bring into question the measurement of consumer surplus changes relative to the market demand schedule.

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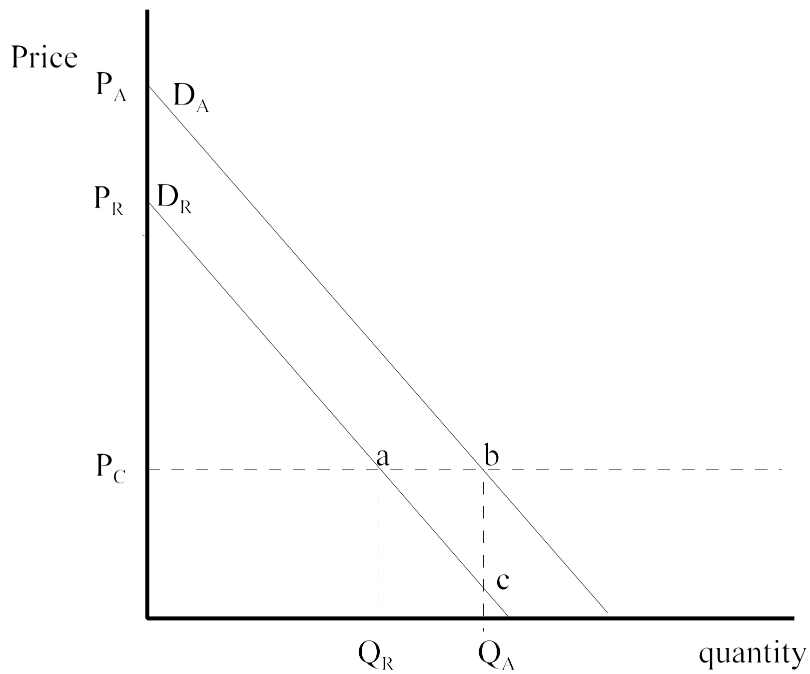
Figure 1

Consumer Surplus in the Presence of Addiction



Adapted from: Australian Productivity Commission, 1999, Appendix C, 11-13

Table 1
Summary Statistics for Variables Included in Models

	Pooled Treatments (N=3,138)	**All Smokers in Survey** (N=6,303)
Bid in Dollars (standard deviation)	1678 (1534)	1699 (1527)
Age in years (standard deviation, s. d.)	43.3 (13.3)	43.4 (13.2)
Income in 1000s of dollars (s. d.)	52.0 (40.2)	52.2 (41.1)
Male — percent male	44.4	44.6
No_HS_Diploma — percent	2.9	2.9
College_grad — percent college graduate	21.8	22.5
Black — percent identifying as Black/African American	5.2	5.3
Hispanic — percent identifying as non-Black Hispanics	6.2	6.5
Early_Smoker — percent smoking before 17 years	63.3	63.0
Packspy — packs per year smoked (s. d.)	286.4 (249)	286.8 (247)
Illness — percent affirming "It aggravated an illness I had."	14.5	15.4
Inconven — percent affirming "...more inconvenient to smoke."	47.0	47.1
Life_shorter — percent believing smoking will shorten life.	67.9	67.6
Enjoy_much — percent reporting enjoy smoking extremely or very much	29.3	29.0
Extreme_cer — percent extremely certain of bid response	44.9	N.A.
Very_cer — percent very certain of bid response	19.9	N.A.
No_phyad — percent reporting no physical addiction	14.3	14.0
Some_phyad — percent reporting some or slight physical addiction	39.4	38.7
Strong_phyad — percent reporting strong physical addiction	27.0	28.1
Vstrong_phyad — percent reporting very strong physical addiction	19.2	19.2
No_psyad — percent reporting no psychological addiction	10.0	9.9
Some_psyad — percent reporting some or slight psychological addiction	34.4	33.6
Strong_psyad — percent reporting strong psychological addiction	31.8	23.8
Vstrong_psyad — percent reporting very strong psychological addiction	23.9	23.8
No_addict — percent claiming neither physical nor psychological addiction	8.6	8.6
Quit_never — percent reporting never trying to quit	15.2	15.2

Quit_once — percent reporting trying to quit once	14.5	13.9
Quit_2to5 — percent reporting trying to quit 2 to 5 times	46.2	46.5
Quit_6to10 — percent reporting trying to quit 6 to 10 times	15.3	15.6
Quit_11to20 — percent reporting trying to quit 11 to 20 times	4.7	5.1
Quit_20plus — percent reporting trying to quit more than 20 times	4.0	3.6
Yes_pleasure — percent in "would not be unpleasant" treatment	33.7	33.3
No_pleasure — percent in "would block pleasure" treatment	33.4	34.0
Price — average price per pack ($s) in state of residence (s.d.)	4.32 (.79)	4.31 (.79)

Table 2
Models of Smoking Consumption (Packs per year)
Estimated for All Smokers in Survey

OLS coefficient (standard error)	**M1** **Packspy**	**M2** **ln(Packspy)**	**M3** **ln(Packspy)**	**M4** **ln(Packspy)**	**M5** **ln(Packspy)**
Price	-9.6* (3.8)	-0.061** (.018)	-0.036** (.014)	-0.061*** (.017)	-0.036** (.014)
Income	-0.35*** (.076)	-0.0019*** (.00035)	-0.0011*** (.00028)	-0.0022*** (.00034)	-0.0010*** (.00028)
Male	23.2*** (6.1)	0.098** (.029)	0.20*** (.022)	0.15*** (.027)	0.21*** (.022)
Age	18.6*** (1.3)	0.11*** (.0062)	0.050*** (.0049)	0.089*** (.0059)	0.051*** (.0059)
Age-squared	-0.17*** (.014)	-0.0010*** (.000068)	-0.00045*** (.000053)	-0.00082*** (.000064)	0.00046*** (.000053)
Black	-108.4*** (13.4)	-0.53*** (.063)	-0.37*** (.049)	-0.41*** (.060)	-0.37*** (.049)
Hispanic	-44.7*** (12.1)	-0.30*** (.058)	-0.17*** (0.45)	-0.25*** (.055)	-0.18*** (.045)
Early_Smoker	31.5*** (6.2)	0.16*** (.029)	-0.0028 (.023)	0.082** (.028)	0.0028 (.023)
College_grad	-60.7*** (7.5)	-0.38*** (.036)	-0.22*** (.028)	-0.39*** (.034)	-0.22*** (028)
No_HS_diploma	38.1*** (17.8)	0.26** (.16)	0.12 (.064)	0.27*** (.078)	0.12 (.064)
Inconven	—	—	0.076*** (.023)	0.25*** (.028)	0.081*** (.023)
Illness	—	—	-0.041 (.031)	0.092* (.037)	-0.029 (.031)
Life_shorter	—	—	-0.031 (.025)	0.23*** (.030)	-0.025 (.024)
Enjoy_much	—	—	0.17*** (.025)	0.49*** (.029)	0.15*** (.025)
Some_phyad	—	—	0.85*** (.046)	—	0.86*** (.046)
Strong_phyad	—	—	1.2*** (.051)	—	1.2*** (.052)
Vstrong_phyad	—	—	1.3*** (.059)	—	1.3*** (.059)

Some_psyad	—	—	0.82*** (.054)	—	0.83*** (.054)
Strong_psyad	—	—	1.2*** (.059)	—	1.3*** (.059)
Vstrong_psyad	—	—	1.4*** (.064)	—	1.4*** (.065)
Quit_once	—	—	—	0.54*** (.051)	0.086* (.043)
Quit_2to5	—	—	—	0.59*** (.042)	-0.036 (.037)
Quit_6to10	—	—	—	0.69*** (.051)	-0.059 (.044)
Quit_11to20	—	—	—	0.60*** (.069)	-0.20*** (.059)
Quit_20plus	—	—	—	0.68*** (.079)	-0.14* (.067)
Constant	-126*** (33)	2.8*** (.16)	2.1*** (.12)	2.5*** (.14)	2.1*** (.12)
Adjusted R^2	0.09	0.13	0.48	0.23	0.48

Statistical significance based on one-sided Student's-t tests: * p<0.05, ** p<0.01, *** p<0.001

Table 3
Bid Responses for Three Elicitation Questions
(Percent Accepting)

Bid (Dollars)	**Basic Elicitation Question** (N=1,032)	**Would Block Pleasure** (N=1,049)	**Would Not Be Unpleasant** (N=1,057)	**Pooled** (N=3,138)
50	70.7	68.8	79.1	72.7
100	69.8	64.5	69.8	68.1
250	50.6	52.9	48.3	50.7
500	31.4	33.3	31.1	31.9
750	28.9	33.3	25.0	29.0
1000	20.2	21.0	20.2	20.4
1500	19.6	20.6	14.7	18.6
2000	17.8	27.7	18.4	21.2
2500	16.3	12.4	10.8	13.0
3000	12.0	13.2	12.5	12.6
4000	13.0	8.3	9.2	10.0
5000	12.8	8.6	12.5	11.5
Overall	30.6	31.4	29.5	30.5

Table 4
Willingness-to-Pay Models

Equation	Variable	WPT1	WPT2	WPT3	WPT4	WPT5	WPT6
Ln (WTP)	Income	0.011*** (.00014)	0.013*** (.0014)	0.034*** (.0014)	0.013*** (.0014)	0.012*** (.0013)	0.012*** (.0013)
	Packspy	0.0017*** (.00028)	.0017*** (.00029)	—	—	—	—
	Pred_packspy	___	___	0.0056*** (.00047)	0.0036*** (.00061)	-0.0044** (.0015)	-0.0018 (.0019)
	Yes_pleasure	-0.14 (.14)	-.11 (.15)	-0.051 (.14)	-0.014 (.14)	-0.019 (.15)	0.0056 (.15)
	No_pleasure	.0039 (.14)	-0.092 (.15)	-0.083 (.14)	-0.061 (.14)	-0.050 (.14)	-0.052 (.14)
	Age	0.058* (.025)	0.078** (.028)	0.0052 (.0248)	-0.012 (.031)	0.072** (.029)	0.033 (.035)
	Age Squared	-0.00063* (.00027)	-0.00077* (.00030)	-0.000096 (.00031)	0.000086 (.00033)	-0.00065* (.00031)	-0.00028 (.00036)
	Male	0.14 (.12)	-0.0045 (.12)	-0.095 (.12)	-0.030 (.12)	0.36** (.14)	0.23 (.15)
	Black	0.47 (.26)	0.48 (.27)	0.80** (.28)	0.80** (.27)	0.042 (.35)	0.38 (.29)
	Hispanic	0.48 (.25)	0.33 (.25)	0.51* (.24)	0.56** (.23)	0.21 (.24)	0.32 (.24)
	College_grad	-0.011 (.14)	0.0035 (.15)	0.32* (.15)	0.23 (.15)	-0.069 (.18)	-0.018 (.18)
	No_HS_diploma	0.33 (.35)	0.063 (.37)	-0.41 (.39)	-0.20 (.34)	0.058 (.35)	0.014 (.24)
	Early_smoker	0.023 (.12)	0.070 (.13)	-0.095 (.12)	-0.23 (.12)	-0.12 (.12)	-0.19 (.13)
	Illness	—	—	—	0.38** (.15)	—	0.32* (.15)
	Inconven	—	—	—	0.24* (.12)	—	0.30* (.13)
	Life_shorter	—	—	—	0.53*** (.14)	—	0.52*** (.15)
	Enjoy_much	—	—	—	-0.23 (.15)	—	-0.061 (.16)
	Quit_once	—	—	—	1.2*** (.29)	—	1.1*** (.30)
	Quit_2to5	—	—	—	1.3*** (.24)	—	0.97*** (.24)

	Quit_6to10	—	—	—	1.8*** (.26)	—	1.5*** (.26)
	Quit_11to20	—	—	—	1.9*** (.34)	—	1.4*** (.36)
	Quit_20plus	—	—	—	1.7*** (.36)	—	1.3*** (.36)
	Some_phyad	—	—	—	—	1.2*** (.28)	0.66* (.32)
	Strong_phyad	—	—	—	—	2.1*** (.36)	1.2** (.42)
	Vstrong_phyad	—	—	—	—	2.4*** (.44)	1.4** (.50)
	Some_psyad	—	—	—	—	1.3*** (.33)	0.75 (.54)
	Strong_psyad	—	—	—	—	1.9*** (.40)	1.0 (.62)
	Vstrong_psyad	—	—	—	—	2.7*** (.46)	1.6* (.69)
	Constant	3.0*** (.041)	2.2*** (.65)	3.2*** (.63)	2.5*** (.71)	0.52 (.75)	0.83 (1.1)
$q=\Phi(V\delta)$	No_addiction	—	—	—	5.2*** (.43)	-2.1 (1.6)	1.4 (1.9)
	Constant	—	—	—	-5.5*** (.29)	-2.6 (1.2)	-2.7*** (.80)
$\ln(\sigma)$	Extreme_cer	—	-1.4*** (.13)	-1.3*** (.12)	-1.4*** (.13)	-1.4*** (.14)	-1.5*** (.14)
	Very_cer	—	-0.91*** (.14)	-0.88*** (.13)	-0.95*** (.14)	-0.93*** (.14)	-0.98*** (.14)
	Constant	0.77*** (.041)	1.71*** (.13)	1.6*** (.12)	1.6*** (.13)	1.6*** (.13)	1.6*** (.13)
Ln of the likelihood function		-1534	-1411	-1373	-1300	-1325	-1291
Percent correct predictions		—	—	—	72.5	72.7	73.2
Mean WTP ($)		307	248	246	316	324	335
Median WTP ($)		152	161	124	201	202	199

Statistical significance based on one-sided robust asymptotic z-scores: *** p<.001, ** p<.05, *p<.1

Table 5
Consumer Surplus Based on Non-addicted Demand
as a Percentage of Consumer Surplus Based on Market Demand

Source	Percentage of Total Consumer Surplus [a]	Weighted Percentage of Total Consumer Surplus [b]	Percentage for a 25 Percent Increase in Price (e=.15) [c]	Weighted Percentage for a 25 Percent Increase in Price (e=.15) [d]
WPT3	61	65	69	71
WPT4	58	63	65	69
WTP5	56	62	65	68
WTP6	55	61	64	68

[a] Sum of individual consumer surplus losses from zero consumption based on addicted (market) demand schedule *divided* by sum of individual consumer surplus losses from zero consumption based on the non-addicted demand schedule.

[b] Weighted sum individual consumer surplus losses from zero consumption based on addicted (market) demand schedule *divided* by weighted sum of individual consumer surplus losses from zero consumption based on the non-addicted demand schedule.

[c] Sum of individual consumer surplus losses from 25 percent increase in price based on addicted (market) demand schedule *divided* by sum of individual consumer surplus losses from 25 percent increase in price based on the non-addicted demand schedule.

[d] Weighted sum of individual consumer surplus losses from 25 percent increase in price based on addicted (market) demand schedule *divided* by weighted sum of individual consumer surplus losses from 25 percent increase in price based on the non-addicted demand schedule.

Appendix A

Estimating the Ratio of Non-Addicted to Addicted Consumer Surplus

The simple model of consumption of an addictive good presented in the text indicates that for the case of linear demand for cigarettes, the compensating variation for removing addiction (setting S=0) was simply $p_c S$. That is, WTP=$p_c S$ so that S=WPT/p_c. It also indicates that the demand for cigarettes is

$$c = \frac{\alpha}{2\rho} + S - \frac{p_c}{2\rho}$$

where the slope of this linear demand schedule is -1/2ρ = -η so that the slope of the inverse demand schedule shown in the conventional way in Figure 1 is -1/η. Setting p_c to zero yields the point of intersection of the observed market demand schedule with the quantity axis, αη+S. The point of intersection for the non-addicted demand schedule would thus be αη, yielding a difference of S. Because demand schedules are linear and parallel, this is also the difference between c_A and c_U, which are the addicted and non-addicted quantities demanded at price p_c, respectively. Projecting the difference in these points, S, to the price axis gives a difference in the choke prices for addicted demand, p_A, and non-addicted demand, p_U, equal to ηS. By simple geometry, the following relations also hold:

$$\eta c_A = p_A - p_C$$
$$\eta c_U = p_U - p_C$$
$$\eta(c_A - c_U) = p_A - p_U$$

The consumer surplus at the market equilibrium measured relative to the non-addicted demand schedule is

$$\begin{aligned} CS_U &= .5(p_U - p_C)c_U - .5(p_A - p_U)(c_A - c_U) \\ &= .5\eta c_U^2 - .5\eta(c_A - c_U)^2 \\ &= .5\eta(c_A - S)^2 - .5\eta S^2 \\ &= .5\eta(c_A^2 - 2Sc_A) \end{aligned}$$

The consumer surplus at the market equilibrium measured relative to the addicted demand schedule is

$$\begin{aligned} CS_A &= .5(p_A - p_c)c_A \\ &= .5\eta c_A^2 \end{aligned}$$

so that the ratio of consumer surpluses is

$$\begin{aligned} \frac{CS_U}{CS_A} &= 1 - \frac{2S}{c_A} \\ &= 1 - \frac{2WTP / p_c}{c_A} \end{aligned}$$

As all these quantities can be estimated from the survey, it is possible to calculate this ratio.

The above ratio would be appropriate for assessing the consumer surplus loss from a complete removal of cigarettes from the market. A more likely applicable approximation is the ratio of the changes in the consumer surplus measured relative to non-addicted and addicted demand. The consumer surplus loss for an increase in the price of cigarettes measured relative to the addicted demand schedule is

$$\Delta CS_A = c_A \Delta p - (\Delta p)^2 c_A e / 2p_c$$

where Δp is the change in price and e is the absolute value of the price elasticity of demand. The consumer surplus loss measured relative to the non-addicted demand schedule equals the increased payment made for units that continue to be consumed minus the reduction in the size of triangle abc in Figure 1:

$$\Delta CS_U = c_A \Delta p - WTP\Delta p / p_c - (\Delta p)^2 c_A e / 2p_c$$

These changes in consumer surplus, and their ratio, can be computed for various estimates of the price elasticity of demand for cigarettes.

Appendix B

Comparison of Raw and Weighted Sample to National Smoking Population (Rounded Percentages by Demographic Category)

		U.S. Smokers,18 Years and Older*	Raw Sample	Weighted Sample
Education by Sex				
Male	No High School Degree	21	3	11
	High School Degree	35	19	41
	Some College	21	41	26
	Associate's Degree	6	10	6
	College Degree	9	19	12
	Post-Graduate Degree	3	8	4
Female	No High School Degree	17	4	22
	High School Degree	37	24	41
	Some College	23	42	22
	Associate's Degree	7	11	6
	College Degree	8	15	8
	Post-Graduate Degree	3	4	2
Age by Sex				
Male	18-24	15	6	13
	25-44	47	41	48
	45-64	32	46	32
	65 and Over	6	7	7
Female	18-24	14	10	12
	25-44	46	46	47
	45-64	32	35	32
	65 and Over	8	9	8
Race/Ethnicity by Sex				
Male	Hispanic	10	5	6
	Black (Not Hispanic)	11	5	8
	All Others (Not Hispanic)	79	90	86
Female	Hispanic	6	7	8
	Black (Not Hispanic)	11	6	9
	All Others (Not Hispanic)	83	87	83

* Estimated from smoking rates for demographic groups from the CDC (2005) converted to marginals for smokers using data on the size of groups from the Census 2000 Integrated Public Use Microdata Series.