A Modern Economic View of Tobacco Taxation

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"Governments can raise significant revenue through cigarette taxes without placing a large net burden on the poor. Indeed, for most parameter values our calculations suggest that tobacco taxes are progressive."

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Executive Summary

Traditional economic analysis implies that because the net externalities from tobacco use are small and tobacco taxes are borne disproportionately by lower-income individuals, taxes on tobacco products should be relatively low. We reexamine these arguments in the framework of a more accurate model of human behavior, where in each period a person has a taste for immediate gratification she would not have approved of earlier. This conflict between short-run desires and long-run goals leads to over-consumption of tobacco products from the person's own point of view. Since tobacco taxes reduce consumption, they help with this over-consumption problem. Furthermore, if lower-income individuals are more price sensitive, taxes have a larger benefit for them in reducing over-consumption, so that tobacco taxes are less regressive than traditional analysis suggests — and perhaps even progressive. We estimate that in the U.S. context, both of these effects are extremely large. According to our calculations, the monetary value of the health damage from a pack of cigarettes is over $35 for the average smoker, implying both that optimal taxes should be very large and that cigarette taxes are likely progressive. Although we do not have sufficient data to perform a similar estimation, we argue that the same is likely to be the case in low- and middle-income countries.

I. Introduction

Tobacco consumption is the leading cause of preventable death in developed and developing countries. Assuming current smoking trends continue, as many as 650 million of the people alive today will die from smoking-related disease. Within several decades, 10 million people will die annually from smoking-related disease, making smoking the largest cause of death throughout the world.

There is an effective and widely recognized tool to combat tobacco consumption: taxation.

Fortunately, there is an effective and widely recognized tool to combat tobacco consumption: taxation. A large literature shows that higher taxes on tobacco significantly reduce tobacco consumption — while providing a major source of government revenue. Yet tobacco taxation remains controversial for two reasons. First, some calculations show that the level of tobacco taxation exceeds the external costs to society of smoking, so that according to the standard economic model, tax levels are already too high. Second, tobacco taxes are viewed as regressive since lower-income groups spend a higher share of their income on tobacco.

In this paper we provide a strong counterargument to both of these contentions. First, we develop the reasons that tobacco taxes should exceed the level of pure interpersonal externalities. In particular, we will focus on failures of individual self-control which lead to excessive smoking relative to desired levels. In such a case, tobacco taxation can provide a corrective force to combat failures of self-control. Second, we show that in models with self-control failures, tobacco taxes may in fact not be a regressive means of revenue raising. This is because lower-income groups are often more price-sensitive in their tobacco consumption decisions, and as a result tobacco taxes deliver more of a self-control benefit to lower-income smokers by inducing more quitting.

Our analysis yields two formulas that can be easily adapted to country-specific conditions and measures to help aid policymakers in thinking about the taxation of tobacco.

Some counterarguments of this type have been made casually in the past, but they have rarely been supported by rigorous economic modeling. We provide that rigorous support. Building on our earlier theoretical and empirical work, we carefully develop the arguments that support the use of tobacco taxation as a means of both revenue raising and public health promotion. We also discuss in depth the distributional implications of cigarette taxation and show why the standard intuition on this topic may be wrong. Our analysis yields two formulas that can be easily adapted to country-specific conditions and measures to help aid policymakers in thinking about the taxation of tobacco. The first is a formula for the "optimal tax" as a function of the health costs and externalities of tobacco,

the value individuals attach to their lives (and possibly other future costs of tobacco consumption), and the extent of self-control problems in the population. The second formula can be used to adjust the distributional impacts of tobacco taxation, and takes as an input the health costs of tobacco, the value individuals attach to their lives, the price sensitivity of consumption, and the extent of self-control problems in the population.

Tobacco taxes should exceed (likely by a large margin) the externalities imposed by tobacco consumption; tobacco taxes are not regressive so long as the poor are sufficiently more price sensitive in their tobacco consumption decisions.

The report proceeds as follows. In Section 2, we present the traditional economic model of smoking, highlighting the key policy conclusion that tobacco taxes should be tied to the size of the externality imposed by cigarette consumption. In Section 3, we discuss the fundamental flaw with this model: it is inconsistent with all available psychological and behavioral evidence. In Section 4,we develop an alternative model which is more consistent with existing evidence, and we show the two key implications for government policy of such a model: that tobacco taxes should exceed (likely by a large margin) the externalities imposed by tobacco consumption; and that tobacco taxes are not regressive so long as the poor are sufficiently more price sensitive in their tobacco consumption decisions.

II. The Traditional View of Tobacco Policy

Taxes on a product should be set equal to the externalities the product's use imposes on others and should not depend on effects on oneself.

The traditional view of tobacco taxation holds that individuals consume tobacco like they consume all other goods. As such, any costs and benefits to themselves are internal and not subject to government intervention. Instead, the only argument for government intervention is the external impacts that smokers impose on others. That is, under the traditional model, if a smoker smokes by herself on a deserted island and dies 6 years earlier as a result, the government has no role other than the informational one of warning her of those health consequences. On the other hand, if that smoker is uninsured and raises the health costs of others through smoking-related illness, this external impact would justify some form of government regulation of smoking. In particular, the theory of Pigouvian taxation holds: taxes on a product should be set equal to the externalities the product's use imposes on others and should not depend on effects on oneself (which are assumed to be internalized in consumption decisions).

This traditional view is based on a model of individual decision-making, anticipated by Fisher (1930) and developed fully into "exponential discounting" by Samuelson (1937), that effectively reduces an intertemporal choice into an atemporal one. Specifically, even in intertemporal choices,

a person is assumed to correctly maximize a single utility function over the vector of consumption. The utility function is of the form

$$\sum \delta^t u_t,$$

where u_t is instantaneous utility at time t and δ is a "discount factor" between 0 and 1. The actions a person takes at different points in time are just different steps in maximizing the above utility function, and δ allows a person to treat the future as less important than the present, but other than that time plays no role in the formulation. Hence, as with atemporal choices, the theory of Pigouvian taxation holds.

As Becker and Murphy (1988) emphasized, this conclusion holds even if the good in question is addictive and harmful. In that case, the individual optimization decision becomes more difficult because individuals must take into account that additional tobacco consumption today increases the desire to consume in the future, increasing both future monetary costs (through more spending on tobacco) and future health damage. So long as individuals perform this calculation correctly, however, the conclusions above hold: tobacco taxes should be set equal to the level of interpersonal externalities.

Another major externality due to smoking is lower workplace productivity.

This is a striking conclusion, because the general consensus is that the net externalities due to smoking are small. There are some large negative externalities from smoking. For example, one estimate suggests that smoking-related disease raises medical costs in the U.S. by over $75 billion per year (American Cancer Society 2006, page 39). Of course, to the extent that those who smoke pay more for their health insurance, this is not necessarily an externality. In fact, however, most group insurance policies do not charge more to smokers than non-smokers, and much of the cost of smoking-related disease is due to the uninsured (whose costs are covered by insured patients) or those on public insurance (whose costs are covered by taxpayers).

The extent to which health care costs are an externality will of course vary with the underlying nature of insurance coverage. In a very poor nation where there is little insurance coverage and individuals more fully bear the costs of their medical care, there will be little externality from health care costs. At the other end of the spectrum, in systems of national health insurance where all individuals are insured and the financing comes not

† All figures in this paper are in 2006 dollars.

from their own payments but from general revenue sources (as in Canada), then all health care costs due to smoking are external.

Another major externality due to smoking is lower workplace productivity. One study found that smokers impose $600–$1,100 per year in productivity and absenteeism costs on businesses, and another found that smokers miss 50% more work days each year due to illness than do nonsmokers (Manning, Keeler, Newhouse, and Sloss 1991). To the extent that such lower productivity is not fully reflected in lower wages for smokers (as seems likely), then it is an externality to the firm. Smokers are also much more likely to start fires than nonsmokers, mostly due to falling asleep with burning cigarettes: in 2000, for example, fires started by smokers caused 30,000 deaths and $27 billion in property damage worldwide (Leistikow, Martin, and Milano 2000). This is a clear externality due to health and property damage to others, not to mention public resources devoted to fire-fighting.

If a consumer initially does not know how harmful or addictive tobacco is, she may experiment with consumption early in life. But since tobacco is addictive, such experimentation can put her on a utility-decreasing path of lifetime consumption. To decrease the prevalence of this and other mistakes, governments can serve a useful role in informing consumers about the features of tobacco.

Offsetting these negative externalities, however, is the financial *benefit* to society from the shorter lives led by smokers. Consider, for example, the Social Security program, which collects payroll tax payments from workers until they retire, and then pays benefits from that date until an individual dies. In the past, smokers have typically died around retirement age, so that they do not collect the retirement benefits to which their tax payments entitled them. In this situation, smokers are exerting a positive financial externality on nonsmokers: smokers pay taxes to finance the retirement benefits but do not live long enough to collect their benefits, leaving the government more money to pay benefits for nonsmokers. Thus, through the existence of the Social Security program, smokers benefit nonsmokers by dying earlier. Moreover, the fact that smokers die earlier also offsets many of the medical cost effects of smoking. If smokers die at 65, then they will not impose large nursing home and other medical costs at very advanced ages. These avoided medical costs offset much of the additional medical costs from treatment for cancers and heart disease at younger ages. This so called “death benefit” received considerable attention several years ago when a report written for Philip Morris projected positive fiscal benefits to the Czech Republic from continued smoking (Arthur D. Little, Inc. 2000).

Offsetting the negative externalities of smoking with these positive fiscal benefits of early smoker deaths, the net external costs of smoking are relatively small. A typical estimate would be the roughly 40 cents/pack estimated by the Congressional Research Service (Gruber 2001). There are

other more controversial elements of the external cost of smoking, most notably the cost of second-hand smoke, but to date these are very hard to determine with certainty.

Thus, the traditional view of tobacco taxation, which implies that tobacco taxes should be equal only to the level of interpersonal externalities, implies relatively low levels of taxes on cigarettes and other tobacco products. Furthermore, because low-income individuals spend a much larger share of their income on tobacco than high-income individuals, tobacco taxation has undesirable distributional consequences. The only argument countering these reasons against tobacco taxation is the fact that because tobacco consumption is relatively inelastic, tobacco taxation is an efficient form of raising revenue. In the next sections, we show that in a more realistic theory of consumer behavior, the relevance of the first two reasons against tobacco taxation is questionable, while the last one in favor of tobacco taxation is equally valid.

In the traditional view of tobacco consumption — like with many other consumption goods — there is one very important role for governments and other social organizations: providing information to consumers based on which they can make reasonable choices. Orphanides and Zervos (1995) show that if a consumer initially does not know how harmful or addictive tobacco is, she may experiment with consumption early in life. But since tobacco is addictive, such experimentation can put her on a utility-decreasing path of lifetime consumption. To decrease the prevalence of this and other mistakes, governments can serve a useful role in informing consumers about the features of tobacco.

People put a much higher weight on the present than on the future, but when trading off two periods that are both in the future, they weight the two periods relatively equally. This creates a conflict between a person's motivations at different points in time.

III. A New View of Tobacco Consumption and Regulation: Motivation

In this section we motivate our new approach to tobacco policy. Our point of departure is a simple and compelling assumption: people put a much higher weight on the present than on the future, but when trading off two periods that are both in the future, they weight the two periods relatively equally. This contrasts with the exponential-discounting view above, and — most importantly — creates a conflict between a person's motivations at different points in time. In particular, when making decisions trading off immediate pleasures and pains with future ones, a person will always tend to act more impatiently than she would have preferred earlier and that is optimal from a long-run point of view.

That individuals experience conflicts between their short-run desires and their long-run goals is probably very intuitive (almost obvious) to non-economists — indeed, it is folk wisdom at least since Ulysses tied himself to the mast — but since it is a relatively new insight in economics, we present both thought experiments and evidence to support them.

One way to see that exponential discounting just cannot be the right description of how individuals make intertemporal tradeoffs is to perform some simple arithmetic calculations. Consider a person who treats next week as 95% as important as this week — a plausible description of how many individuals weight the future. If she is an exponential discounter, she will then weight one year from now $(0.95)^{52} \approx 0.07$ times as much as this week, and anything that happens ten years from now $(0.95)^{52 \times 10} = 2.6 \times 10^{-12}$ as much as this week. While the short-term discounting of a one-week delay seems very reasonable, under exponential discounting it implies extremely unreasonable long-term discounting. It implies, for example, that the person would not be willing to reduce consumption by $1 today in exchange for becoming the richest person in the world in ten years!

Exponential discounting implies that the person would not be willing to reduce consumption by $1 today in exchange for becoming the richest person in the world in ten years!

Experimental evidence confirms that exponential discounting cannot describe short-term and long-term preferences at the same time, and that people tend to be most impatient when it comes to short-term decisions. Thaler (1981) elicited subjects' preferences between $15 today and amounts of money at various times in the future. For instance, Thaler asked "What amount X makes you indifferent between $15 today and $\$X$ in 1 month?" The median answer was $X = 20$, implying an annualized discount rate of 97%. But when he asked the same question regarding money six months from now, the median answer was $50, implying an annualized discount rate of 36%. And when he asked the question regarding money in ten years, the median answer was $100, implying an annualized discount rate of 17%. The pattern, confirmed many times subsequently in monetary as well as other decisions in the laboratory, is clear: people are just more patient when it comes to long-term decisions than when it comes to short-term decisions.†

A new generation of empirical research in economics confirms the conflict between short-run decisions and long-run goals in the field, including for some very important economic decisions. For instance, DellaVigna and Malmendier (2004) document that the majority of individuals who sign up for an expensive membership at a gym rarely take advantage of the membership, suggesting that their long-run desire

† See Ainslie (1992) and Ainslie and Haslam (1992) for reviews of this literature.

of staying healthy conflicts with their short-run inclinations when it comes to actually paying the effort cost of exercising. Ausubel (1999) and Shui and Ausubel (2004) find that credit-card customers are responsive to initial "teaser" interest rates but not to the much more important long-term interest rates or the length of the introductory period, suggesting that they care about short-term incentives but do not care about (or cannot predict) how much they will pay in interest in the future. And Laibson, Repetto, and Tobacman (1998, 2003, 2007) show that people tend to have very little liquid savings (or even a lot of short-term debt) but substantial savings in long-term illiquid assets, suggesting that they are impatient on short-term decisions but more patient on long-term decisions. Some of these authors (as well as others) explicitly estimate the key parameter in our model below, β, based on field data, and find numbers roughly consistent with the laboratory estimates we use for our calculations.

Tobacco consumption is one of the most natural and immediate applications of problems of self-control in consumption: the benefits are immediate (satisfying craving) while the costs are only in the often distant future (shorter life). Indeed, two types of evidence suggest that self-control problems play an important role in smoking decisions. First, an important implication of models with self-control failures is that people will search out means of controlling their own future behavior — so as to prevent themselves from giving in to their taste for immediate gratification. In fact, the literature on self-initiated attempts at quitting smoking focuses exactly on the use of these sorts of self-control devices. People regularly set up socially managed incentives to refrain from smoking by betting with others, telling them about the decision, and otherwise making it embarrassing to smoke (Prochaska, Crimi, Lapsanski, and Martel 1982). Various punishment and self-control strategies for quitting are also widely studied in controlled experiments on smoking cessation (Miller 1978, Murray and Hobbs 1981, Bernstein 1970), and they are recommended by both academic publications (Grabowski and Hall 1985) and self-help books (CDC various years). If individuals had no self-control problems, there would be no reason to punish themselves for smoking; thus, these types of punishments are evidence that individuals recognize they have a self-control problem and are trying to solve it.

Gruber and Mullainathan (2002) suggest a natural empirical test for the self-control model in the context of smoking: examining the impact of tobacco taxation on the well-being of smokers (both actual and potential). Under the standard model described earlier, tobacco taxes can only make smokers worse off; the government is raising the price of a good that they

would like to consume, restricting their opportunity set. But under the self-control model, tobacco taxes can make smokers better off by providing them with the commitment device they crave (but cannot find without government compulsion). Based on happiness data from both the U.S. and Canada, Gruber and Mullainathan find that higher tobacco taxes make actual and potential smokers happier, not less happy as the standard model would predict. This is consistent with the self-control-based demand for taxes as a commitment device.

IV. The New Approach

In this section we present and apply to tobacco consumption an economic model of the main regularity we have motivated and documented above: that people experience a conflict between their short-run desires and their long-run goals. Variants of this model, first introduced by Strotz (1956), Phelps and Pollak (1968), and Laibson (1997), have recently been widely used in economics. We show that the more accurate description of human psychology captured in our model radically changes optimal government policy toward harmful substances, and in particular questions previous arguments against the taxation of tobacco.

A person discounts the future relative to the present quite heavily, but does not discount between future periods as much.

Hyperbolic Discounting

We first formalize the findings above that a person discounts the future relative to the present quite heavily, but does not discount between future periods as much. For a more thorough introduction, see Laibson (1997). Suppose there are T periods, $t = 1,...,T$. To highlight that a person may have conflicts between her preferences at different points in time, we call the period-t incarnation of the individual "self t." Denoting by $U_1,U_2,...,U_T$ the instantaneous utilities at times $1,2,...,T$, self t's discounted utility is

$$U_t + \beta \sum_{i=1}^{T-t} \delta^i U_{t+i}. \qquad (1)$$

The key parameters capturing intertemporal preferences in this model are β and δ, which are usually assumed to be between 0 and 1. The "long-term discount factor" δ can be thought of as the analogue of the exponential-discounting parameter from standard models. The "short-term discount factor" β is intended to capture the essence of the findings above,

that people can be much more impatient when making decisions between the present and the future than when making decisions between future periods. Indeed, the discount factor between consecutive future periods (δ) is larger than between the current period and the next one ($\beta\delta$).

That consumers discount short-run decisions more than long-run decisions means that they are time inconsistent in the sense that their preferences at different points in time are inconsistent with each other. To see this, notice that when looking forward to periods $t + 1$ and $t + 2$ in period t, self t puts a relatively high weight (δ) on period $t + 2$ relative to period $t + 1$, so that she would like self $t + 1$ to behave relatively patiently. But when period $t + 1$ rolls around, self $t + 1$ puts a relatively low weight ($\beta\delta$) on period $t + 2$ relative to period $t + 1$, and acts relatively impatiently. This creates a conflict between the different selves regarding how to behave, and introduces the scope for a variety of self-control problems in behavior. By making the implicit parameter restriction $\beta = 1$, standard models have implicitly assumed that no such self-control problem exists.

Since different selves disagree about the optimal consumption path, our model must make an assumption about the preferences relevant for the individual's welfare and hence the appropriate input into social welfare maximization. In line with much of the literature (Gruber and Kőszegi 2001, DellaVigna and Malmendier 2004, Gruber and Kőszegi 2004, O'Donoghue and Rabin 2006), we take the position that a consumer's long-run preferences (those excluding β) are appropriate for welfare analysis. There are several reasons that the literature has converged on this assumption. First, a person underweights the future consequences of period-t consumption only in period t; all earlier selves would like her to place a higher weight on later outcomes. Hence, it seems reasonable to base welfare judgments on earlier selves' preferences (O'Donoghue and Rabin 2006). Second, as emphasized by Gruber and Kőszegi (2001) and as we show below, bringing the decisionmaker's consumption level in each period closer to earlier selves' wishes in fact increases the discounted utility of *all* selves; hence, such interventions are welfare-improving under virtually any criterion and would be preferred also by the individual's own account.

In most applications of hyperbolic discounting, it matters whether consumers understand their time-inconsistent taste for immediate gratification.† Since this issue does not affect predictions in our simplified model below, we do not discuss it in detail.

† *Sophisticated* consumers understand their time inconsistency perfectly, and take it into account in a fully rational manner when making decisions. This means, for example, that they look to commit their own future behavior, so as not to give in to their future taste for immediate gratification. At the other extreme, *naive* consumers do not understand their time inconsistency at all, perpetually believing that future selves will follow the current optimal plan. For a discussion of sophistication versus naivete, as well as for definitions of intermediate levels of sophistication, see O'Donoghue and Rabin (1999, 2001).

A Simple Model of Tobacco Consumption

We present our points using a simple model of tobacco consumption, stripping away many specifics of the product and focusing on its harmfulness. We discuss how additional considerations — such as the fact that tobacco is addictive — affect our results in the section titled "Alternative Motivations" (p. 20). In each period 1 through $T - 1$ consumers make a zero-one decision of whether to smoke.† For a consumer i, smoking in period t causes some benefit b_i in period t and harm h in period $t + 1$, all expressed in monetary terms. Consumers differ in the pleasure b_i they get from smoking, but everyone is harmed by it to the same extent. Although most harm due to tobacco consumption occurs later in life rather than in the subsequent period, the essence of the problem is captured by our simplified model; in our calibrations below, we will appropriately discount the health costs of smoking. Suppose that the competitive producer price of cigarettes in period t is p_t and the tax is τ, so that the tax-inclusive price is $p_t + \tau$.

Even though the consumer will be worse off in the long run from her consumption decisions, these consumption decisions are made in an impatient state when short-run gains and costs are weighted very strongly.

To illustrate that a person may overconsume in this situation even from her own point of view, suppose $\beta = 1/2$, $\delta = 0.95$, $b_i = 2$, $p_t = 1$, $\tau = 0$, and $h = 2$. In the first period, the person decides to smoke by assessing whether the enjoyment of smoking ($2) exceeds the cost of purchasing a pack of cigarettes ($1) plus the discounted value of health damage in the next period. Given her preferences, that discounted value is $2*0.95*0.5 = $0.95. Thus, the consumer decides to smoke. Moving on to the next period, the consumer faces exactly the same decision, and will once again decide to smoke. And so on throughout her life.

Yet this stream of lifetime consumption generates the stream of instantaneous utility 1,-1,-1,-1,. . . ,-1,-2, which is far inferior to a lifetime of no consumption — not only from the long-term point of view, but from *every self's* point of view. Even the first-period self is worse off: given self 1's discount parameters, the future stream of negative utilities far outweighs the initial pleasure from starting consumption. Hence, this consumer voluntarily engages in an activity that makes her unambiguously worse off.

The numbers in the above example are chosen for expository purposes, but the phenomenon they illustrate is a general one. Even though the consumer will be worse off in the long run from her consumption decisions, these consumption decisions are made in an impatient state when short-run gains and costs are weighted very strongly. That is, the consumption decision for each period is made when the smoker is most impatient about it — when she is about to experience the immediate pleasure of smoking,

† Our findings would be essentially the same if we modeled the amount of smoking each period rather than the 1-0 decision to smoke.

which outweighs the long-term health costs. In the next section, we turn to how tobacco policy can be used to counteract this overconsumption.

Analysis of Optimal Taxation and Incidence

Optimal Taxation

We now show how taxes can be used to correct problems of tobacco consumption associated with a free market. In order to address this issue, we also consider classic externalities associated with consumption. Let the externality associated with tobacco consumption be e.

It is easy to see that in any period $t \in \{1, \ldots, t-1\}$, consumer i will smoke if and only if

$$b_i \geq p_t + \tau + \beta\delta h.$$

In contrast, it is socially optimal for consumer i to smoke if and only if

$$b_i \geq p_t + \delta h + e.$$

There are three differences between the condition for optimal choice from an individual and social points of view. First, whereas the consumer considers the tax payment as a wasted expenditure, from a social point of view it is only a transfer to the government. Hence, the individual's condition includes τ as a cost while the social optimum condition does not. Second, the individual does not take the externalities from smoking into account in her private choice, but a welfare-maximizing government does. Both of these effects are standard. Third, however, whereas the individual at each moment in time discounts the harm from smoking using the discount factor $\beta\delta$, from a long-run point of view (which we assume is relevant for welfare) the appropriate discount factor is δ.

Based on the above, the following tax aligns each self's incentives perfectly with the social optimum, and hence is the optimal tax:

$$\tau^* = e + (1 - \beta)\,\delta h. \qquad (2)$$

Equation 2 extends the formula for the standard optimal tax to our model of hyperbolic discounting. As is well-known in standard settings since at least Pigou, when there are externalities, the optimal tax on a product equals the externality that product's use imposes on others. Our formula says the same thing if $\beta = 1$ — if consumers are time consistent. If $\beta < 1$, the optimal tax includes an additional term intended to correct for consumers' time-inconsistent taste for immediate gratification. Intuitively, the consumer's time inconsistency means that she "underweights" the

future consequences of consumption, δh, by a factor β. Taxing her at rate $(1 - \beta)\delta h$ corrects that underweighting.

That is, for the time-inconsistent consumer, the government is providing a self-control device that will allow that consumer to avoid making sub-optimal consumption decisions. In principle, the consumer could find such self-control in the private market. In practice, this is impossible, since the private market does not have the power of compulsion available to the government. Any "punishment strategy" that the individual sets up to reduce their incentive to smoke can simply be evaded by not following the strategy should smoking occur. But the higher price through taxation cannot be evaded (other than through illegal smuggling).

The government is providing a self-control device that will allow that consumer to avoid making sub-optimal consumption decisions.

While for many consumption goods the classic externality term in Equation 2 may be much more important than the new self-control term, tobacco happens to be a good where the opposite is the case — by far. Given the huge damage people are doing to themselves through smoking, and the large value most people place on their lives, the self-control term will dominate the externality term by a large margin even for moderate values of β. It is only when β is extremely close to 1 — when consumers are almost perfectly time-consistent and self-controlled — that the externality is the more important term to consider. In this sense, the traditional economic model is a knife-edge case. The traditional model emphasizes what turns out to be the less important element of optimal government policy, and deviating from this model even a small amount has dramatic implications for policy.

Although we frame our model in terms of a social planner intervening in a competitive economy, the logic of our results extends to a setting where a government monopoly manufactures and distributes tobacco. Since in a competitive economy p_t is just the cost of production, the τ^* we derive below is the optimal difference between the price of tobacco and its cost of production. Hence, in an economy where tobacco is provided by a government monopoly, the welfare-maximizing markup is exactly τ^*.

Incidence

In this section we argue that the traditional economic methods for incidence analysis are incomplete for harmful goods in the presence of time inconsistency, and we provide a corrected measure.

Broadly speaking, the goal of incidence analysis is to determine who is "hurt" by different tax policies. For an economist, the appropriate measure for this analysis is utility — how the tax policy affects each person's utility in

society. Tax incidence is typically computed by relying on the quantities consumed by different consumers because in standard settings, the utility impact of a tax is equal to the amount a person consumes times her marginal utility of wealth. Intuitively, the main effect of an increased tax is that she has to pay more for the given product, and — since people start off at their utility-maximizing choice — any induced change in behavior has a second-order effect on utility. Of course, most economists and policymakers are sensitive to the idea that lower-income individuals have a higher marginal utility of wealth; that is, after all, why most do not like regressive forms of taxation. Without a direct measure of people's marginal utility of wealth, most researchers use the inverse of income as a proxy. Hence, measuring expenditures divided by income is the typical way to assess the distributional impacts of tax policies.

While we agree with the above basic view of the goal of tax incidence, in our new framework it implies a different formula for assessing the incidence of a tax. Specifically, because consumers can behave suboptimally, it is no longer true that the sole impact of a tax increase comes from the increased expenditures on the product. Consider a marginal change in the price of cigarettes at time t, Δp_t. Let N_t be the number of smokers in the population, q_t the number who quit in response to the price change, and b_i the pleasure from smoking for those consumers who quit. The utility impact of the price change is then

Our new framework implies a different formula for assessing the incidence of a tax.

$$-N_t \Delta p_t + q_t\,(-b_i + p_t + \delta h).$$

By definition, any consumers who quit in response to a marginal change in taxes must be approximately indifferent between smoking and not smoking at this price, so that $b_i = p_t + \beta\delta h$. Hence, the above becomes

$$-N_t \Delta p_t + q_t\,(1-\beta)\delta h.$$

The first term is the standard incidence term: if the price rises, the N_t consumers must pay a higher price for their tobacco, hurting their utility. The second term is specific to our model: because the price increase induces some consumers to quit, and it was individually suboptimal for these individuals to consume cigarettes, the price change also increases their utility. Simply put, they should have quit already, and the price change helped them achieve that goal. That is, the tax increase is providing a commitment device that is valuable to these time-inconsistent consumers. As a result, incidence is lower than for a time-consistent agent.

The above can be put in a slightly more convenient form:

$$-N_t \Delta p_t \left(1 - \frac{q_t/N_t}{\Delta p_t/p_t}(1-\beta)\delta h/p_t\right)$$

or

$$\boxed{-N_t \Delta p_t [1 - \epsilon_t (1-\beta)\delta h/p_t]}, \tag{3}$$

where ϵ_t is the price elasticity of demand. Since $-N_t \Delta p_t$ is the utility impact of the price change in a standard model, the bracketed term is an "incidence adjustment factor" for the time-inconsistent case. The incidence adjustment factor is 1 for $\beta = 1$, but it is less than 1 for $\beta < 1$, reflecting that — as explained above — incidence is lower than in the standard model. As does the optimal tax, the adjustment factor depends on the discounted harm from smoking, δh, albeit in this case normalized by the price of cigarettes. Intuitively, the higher is the harm from tobacco consumption, the more costly is the consumer's time-inconsistent taste for immediate gratification, so the more beneficial is a price-induced decrease in consumption. The normalization by p_t is necessary because if a person still consumes cigarettes when the price is high, then (given her price elasticity of consumption) the same price increase will be less effective in getting her to quit. In addition, the lower is β, the greater is the consumer's time inconsistency, so again the more beneficial is a price-induced decrease in consumption.

Lower-income individuals are much more price elastic than higher-income individuals. This tends to decrease the regressivity of tobacco taxation relative to standard measures.

Most importantly, the adjustment factor is decreasing in the price elasticity of demand: the more responsive are consumers to price increases, the lower is their incidence. The intuition is simple: since a time-inconsistent person consumes too much in each period, the price hike increases utility by restraining her overconsumption. This self-control is more effective if the consumer is more responsive to price incentives.

Ultimately, we are interested in how accounting for hyperbolic discounting in measuring the true incidence of taxation affects the regressivity of tobacco taxes. Unfortunately, we are not aware of any systematic studies on whether different income groups differ in their average β's, so as a reasonable first approximation we assume that they do not. But in countries for which we have data, lower-income individuals are much more price elastic than higher-income individuals. This tends to decrease the regressivity of tobacco taxation relative to standard measures. As we show through some examples of specific calibrations below, to the

extent that time inconsistency is a non-trivial issue, the adjustment due to the fact that the poor are more price responsive can in itself reverse the regressivity of taxation.

To the extent that lower-income groups attach a lower value to the future costs of smoking, tobacco taxes are more regressive than standard models suggest. There is, however, no evidence that tobacco consumption is less harmful for lower-income individuals, and neither does it seem appropriate for public policy to assign systematically different values to the health and lives of citizens from different income groups. Overall, therefore, it is unambiguous that accounting for hyperbolic discounting decreases the regressivity of tobacco taxes.

Calibrating Tax Levels and Incidence: Example from the U.S.

The issues raised in the previous two subsections are not academic. In this section we provide some illustrative calculations to highlight the empirical relevance of this alternative formulation of smoking decisions. Because we have not been able to find all the necessary data for other countries, our example is based on U.S. evidence. But at the end of this section, we argue that our conclusions are likely to hold in lower-income countries as well. In any case, policymakers can commission studies in their own countries and perform calculations similar to those below to arrive at the most locally relevant conclusion.

We assume that the only disutility from smoking is in the increased chance of early death.

These calibrations follow those in Gruber and Kőszegi (2004), and we summarize our approach here. One difficulty with estimating the optimal tax is parameterizing the health damage. Clearly, there is a lot of disutility associated with smoking that is hard to quantify, such as that from constant coughing and increased vulnerability to various illnesses. We will ignore all these, and assume that the only disutility from smoking is in the increased chance of early death. Viscusi (1993) reviews the literature on life valuation in the U.S. and suggests a consensus range of 3–7 million 1990 dollars for the value of a worker's life; choosing the midpoint value and expressing it in current dollars gives a figure of $6.8 million. Presumably, this is a present discounted value for all remaining years. We assume that the average worker is 40 years old, and would live to age 79 if a nonsmoker. We use the fact that smokers die on average roughly 6 years earlier (Cutler, Gruber, Hartman, Landrum, and Rosenthal 2001), and compute for each age 15–73 the present discounted value of the cost of losing 6 years at the end of life. We then take a weighted average of these costs at each age, where the weights are the share of cigarettes smoked at each age from the May 1999 Current Population Survey Tobacco Use Supplement, a nationally

representative survey of smokers in the U.S. Finally, we divide this weighted average by the average number of cigarettes smoked over one's lifetime; that is, we assume that average and marginal damage is equal.

Using a long term annual discount rate of 3%, these calculations imply that the cost in terms of life years lost per pack of cigarettes is $35.64. This is an enormous figure that dwarfs any estimates of the per-pack externalities from smoking.

In Table 1, we show the implications for the optimal tax derived from our simplified model. A crucial parameter for measuring the optimal tax is the short-term discount factor β. Existing laboratory and field evidence suggest that β has a value somewhere between 0.6 and 0.8 for the typical person. To show the importance of this parameter, we consider a range of values from 0.6 and 0.9. We assume a value for externalities per pack of 40 cents.

The cost in terms of life years lost per pack of cigarettes is $35.64.

This table shows that the optimal tax is very high. If β is 1, then the model collapses to the traditional case and the tax is equal to the level of expernalities, or 40 cents. For a value of β of 0.9, however, the optimal tax is almost $4, or about 10 times as high as it would be due to externalities alone. If β is as low as 0.6, then the optimal tax is almost $15 per pack. Thus, as emphasized above, the implications of incorporating time inconsistency into the standard model are enormous.

We also find that tax incidence conclusions are quite different using this alternative model. We can rely on many of the same parameters from Table 1 to compute incidence, but we need one more key parameter here: the price elasticity of demand for cigarettes, and in particular how it varies across income groups. Gruber and Kőszegi (2004) find that the price elasticity is much higher for lower-income groups than for higher-income groups, with an elasticity of more than one in absolute value for the lowest quartile of the U.S. income distribution. For these incidence calculations, we ignore the fact that low-income individuals typically smoke cheaper cigarettes; as we have discussed above, accounting for this would reduce the regressivity of taxation or increase its progressivity. We also assume that the values of life are equal across income groups, avoiding normative

Table 1: Optimal Taxes in US Dollars for Different Values of β

β	1	0.9	0.8	0.6
optimal tax	0.40	3.96	7.53	14.66

issues of valuing life more highly for higher income individuals; our conclusions hold broadly so long as life values are not tremendously higher for rich than for poor.

The results of our alternative model for tax incidence are shown in Table 2, assuming a price per pack of $4.54. The figures in the table represent the incidence of a $1 tax per pack of cigarettes, as a share of income. Incidence without our correction term, which corresponds to the standard, $\beta = 1$ case, is shown in the first column of the table. This confirms the typical conclusion of incidence analyses, that tobacco taxes are regressive: the poor spend almost ten times as much on cigarettes, as a share of income, as do those in the higher-income quartile.

The remainder of the results show incidence after applying our time inconsistency adjustment.

The results here are quite striking. Even for a β of 0.9, tobacco taxes are only mildly regressive; a $1 tobacco tax has an incidence on the poor (0.24% of income) which is only twice that of the rich (0.12% of income), and incidence is basically flat for the bottom three income groups. As β falls, the conclusion is reversed, and tobacco taxes become progressive, with the incidence actually being negative for lower income groups. That is, the self-control benefits of tobacco taxation are so large for the lowest income groups that on net they are better off from taxation. Indeed, for a value of β of 0.6, every group is made better off — but the poor are much better off than the rich.

This switch to progressivity once we correct incidence is due to the higher price elasticity of low-income consumers. Since low-income consumers will reduce their smoking more in response to a tax, they will gain more of the benefits from reduced smoking, offsetting the payments they make in higher taxes or the pleasure they have to give up from stopping smoking.

Table 2: The Effect of Time Inconsistency on the Incidence of Cigarette Taxes

	Incidence (percent of income)			
Income group	Standard	$\beta = 0.9$	$\beta = 0.8$	$\beta = 0.6$
I (highest)	0.18	0.12	0.07	–0.04
II	0.47	0.27	0.08	–0.31
III	0.71	0.32	–0.07	–0.85
IV (lowest)	1.69	0.24	–1.20	–4.09

Given that all of the above estimates are for the U.S., we briefly discuss how they might be different in low- and middle-income countries. In short, although empirical research to determine the values of some of our variables would of course be extremely useful, there is no reason to expect the thrust of our arguments to be weaker in low- and middle-income countries. Admittedly, for non-rich countries we have not found evidence for two key variables driving our model's predictions: the discounted value of life δh and the taste for immediate gratification β. It is very likely that citizens in lower-income countries value their lives less in dollar terms than citizens of the U.S., but we find it unlikely that they would value their lives less *relative to income* than Americans — and would be extremely uncomfortable basing any conclusions on this presumption. Similarly, based on previous cross-cultural work that has found no deep differences between cultures (outside of hunter–gatherer societies) in other types of behavioral preferences (Camerer 2003), there is no reason to expect β to be significantly different for countries with different income levels. Hence, it is likely that the optimal tax relative to income is as high in low- and middle-income countries as in the U.S. Finally, it is important to note that while the optimal tax is (as we have emphasized) sensitive to these parameters, *whether* tobacco should be taxed heavily is much less so: unless we are very confident that almost everyone is extremely close to time-consistent or does not value her life very highly, a large tax on tobacco is called for.

From the perspective of our model, a broad-based tobacco tax is optimal to prevent consumers from switching to cheaper tobacco products rather than reducing consumption.

There is some evidence from low- and middle-income countries on a key input into our incidence calculations, the price elasticity of demand. Overall, the price elasticity of demand is higher in low- and middle-income countries than in high-income countries (Chaloupka, Hu, Warner, Jacobs, and Yurekli 2000), so that the overall incidence of tobacco taxation tends to be lower in these countries. Furthermore, the differences in the price elasticities between income groups seem to be similar in low-, middle-, and high-income countries (Yurekli and Onder 2007), so that the implications of time inconsistency for incidence analysis should be similar.

The Importance of Broad-Based Taxation

The model we have considered so far assumes that there is only one tobacco product consumers can choose. An important consideration in reality, however, is how consumers choose between different tobacco products and by extension, how this choice is affected by tobacco policy. In some countries there are cigarette-like products (such as bidis) that are substitutable for cigarettes. In this section, we argue that from the perspective of our model, a broad-based tobacco tax is optimal to prevent consumers from switching to cheaper tobacco products rather than

reducing consumption. The general principle that should guide taxation is simple: if an individual stops consuming a tobacco product due to increased taxes on that product, it is best if that individual quits rather than switches to an untaxed (or lower-taxed) tobacco product.

To make this point most simply, imagine that there are two tobacco products available, product 1 and product 2, and consider a group of individuals initially consuming product 1. Suppose that the government imposes a large tax on product 1, but — for instance, not to burden another group of individuals — no tax on product 2. Consumers may then switch to consuming product 2, so that the tax does not move the economy toward the goal of reducing the number of tobacco users. Imposing a uniform tax on the two products would solve this problem.

Note that despite its adverse effect on public health and social welfare, the above kind of tax can raise a lot of revenue if a substantial part of the population keeps consuming product 1. Hence, whether a cigarette tax raises a lot of revenue is not necessarily a good indication of whether it is effective as a public-health measure.

Alternative Motivations

The model that we have presented thus far has taken the standard model of choice over time with harmful goods and added one wrinkle, time inconsistency. But there is reason to believe that there are further deviations from this model that are important in describing smoking behavior.

One obvious shortcoming of our model is that it ignores the addictive nature of tobacco consumption. We consider the implications of addiction in detail in our earlier papers (Gruber and Kőszegi 2001, Gruber and Kőszegi 2004). As noted earlier, addiction by itself does not invalidate the conclusions of the standard economic model. Indeed, even within the self-control model we have presented thus far, *if* people anticipate addiction rationally, higher addiction actually leads to less motivation for government intervention. Intuitively, the concern about getting addicted, and hence about making their taste for immediate gratification worse, helps individuals overcome their short-sightedness.

But the picture is entirely different if beginning smokers do not anticipate how addicted they will get to tobacco. If young smokers feel that they will not become addicted, they will be much more likely to smoke than is suggested as optimal by the rational-addiction model, and through addiction this will lead to excessive life-long smoking and excess mortality.

By the time these youths become adults and understand their mistake, it is too late because they are already addicted. Then, intervention to prevent that mistaken initial step may be warranted.

Although it is very diffcult to settle conclusively whether individuals understand the addictive nature of products, some strongly suggestive evidence indicates that they do not. In general, people seem to underappreciate the effect of various changes in one's state (hunger, standard of living, disability, etc.) on one's preferences, projecting their current preferences onto their future ones. Such "projection bias" has been documented widely in the psychology literature; see, for instance, Loewenstein and Schkade (1999) or Gilbert, Pinel, Wilson, Blumberg, and Wheatley (1998) for reviews.

There is also some evidence that projection bias extends to choices regarding addiction. For instance, Giordano, Bickel, Jacobs, Loewenstein, and Badger (2005) elicited (using an incentive-compatible procedure) the monetary valuations for a dose of the heroin substitute (and treatment alternative) "buprenorphine" (BUP) among heroin addicts. A major innovation of the study was to elicit these valuations at different points of BUP satiation, holding constant the satiation levels at the time that the addicts would actually receive the BUP dose. That is, addicts were told that when they next received their BUP dose, they would have the chance to get an additional dose, and asked how much they would value that additional (future) dose. The authors found that the extra future dose of BUP was valued significantly higher when they were deprived of BUP at the moment of elicitation than if they were satiated at the moment of elicitation. This finding is consistent with the idea that when satiated, addicts do not appreciate how powerfully cravings will influence their desire for BUP. If these addicts — who went through cycles of satiation and craving many times in their lives, and are at a clinic because they recognize their problem and want to quit — do not appreciate the strength of cravings, it seems unlikely that young individuals who have no experience with addictive products whatsoever would understand the process of addiction.

A U.S. survey asked high school seniors who smoked a pack a day or more whether they would be smoking in five years and then followed the seniors up five years later. Among those who had said they would be smoking in five years, the smoking rate was 72%— but among those who said they would not be smoking in five years, the smoking rate was 74%!

This is especially so since most smokers begin smoking at a young age. Three-quarters of smokers in the U.S. begin before age 19. The typical age of initiation in countries as diverse as the Ukraine, China, Spain, and Germany is all below age 19.† And for teen smokers there is some compelling evidence that they do not appreciate the addictive nature of their habit. A U.S. survey asked high school seniors who smoked a pack a day or more whether they would be smoking in five years and then followed the seniors up five years later. Among those who had said they would be smoking in five years, the smoking rate was 72% — but among those who said they would not be smoking in five years,

† See Andreeva, Krasovsky, and Semenova (2007) on the Ukraine, Zhong (2006) on China, Borras, Fernandez, Schiaffino, and Vecchia (2000) on Spain, and Göhlmann (2007) on Germany.

the smoking rate was 74%! This result suggests that teens who smoke may not account for the long-run implications of addiction (Gruber and Kőszegi 2001).

While our model also assumes that consumers know the health cost of tobacco use, a reasonable question is whether actual consumers understand these risks. Some claim that smokers in the U.S., even young smokers, over-estimate the health risks of smoking (Viscusi 1998), although others have questioned whether individuals think the risks apply specifically to them or only to the general population. In developing countries, however, the picture is much less clear. In China, for instance, most smokers believe that cigarettes do them little or no harm. Once again, in as much as consumers under-estimate the health risks of smoking, their decision to initiate may lower their individual well-being and warrant an intervention in the market.

V. Concluding Comments

In this paper we argue that there is a clear and strong case for using tobacco taxation as both a means of revenue raising and a tool of public health. To raise revenues efficiently, optimal tax theory suggests that governments target goods with inelastic demand. Yet the counterargument to such an approach is that these inelastic goods are typically consumed more by the poor, so that such taxes are inequitable.

For tobacco taxation, there is a clear resolution to this dilemma: while the overall elasticity of demand is much less than one, the elasticity of demand for the lowest-income consumers is much higher than for high-income consumers. Hence, governments can raise significant revenue through higher cigarette taxes without placing a large net burden on the poor. Indeed, for most parameter values our calculations suggest that tobacco taxes are progressive, at least in the U.S. context, with the self-control benefits through reduced smoking exceeding the higher tax cost for the poor.

Governments can raise significant revenue through higher cigarette taxes without placing a large net burden on the poor. Indeed, for most parameter values our calculations suggest that tobacco taxes are progressive.

While we have concentrated on tobacco taxation in the current paper, this tool should of course always be considered within a broader set of tobacco control policies. Regardless of economic implications, tobacco taxation is probably the most effective means of combating smoking in general – especially in the short run and in circumstances of revenue need.

Other policies, such as banning smoking in certain places, could reduce smoking and lower the externalities associated with tobacco use. To help individuals make an appropriate choice regarding tobacco consumption, restrictions on tobacco company marketing and promotion, and information campaigns about the addictiveness and health consequences of tobacco are extremely useful.

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