An Economic Model of Youth Smoking: Tax and Welfare Effects

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This paper presents a model of smoking choice in which rationality is bounded by limitations in intertemporal computational abilities. The model is applied to the youth decision to initiate smoking. Lifetime smoking paths of representative smokers indicate that youths may experience a reduction in lifetime utility and come to regret their decision to smoke. It is suggested that public policy interventions that raise the near term cost of smoking will be more effective in reducing lifetime smoking than informational campaigns that emphasize future health costs. However, youth taxes would have to be quite high to substantially reduce smoking rates among youths who have already begun to smoke. Also, low youth taxes would not prevent future smoking as an adult, although they would reduce smoking rates and lead to earlier quitting.

JEL Codes: I12, D11, D60, D91

Keywords: cigarettes, youth, smoking, taxation, welfare

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1. Introduction

Use of tobacco is attributed to over 430,000 early deaths in the US each year making tobacco use the number one preventable health problem. Each day, according to the American Lung Association, more than 4,800 adolescents (ages 11-17) will try their first cigarette. Among these, more than 2,000 will become regular smokers. Currently more than 4.5 million adolescents smoke. This amounts to 28% of US high school students and 11% of middle school students. It is estimated that if current smoking patterns persist, more than 6.4 million of today's teenagers will die prematurely from a smoking-related disease.[1] Adding to this concern is the fact that teen smoking rates were again on the rise during the 1990s.[2]

Concern about the potential health consequences of teen smoking are heightened by the fact that most adult smokers began smoking when they were teens, and most of those began before they were of legal smoking age.[3] Most teens are aware of the negative health consequences but many choose to smoke nonetheless. Many teens expect that smoking will be temporary, only 5% of teens expect to be smoking within 5 years. In reality, about 75% are still smoking after 5 years.[4] Since cigarettes contain nicotine, an extremely addictive agent, quitting smoking proves to be very difficult for most, and impossible for some. Thus, intervention to arrest smoking initiation among teens may have a considerable long-term positive impact on public health.

In recent years interventions have included campaigns to encourage merchants to check IDs before selling to minors coupled with fines for merchants caught selling to underage

[1] American Lung Association Fact Sheet, Teenage Tobacco Use, http://www.lungusa.org/tobacco/teenager_factsheet99.html
[2] See Gruber (2000).
[3] According to the National Population Health Survey of Canada, 1994, 86% of adult smokers began at age 19 or earlier, while 86% began age 17 or before. 16% of adult smokers began before age 14. See http://www.cansim.com/Daily/English/980429/d980429.htm
[4] Gruber (2000).

smokers, bans on vending machines located in areas accessible to youths, and bans on cigarette advertising in the broadcast media. There has also been a major effort in elementary schools to educate children about the risks inherent in smoking and to promote strategies for avoidance. These policies are designed to reduce youth access to tobacco products and to provide knowledge that encourages youths not to smoke.

However, some of these policies have been shown to be ineffective. As an example, a 15-year National Cancer Institute (NCI) study of a school-based intervention program from the third through 12th grade showed that it had no impact in reducing youth tobacco usage.[5] These facts point to a need for further study of the smoking initiation process.

The rationale for smoking, in general, and teen smoking, in particular, tends to vary across researchers and disciplines.[6] Typical views are that teens are short-sighted, think only about the present and very little, if at all, about the future. Alternatively, teens may simply be immature and incapable of evaluating information properly, especially the long term impacts of smoking.[7] The standard economic view of the decision to smoke is that individuals plan a lifetime consumption path that maximizes discounted lifetime utility. Smoking occurs because the benefits exceed the costs. Thus, teens will recognize the future negative consequences of current smoking, but early smoking may arise due to unreasonably high discount rates.[8]

In this paper's approach to teen smoking initiation, which extends the analysis in Suranovic, Goldfarb and Leonard (SGL, 1999), it is assumed that teens do make a determination about whether to smoke by weighing the perceived costs and benefits.

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[5] See National Cancer Institute, http://www.cancer.gov/newscenter/hutchqanda.
[6] For a discussion of competing theories see Goldfarb, Leonard and Suranovic (2001)
[7] See Herrnstein and Prelec (1992)
[8] See Becker-Mulligan (1997) for a discussion of variable discount rates.

However, unlike the rational choice and hyperbolic discounting models in the economics literature, [Becker-Murphy (1988), Gruber-Koszegi (2002)] it is not assumed that teens plan a complete future course of smoking. Instead, teens choose whether to smoke on a period-by-period, day-by-day basis. It is assumed that teens are sophisticated enough to recognize the future health consequences of smoking and they factor that into their decision each period. Teens are also responsive to the withdrawal costs that arise if they cut back their consumption after having achieved a habitual rate of smoking. However, teens lack the sophistication of an intertemporal maximizing agent who would recognize that future consumption choices may affect one's current choices, and vice versa. The motivation for this assumption is twofold. First, as argued in SGL, 1999, the bounded rationality setup is a better description of the actual way individuals make decisions. Second, the model provides better intuitive explanations for many of the empirical observations involving cigarette consumption. The model also provides an alternative justification for government intervention: intervention corrects individual "mistakes" that arise from the inability to calculate an optimal lifetime consumption path.

1.1. The Smoking Initiation Process

The initial decision to smoke is complicated by several factors and might best be described as occurring in stages. In the initial stage, pre-teens or very young teens are generally restricted from consuming cigarettes. Unlike other goods, youths do not have opportunities to sample cigarettes and thus will not know how much utility a cigarette might provide. However, youths will recognize that smoking is an "adult" good and since children often find value in acting adult, they may imagine a positive utility in consumption. In addition, youths may observe from social settings that smokers have certain qualities worth emulating, that is, smokers may seem “cool.” This is an image that may be reinforced through popular cinema and advertising. This means that sampling is not necessary for teens to develop a positive preference for cigarettes.

Teens and pre-teens face another problem consuming cigarettes. In most cases, parents and guardians do not allow smoking in their presence. Since young children experience virtually constant adult supervision, even if they had a desire to smoke, the consequences of smoking in the presence of adults would undoubtedly lead to reprimand and punishment. Thus, for young children the cost of smoking (in the form of punishment) is very high and would likely overwhelm any perceived benefits.

In the next stage, typically as children reach middle school, the amount of unsupervised time begins to rise. This provides periods of time where the punishment cost of smoking may fall close to zero, since smoking will go unseen. A likely scenario may be a middle-school youth home alone where there are cigarettes left in the house by an adult family member. A second common story is when kids walk home from school through an isolated area. If one student has easy access to a cigarette, perhaps one obtained surreptitiously at home, this may inspire a whole group to experiment. In these situations, peer pressure may suddenly raise the perceived benefits of smoking in order to be accepted by one’s peers.

After the first smoking incident, a youth may begin an experimentation stage. Cigarette consumption may occur only sporadically since unsupervised time and cigarette availability may be somewhat random. The decision to smoke at this stage may also be unrelated to typical budget constraints, since the teen may not pay for his cigarettes (if they are freely provided by a friend, or stolen).

During the experimentation stage, a youth has an opportunity to reach an informed opinion about the utility benefits of smoking. These benefits may arise partially from peer acceptance and partially from the physical effect of nicotine and cigarette smoking itself. This latter effect is more likely to be learned at this stage, but the former effect might also be solidified as a youth determines how important smoking is to remain a part of this peer group.[9]

After the experimentation stage, a teen will either decide to stop smoking, or will become a regular smoker. As a regular smoker, the teen will ultimately have to pay for his own cigarettes and will become subject to the standard choice problem dependent on known preferences, prices and income.

In the model developed below, the smoking initiation process is simplified by concentrating the experimentation and learning phase into an instantaneous, exogenous, shock to the youth's utility function at a young age. This shock makes it beneficial to smoke if no additional effects of smoking are considered. The timing of the shock and the magnitude of the perceived benefits will be idiosyncratic and will depend upon the factors discussed above.

2. The Model

The model considers the decision process of an individual smoker who weighs the perceived benefits and costs of smoking. We imagine that costs and benefits of smoking arise in three distinct ways; as immediate benefits of consumption derived while smoking, as

[9] Survey studies have defined smokers as "experimental smokers" if one has smoked less than 100 cigarettes in their lifetime and "established smokers" if one has smoked more than 100. See Ross, Chaloupka and Wakefield (2003) for a description of the smoking initiation process.

perceived future smoking-related health losses, and as withdrawal or quitting costs if consumption is cut back from one's habitual level.[10]

2.1. Current Benefits from Smoking.

Consumption of cigarettes generates benefits just as other consumption goods do, however, one's past usage, or stock of consumption will also affect the utility obtained. Two features of tobacco consumption, that distinguish it from normal goods, are reinforcement and tolerance. Tolerance refers to the reduced effectiveness of addictive drugs as usage increases; i.e., one gets less utility, or less of a "high," as past consumption cumulates. Reinforcement means that as past usage of the drug rises, the current marginal utility of consumption rises. Reinforcement and tolerance combine to induce an individual to crave a drug and wish to consume more of it.[11] These two features imply that the youth's utility for cigarettes will change as a function of his past smoking history.

For simplicity, I adopt the quadratic utility function used in Becker-Murphy (1988) and Gruber-Koszegi (2002). The specific function is:

$$B_A(c,S_A) = \alpha_C c + \frac{1}{2}\alpha_{CC}c^2 + \alpha_{CS}cS_A + \alpha_S S_A + \frac{1}{2}\alpha_{SS}S_A{}^2 \qquad (1)$$

Here, B_A refers to the current benefits of smoking at age A, c is the current daily level of cigarette consumption, S_A is the accumulated past stock of cigarette consumption as of age A, while the αs are exogenous parameters such that α_C and α_{CS} are positive while α_{CC}, α_S, and α_{SS} are each negative. α_C is the parameter that will be shocked to induce smoking initiation.

[10] The habitual level is defined as the level of smoking chosen in the previous period.

[11] This component of the utility function incorporates positive reinforcement as one aspect affecting the individual's choice. See Glautier (2004) for an overview of positive reinforcement modeling in the literature.

Tolerance requires $\partial B_A(c, S_A)/\partial S_A < 0$. Thus, for the specific utility function assumed, we need:

$$\frac{\partial B_A(c, S_A)}{\partial S_A} = \alpha_{CS}c + \alpha_S + \alpha_{SS}S_A < 0 \quad (2)$$

Reinforcement requires that $\partial B(c,S)/\partial c\partial S > 0$. The specific utility function assumed yields the following expression for the marginal utility of a cigarette:

$$\frac{\partial B_A(c, S_A)}{\partial c} = \alpha_C + \alpha_{CC}c + \alpha_{CS}S_A \quad (3)$$

It follows that $\partial B_A(c,S)/\partial c\partial S_A = \alpha_{CS} > 0$, which incorporates the reinforcement effect.

2.2. Health Effects of Smoking.

I assume that individuals recognize the future health consequences of smoking and incorporate this explicitly into their decision-making process. In the Becker-Murphy and Gruber-Kosegi models, health consequences are implicitly incorporated through the tolerance effect and through an effect on future wealth. However, neither effect is explicitly placed at the end of life in these models, thus they do not capture an important element of these effects.[12]

Suranovic, Goldfarb and Leonard (SGL,1999) present several ways to model a perception of future health effects. The first method is to assume that each cigarette smoked reduces one's life expectancy by a fixed amount of time. For example, a recent study reported in the British Medical Journal indicates that every cigarette consumed reduces one's life by eleven minutes.[13] An alternative approach is to assume that each cigarette raises the

[12] See Goldbaum (2001) for an explicit treatment of end-of-life health effects in a Becker-Murphy type model.
[13] Dr. Mary Shaw et.al. British Medical Journal 2000;320:53

probability of early death in all future time periods. For computational efficiency reasons, I will adopt the first model since the results are quite similar under either assumption.

Consider a person who expects to live until an age defined by their life expectancy. Suppose every cigarette consumed reduces this person's life expectancy by a fixed amount of time. Individuals evaluate future losses by calculating the present discounted value of the expected reductions in length of life weighted by their expected utility in that period. The expected future health losses, L, can be written as,

$$L(c,S_A) = z \int_{75-b(S_A+ES)-bc}^{75 - b(S_A+ES)} e^{-r(t-T)} dt \tag{4}$$

In this paper I'll begin with an individual approximately 15 years old. I'll assume a 15 year old expects to live to age 75.[14] Assuming every cigarette smoked reduces life expectancy by a fixed amount, a smoker's life expectancy at age A can be written as (75 - $b(S_A + ES)$, where b is a parameter indicating the number of years of lost life per cigarette, S_A is the stock of cigarettes consumed by age A, and ES is the expected stock of future consumption. The effect of future consumption on health, and thereby an effect on current consumption decisions, is incorporated with ES. ES is directly associated with a person's expectation about how long he will continue to smoke. The appropriate value to use for "b" is the individual's expectation of loss of life, which may or may not equal the actual loss of life. Survey results by Viscusi (2001) in Spain show that people estimate that 20 years of smoking 20 cigarettes per day will lead to a 10.94 year reduction in life expectancy. Based on this, I will assume that each cigarette causes a loss of 39 minutes of life, which is

[14] US life tables from 2000 indicate that life expectancy for a white male 15 year old is about 60 years, for a black male it is 54.6 years while for females it is 65.2 years. See http://www.cdc.gov/nchs/fastats/pdf/nvsr51_03t11.pdf

considerably higher that the actual effect which is estimated to be between 7 and 11 minutes per cigarette.[15] In the expression, "bc" represents the additional loss of life that arises due to the additional cigarettes, c, smoked at age A. z represents the per period expected utility value attributed to one's end of life. The health losses, then, represent the additional losses of utility that occur due to the additional cigarettes smoked this period, discounted at a rate of r, from the perspective of time T.[16]

Health losses increase with smoking since each cigarette eliminates expected benefits in the final moments of life. Losses rise at an increasing rate because each cigarette draws the terminal date closer resulting in a higher discount factor being applied to the final minutes of life.

2.3. Withdrawal Costs of Quitting

I assume that a smoker experiences withdrawal symptoms inducing utility losses when reducing consumption below a previous habitual level. Define the habitual level, h, as the previous year's daily smoking rate. These withdrawal symptoms represent a kind of adjustment cost that occur only with reductions in consumption; the greater the reduction below the habitual level, the greater the cost incurred. These well-documented costs may

[15] It is important to recognize that we are merely trying to incorporate, in a mathematically useful way, a person's *feeling* that smoking is harmful due to future health consequences. That feeling may not correlate very well with actual, statistical, estimates of expected loss of life since most individuals do not have that information readily at hand. Instead people process information heard in a variety of contexts into a negative feeling that weighs in upon them. Different individuals may have widely different inputs and may process that information differently, leading to significantly variable feelings about the future health consequences of smoking.

[16] For most of the analysis I assume T = A. In other words, a person evaluates the health effects at the time one makes the decision. However, when regret is considered later in the paper, the period of evaluation T will not be the same as the period in which a choice is made.

include anything from a loss of concentration to extreme irritability.[17] We use the following functional form to represent an individual's withdrawal adjustment costs C:

$$C_A(c, S_A) = \begin{cases} \rho\sqrt{S_A\,(h^2 - c^2)} & \text{if} \quad h \geq c \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

The function is chosen to have several important features. First, adjustment costs are assumed to be zero for all consumption levels *above* the previous year's level of smoking, h, which is treated as the habitual level. Withdrawal costs rise as smoking is reduced below the habitual level. This implies that C is a decreasing function as c, the current level of smoking, rises. Second, these adjustment costs are assumed to be a function of the past stock of smoking, so that as the stock, S, rises, ceteris paribus, the adjustment cost of reducing consumption also rises, albeit at a decreasing rate. The idea is that withdrawal effects are likely to be larger the more habitual is the past usage of cigarettes. Lastly, ρ is a scale parameter that affects the magnitude of these adjustment costs.

2.4. The Consumption Choice Problem

I assume that an individual at age A chooses a quantity of current cigarette consumption and a quantity of a composite good "y" subject to a budget constraint so as to maximize the present value of the previously defined current and expected net benefits. Define cigarette utility as $U_A(c, S_A) = B_A(c, S_A) - L_A(c, S_A) - C_A(c, S_A)$. Total utility, W, is

[17] Withdrawal effects incorporate negative reinforcement effects into the individual's choice problem. See Eissenberg (2004) for an overview of negative reinforcement models in the literature.

given as the sum of utility from cigarettes and utility from composite good consumption, i.e., $W_A(c,S_A,y) = U_A(c,S_A) + \Gamma(y)$. The individual's problem is,

$$\begin{aligned} &\underset{c,y}{\text{Max}}\ W_A(c, S_A, y) = U_A(c, S_A) + \Gamma(y) \\ &\text{s.t.} \qquad p_s c + p_y y = I_A \end{aligned} \tag{6}$$

Assume that the individual makes an annual decision about how much to smoke. One year corresponds to one period in the model. Let c_t represent the average daily number of cigarettes consumed in period t. Assume the smoking stock depreciates at a rate of δ per year. The smoking stock at age A can now be written as

$$S_A = \int_{t=15}^{A} (1 - \delta)^{A-t} c_t \, dt \tag{7}$$

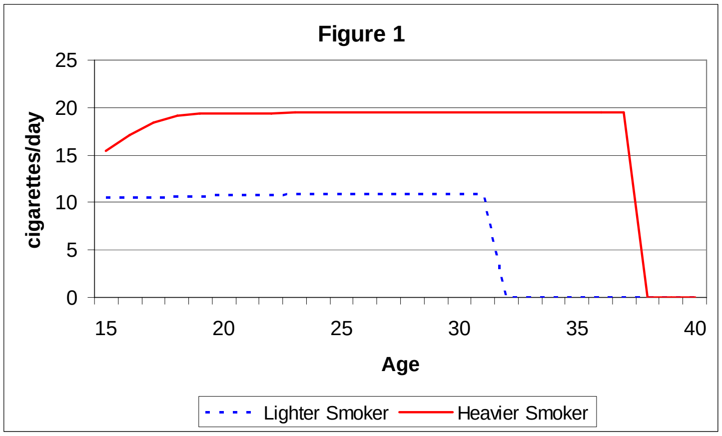
As mentioned previously, I'll assume that a shock to the α_C parameter in the benefit function occurs at some date in the teen's life. The shock involves a sudden realization that there is positive utility associated with consumption of cigarettes. I'll also assume that a teen's income, used to purchase cigarettes, is fixed. This abstracts from the reality highlighted in Emery et. al. (2001) that youths do not begin to buy cigarettes until they become regular smokers. I'll also ignore the fact that teen income may not be the appropriate budget constraint since they often rely on transfers from parents or obtain free cigarettes from peers. Time paths of consumption are determined beginning at the time of the shock with a teen agent who has no prior history of smoking. Optimal consumption for the teen in that year is then calculated. For each successive year, determining the new consumption level involves the following: a) the consumption stock is updated with the prior year's smoking rate; b) depreciation of the smoking stock is calculated; c) the habitual smoking level is reset at the previous year's smoking level; and d) re-optimization occurs. The individual **only** decides how much to smoke in the current year and does not attempt to choose or predict future smoking choices. It is in this sense that the teen's rationality is bounded. He makes a reasoned decision taking some information about future mortality effects into account, but he does not attempt to calculate the full future consequences of today's smoking.

3. Simulation Results of the Model

3.1. Representative Smoking Time Paths

Smoking behaviors within the population are extremely diverse. Most people never pick up the habit. Others smoke for a short while and then quit. Others still, begin smoking when young and continue throughout their life. This model can explain each of these patterns, and many more, if we assume that different individuals face different parameter values. For example, if the benefits of smoking were very high, the cost of quitting high, and/or the perceived health costs of smoking very low, then a person would smoke for his entire life. If these parameters were skewed in the opposite direction, then a person might decide never to smoke. Understanding how these parameters affect the time path, provides an understanding of why people respond differently to similar stimuli (i.e., same prices, same advertising, etc.)

Consider a teen that experiences a shock to his utility function at age 15 in the form of an instantaneous increase in the parameter α_C from 0 to a positive number. I will consider two separate time paths, shown in Figure 1, one for a light smoker and one for a heavier smoker. The light smoker time path assumes a smaller value for α_C. The path for the heavy smoker not only has a higher value for α_C, but also is assumed to have a higher value for the

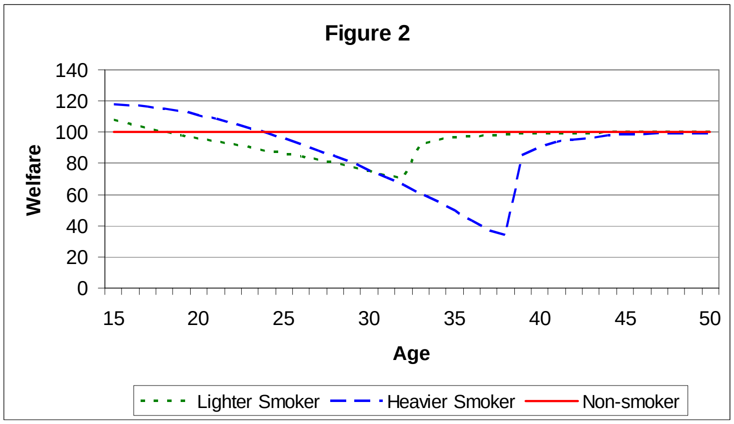


reinforcement parameter, α_{CS}. For the light smoker, consumption in the initial period is just over 10 cigarettes per day. The time path shows a very moderate consumption increase to a plateau, attained through most of his smoking life. At age 34, this smoker instantaneously quits smoking, cold-turkey, and refrains from smoking forever after. For the heavier smoker, there is a more prominent increase in the rate of smoking in early years. This arises from the stronger reinforcement effect and is consistent with teen smoking behavior.[18] The heavy smoker also reaches a plateau and also quits cold-turkey. However, the heavier smoker quits more than five years later than the lighter smoker; this despite the fact that both smokers are assumed to have the same withdrawal, or quitting cost, function. Thus, the model is consistent with the observation that heavier smokers wait longer to quit than lighter smokers.

The reason for the shape of the time path can be seen more readily by plotting the smokers' utility levels at each age. This is shown in Figure 2. The base line utility, i.e., utility attained if the individual were a non-smoker his entire life, is normalized to 100. For both types of smokers, smoking raises utility in early teen years above that attained from abstinence. At about age 20 for the lighter smoker (25 for the heavy smoker), the welfare level dips below that which would have been attained had he never smoked. It is at this stage that a smoker is likely to regret his decision to start smoking and wish he were a nonsmoker. However, it is not optimal for the smoker to quit at this stage due to the presence of quitting

[18] A survey of California smokers shows that mean daily consumption for teen smokers was 12.5 cigarettes per day , increasing to 15.5 cigarettes per day for daily smokers in their thirties. This is consistent with the reinforcement effect generating increased usage over time. See Pierce et.al. (1998).

costs. Quitting would be more painful than continuing to smoke. Thus the smoker will continue to consume for another 10 plus years, perhaps all the while feeling unhappy about it.[19] When cold-turkey quitting occurs at age 34 for the lighter smoker (age 39 for the heavy smoker), the smoker actually becomes even more miserable during the quitting year.



However in the next and subsequent years, utility rises rapidly since quitting costs are assumed to last for only one year and because smoking stock depreciation reduces the perceived future health consequences of past smoking. Within about 5 years after quitting for both smokers, welfare levels will approach the level attained if one had never smoked.

3.2. Measuring Lifetime Utility

Measuring lifetime utility for this individual raises some important issues. It is typical to evaluate welfare on a discounted basis from the viewpoint of the year in which the analysis takes place. By its nature, discounting puts greater emphasis on the present over the future. However, arguably, from a more detached perspective for policy analysis, one should not put greater emphasis on any one year over another. Similarly, and ideally, a person planning one's own life dispassionately, ought not weight different periods differently. As Jevons put it, "to secure a maximum benefit in life, all future events, all future pleasures or pains, should act upon us with the same force as if they were present,

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[19] This is the justification for the "unhappy smoker" provided by Suranovic, Goldfarb and Leonard (1999).

allowance being made for their uncertainty … time should have no influence."[20] Jevons conceded that discounting must be applied to describe how individuals actually do make intertemporal decisions. However, the reality of discounting represents at best a problem to be overcome, and at worst a character flaw.

For these reasons, I evaluate welfare effects ex post, using the undiscounted sum of utility obtained by an individual during his lifetime. For contrast, I will also present the discounted values of each lifetime utility stream for several different discount rates.

With this in mind, consider the lifetime welfare effects of the lighter smoker versus a nonsmoker in the above example. Assume the individual lives until age 75, his age 15 life expectancy. The discounted values are evaluated from the perspective of age 15.[21]

Table 1
Lifetime Welfare
(Normalized to non-smoker case)

	Zero discount	5% discount	10% discount	25% discount
Non-smoker	100	100	100	100
Light Smoker	96.4	94.6	95.4	101
Heavy Smoker	93.4	94.9	101.2	113

Table 1 shows that if we compare undiscounted utility between a non-smoker and a smoker, the non-smoker is best-off, while the lighter smoker is better-off than the heavy smoker. Evaluated this way, smoking harms the smoker and the more cigarettes smoked, the worse-off a person will be. Despite this, because of the way in which the individual makes his

[20] From Jevons (1872), quoted from Peart (2000) who also discusses similar points of view in the writings of Fisher, Marshall and Pigou.

[21] Note that utility is summed to age 75 for both non-smoker and smokers. This is because both representative smokers eventually quit. In time, the depreciation of the smoking stock implies that the life expectancy effect reverts back to that of a non-smoker. If the smoker smoked till the end of his life, then lifetime utility would be reduced by the early loss of life.

period-by-period decision, in other words, due to his bounded rationality, he would still choose to smoke even though it will harm him over his lifetime. In contrast, if we assume the 15 year old has the information concerning his future utility stream under both smoking and non-smoking scenarios, he might evaluate these by comparing the present discounted values of future utility streams. At a low discount rate of 5%, non-smoking continues to dominate smoking for both the light and heavy smoker. At a 10% discount rate, the heavy smoker perceives a lifetime of smoking to be better than not smoking while the light smoker would still prefer not to smoke. At the much higher discount rate of 25%, both light and heavy smokers would prefer the smoking path over the non-smoking path. This suggests why some authors contend that a very high discount rate is needed to make an individual choose to be a smoker at young ages. However, this conclusion holds only if it is also assumed the individual is indeed maximizing the discounted value of the stream of lifetime utility. In this paper's approach, high discount rates are not needed. Instead, bounded rationality in the form of period-by-period optimization generates the observed consumption patterns.[22]

3.3. Smoking Initiation

The time path of smoking and the lifetime utility effects of smoking will depend in this model on the timing of smoking initiation. In the above example, smoking onset is at

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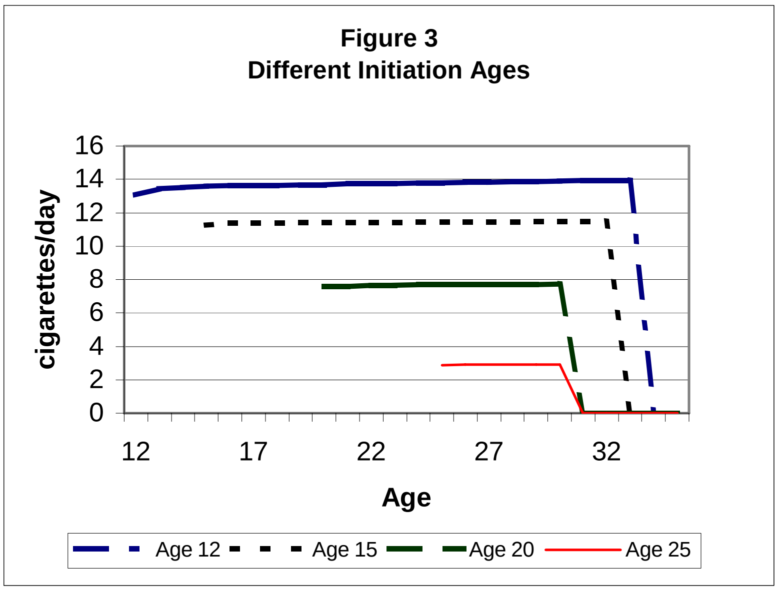
[22] Becker and Mulligan (1997) build a theory of endogenous time preference based in part on the observation that individuals have excessively high discount rates especially when young.

age 15, when a shock is presumed to have occurred. In Figure 3, time paths of smoking rates are shown for alternative onset shock ages; age 12, 15, 20 and 25, each in the case of the lighter smoker. The model shows that the earlier the onset shock of smoking among teens, the higher the daily rate of smoking and the longer smoking will continue before quitting occurs.[23] Figure 3 indicates that when smoking begins at age 12, the teen will plateau at 14 cigarettes per day, compared to 11 cigarettes for age 15 onset, 8 cigarettes at age 20 and 3 cigarettes at age 25. Thus, preventing early smoking initiation by youths will reduce the likelihood that they would ultimately begin. This outcome occurs in the model because the health consequence of each cigarette becomes higher as one becomes older.[24]



Lifetime welfare for each of the time paths indicates that undiscounted utility rises as the date of smoking initiation increases. This offers support for the notion that today's teens would be better-off over their lifetimes if smoking initiation is effectively delayed or prevented.

Another aspect of teen smoking not modeled here, but supporting this conclusion, is the changing influence of peer pressure as one gets older. It is likely that the benefits of

[23] This result is consistent with Gruber and Zinman (2001) and Auld (2003). Auld's data suggests that a youth who initiated smoking before age 14 is 5.5 times more likely to smoke later in adolescence than a youth that did not begin so early.

[24] Note that this result is not sensitive to the parameter values but to the nature of the utility maximization. Any person whose parameters lead them to smoke would exhibit this pattern.

smoking may fall as the teen moves into adulthood. Peer pressure, which is all-important in teen years, may disappear entirely once a person reaches his twenties. This could be modeled as a falling α_C since the benefits of smoking would wane in time. This, coupled with the rising health effects, would make it even less likely for an older youth to choose to begin smoking. This also is consistent with the observed evidence that almost all smokers began in their teen years.

3.4. Ex Post Regret

One piece of evidence sometimes cited to support cigarette regulation is the fact that smokers often wind up regretting their earlier decisions to smoke. Many smokers even regret smoking while they are smoking. This type of behavior truly confounds the rational choice approach to explaining addictive behavior. One paper that addresses this issue is by Orphanides and Zervos (1999). Their paper extends the Becker-Murphy rational choice model to include uncertainty about whether one is an "addictive type" or not. The addictive type suffers negative consequences from smoking in the future whereas a non-addictive type does not. At smoking onset, an individual does not know which type he is and thus makes a decision based on presumed probabilities. Later, his type is revealed to him. If he had chosen to smoke and ultimately learns that he is an addictive type, he regrets his initial decision.

However, this type of regret can only occur once a person begins to suffer negative consequences from smoking. In reality, many smokers regret their decision to begin smoking long before they experience such negative consequences.

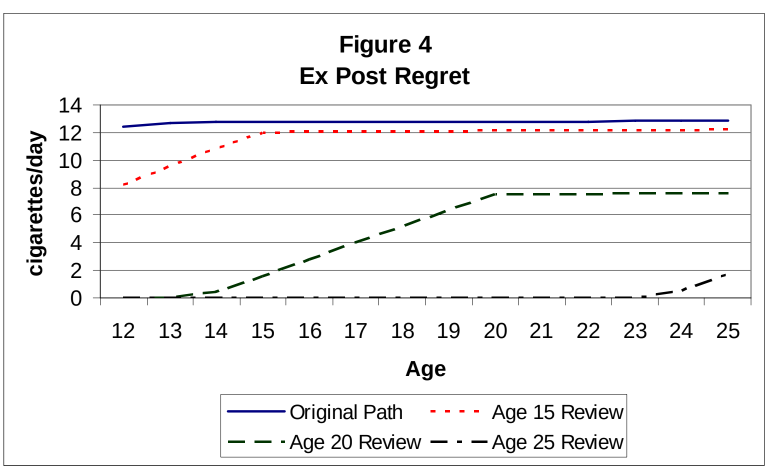
This paper offers two distinct ways to model regret, neither of which is based on an ex post discovery of bad news. The first way is based on a simple comparison of the smoker's current utility, with the utility one would have attained had one never smoked. This is a simple comparison for a person to make since the thought experiment requires only the determination of how one would feel today if one had never smoked a cigarette, did not have an urge to smoke a cigarette, did not experience any withdrawal effect from smoking, and felt no concern about one's future health consequence from smoking. This is equivalent to asking, what if I receive no utility or disutility from cigarettes? Comparing that with a smoker's utility from smoking will generate regret whenever the net utility effects of present smoking are negative. As shown in the above welfare plot in Figure 2, welfare will fall below the non-smoking, baseline level, for quite a few years before smoking cessation occurs. During this entire period a person would reasonably regret his decision to become a smoker. However, he cannot instantly erase the pent up stock effect of past smoking, therefore he cannot eliminate the painful withdrawal effects that would arise from cessation. Thus, he continues to smoke, and continues to regret it, until the cost of quitting is less than the cost of continuing.

The second way a person might come to regret his past decisions is through a kind of ex post evaluation of past decisions. Suppose a person were to contemplate at the ripe old age of 20, whether he *should* have smoked back when he was a teenager. More specifically, suppose a person were to calculate the optimal level of age 15 smoking from the vantage point, or perspective, of a 20 year old. How would he perform such a calculation?

Just as we would expect a person to discount future utility, such as the future health consequences, in order to value it today, so we should expect that a hindsight evaluation would also discount the decisions of the past proportional to one's "distance" from them. For example, the peer pressure effects, and hence the benefits from smoking, are likely to be weighted much more highly by the teen at age 15, than it would be by the "mature" 20-year-old. The 20-year-old self will be less likely to think that such peer pressure will contribute as much to their sense of well-being. The 30- or 40-year-old self would probably think even less of the peer pressure effects.

Thus, a simple way to model this effect is with a hindsight discount factor. A 20 year old will discount age 19 decisions by one year and age 15 decisions by 5 years, etc. Although we do not have an explicit peer pressure effect, one can still consider such ex post evaluations in the context of the model. The results are shown in Figure 4 for the case of the lighter smoker.

The figure shows that a 15 year old teen would prefer to have smoked about 40% less at age 12 than he actually did. Subsequent year smoking levels rise up to a similar level to his current age 15 rates. For the 20 year old looking back, however, he would prefer to have never started smoking at age 12. His optimal smoking rate is considerably reduced for all years in hindsight including the current year. The reason he prefers to be smoking less currently, at age 20, is because he wishes he had a lower past smoking stock, which would in turn enable him to smoke less today. At age 25 the



smoker wishes he had never smoked at all during his teen years. He would still like to smoke a small amount presently (perhaps preferring to be an occasional smoker), but he clearly regrets his past smoking history. If the evaluation is pushed up further to age 30, which is four years earlier than when he would otherwise have quit cold-turkey, the smoker's optimal time path is zero for all years. At this stage, the smoker clearly regrets that he had ever begun to smoke.

Notice however, that regret, in this model, does not arise due to a lack of information. The individual has precisely the same info available at all dates. However, the information is processed differently, i.e., weighed differently, depending on one's vantage point in time.

3.5. Teen Smoking Intervention

As shown above, teens who choose to smoke may be reducing their welfare and are likely to regret their decisions at some future date. For these reasons it may make sense to intervene to prevent or reduce the initiation of smoking and the rate of smoking. The question then becomes, what methods are likely to be most successful in achieving that goal?

The model shows that teens choose to smoke because the sudden and immediate benefits outweigh the perception of future health costs. Afterwards, teens become entrapped in smoking because the withdrawal costs increase together with their growing habit. In order to change behavior, intervention that will change the parameters affecting teen decisions is required. Next I will discuss several non-tax alternatives before focusing on taxation.

3.6. Health Consequences

Since the Surgeon's General 1960s report on the dangers of smoking, media attention has continued to raise public perception of smoking risks. School children are taught in elementary schools about the dangers of smoking in drug awareness programs. This increased awareness has contributed to a substantial decrease in the smoking rate in the US, down from 42% of adults in 1965 to 23% in 2001. This result is consistent with our model since any increase in the perception of future health consequences will prevent some individuals from starting to smoke and will induce some smokers to quit earlier.

However, the effect of this governmental and media attention may have been to exaggerate perceptions of negative health consequences.[25] Thus, additional attention on the health consequences of smoking is unlikely to have a profound effect, especially for teens. Because teens already have good, perhaps even exaggerated, information about health consequences, and because teens discount future health effects much more than adults, because these effects are more distant, this is a very weak lever for affecting teen decisions.

3.7 Quitting Difficulties

An alternative approach, complimentary to information about health effects, is to emphasize the withdrawal effects and the difficulties with quitting. If teens are aware that entrapment may occur, such that a few cigarettes today may lead to a lifetime of smoking, they may be more likely to refrain. In the model this effect can be captured through the expected future consumption effect (ES in equation (4)). The more difficult one expects quitting to be, the higher will be one's future expected smoking level and the higher will be

[25] See Viscusi (1992) and Lundborg and Lindgren (2004) for evidence suggesting that smokers overestimate the true risk of smoking.

the expected losses from smoking. Thus, the model shows that the greater the expected quitting difficulty, the less likely for a person to smoke. The corollary is also predicted. The easier teens expect the quitting process to be, the more likely it will be for them to begin smoking. Thus, information about new effective quitting techniques, may actually lead to an increase in smoking rates. In essence, information about quitting difficulties represent an encouragement to plan more intelligently; to recognize that today's smoking may affect tomorrow's decisions and to plan for one's future welfare. In this sense, it is like asking people to become more effective intertemporal optimizers and to overcome problems associated with bounded rationality.

3.8. Resisting Peer Pressure

Programs for elementary school children recognize that children often are introduced to smoking by their siblings and friends. Thus, considerable emphasis is placed on teaching children to resist peer pressure.   In terms of the model, this is an attempt to affect the α_C parameter that affects the size of the benefits obtained through smoking. Peer pressure consists of encouragement to conform to the group and potential threats of banishment if one does not conform. Although a teen's initial perceived benefit from smoking may be low to non-existent, peers can affect the perception of benefits and costs and induce a person to begin smoking.

One potential problem with this intervention is that it is, in effect, asking teens to disregard a component of their benefit function. To resist peer pressure means to ignore a very real component of the initial benefits of smoking. This would seem, prima facie, to be a very difficult thing for teens to do.

3.9. Image of Smoking

Nevertheless, attempts to affect the α_C parameter may still be an effective method, especially since it is a shock to this parameter that initiates smoking and its size affects how much a teen will smoke. Furthermore, reducing perceived near term benefits for teens should be more effective than raising perceived health costs at the end of life, due to the discounting of future health losses.

One effort in this regard is the attempt to restrict cigarette advertising, especially when directed at teenagers. Well-known ads featuring the cartoon character Joe Camel had been widely criticized for their suspected appeal to teens or pre-teens. In 1997 RJ Reynolds agreed to eliminate all ads featuring the character. More recent efforts have focused on reducing smoking in major Hollywood motion pictures. A recent study suggests that over 50% of adolescent smoking initiation can be attributed to smoking in movies.[26]

Reducing the "glamour" of smoking is perhaps the most direct method to affect teen smoking initiation rates since this will lower the size of the shock parameter α_c in the benefit function. If many teens come to believe smoking is not glamorous, then peer pressure effects will be simultaneously reduced as well. However, policy effectiveness will also be influenced by whether public pressure or policy can induce the necessary changes in advertising, movies and other venues where smoking is glamorized.

4. Effects of Cigarette Taxation

[26] See Dalton, MA et.al., (2003).

Higher taxes are often suggested as a policy to help reduce or prevent teen smoking. There have been numerous empirical studies investigating the effects of taxes or higher prices on teen smoking. Ross and Chaloupka (2003) survey these studies and show that the results appear mixed. Some studies suggest some responsiveness to price. Some show more responsiveness for teens than for adult smokers. Other studies suggest there is little to no effect upon teen demand in response to price. However, more recent studies suggest that price increases can affect the initiation of cigarette smoking.[27]

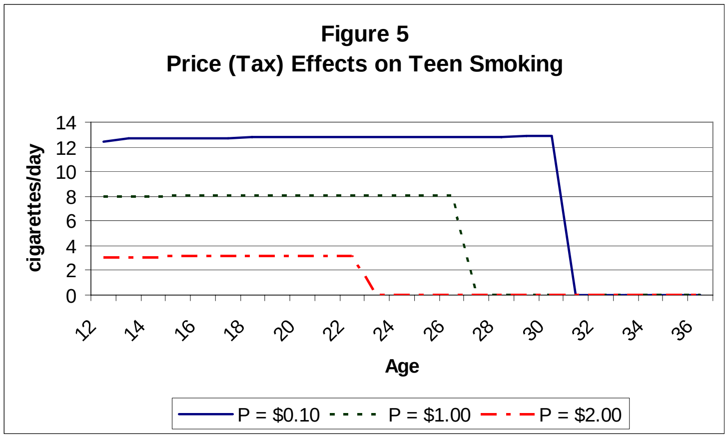
Using this paper's model, we can investigate probable behavioral reactions to higher cigarette taxes imposed at different stages of a teen's smoking history. Higher prices are assumed to come about as a result of an increase in a tax. First, I'll consider the effects of imposing higher prices at the time the person reaches his teen years with these prices remaining high for the person's entire life. Next I'll consider the effect of higher prices imposed on a teenager who has already begun to smoke. Finally I'll consider the effects of a teen tax that raises prices only during a smoker's teen years.

4.1. Lifetime Tax

First, consider the effects of imposing a tax over the teen's entire life. Figure 5 shows the effects of different prices on the heavier smoker. The original price is assumed to be 10 cents per cigarette, which means a price of $2.00 per pack. The solid line shows the consumption path at this price. Smoking reaches a plateau at about 13 cigarettes per day and cold-turkey quitting occurs at age 31 for this representative smoker. A 10% price increase has an almost imperceptible effect, so it is not displayed. If the price rises tenfold to $1.00 per cigarette the smoking rate is cut to about 8 per day and quitting ultimately occurs earlier

[27] See for example, Tauras and Chaloupka (1999), DiCicca et.al., (2002) and Emery et.al., (2001).

at age 26.[28] If the price is raised twenty-fold to $2.00 per cigarette, the smoking rate is reduced to about 3 per day and quitting occurs at age 22. If the price is raised slightly higher the teen could be induced to completely refrain from smoking forever. Hence the model suggests that higher cigarette taxes are likely to reduce the quantity of cigarettes smoked over a smoker's lifetime and to induce an earlier quit date. This is consistent with the findings of Hamilton et. al (1997) who showed lower quit rates and higher initiation rates in Canada after a price increase in the 1990s. Secondly, the results show that much higher cigarette taxes, which raise prices proportionally, could reduce or eliminate teen smoking but the levels of taxes may need to be quite high.



The total welfare attained for each price is shown in Table 2. Also shown is the welfare level for a non-smoker. This corresponds to the case of a tax set sufficiently high to eliminate all smoking. The first column demonstrates that undiscounted welfare rises as the price/tax is increased. Thus, the greater the tax, the greater will be the lifetime utility of this representative smoker. If, in contrast, welfare is discounted from age 12 at a sufficiently high rate, say as at 20% as shown in column 2, the price/tax increase would not raise welfare. In this case, the higher discount rate makes the smoker much more concerned about the extra

[28] This corresponds to an elasticity of demand around -0.05 which is much lower than typical estimates. Measured elasticities are based on average effects across many different smoker types of many different ages. However, what is shown is simply the effect for one representative smoker. There has been no attempt to calibrate the model to mimic an average smoker since the point is more to demonstrate how variability in behavior can be explained.

cost of smoking in his early years due to the tax, and much less concerned about the future health benefits that arise from smoking reduction and earlier cessation.

Table 2 **Welfare and Expenditure Effects of Taxes** (Welfare normalized to non-smoker case)			
	Undiscounted Welfare	20% discounted Welfare	Average daily expenditures
Non-Smoker	100	100	$0.00
Price = $2.00	99.4	98.4	$6.26
Price = $1.00	98.1	98.8	$8.05
Price = $0.10	96.2	102	$1.27

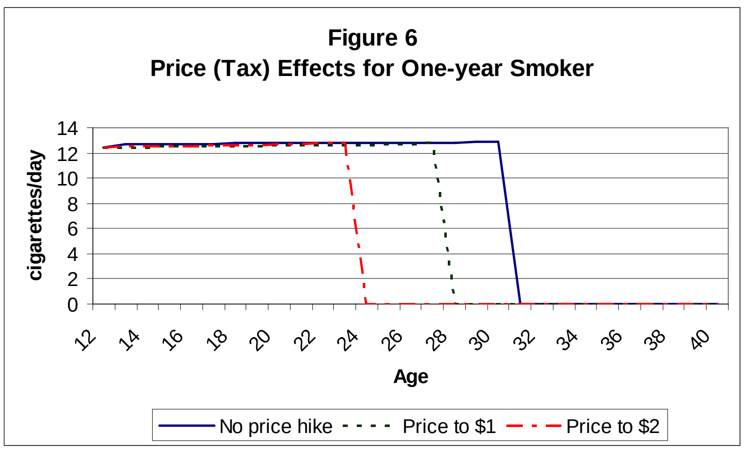
Note also that daily expenditures rise dramatically for the continuing smoker as price/tax is raised despite the reduction in consumption. At the price of $2 per cigarette the reduction in consumption finally catches up with rising price and total cigarette expenditure falls.[29]

On the other hand, this analysis treats teens and their consumption decisions as if they had their own income and made choices about how to allocate spending between cigarettes and other goods. Since early teens are dependent on their parents for most of their consumption, the effects of higher prices may not work as shown. Indeed, teens may be more sensitive to price changes than indicated especially if cigarettes make up a substantial amount of their disposable income.

[29] For a heavier smoker undiscounted welfare can fall with the increase in the price/tax. This is due to the fact that a much larger share of income is spent on cigarette consumption and quitting occurs at a much later date, if at all. This suggests that the welfare effects will be influenced by the type of smoker an individual is.

4.2. Tax after smoking initiation

Next consider a tax on cigarettes that is implemented after a teen has already begun to smoke. Figure 6 depicts a base case smoking path for a smoker that begins at age 12 and permanently faces the initial price of $0.10 per cigarette. The effect of a price increase is shown in two cases. The "price to $1" line shows the path for a smoker who begins at age 12 but experiences a 10-fold price increase one year later. Note that the large price increase has almost no effect upon the smoker's consumption level. It will reduce it very slightly, but not even a discernable difference. The main effect of the price hike is to induce quitting three years earlier.



An even larger price hike to $2 at age 13 is also shown. A similar effect occurs: no significant decrease in the smoking rate, but quitting now occurs 5 years earlier.

The reason for this result is the presence of quitting costs. Once the teen has smoked for an entire year, he has built up a stock of consumption that in turn raises the withdrawal cost of quitting. Thus, despite the much higher prices, the teen will become trapped in his original decision.

If the price is raised much higher than $2, even earlier quitting can be induced. In the limit, if the price is increased sufficiently, immediate quitting would occur. However, the magnitude of the price increase needed to achieve this may be enormous due to the inelasticity of demand.

4.3. Effect of a Teen Tax

One last policy change worth considering is the effect of a teen tax. It is commonly reported that the majority of smokers began their habit when they were teenagers. Furthermore, very few people begin to smoke in their twenties. Thus, one might conclude that if higher taxes and/or restrictions on teen smoking were implemented, this could prevent the onset of smoking and help people to lead smoke-free lives.

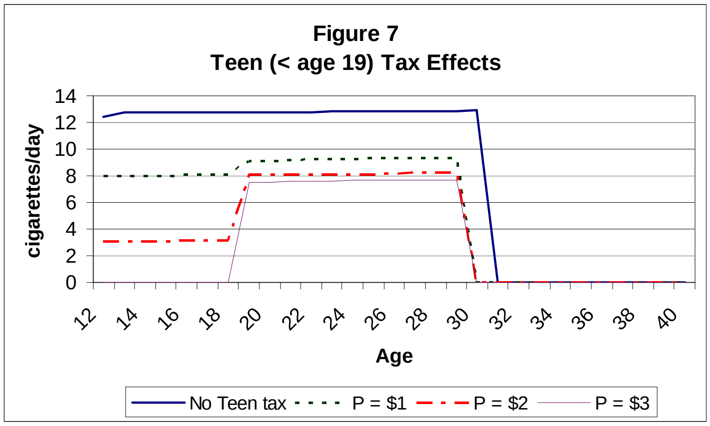
Possible restrictions include more stringent prohibitions for sales of cigarettes to minors and higher penalties for sales to minors. Since these types of regulations are targeted at teens, objections related to government paternalism are tempered slightly. These policies would be designed to affect underage teens, but leave the sales of cigarettes to adults largely unrestricted.[30]

Although the implementation of these policies might differentially affect the costs and benefits of smoking, I will assume for simplicity that the effect can be translated into a dollar equivalent tax. In other words, suppose the effect on teens of an increase in smoking restrictions were equivalent to an increase in the price of cigarettes. Since these prohibitions affect teens and not adults, the effective price increase is presumed to occur only during the teen years.

Figure 7 displays the results for different levels of a teen tax. The original path for a smoker who begins at age 12 is shown as the solid line. The other three lines show the effect of an increase in price that obtains only for ages 12-18, with the price reverting to its original level afterwards. Notice several things. First, the effect of greater restrictions or taxes on teens is to reduce the level of smoking during the teen years. If the price is raised high

[30] See Leonard, Goldfarb and Suranovic (2000) for some discussion of paternalism and cigarette regulation.

enough, teen smoking may cease. However, the other, perhaps surprising, result is that these restricted teens will raise their smoking levels once they become adults. This is true even for the smoker who refrains entirely during his teen years. This would suggest that successful prevention of teen smoking may not prevent adult smoking. This result conflicts with the observation that very few individuals begin smoking after their teen years. However, actual observations of twenty-something smoking initiators, does not include individuals who began smoking as teens. This model depicts the effect for a person who, before taxes, would have chosen to smoke but who, after teen taxes are imposed, chooses to refrain. This result is also consistent with Glied (2002) who concludes that, "reducing smoking among teens through tax policy may not be sufficient to substantially reduce smoking in adulthood."



However, despite the fact that adult smoking rises once the teen tax is removed, the model predicts considerable reduction in smoking rates relative to the no teen tax base case. Furthermore, quitting occurs at an earlier age for all who faced the teen tax.

The lifetime welfare level for each smoking path is shown in Table 3. I present undiscounted welfare and welfare discounted at a 15% annual rate from the perspective of the 12 year old. In terms of undiscounted welfare, the higher the teen tax, the greater is lifetime welfare. If we consider discounted welfare, then all tax plans are inferior to no tax from the teen's perspective since he would place considerable weight on the smoking opportunities foregone due to the higher taxes. If the discount rate were lower, say at 5%, then the welfare effect follows the undiscounted pattern in that the higher the tax the better off is a person.

Table 3
Lifetime Welfare with Teen Taxes
(normalized to base case)

	Undiscounted	15% discount
No Tax Base Case	100	100
Lower Tax	101.6	98.5
Medium Tax	102.0	98.2
Higher Tax	102.5	99.4

One other factor not included in the model could make the teen tax even more effective. If all, or most, teens refrained from smoking during the teen years, that might affect the final size of the α_C parameter. Recall that this affects the perceived benefits of smoking. Those benefits might be much larger in the situation where many other teens smoke with associated peer pressures. However, if individuals can avoid those pressures in their teen years, these benefits might be much smaller once the individual is in his twenties. This would imply that smoking initiation, once the teen tax is removed, might not occur. In this case the teen tax would prevent the onset of smoking and result in a definite increase in lifetime welfare.

5. Conclusion

This paper has applied an economic model of smoking behavior to the issue of youth smoking initiation. Initiation begins with a shock to the smoking benefit function that makes smoking suddenly desirable. The benefit function incorporates both the peer pressure effects and the pleasures associated with nicotine consumption. The individual also recognizes the long-term negative health consequences by assuming each cigarette will reduce life expectancy. However, since this occurs late in life, it has only a small effect during teenage years. Once regular smoking begins, the smoking stock, or smoking history, rises to induce a reinforcement and tolerance effect typical of addictive goods. Cessation of smoking is also assumed to induce a withdrawal effect causing a loss of utility.

The model assumes a youth makes a decision each year about how much to smoke to maximize net benefits. He or she weighs the benefits of smoking against the expected loss of life effect and the effects of potential withdrawal. The paper presents several timepaths of lifetime smoking histories that can arise under these assumptions. The paths demonstrate that once smoking begins, daily consumption may initially increase due to the reinforcement effect. Eventually a plateau is reached and maintained throughout one's smoking years. Once the smoker reaches his 30s, smoking is suddenly ended cold-turkey. This occurs because eventually the loss-of-life effect outweighs the withdrawal effects. The timepaths clearly demonstrate that the kinds of smoking behavior typically observed can be explained under the assumptions of the model. Heterogeneity of parameter values among individuals would allow depiction of a wider range of smoking behaviors, including individuals who would choose to smoke their entire lives and those who would refrain their entire lives.

Calculation of welfare effects for a representative smoker shows that although smoking may raise welfare above the non-smoking baseline for several of the teenage years, during most of a youth's smoking history utility falls below that baseline. Simple summation of undiscounted welfare is used to show that smoking can reduce over-life well-being for some smokers. The reason a person chooses something that makes him worse-off is due to a simple bounded rationality assumption. The teen simplifies the choice problem by choosing only for today, rather than planning a consistent over-life consumption pattern. It is also shown why, under these assumptions, a teen may eventually regret his past decisions.

These implications support efforts for intervention, either governmental or otherwise, to help prevent smoking onset. This model suggests that interventions can reduce smoking and can be welfare improving for some smokers. In essence, interventions prevent choice mistakes that arise because of difficulties in planning a consistent overlife consumption plan.

However, different types of intervention can have surprising results. For example, expanded education programs to inform youths about the dangers of smoking are unlikely to have much impact. Youths are reasonably well-informed already and are incorporating that information into their choice problem. Moreover, the health consequences are so far in the future, it would be necessary to considerably exaggerate the effects to have even a small impact on teen decisions.

Taxes (implemented as price increases) are also considered. It is shown that sufficiently high taxes could eliminate smoking and improve the lifetime utility of smokers. However, for the representative smokers shown, these taxes would need to be very high throughout the individual's lifetime. If taxes were raised only during teen years, as with a teen tax or with effective regulations, smoking would be reduced, but may not prevent a rebound of consumption once the restrictions are no longer binding. Finally, it is shown that higher taxes implemented after smoking has begun, would have little effect upon smoking levels due to the presence of withdrawal costs. However, such taxes would have the positive effect of bringing forward the date at which quitting occurs.

A key strength of this approach is that it allows us to identify several key parameters that may vary among the population and lead to the heterogeneous smoking patterns that are actually observed. Most aggregate studies presume that smokers all conform to a model fitted to societal averages and ignore the obvious heterogeneity that exists. With a more accurate model describing the individual decision-making process, it is easier to evaluate the effects of diverse policies that influence different aspects of the choice process.

One limitation of this paper is that it simulates consumption paths only for several typical smokers. This makes it impossible to directly infer the effect of different tax rates on aggregate variables such as teen smoking rates, teen consumption levels, initiation rates or quit rates. However, it may be possible to extend this model to simulate the choices of the broader population, by characterizing several different smoker and non-smoker "types" using different parameter combinations. An aggregate model could then be calibrated by matching the simulated aggregate results to estimated demand elasticities. It would then become possible to simulate the aggregate effects on smoking patterns due to tax increases. This task remains for future research.

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