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Time-Inconsistent Preferences and Excessive Smoking - Cigarette Taxation as a Self-Control Device

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Summary

The primary objective of this thesis is to explore whether time-inconsistency in preferences affects the optimal level of cigarette taxation. The traditional view is that only the externalities of smoking should be considered when setting the cigarette tax level, as smokers are assumed to fully internalize the costs to themselves when making the decision to smoke.

The underlying questions concern the existence of self-control problems among smokers resulting in overconsumption of cigarettes, and the ability of taxation to correct these distortions. Related topics considered include the price-elasticity of cigarettes, the distinctive properties of cigarette taxation, private market solutions to self-control problems, and the distributional effects of cigarette tax increases.

The study is conducted as a literature review. Studies from the fields of behavioral economics, health economics, public economics and psychology are reviewed, examined and compared. Existing cigarette tax levels are evaluated in relation with the results from the literature.

Although estimating exact costs of smoking and optimal cigarette tax levels is extremely difficult, it can be stated with certainty that self-control problems (and consequently the internal costs of smoking) should be considered when setting cigarette taxes. Taxes act as a self-control device, reducing the overconsumption caused by self-control problems.

Empirical evidence supports time-inconsistency in preferences. Although it is unclear exactly how severe the tendency to pursue immediate gratification is in relation to smoking decisions, calibrations show that even small levels of self-control problems imply very large optimal tax levels because of the enormous costs of smoking to the smoker herself.

The self-control function most benefits low-income individuals, young individuals, and individuals in developing countries, as they have a relatively high price-elasticity of smoking. This fact also reduces the regressiveness of cigarette taxes. It may even, under realistic conditions, make them progressive. Market solutions to self-control problems are unlikely to be as effective as taxation, as firms are unable to force smokers into reducing the consumption of cigarettes.

If the existence of self-control problems is accepted - as it should be in the light of existing empirical evidence - cigarette tax levels are currently too low despite having been raised considerably in the past decade. The well-being of smokers and the society as a whole can be increased by raising cigarette taxes further.

Table of Contents

Index of Figures

Index of Tables

1. Introduction

Classic economic theory assumes that consumers act rationally and know what is best for themselves. According to this view the most efficient way of allocating the scarce resources in society is to allow people to make their own consumption choices in a free market. Recent research on addictive goods in psychology and behavioral economics suggests that consumers may not always be able to maximize their long-run utility on their own due to self-control problems, and that there may exist valid reasons for government intervention.

Smoking is extremely harmful to one's health and causes enormous costs to the society. The fiscal treatment of tobacco products is a challenge for policy makers. The focus of this thesis is on time-inconsistency of preferences regarding smoking decisions and its implications on government tax policy. The main research question is if and how time-inconsistency in consumer preferences affects the optimal, long-run social well-being -maximizing level of tobacco taxation. How do prevailing taxes compare to this level?

Tobacco control policy is always a mix of different instruments, targeting either the supply side or the demand side of the tobacco industry. Smokers respond to price changes quite well (see section 4), making taxation the most effective of these policy instruments. According to the World Health Organization (2008) "increasing the price of tobacco products through significant tax increases is the single most effective way to decrease tobacco use and to encourage current users to quit. In addition, higher tobacco taxes are particularly effective in keeping youth from taking up tobacco use and in reducing use among the poor, as both groups are highly responsive to price changes."

Taxes also generate revenue for the government. According to Veronmaksajain Keskusliitto ry (2010) the revenue from cigarette taxes in Finland was 611 million euros in 2009. According to the World Health Organization (2008) global annual government revenue from cigarette taxes is US $167 billion and expenditure on

tobacco control policies US $965 million (of which 99 percent is spent by 17 high-income countries).

Figure 1, adapted from the World Health Organization (2008), exhibits the prevalence of different types of tobacco control policy instruments in 204 countries. Fewer than one-half of the countries have complete or moderate taxation policies.

FIGURE 1: *The state of selected tobacco control policies in the world, 2008*
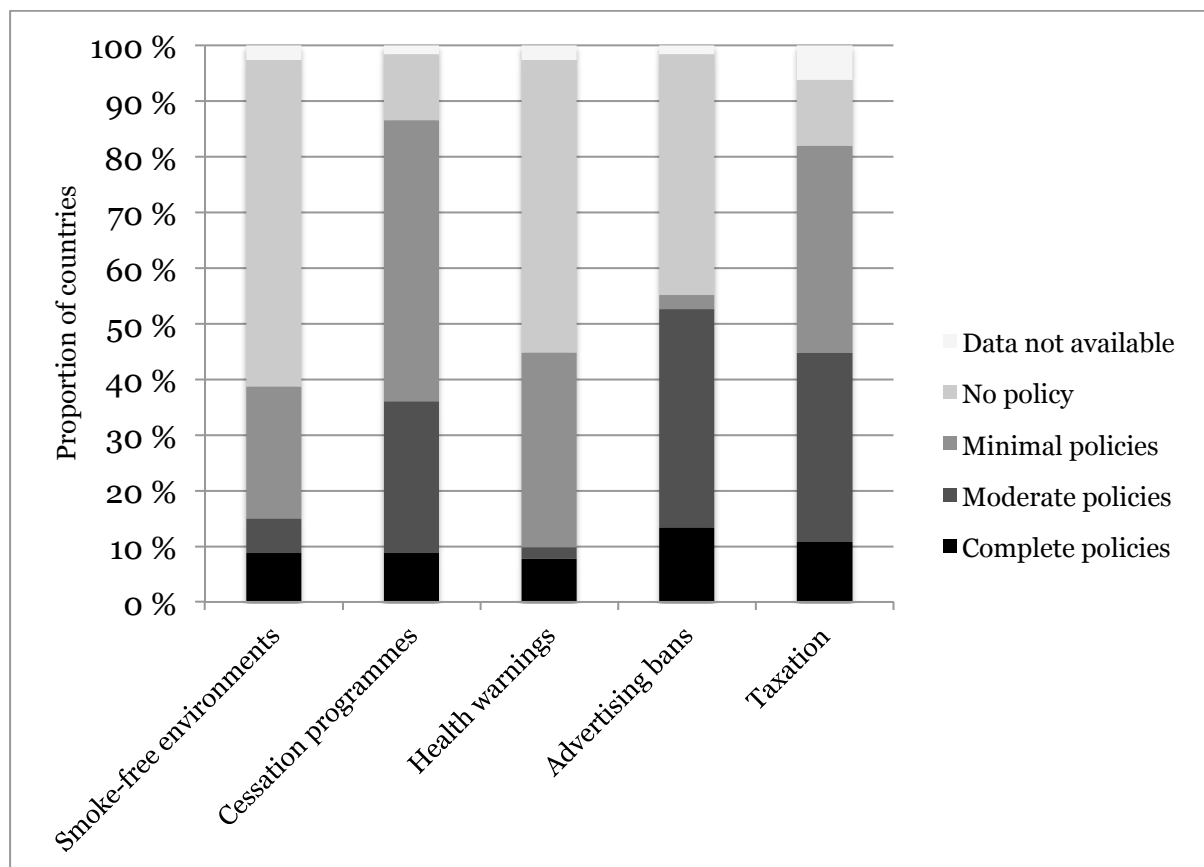
My intention is not to estimate an exact optimal tax for cigarettes as the calculations required for a realistic estimate are too complex for this thesis (too complex for any study according to some researchers, as the full amount of costs from smoking is very difficult to calculate accurately enough, see section 2.2). The primary goal is to

explore whether or not, and for what reason, internalities should be taken into account through an 'internality tax' in any magnitude. The secondary goal is to find a ballpark estimate for this magnitude, and compare it to existing tax levels.

The important underlying questions concern: (1) The level of self-control problems among smokers, or how large the decision-making errors are if they exist; (2) The differences in the level of self-control between smokers; (3) The ability of taxation as a tool to correct the market failure caused by self-control problems, e.g. how smokers respond to cigarette price increases.

My hypothesis is that the welfare of smokers - as well as the welfare of the society as a whole - can be increased by maintaining a level of tobacco taxes that is above the level of the net externalities caused by smoking. The reason for this is that many individuals constantly smoke more than they would really want to in the long run. Because of self-control problems, smoking decisions are not made optimally. Taxation may serve as a commitment device that helps smokers achieve the consumption level desired according to their long-term preferences (the reason why long-run preferences matter instead of short-run preferences is discussed in section 5.3).

The purpose of this thesis is to explore a rationale for government intervention that has traditionally been controversial among economists, but recently gathered more attention and acceptance: rational decision-making errors in the markets for addictive goods. Although it is debatable whether or not the behavior I study should be called 'irrational', it is clear that a time-inconsistent individual fails to maximize her long-run utility also from her own point of view.

Impatience (again a word that should be used cautiously, more on that in section 5.3) is not to be confused with ignorance. The smokers I consider are fully aware of all future costs of their smoking decision, i.e. they do not underestimate the loss of life-years, health costs, etc. In fact, according to Viscusi (1998) smokers (young ones included) in the United States actually over-estimate the health risks of smoking. In many developing countries the situation is probably different. It seems that for example in China the majority of smokers believe that cigarettes do them little or no

harm. Grossman et al. (1993) find that teenagers attach a higher risk to smoking than the rest of the population and that smokers in general do not underestimate the fall in life expectancy due to smoking.

Whatever the case may be, the 'internality tax' considered in this thesis is meant as a tool for correcting cognitive errors instead of errors resulting from lack of information. When consumers are not fully rational because of incorrect risk perceptions, the government may appropriately close the information gap, e.g. through public information campaigns.

Naturally, an additional tax on cigarettes might also be levied with the intention of signaling to smokers those costs that they have not recognized correctly, and the tax could reduce consumption closer to the levels consumed under complete information. My interest is nevertheless in self-control problems and I assume that smoking related risks are on the average correctly perceived.

I also assume that smokers correctly anticipate the addictiveness of cigarette consumption. Recent literature has provided evidence that this may not be a realistic assumption. This evidence and its implications for optimal cigarette taxation will be discussed briefly in the conclusions.

Taxes do not exist solely for the purpose of correcting the market failure caused by negative externalities, they also have the important task of raising revenue for the government and redistributing wealth. These important aspects of taxation are beyond the reach of this thesis. Although actual prevailing cigarette tax levels usually reflect an existing government revenue target, the comment given here on their optimality is based only on their ability to correct market distortions.

In other words, in this thesis by 'optimal tax' I do not refer to a tax level that would collect a targeted amount of revenue for the government with the minimum amount of market distortion or loss of economic efficiency. Instead, I am trying to determine the tax level that would eliminate market distortions and maximize economic efficiency. From the point of view of this thesis, if smokers have 100% self-control

and smoking does not have (net) negative externalities, there is no reason to tax cigarettes at all.

When a government revenue target is considered, according to the inverse elasticity rule by Ramsey (1927) market distortion is minimized by taxing commodities in inverse proportion to their elasticities, appointing the highest taxes to commodities the consumption of which is least affected by price changes. However, Ramsey only considers commodity taxation, not income taxation. According to Crawford et al. (2010) when considering government revenue generation only, there is no evidence that separate taxation of goods and services has efficiency benefits over income taxation. The need for taxing unhealthy goods such as cigarettes should therefore be decided based simply on their negative externalities and possibly consumers' self-control issues.

Tax incidence is a much-debated and closely related topic. The major argument against cigarette tax increases is that the tax is regressive, which means that it places a bigger burden on the poor than on the rich. I will also comment on whether or not this argument has merit in the context of time-inconsistent preferences. The hypothesis is that the existence of self-control problems reduces the regressiveness of cigarette taxes.

Naturally, the conclusions reached may also be applicable to other addictive products or services such as drinking, overeating, gambling etc. Smoking is the research subject in many recent time-inconsistency studies because smoking decisions seem to make an especially good example of time-inconsistent behavior.

Time-inconsistency in preferences in the context of addictive products and taxation is a fairly new research topic. The issue of self-control has generally not been incorporated into analyses of optimal tax levels. My thesis is a literature review, comprising mostly of research from the past 10 years or so. I will review and evaluate the relevant previous studies on the topic, both for and against my hypothesis, and present the appropriate models and the existing empirical evidence backing up their validity. I will not review studies that have been funded by the tobacco industry.

The vast majority of existing studies on cigarette consumption, externalities of smoking, cigarette taxes etc. is based on data from the United States and my thesis reflects this fact. I will nevertheless also try to comment on the appropriateness of the cigarette tax level in other areas, e.g. Finland.

The model that forms the core of my thesis is an extension of the Becker and Murphy rational addiction model (1988) by Gruber and Koszegi (2001). They modify the model to incorporate time-inconsistency in preferences, inspired by recent research in behavioral economics.

The structure of the thesis is as follows: I begin, in section 2 with the different types of costs of smoking. Section 3 concerns some basic economics of taxation and the effectiveness of taxation as a tool to combat self-control problems. Section 4 is a survey of estimates of the price-elasticity of cigarettes, and section 5 - the core of the thesis - presents the relevant addictive good consumption models and their implications.

In section 6 I take a look at empirical evidence of time-inconsistency in preferences. Prevailing cigarette tax levels are the subject of section 7, while in section 8 I assess the feasibility of private market solutions to self-control problems. Section 9 concerns the distributional effects of cigarette taxation. Section 10 is a look at contradictive addictive good consumption models, and section 11 concludes.

2. Costs of smoking

Tobacco consumption causes an enormous amount of harm to the society. In the following I will first take a brief look at the health effects of smoking and then go through the monetary costs in more detail.

2.1 The health impact: Deaths and diseases attributable to smoking

According to the World Health Organization (2002, 2008) tobacco is the single greatest cause of preventable death in the world. Smoking is a major risk factor for heart attacks, strokes, chronic obstructive pulmonary disease, emphysema, lung cancer, cancers of the larynx and mouth, pancreatic cancer, peripheral vascular disease and hypertension. More than 4,000 toxic or carcinogenic chemicals have been found in tobacco smoke.

About one third of the male adult global population smokes. Although smoking rates in the developed world have either peaked or declined from 1965 onward, they continue to climb in the developing world at an average rate of 3.4 percent per year. Between 80,000 and 100,000 children worldwide start smoking every day, roughly one half of them in Asia.

Half of long-term smokers will die because of smoking. Every cigarette smoked cuts on average more than five minutes from one's life. Smoking caused 5.4 million deaths in 2004 and a total of 100 million deaths in the 20th century. Assuming that current smoking trends continue, as many as 650 million of the people alive today are expected to die from smoking-related diseases. Within several decades, 10 million people will die annually from smoking-related diseases, predicting a total of one billion deaths in the 21st century.

2.2 The economic impact: The costs of smoking

Smoking has both internal and external costs. Internal costs a.k.a. private costs are the costs felt and taken into account when making smoking decisions by the smoker himself. External costs a.k.a. social costs or externalities are the costs to others that are not taken into account by the smoker.

There are several things which make calculating the costs of smoking – the amount on which a corrective tax shoud be based - very challenging. One is the long lag between smoking initiation and most smoking-related illnesses. Smoking-related costs in any given year reflect historical trends in smoking, and this needs to be correctly taken into account.

Another challenge is the existence of other attributes of smokers that influence external costs. These other attributes need to be statistically controlled. Hersch and Viscusi (1998) found that teenage and adult smokers are more prone to take risks than non-smokers. For example, fewer smokers wear seat belts and smokers tend to accept riskier jobs without demanding higher economic compensation. According to Viscusi and Hersch (2001) the wage premiums required by smokers for risky jobs are approximately one half of those required by non-smokers.

The choice of discount rate used to value future costs is also important. The discount rate generally used in the studies is 5 percent (Chaloupka and Warner, 2001). Results are very sensitive to changes in the discount rate especially for rates below 5 percent because the large savings of old age health care costs, retirement pension, disability compensation, and nursing home costs occur at the end of the smoker's life. Figure 2, adapted from van Baal et al. (2008), compares the average annual health care costs of smokers, obese individuals and healthy-living individuals at different ages. The lack of dramatic differences between the types is notable.

FIGURE 2: Average annual health care costs of smokers, obese individuals and healthy individuals
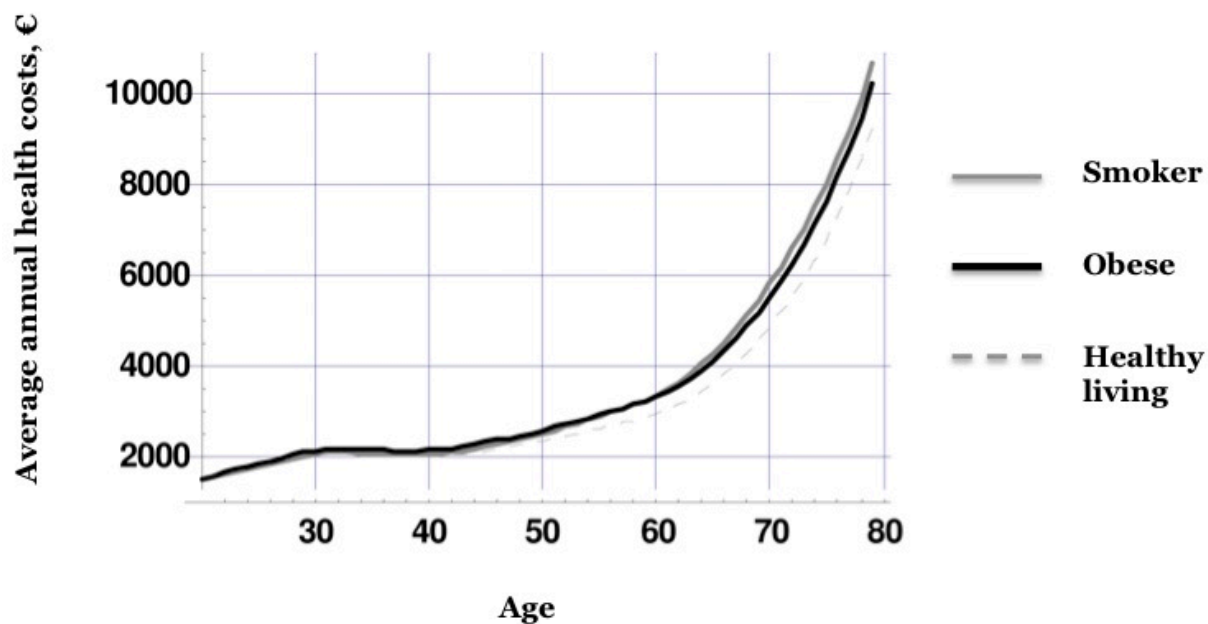
In the following I will describe the different types of costs from smoking and quote some rough estimates of their monetary magnitude. The estimates are from various different studies. Unless otherwise stated they are in U.S. dollars and have not been converted to present-day values.

2.2.1 Negative externalities

There is no complete consensus on precisely what consequences from smoking should be included in the calculations for externalities, and even for those for which a consensus exists, estimates of the magnitudes vary widely.

The most significant externality from smoking is the financial burden of medical costs from smokers' smoking related diseases on taxpayers. The magnitude of this externality depends on the nature of health insurance in the country in question. In

countries with low health insurance coverage externalities from smoking will be smaller as smokers bear the medical costs mostly themselves. When insurance coverage is higher the magnitude of externalities depends on insurance policy parameters and on the financier of the insurance. Smokers rarely pay more for health insurance than non-smokers, which means that the latter subsidize the former. This is a negative externality to non-smokers. In countries with national health insurance, where everyone is insured and the financing comes not from insurance payments but from tax revenue, a very large percentage of health care costs due to smoking are external costs.

A potentially substantial externality overlooked in most the literature is the annoyance to non-smokers from smokey environments, independent from the health care costs and not to be confused with environmental tobacco smoke costs below. Willingness to pay to avoid cigarette smoke is the appropriate measure for this externality. Using the United States as an example, Warner et al. (1995) suggest that if the average non-smoker would be willing to pay $50 yearly to avoid the annoyance from cigarette smoke, this alone would warrant a tax of 42 cents per pack. Unlike many of the other externalities, annoyance is a present day cost attributable to present day smoking.

Smoking breaks and sick-leave absenteeism lead to lost productivity in the workplace. If smokers do not compensate through lower wages – and it is unlikely that they do - the lost productivity is a negative externality. Manning et al. (1991) found that smokers impose $600–$1,100 per year in productivity and absenteeism costs on businesses, and that smokers miss 50 percent more work days each year due to illness than do nonsmokers.

Smokers are also much more likely to start fires than nonsmokers, mostly due to falling asleep with burning cigarettes. In the year 2000, for example, fires started by smokers caused 30,000 deaths and $27 billion in property damage worldwide (Leistikow et al., 2000). This is a clear externality due to health and property damage to others, not to mention public resources devoted to firefighting. Other external costs include street cleaning costs, building maintenance costs etc.

The costs listed above can clearly be categorized as externalities. The case with environmental tobacco smoke, a significant burden on the non-smoking population, is less clear because they are mostly felt by the smoker's family. Secondhand smoke health costs are an ambiguous and controversial topic. Exposure to the smoking of others increases for example lung cancer and cardiac disease risk. According to Chaloupka and Warner (2001) these costs may amount to as much as 70 cents or several dollars per pack of cigarettes depending on the definition of an economic unit (see below).

According to the World Health Organization (2008) second-hand tobacco smoke exposure in the United States alone costs an estimated $5 billion annually in direct medical costs and another $5 billion in indirect costs caused by productivity losses from lost wages due to disability and premature death. It is estimated that 10 percent of total tobacco-related economic costs are attributable to environmental tobacco smoke.

How large a share of the second-hand smoke costs is considered internal and how large a share external depends on how an economic unit is defined. The smoker's family is often considered to form one economic unit, and therefore secondhand smoke costs are considered to have been internalized by the smoker when making the decision to smoke (Gruber and Koszegi, 2004). Some researchers refer to costs of this type as quasi external costs.

Another cost is a result of smoking while pregnant. Smoking leads to an increased incidence of low birthweight babies, imposing both short run health care costs and long run special education costs. According to calculations by Evans et al. (1999) these costs may amount to 42 to 72 cents per pack. Again, the costs caused by smoking while pregnant are often considered to be internal costs.

2.2.2 Positive externalities

On average smokers die about 6 years earlier than non-smokers. Therefore smokers do not collect part of or any of the retirement benefits to which they would otherwise be entitled, and in this way they subsidize non-smokers' social security payments. In addition, smokers who die early do not impose the large nursing home and medical costs that usually occur at advanced ages.

According to van Baal et al. (2008) average expected remaining lifetime health-care costs at age 20 are 281,000 euros for healthy-living individuals, 250,000 euros for obese individuals and 220,000 euros for smokers. The life-expectancy estimates at age 20 are 64.4 years, 59.9 years, and 57.4 years, respectively.

Although calculating benefits from premature deaths may seem inappropriate, they have an undeniable offsetting effect when calculating the monetary value of net externalities. Manning et al. (1989) estimate the 'external savings' due to premature deaths at 27 cents per pack.

The offsetting effect by the premature deaths of smokers is considerable, even to the extent that some researchers have claimed that the positive externalities more than completely offset the negative externalities, and consequently smoking actually generates net positive benefits for the society. According to Viscusi (1995) "detailed calculations of the financial externalities of smoking indicate that the financial savings from premature mortality in terms of lower nursing home costs and retirement pensions exceed the higher medical care and life insurance costs generated."

Viscusi estimates that every pack of cigarettes smoked generates a net negative externality of 27 cents to the society when using a discount rate of 5 percent, and net cost savings (a positive externality) of 32 cents when using a discount rate of 3 percent. This would imply that the optimal tax for cigarettes from the externalities point of view is quite close to zero. In countries with a high level of social security the benefits from earlier deaths are naturally larger.

2.2.3 Net externalities

Plenty of studies have attempted to calculate the net negative externalities of smoking, despite the apparent problems with measuring some of the costs. A typical estimate of net externalities is around 40 cents per pack (Gruber, 2001). Estimates quoted by Chaloupka and Warner (2001) range from 16 cents (in 1986 dollars) to $4.80 (in 1991 dollars).

Many of the studies omit costs from environmental tobacco smoke as they are seen largely as a cost to the smoker's family anyway, and the family is considered to be one economic unit. As discussed above, including these costs would have a significant effect on the results.

As Chaloupka and Warner (2001) note, partly because of the above reason and partly because of the financial benefits from premature deaths, the studies more often than not estimate a rather low amount of net externalities. With the traditional view of externality-based taxation they therefore advise against cigarette tax hikes because existing taxes are usually already above these levels.

2.2.4 Internalities

The vast majority of the harm done by a smoker is to himself and these 'internal costs' are the primary interest in this thesis. Again, there are various such costs that are nearly impossible to quantify and thus seldom included in calculations, for example increased coughing, the disadvantage from lowered immunity to diseases etc. The self-perceived value of a human life plays a central part in estimating the internal costs from smoking.

Using measures such as the wage premiums associated with risky jobs Viscusi (1995) estimates that the self-perceived value of a human life is $3-7 million (1990) in U.S.

dollars. Gruber and Koszegi (2001) take Viscusi's midpoint value and convert it to 6.8 million (2001) dollars. Taking the fact that smokers die on average 6.1 years earlier than non-smokers, combining it with data on the shares of cigarettes smoked at different ages, and using a discount rate of 3 percent, Gruber and Koszegi calculate that in terms of lost life expectancy alone a pack of cigarettes costs on average $35.64 to the smoker.

This internal cost estimate is roughly 100 times more than typical estimates of the interpersonal externalities per pack. Naturally there is variation depending on the age of the smoker and the discount rate used (since the discounted costs are at the end of life, they fall as the discount rate goes up), but the cost is nevertheless strikingly large for any reasonable discount rate.

It is worthwile repeating that this figure does not include any medical or other costs besides the lost life years. Likewise, none of the considerable secondhand smoke costs discussed above, that are supposedly internalized by the smoker, are included. It is therefore likely that the full amount of internal costs is significantly higher than $35.64 per pack.

3. Economics of taxation

In this section I will first go through some basic economics on externalities and taxes, and then discuss the properties of taxation as a tool for combatting self-control problems.

3.1 The basics

In a perfectly competitive market, taxes on goods create market inefficiencies by producing a deadweight loss. In the absence of taxes the price of a good adjusts to ensure that all trades that benefit both the buyer and the seller occur. After a tax is introduced, the price received by the seller is less than the cost to the buyer, resulting in fewer trades and loss of gain from market participation. The value that is lost is the deadweight loss from the tax.

The market for tobacco is an imperfect market because of the large number of negative externalities associated with smoking, most importantly the public healthcare costs not felt by the smoker himself. With negative externalities, the market trades too much of the good, because some of the costs are felt by someone else than the participants of the trade.

The market failure may be corrected by introducing a tax on the good. This kind of tax, equal to the size of the negative externality, increases economic efficiency and overall welfare. It is known as a Pigovian tax.

Figure 3 depicts how taxation lowers the quantity consumed to the socially optimal level. D is the demand curve, PC the supply curve. SC the social cost curve (private costs + externalities) and PC+T the supply curve after the excise tax. Because of externalities, consumption is above the social optimum. After a tax is levied,

consumption decreases from Q_1 to the socially optimal level Q_2 and price increases from P_1 to P_2.

FIGURE 3: Using taxes to internalize negative externalities
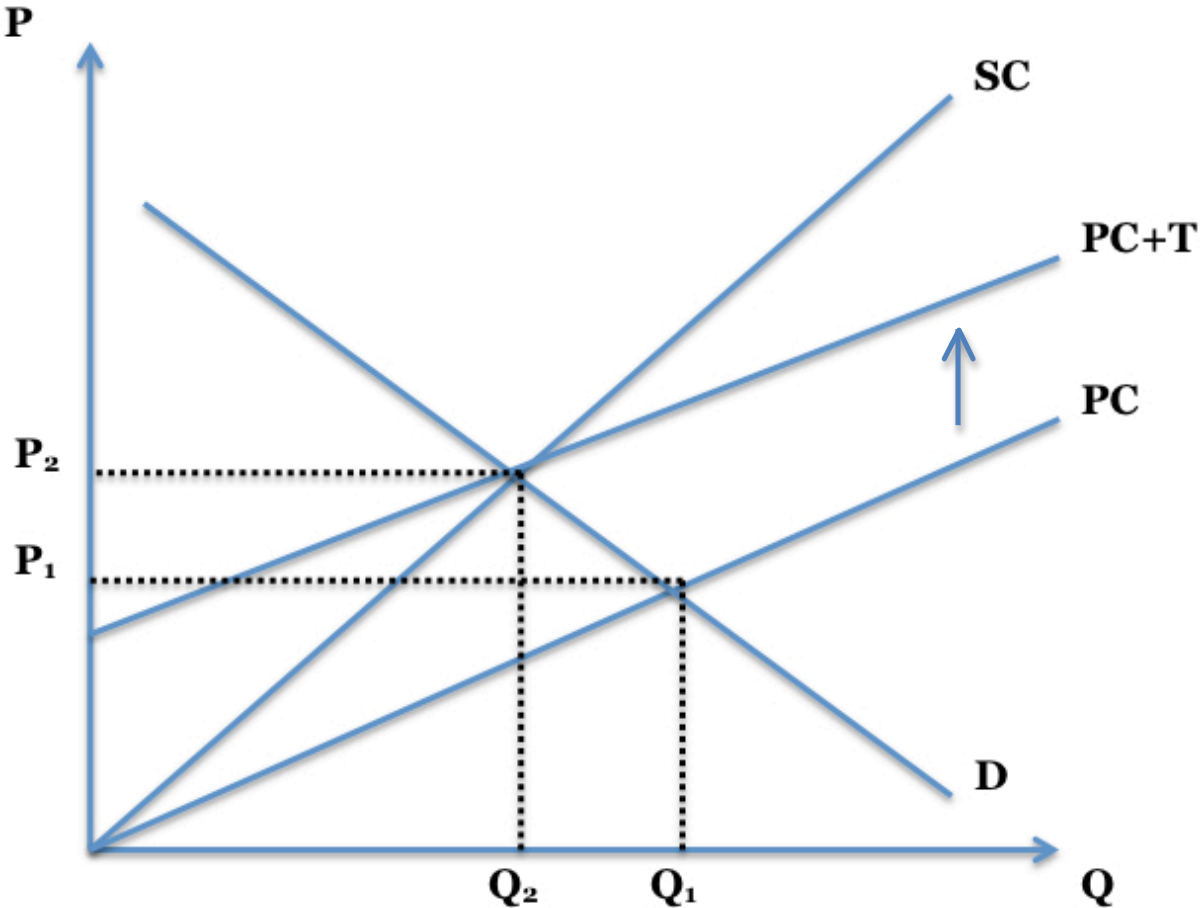
3.2 Taxation and internalities

Taxation is an effective tool for combatting self-control problems (the mechanism will be explained below in section 5) because the government has the power to force. Unlike many other government policy instruments and private market solutions, taxation can not generally be avoided. Taxation is nevertheless not a flawless

solution, it has many issues that need to be considered when setting the tax level. These will be discussed next.

Smuggling and tax-free imports (although imports are usually also controlled by the government to a large extent) may lower the effectiveness of taxes. Intuitively the incentive to smuggle or to import from a lower-tax area abroad increases with rising taxes. The corrective taxation needs to be enforceable to be effective.

The World Bank (1999), however, found no evidence that tax increases or high existing taxes lead to an increase in large-scale cigarette smuggling. Smuggling is common in many countries with low cigarette prices (e.g. Italy and Spain) and uncommon in many countries with high cigarette prices (e.g. Finland, Norway and Sweden). The prevalence of smuggling in any given country seems to have more to do with weak border controls, poor tax administration, the presence of informal distribution channels, and the general acceptance of black market selling of any kind among its population.

Another question concerns the effect of tax increases on actual retail cigarette prices. Smokers adjust their consumption according to the cigarette price. As such, the design of an optimal cigarette tax level based on economic efficiency grounds needs to adjust for price changes that exceed the change in tax. The tobacco industry may react to increased taxes by adjusting their pre-tax pricing upwards or downwards for profit maximization purposes.

Chaloupka and Warner (2001) note that the oligopolistic nature of the cigarette industry and the addictive nature of cigarette demand have important implications for the effects of cigarette tax increases on cigarette prices.

Economic theory states that tax increases would be fully passed on to consumers in a perfectly competitive market with fully elastic supply. A monopolist, on the other hand, would share some of the increase with the consumer. In most of the developed world the cigarette industry is an oligopoly. For example in the United States three cigarette producers of a total of six control over 90 percent of the market, whereas in many developing countries there is a domestic monopoly.

Interestingly, all of the studies quoted by Chaloupka conclude that the retail price increases motivated by tax hikes have been higher than the magnitudes of the increases (from 11 percent to 112 percent higher) in the United States. The difference, it seems, exists because the cigarette industry uses federal tax increase announcements as focal points for joint oligopolistic price increases. In a comprehensive study Keeler et al. (1996) estimate that a one-cent tax increase would lead to a retail price increase of 1.11 cents.

If the retail price rises by more than the tax increase, which seems to be the case in the United States at least, a tax rate designed to move consumption towards the Pareto-efficient level may reduce consumption below the intended level. This needs to be taken into account when calculating the tax hike.

Consumers differ in the quantities they smoke and some of the costs of smoking do not increase in a linear fashion. For example lung cancer incidence increases with the square of the daily amount smoked and with the duration of smoking raised to the power of four to five (U.S. Department of Health and Human Services, 1989).

Nevertheless, in practice the only available taxation method for cigarettes is a constant, uniform per pack rate. Ideally, the marginal tax rate would reflect the marginal cost of smoking, but taxing cigarettes this way is not possible. Therefore, the tax will unevitably lead to some level of over-taxation of consumers who only smoke small amounts or for short periods in their life, and to under-taxation of heavy, life-long smokers.

O'Donoghue and Rabin (2006) suggest considering whether more sophisticated taxation methods would be possible to implement, for example a policy where the government would offer a tax menu wherein each smoker chooses in advance her per-unit tax and the associated lump-sum transfer. This method would take advantage of the fact that smokers with self-control problems have a desire to constrict themselves in the future.

As noted by the World Health Organization (2008) tobacco taxes should also make tobacco products progressively less affordable by offsetting the combined effects of

inflation and increased consumer incomes and purchasing power. This requires periodic increases in cigarette taxes to maintain their impact.

Many countries have tobacco products that are becoming increasingly more affordable because taxes do not keep up with inflation and incomes. As discussed below in section 7, prevailing cigarette tax methods are usually a combination of a specific excise tax that should be periodically increased, and an ad valorem excise tax that is a percentage of the retail price and thus adjusts automatically.

Chaloupka and Warner (2001) note that studies of compensating behavior by smokers in response to tax and price changes have found consistent evidence that, although smokers reduce the amount of cigarettes smoked in response to higher taxes, they also compensate by smoking longer cigarettes, and those with a higher tar and nicotine content. This may overstate health benefits from higher cigarette taxes. It has therefore been suggested that taxes based on tar and nicotine content would be more appropriate.

Compensating behavior also extends to substitutive tobacco products. Studies on cross-price effects for cigarettes and other types of tobacco products are scarce. The ones that exist concern smokeless tobacco and hand-rolled cigarettes.

Ohsfeldt and Boyle (1994) find that higher cigarette excise taxes have a positive and significant effect on the prevalence of smokeless tobacco use. Pekurinen (1989) concludes that some Finnish cigarette smokers would switch to less expensive hand-rolled cigarettes in response to increases in the prices of manufactured cigarettes. In a contradicting study, Leu (1984) finds little evidence of substitution among tobacco products by Swiss tobacco users in response to changes in their relative prices. If compensating behavior is significant, tax adjustments need to be consistently applied to all tobacco products.

Non-taxable substitutes may also exist. O'Donoghue and Rabin (2006) point out that "if policymakers naively ignore the existence of substitute and non-taxable sins, then imposing taxes may inadvertently do more harm than good. This is especially a concern if substitute sins have larger health costs — for instance, cigarette taxes

might lead people to substitute into black-market, unfiltered cigarettes."

Other government policies such as clean air regulations that limit smoking in public places may also act as self-control devices, making it more 'costly' to smoke by limiting the amount of places to do it. Taxation nevertheless appears to be the most effective policy. Additionally, while the majority of tobacco control policies cost money for the government, taxation creates revenue.

The feasibility of private sector solutions to self-control problems is considered in section 8.

4. Price elasticity of demand for cigarettes

In order for taxes to be an effective policy in reducing excessive smoking, smokers must respond to changes in prices. As will be discussed in section 5, it has not always been self-evident that they do. Since the 1980's plenty of research has nevertheless shown that cigarettes have a regular downward-sloping demand curve. The purpose of this section is to prove that smokers are price-sensitive, and to find out how much so.

Price elasticity of demand measures the responsiveness of the quantity demanded of a good to a change in its price:

$$E = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}} = \frac{\Delta Qd/Qd}{\Delta P/P}$$

To get a general idea, according to Sunley et al. (2000), a tax increase that would raise the real price of cigarettes by 10 percent would reduce consumption between 1.2 percent and 3.36 percent in high-income countries, and by 4 percent to 6 percent in low-income countries.

Chaloupka and Warner (2001) summarize a large amount of literature on price elasticity of cigarettes. The estimates fall within the range of -0.14 to -1.23, with the majority falling between -0.30 and -0.50. Most of the studies, using aggregate time-series data, individual level data as well as experimental data, produce quite consistent estimates in a narrow range, centered on -0.40.

Looking at different subgroups, women are generally more price sensitive than men (elasticities of -0,50 and -0,34, respectively, according to Gallet and List (2003)), both men and women in lower socioeconomic groups are more sensitive than those that are better off, and youth and young adults are more sensitive than adults.

The World Bank (1999) gives estimates of -0.40 in developed countries and -0.80 in developing countries. In a meta-analysis reviewing 86 studies published to the year 2001, Gallet and List (2003) find a mean price elasticity of −0.48.

It has been argued that price responsiveness in less developed countries is likely to be greater than in the developed world because of the relatively low incomes and relatively low levels of cigarette consumption by smokers in those countries. The findings of Becker et al. (1994) (among others) are consistent with this argument. They estimate a price elasticity of -0.40 in high-income countries and -0.60 to -1.00 in middle- and low-income countries.

Using individual-level data allows researchers to consider the effects of price on smoking participation (whether people smoke at all) and on average cigarette consumption (how much they smoke) separately. Lewit and Coate (1982) found an overall price elasticity of demand of -0.42 and an elasticity of smoking participation of -0.26.

According to Chaloupka and Warner (2001) most of the effects of price on smoking among young people is on participation, mostly by reducing smoking initiation. Among older people, price increases are believed to be more likely to affect both average consumption and participation, the latter mainly through quitting rather than preventing initiation.

In a study on the demand of tobacco products in Finland Pekurinen (1989) finds that the demand for cigarettes is almost twice as sensitive to falling prices (elasticity of -0.94) than to rising prices (elasticity of -0.49). Young (1983) reaches the same conclusion. They both interpret the results as evidence of the addictive properties of cigarettes.

Similarly, Mullahy (1985) found that smokers with a larger addictive stock (more smoked cigarettes in the past) were less price sensitive than their less-addicted counterparts. Becker et al. (1994) suggest that because of the addictiveness of smoking the long-run price elasticity of cigarettes may be twice the short-run elasticity.

Though unsurprising, an important thing to note (and one that will be revisited in section 9 on tax incidence) is that according to Gruber and Koszegi (2004) the price sensitivity of smoking is much larger for the lowest income groups than for their higher income counterparts. The bottom income quartile has a price elasticity of demand of -1.00.

Concluding, studies on the price elasticity of demand for cigarettes have consistently shown that smokers are price sensitive, and that -0.40 is a good estimate of the overall elasticity in developed countries.

5. Addictive good consumption models

Early research considered addictive behaviors such as smoking irrational and therefore unsuitable for conventional economic analysis. It was widely believed that the demand for cigarettes does not follow even the most basic laws of economics such as the downward-sloping demand curve. The substantial body of economic research from the past 30 years demonstrates however, that smokers do in fact respond to changes in prices and other factors (Chaloupka and Warner, 2001).

Early literature (before the 1980's) on the consumption of addictive goods concentrates mostly of the habit formation –aspect (or reinforcement, as referred to below) of smoking. Unsurprisingly, a number of articles show that past consumption has an effect on current consumption of cigarettes (Chaloupka and Warner, 2001).

The primary concept in economics used to analyze decisions involving the time dimension is discounting, or the tendency to attach a lower value to the future than to the present. It is precisely the question of the discounting method that best describes real-world behavior that has become one of the main topics of interest in modeling addictive goods in recent years.

I will next present three consumption models. The first one is the rational addiction model by Becker and Murphy (1988), which, though controversial, has become the standard approach to understanding addiction in economics. The model was groundbreaking because previously addicted consumers were viewed as being myopic.

It was widely assumed that addicts ignored the effects of current consumption on future welfare, and that the consumption of addictive goods is unresponsive to price changes. Myopic behavior implies an infinite discounting of the future. Becker and Murphy were the first to view addictive behavior as rational and fit it in the context of standard economics.

The second model is an extension of the rational addiction model by Gruber and Koszegi (2001) with one distinctive difference: It allows agents to be time-inconsistent, by suggesting a different way that agents may in fact discount the future in the real world. As the two models share mostly the same features and the latter model is more relevant for this thesis, I will go through it with more detail and only describe the essential components and implications of the rational addiction model, and the assumptions behind it.

The third model I will discuss, by O'Donoghue and Rabin (2006), concentrates on the consumption distortions to time-consistent agents created by taxes meant to help time-inconsistent ones. The main idea of this model is the same as of the Gruber and Koszegi model, but it goes a bit further in its analysis.

5.1 The rational addiction model

According to Becker and Murphy (1988) smokers are 'rational addicts'. The decision to smoke is made optimally recognizing the addictive properties of cigarettes and correctly calculating all benefits and costs from smoking including immediate pleasure, status within a social group, current and future cigarette prices, immediate harm and harm from ongoing use, medical costs, costs of quitting etc.

Smoking is modelled as the building of an addiction stock. Utility at any point in time depends on current addictive consumption of cigarettes, current non-addictive consumption of other goods, and the stock of past addictive consumption. A cigarette smoked today increases the addiction capital of tomorrow.

High addiction capital lowers average utility but increases the marginal utility of smoking. In other words it increases the craving for a cigarette while reducing the pleasure achieved from smoking one. These effects are widely known in the literature, respectively, as reinforcement and tolerance. They are the two conditions required for a good to be considered addictive.

The 'rational addicts' recognize the tradeoff with current consumption created by the addiction stock. Smoking a cigarette increases today's utility but lowers long-run utility.

The key feature of the model for the purposes of this thesis is how consumers deal with the intertemporal problem, what method they use to discount the future. In the rational addiction model agents make a time-consistent choice to smoke, which means that they act in a way best described by the traditional method of exponential discounting. The utility function of an exponential discounter (first presented by Samuelson, 1937) is of the form

$$U_t = (u_t, \dots, u_T) = u_t + \sum_{s=t+1}^{T} \delta^{s-t} u_s$$

where U_t is long-run utility, u_t is utility at time t and δ is a constant discount factor between 0 and 1. A discount factor closer to 1 corresponds to a more 'patient' individual, and vice versa. After discounting future net utility with more distant effects receiving less weight, addicts arrive at either a positive or a negative net utility from smoking and act accordingly in their current smoking decisions, in a rational manner.

Becker and Murphy claim that individuals are time-consistent, forward-looking and rational, they recognize the dependence of the current consumption level on past consumption. Current consumption of an addictive good is inversely related to not only the current price of the good, but also to all past and future prices, or equivalently, current consumption is positively related to past and future consumption. Consequently, the long-run effect of a permanent change in price will exceed the short-run effect.

People are aware of the addictive nature of cigarette smoking and they choose to smoke simply because the discounted lifetime benefits are greater than the discounted costs. A rise in taxes can only lower discounted utility today. If this were

not the case, the rational addict could emulate the tax and raise utility by reducing smoking by the same that the tax does. Hence, according to Becker and Murphy, cigarette taxes reduce the well-being of smokers.

5.2 Critique and empirical evidence

Becker and Murphy's claim, that consumption of addictive goods not only depends on past consumption but on future consumption, has been tested and widely accepted in the literature. Becker et al. (1994) among others have shown with micro data and time series data that addicts are forward-looking, as higher future prices lead to lower consumption in the present.

Gruber and Koszegi (2001) criticize the assumption of addicts' perfect foresight in the rational addiction model. They do not find it realistic that smokers anticipate cigarette price changes very far in advance. However, in an alternative test of their own, they also find support for some degree of forward-lookingness. Cigarette tax increases that have been announced but not yet put into effect seem to have an effect on current consumption according to their results.

Most importantly for the purposes of this thesis, Gruber and Koszegi point out that forward-lookingness tests only the non-myopia condition. It does not imply time-consistency, which is a key assumption in the rational addiction model. Recent developments in behavioral economics suggest that time-inconsistent models may be more appropriate in modeling addiction. Gruber and Koszegi argue that smokers can possibly be made better off by increasing cigarette taxes.

5.3 Addiction with time-inconsistent preferences

In the following I will first present the time-inconsistency –model and then demonstrate through a hypothetical example how time-inconsistency may result in overconsumption of cigarettes.

5.3.1 The model

Gruber and Koszegi (2001) modify the Becker-Murphy addiction stock model by adding the possibility of time-inconsistency in preferences, resulting in self-control problems. A time-inconsistent individual would like to smoke less in the future than she is actually able to. The problem arises because she is patient about the future but impatient about the present. The result is that when the future arrives the individual is impatient again, and will end up smoking more than she would like to from today's vantage point.

Time-inconsistency is added by introducing quasi-hyperbolic discounting (henceforth referred to simply as hyperbolic discounting, which in actuality is a more complicated version of the theory, though with the same qualitative properties), in contrast with the traditional method of exponential discounting described above.

With hyperbolic discounting, an additional discount factor β (again between 0 and 1) is added, to model the individual's tendency to pursue immediate gratification. The next period from now is discounted by $\beta\delta$, the period after that is discounted by $\beta\delta^2$, and k periods after that by $\beta\delta^k$. The utility function of a hyperbolic discounter, also known as Beta-Delta utility (first introduced by Laibson, 1997) is of the following form:

$$U_t = (u_t, \dots, u_T) = u_t + \beta \sum_{s=t+1}^{T} \delta^{s-t} u_s$$

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

The individual discounts her short-run decisions more heavily than her long-run decisions. 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 $t + 1$ arrives, self $t + 1$ puts a relatively low weight ($\beta\delta$) on period $t + 2$ relative to period $t + 1$, and acts relatively impatiently.

This form of discounting creates a conflict between the different selves regarding how to behave, and introduces the scope for a variety of self-control problems in behavior. As Gruber and Koszegi (2008) note, by making the restriction $\beta = 1$ standard models have implicitly assumed that no such self-control problems exist.

I mentioned earlier that the word impatience should be used cautiously. It is important to be clear as to what hyperbolic discounting is and what it is not. It is not the same thing as a high-level of impatience or time-preference. A person may be very impatient also under standard exponential discounting by having an overall discount factor close to zero.

The key to hyperbolic discounting is that the individual's high rate of discounting for a given future time period's utility changes as that time period approaches. There is a conflict between the intertemporal selves. The self-control problem is a problem because the discount factor β reflects a short-term desire or propensity that the person disapproves of at every other moment in her life.

The discount factor β may reflect, for example, the extent of a smoker's underappreciation of future health costs. Alternatively it may reflect the extent of a smoker's incorrect optimism that the negative health consequences won't occur for her.

Gruber & Koszegi solve the optimal tax problem for three types of agents separately: (1) Time-consistent agents; (2) Sophisticated time-inconsistent agents, who know that they will change their mind in the future, and behave strategically according to this; (3) Naïve time-inconsistent agents, who are unaware that they will be impatient again in the future.

The model is very complicated and contains many properties that are unnecessary for the purposes of this thesis. Instead of going through the full model I will present a simplified version of it, that captures everything that is necessary to show how overconsumption may occur, and how it can be corrected through taxation. This version is adapted from Gruber and Koszegi (2008), and it concentrates on the harmfulness of cigarette consumption. The effect of the addictive properties will be discussed later.

In each period from 1 to T - 1 agent i makes a decision of whether or not to smoke (modeling the amount of smoking instead would lead to approximately the same results). Smoking in period t causes benefits b_i in period t and harm h in period $t + 1$, expressed in monetary terms. The amount of harm is the same for all smokers, but the experienced benefits vary between them. The producer price of cigarettes in period t is p_t and the tax is τ, making the consumer price $p_t + \tau$. Externalities are noted by e.

To demonstrate a hypothetical situation that results in overconsumption, consider the values below:

$\beta = 0.5$
$\delta = 0.95$
$b_i = 2$
$p_t = 1$

$\tau = 0$

$h = 2$

In period 1, the agent compares the pleasure from smoking ($2) to the cost of a pack of cigarettes ($1) plus the discounted value of health damage in period 2 ($2 * 0.95 * 0.5 = $0.95). The benefits are greater than the costs and the agent decides to smoke. The situation in the next period and all the periods after that is exactly the same. The agent will smoke throughout his life.

The stream of instantaneous utility from this consumption pattern is

{1, -1, -1, -1, ..., -1, -2}

which is inferior to a lifetime of no consumption. The agent thus voluntarily engages in an activity that makes him worse off in the long-run, because the consumption decisions are made in an impatient state, when the agent is about to experience the immediate pleasure of smoking. At this moment short-run gains and costs are weighted very strongly against the long-term health costs.

To see how taxation may be able to correct problems from free market cigarette consumption, consider the following optimality conditions:

In any period $t \in \{1, ..., t - 1\}$, agent i will smoke if and only if

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

In contrast, from the point of view of the society it is optimal for agent i to smoke if and only if

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

The differences are: (1) From the social point of view taxes are a transfer to the government instead of a wasted expenditure. (2) As noted many times above, externalities are by definition not taken into account by the smoker, but affect the social optimum. (3) The appropriate discount factor for social optimality is the long-run discount factor δ, whereas the agent himself at each moment in time discounts using $\beta\delta$.

Combining the optimality conditions of the individual agent and the society as a whole we arrive at the optimal tax, which aligns the incentives of both parties perfectly:

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

It is easy to see that if agents are time-consistent ($\beta = 1$) the optimal tax equals the monetary value of the externalities (Pigouvian tax, section 3). However, if agents suffer from self-control problems ($\beta < 1$), the optimal tax equation includes an additional term $(1 - \beta)\beta h$ intended to correct the underweighting of future consequences of consumption.

Gruber and Koszegi argue that while for many consumption goods the externality term may be much more important than the self-control term, for cigarettes the opposite is true, by a margin. Due to the huge damage smokers do to themselves and the large value they place on their lives, the self-control term dominates the externality term even for moderate values of β.

Existing laboratory and field evidence suggests that a realistic value for β is somewhere between 0.6 and 0.8 for the typical smoker. Levy (2010) estimates a δ of 0.9 and a β of 0.7 to 0.8. As he indicates, these numbers are very similar to those estimated by other researchers. Table 1 exhibits the optimal tax levels for a pack of cigarettes for different levels of time-inconsistency, assuming that the value of net externalities is 40 cents per pack (not an unrealistic estimate, as seen in section 2.2.3). The value of internalities used is $35.64. This is the estimated cost for lost life

expectancy from section 2.2.4. As discussed in that section, it almost definitely underestimates the actual amount of internal costs.

TABLE 1: Optimal taxes for different values of β

β	1	0,9	0,8	0,6
Optimal tax	0.40	3.96	7.53	14.66

It is clear that the internalities dwarf the externalities. Using the not unrealistic β of 0.6 suggests a tax of almost 15 dollars for a pack of cigarettes. Only if β is extremely close to 1 does the externality term become more important.

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 – as shown above - deviating from this model even a small amount has dramatic implications for policy. It should also be reminded that the estimates above are based on the loss of valuable life years only. All non-mortality related costs from smoking such as reduced health and other disadvantages discussed earlier are ignored.

The calculations above are based on parameters in the United States, a high-income country. Gruber and Koszegi argue that although smokers in lower-income countries probably value their lives less in dollar terms, it is unlikely that they do so relative to income. There is also no evidence that β would be different in countries with different income levels. Therefore it is likely that the optimal tax relative to income is as high in countries of all income levels.

The simplified model above ignores the addictive properties of cigarettes, which are considered in detail in the full version of the model. However, addictiviness (tolerance and reinforcement) in itself does not invalidate the conclusions of the

rational addiction model, if it is anticipated correctly. In this study I assume that the addictiveness of cigarettes is anticipated correctly.

Since different selves disagree on the optimal consumption path, it needs to be made clear which preferences are considered relevant for welfare evaluation. There is a quite strong consensus in the literature (e.g. Bernheim and Rangel, 2005 and Gruber and Koszegi, 2004) that the long-run perspective should be used – as I do in this thesis - as the appropriate welfare criterion.

There are two reasons for using the long-run perspective. Firstly, long-run preferences are the welfare measure that would be used by an agent if she were to vote for a tax change to be implemented from the next period onwards. Secondly, when thinking about the agent as a sequence of distinct selves with conflicting preferences like I do above, the long-run preferences apply to all the selves except for the present one. Since the agent judges trade-offs between period *t* and *t+1* by exactly the same criteria in all periods but one, the influence of any one self must decline to zero as the number of selves becomes large.

5.3.2 Hyperbolic discounting and overconsumption of tobacco: A hypothetical example

What follows is a numerical example that demonstrates the difference that exponential and hyperbolic preferences might have in real-world values, adapted from Cherukupalli (2010).

Table 2 presents calculations of the total discounted costs of a pack of cigarettes for three different types of smokers: an exponential discounter of the traditional view and two time-inconsistent individuals A and B with short-term discount factors of 0.9 and 0.6, respectively. All three indiduals share the same long-term discount rate, pay the same price for a pack of cigarettes and have the same perception of health costs from smoking.

***TABLE 2: Hypothetical cost-benefit calculations by an exponential discounter and two hyperbolic discounters***

	Exponential Discounter	Hyperbolic Discounter A	Hyperbolic Discounter B
Smoker's valuation of benefit, €	25.00	25.00	25.00
Retail pack price paid by the smoker, €	5.00	5.00	5.00
Smoker's perception of health cost/day, €	0.01	0.01	0.01
Long-term discount factor	0.95	0.95	0.95
Short-term discount factor	1.00	0.90	0.60
Discounted value, today, of hypothetical health costs (1 cent/day) incurred at different points in the future, cents			
Today (day 0)	1.0000	1.0000	1.0000
Tomorrow (day 1)	0.9999	0.8999	0.5999
In 1 week (day 7)	0.9990	0.8991	0.5994
In 1 month (day 30)	0.9959	0.8963	0.5975
In 1 year (day 365)	0.9512	0.8561	0.5707
In 5 years (day 1826)	0.7787	0.7008	0.4672
In 10 years (day 3652)	0.6064	0.5458	0.3638
Sum (discounted value of costs, day 0−3652), €	28.74	25.87	17.25
Total costs (retail pack price+discounted value of perceived health harm), €	33.74	30.87	22.25

For the exponential discounter the total costs of 33.74€ from smoking a pack of cigarettes exceeds the benefit valued at 25.00€ from it. Therefore he will smoke less than a full pack. The hyperbolic discounters A and B place a higher premium on the present than the immediate future by having additional short-term discount rates, which results in underrating all cumulative future harm. For individual B this leads to overconsumption of cigarettes.

The area under the solid line in Figure 4 represents the present value of perceived harm for smoker B. He predicts that one week from the present smoking a full pack

of cigarettes will not be worthwile, but after the week he will again end up smoking a full pack.

FIGURE 4: Model of exponential discounting and hyperbolic discounting
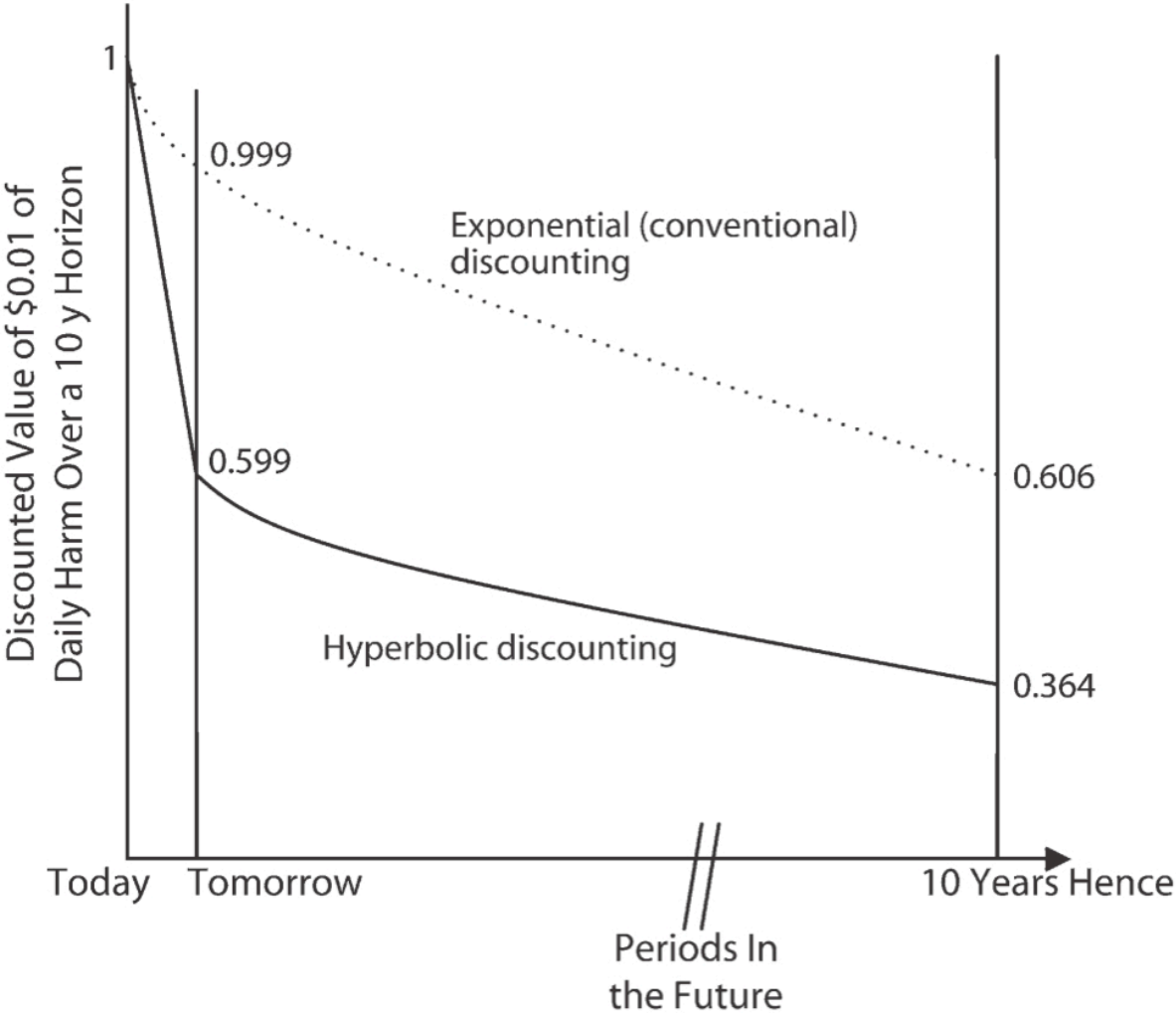
5.4 Consumption distortions with differing degrees of time-inconsistency

It is intuitively apparent that people are not identical when it comes to time-inconsistency, but it is only possible to have a single cigarette tax level that applies to everyone. Therefore a trade-off emerges between, on the one hand, creating consumption distortions for the fully self-controlled persons, and, on the other hand, reducing overconsumption by persons with self-control problems.

O'Donoghue and Rabin (2006) model an economy where individuals have hyperbolic preferences for 'sin goods'. Similarly to Gruber and Koszegi (2001) they find that in the absence of taxes self-control problems lead to over-consumption (of potato chips in this case) because future costs are not given full weight. Current consumption imposes a negative externality on future selves. When consumers are identical, a Pigouvian tax-and-transfer scheme can be used to correct the over-consumption. A per-unit tax is imposed and the proceeds of the tax are returned to consumers via a uniform lump sum.

The more interesting part of the model is the more realistic case where consumers differ in both their taste for the sin good and in their degree of time-inconsistency. O'Donoghue and Rabin study how consumer heterogeneity affects the optimal consumption tax policy when the government is limited to using linear taxes and lump sum transfers that are the same for all consumers.

Their main insight is the following: Taxes necessarily create consumption distortions for fully self-controlled people. However, the distortions are second-order relative to the benefits from reducing over-consumption by people who have self-control problems. If at least a part of the population has self-control problems (if the average β is less than 1), then it is always optimal to tax potato chips.

Policies aimed at helping people overcome their errors do not need to be detrimental to the rational. The general intuition is that if a policy can make irrational people strictly better off, then there is scope to make fully rational people better off as well

by reallocating resources from irrational people to rational people. With sin taxes the same policy can automatically accomplish both at the same time.

O'Donoghue and Rabin also find that even very low levels of time-inconsistency may have a large effect on the optimal tax level, and that even relatively large taxes are unlikely to cause much harm to completely self-controlled agents. As no estimates of future health costs from snack foods is available, they use the Gruber and Koszegi lost life expectancy cost estimate for cigarettes of \$35.64 and consider several distributions over relatively small values of β from 0.9 to 0.99 and using among others a price elasticity of -0.50, roughly similar to the elasticity for cigarettes.

The results are quite dramatic. If half the population has a very small β of 0.99, the optimal tax is 5.15 percent. If instead half the population has a β of 0.90 – still a much smaller degree of self-control problems than studies suggest - the optimal tax is 63.71 percent. O'Donoghue and Rabin conclude that "while it is an open empirical question exactly by how much the existence of self-control problems would alter optimal taxes, these numerical examples highlight that we should not presume the effect to be small."

They also find that under realistic environments, an individual's awareness of her own self-control problems mitigates the over-consumption of an addictive product.

Next I will present a simplified version of the O'Donoghue and Rabin model, adapted from Kan (2007). The purpose is to demonstrate why a sophisticated time-inconsistent smoker has a demand for a self-control device. This version of the model does not consider heterogeneity in time-inconsistency or tastes.

An infinitively lived smoker faces two choices, to continue smoking or to quit. The corresponding lifetime utilities are

| {*S, S, S, ...*} | if she continues smoking, and |
| {*Q, N, N, ...*} | if she quits. |

S, Q, and N are per-period utilities, with $Q < S < N$. The disutility from quitting is assumed to make the quitting period (Q) less satisfying than a period of smoking (S). Due to the harmfulness of smoking a period of abstinence from cigarettes (N) is the one that provides most utility. The condition for the smoker to quit in the current period is

$$Q + \beta \sum_{t=1}^{\infty} \delta^t N > S + \beta \sum_{t=1}^{\infty} \delta^t S$$

$$\Leftrightarrow S - Q < \frac{\beta \delta}{1 - \delta}(N - S).$$

The cost of quitting ($S - Q$) must be smaller than the lifetime gain from not smoking $((\beta\delta/(1 - \delta))(N - S))$ in order for the smoker to quit. From the perspective of the current period the condition to quit in the next period is

$$\beta Q + \beta \sum_{t=1}^{\infty} \delta^t N > \beta S + \beta \sum_{t=1}^{\infty} \delta^t S$$

$$\Leftrightarrow S - Q < \frac{\delta}{1 - \delta}(N - S).$$

Since $\beta \leq 1$, it is more likely for the smoker to plan to quit in the next period than to actually quit in the current period, as $(\delta/(1 - \delta))(N - S)$ in the next period condition would be greater than $(\beta \delta/(1 - \delta))(N - S)$ in the current period condition.

If the following inequality holds, the smoker will keep on postponing quitting smoking forever:

$$\frac{\beta\delta}{1-\delta}(N-S) < S - Q < \frac{\delta}{1-\delta}(N-S)$$

In this case the smoker will not quit in the current period, but will plan to quit in the next. When the next period arrives, she will again postpone the plan for another period, and so on. If the smoker realizes that she has a self-control problem, she will now have a demand for a self-control device denoted by C.

C is a cost that the smoker must pay if she smokes in the next period. To be effective, the cost must be large enough such that when the next period comes the lifetime utility associated with quitting is greater than the costs, or

$$S - Q - C < \frac{\beta\delta}{1-\delta}(N-S)$$

$$\Leftrightarrow C > S - Q - \frac{\beta\delta}{1-\delta}(N-S).$$

6. Evidence for hyperbolic discounting

There is a considerable amount of empirical evidence from behavioral economics suggesting that consumers' preferences are not time-consistent and that smoking behavior exhibits an especially good example of this. A survey follows, with the evidence divided into five categories. The first two are more general, the last three specifically related to smoking behavior. In the last section I take a look at contradicting evidence.

6.1 Laboratory experiments

Laboratory experiments consistently document time-inconsistent behavior. In experimental settings consumers reveal a lower discount rate when making decisions over time intervals further away than for ones closer to the present. Thaler (1981) tested preferences by asking individuals what amounts of money received at various points in the future would be equal to $15 received today. The median response for 1 month from now was $20 implying an average annual discount rate of 345 percent. For one year it was $50, a discount rate of 120 percent. For 10 years the median answer was $100, a discount rate of 19 percent.

According to Ainslie and Haendel (1983) preferences between two delayed rewards can reverse in favor of the more proximate reward as the time to both rewards diminishes. For example, someone may prefer 110€ in 31 days over 100€ in 30 days, but also prefer 100€ now over 110€ tomorrow. It is quite clear that exponential discounting can not describe short-term and long-term preferences at the same time in a real-world setting.

6.2 Observed patterns in real-world behavior

Other studies take models with and without time-inconsistent behavior and assess which of these is better supported by observed real-world behavior. Gruber and Koszegi (2001) note that empirical studies consistently reveal the prevalence of self-control problems in decisions such as consumption versus saving.

Credit-card customers are more responsive to initial low 'teaser' interest rates but less responsive to the more important long-term interest rates or the length of the introductory period, suggesting that they care more about short-term incentives than about how much they will pay in interest in the future. In addition, people in general tend to have very little liquid savings but substantial savings in long-term illiquid assets, suggesting that they are impatient on short-term decisions but more patient on long-term decisions.

DellaVigna and Malmendier (2004) find that the majority of individuals who sign up for an expensive gym membership rarely take advantage of the membership. In the majority of the cases, paying per visit instead would have been more economical in retrospect. This suggests that individuals' long-run desire of staying healthy conflicts with their short-run inclinations when it comes to actually paying the effort cost of exercising.

6.3 Use of self-control devices or techniques

A self-control device needs to be distinguished from a quitting aid. A quitting aid lowers the disutility from not smoking, whereas a self-control device lowers the utility from smoking. A time-consistent person might use a quitting aid when quitting smoking, but not a self-control device. Lowering the utility of an undesired alternative is irrelevant for decisionmaking. Taking advantage of a self-control device

that makes smoking more costly only makes sense for an agent who recognizes that he is time-inconsistent.

According to a study by Prochaska et al. (1982) smokers attempting to quit regularly set up socially managed incentives to refrain from smoking by betting with others, telling them about attempt and otherwise making failure to quit embarrasing for themselves. Various punishment and self-control strategies are recommended by academic publications (Grabowski and Hall, 1985). They are also prominent in a variety of self-help books.

Kan (2007) empirically tests smokers' demand for self-control devices. The estimation results from Taiwanese survey data indicate that a smoker's intention to quit has a positive effect on the smoker's support for smoking bans in public areas and cigarette excise tax increases. Kan describes the effect as 'numerically very significant'.

Ariely and Wertenbroch (2002) conducted a study where students had to write three papers for a class and were assigned to one of two experimental conditions. In one, deadlines were imposed by the instructor and were evenly spaced across the semester. In the other, each student was allowed to set her own deadlines for each of the three papers. The delay penalties were the same for both choices. Although students could have made all three papers due at the end of the semester, many chose to impose deadlines on themselves, suggesting that they appreciated the commitment device. Few students chose evenly spaced deadlines, however, and those who did not choose them evenly performed worse in the course than those who did.

6.4 Inability to actualize desired future levels of smoking

Naive hyperbolic discounters do not understand that they are unable to follow through plans, or in other words unable to make consistent plans through time. A large proportion of smokers express the desire to quit, but fail to do so. According to

Burns (1992) 80 percent of smokers in the U.S. would like to quit but most of the intentions are not actualized. A time-consistent smoker would simply make the decision to smoke or to quit and follow through.

Whereas the evidence for adults on their specific predictions or intentions about future smoking behavior is still scarce, there is clear evidence that young people underestimate the future likelihood of smoking. According to the U.S. Department of Health and Human Services (1994) 56 percent of smoking high school seniors believe that they will not be smoking 5 years later, but only 31 percent of them will in fact have quit at that time. Moreover, among those who smoke more than one pack per day, the smoking rate 5 years later among those who stated that they would be smoking (72 percent) is actually lower than the smoking rate among those who stated that they would not be smoking (74 percent).

According to Harris (1993) 83 percent of American smokers have unsuccesfully tried to quit at some point in the past. Most have tried several times, with an average smoker trying to quit once every eight and a half months. 54 percent of serious attempts to quit fail within one week.

6.5 Effect of cigarette tax increases on subjective well-being

Gruber and Mullainathan (2005) argue that the effect of cigarette tax increases to smokers' self-reported happiness is a good test of time-consistency. Happiness has been repeatedly validated as a good correlate of well-being, using alternative psychological, physiological, and economic measures of well-being.

Since the rational addiction model and the time-inconsistency model make very different predictions of how taxes ought to affect happiness, this data allows a distinction to be made between them in a way that traditional behavioral data cannot. Under the assumptions of the rational addiction model taxes can only make smokers worse off by making smoking more costly. However, if smokers are time-inconsistent,

taxation may provide a valuable self-control device. A time-inconsistent agent smokes more than she would like to in the long run, and therefore a tax that forces down smoking should increase the agents well-being.

Gruber and Mullainathan use two independent survey data sets from the United States and Canada that contain information on subjective well-being, smoking behavior and a variety of demographic variables. The data is matched to cigarette excise tax data in each country, controlling for other factors that may affect happiness.

The results - from both data sets - are striking. Those who are predicted to be smokers are significantly happier when excise taxes rise. To give a few examples from the results, U.S. data suggests that each cent of cigarette excise taxation reduces unhappiness by 0.156 percentage points among predicted smokers. Canadian data suggests that each cent of excise taxation lowers the odds of smokers being unhappy by 0.048 percentage points.

In dollar amounts, a \$0.50 real excise tax on cigarettes would make predicted smokers as happy as those not predicted to be a smoker in the United States, and a \$2.00 real excise tax would have the same effect in Canada. Reducing smoking by 60 percent would fully remove unhappiness among smokers in the United States, and reducing smoking by 40 percent would fully remove unhappiness among smokers in Canada.

The effects in Canada are consistently smaller than in the United States despite the fact that the elasticities of smoking with respect to price are similar across the two countries. Gruber and Mullainathan interpret this as being a result of the higher level of cigarette base prices in Canada. With high taxes already in place the remaining pool of smokers are probably those with the highest level of self-control problems. These smokers presumably need much larger tax changes to dissuade them from smoking.

Gruber and Mullainathan state that the findings are inconsistent with two alternative explanations for the results, interpersonal externalities within the family, and long

run impacts of taxes in a time consistent setting. Therefore the rise in happiness does not simply reflect the fact that the tax revenues are used in a welfare-enhancing way, or that the non-smoking family members are better off when a smoker reduces smoking.

This is is compelling evidence not only for the existence of self-control problems, but also for the feasibility of taxes to correct distortions that they cause. The findings do not seem to have an explanation if indiduals have standard, time-consistent preferences. For the purposes of this thesis, this is as concrete evidence as there exists so far.

6.6 Contradicting evidence

Although evidence that supports hyperbolic discounting dominates the studies, some researchers have found contradicting evidence. Read (2001) suggests that there may be another reason for the phenomenon usually attributed to hyperbolic discounting. He suggests that declining impatience, the inverse relationship between the discount rate and the magnitude of the delay may be a result of so-called subadditive discounting. Subadditive time discounting means that discounting over a delay is greater when the delay is divided into subintervals than when it is left undivided.

The view that subadditive discounting is a better explanation than hyperbolic discounting has not received much support in the literature. Frederick et al. (2002) suggest that "if Read is correct about subadditive discounting, it's main implication for economic applications may be to provide an alternative psychological underpinning for using a hyperbolic discount function, because most intertemporal decisions are based primarily on discounting from the present."

According to Frederick et al. (2002) some laboratory experiments have also found evidence of future bias, or increasing discount rates. The studies have concluded that these cases should be treated as exceptional. Of course, equivalently to the self-

control problem case, in the extremely unlikely case that smokers were to exhibit a preference for future gratification instead of immediate gratification - formally a case of $\beta > 1$ - and smoking would have no net externalities, it would be socially optimal for the government to subsidize smoking. Otherwise there would be under-consumption of cigarettes.

Concluding, it can be stated with much certainty that humans have a tendency to pursue immediate gratification, and this tendency is best modeled by a hyperbolic discounting function.

7. Prevailing cigarette tax levels and methods

In the European Union cigarette tax levels in each country are based on the retail price of the most popular cigarette brand in that country (Veronmaksajain Keskusliitto ry, 2010), and therefore vary quite a bit. The levels are set by each country independently according to certain requirements. In addition to a minimum tax percentage of retail price requirement (ad valorem excise tax) there is a minimum tax euros per cigarette requirement (specific excise tax).

Table 3 lists the retail price of a pack of the most popular brand of cigarettes including taxes, the sum of all taxes for a pack (including Value Added Tax), and the price of the most popular brand before taxes for each of the 27 countries in the European Union.

TABLE 3: Cigarette taxes in the European Union, 2009

	Price of most popular brand including taxes (€/pack)	Sum of all taxes (€/pack)	Price of most popular brand before taxes (€/pack)
Bulgaria	1.48 €	1.27 €	0.21 €
Lithuania	1.77 €	1.27 €	0.49 €
Romania	1.93 €	1.45 €	0.47 €
Estonia	2.06 €	1.62 €	0.44 €
Poland	1.70 €	1.66 €	0.04 €
Latvia	2.09 €	1.72 €	0.37 €
Slovenia	2.35 €	1.77 €	0.58 €
Hungary	2.35 €	1.83 €	0.52 €
Slovakia	2.10 €	1.89 €	0.21 €
Czech Republic	2.41 €	1.90 €	0.51 €
Cyprus	2.82 €	2.03 €	0.79 €
Greece	3.00 €	2.21 €	0.80 €
Spain	3.00 €	2.33 €	0.67 €
Luxembourg	3.44 €	2.43 €	1.01 €
Portugal	3.40 €	2.66 €	0.74 €
Austria	3.60 €	2.68 €	0.92 €
Malta	3.59 €	2.74 €	0.86 €
Italy	3.70 €	2.78 €	0.92 €
Denmark	4.29 €	3.15 €	1.14 €
Finland	4.40 €	3.38 €	1.02 €
Netherlands	4.74 €	3.49 €	1.25 €
Germany	4.71 €	3.57 €	1.14 €
Sweden	5.04 €	3.62 €	1.42 €
Belgium	4.74 €	3.62 €	1.11 €
France	5.30 €	4.26 €	1.04 €
Great Britain	7.39 €	5.62 €	1.77 €
Ireland	8.45 €	6.71 €	1.74 €

The sum of taxes for a pack range from 1.27€ in Bulgaria and Lithuania to 6.71€ in Ireland, with a median of 2.43€ and an average of 2.73€. The average price for a pack of cigarettes in the EU is 3.55€.

Table 4, adapted from Orzechowski and Walker (2009), lists the combined amount of state and federal excice taxes in the United States per pack of cigarettes. Some counties and cities also have their own local cigarette taxes (most do not), which are

not reflected here. General state and local sales taxes are also not included in these numbers (average state sales tax is 5-7 percent, local sales taxes are on average 1-2 percent), though a number of states do not charge sales taxes on cigarettes.

TABLE 4: Cigarette taxes in the United States, 2009

Missouri	$1.18	Colorado	$1.85	Utah	$2.71
Virginia	$1.31	California	$1.88	N. Hampshire	$2.79
Louisiana	$1.37	Illinois	$1.99	Alaska	$3.01
Georgia	$1.38	Indiana	$2.01	Arizona	$3.01
Alabama	$1.44	Oklahoma	$2.04	Maine	$3.01
North Dakota	$1.45	Arkansas	$2.16	Maryland	$3.01
North Carolina	$1.46	Oregon	$2.19	Michigan	$3.01
West Virginia	$1.56	Ohio	$2.26	Vermont	$3.25
Idaho	$1.58	Florida	$2.35	DC	$3.51
South Carolina	$1.58	Iowa	$2.37	Massachusetts	$3.52
Kentucky	$1.61	Texas	$2.42	Wisconsin	$3.53
Wyoming	$1.61	South Dakota	$2.54	New Jersey	$3.71
Tennessee	$1.63	Minnesota	$2.59	Connecticut	$4.01
Nebraska	$1.65	Delaware	$2.61	Hawaii	$4.01
Missisippi	$1.69	Pennsylvania	$2.61	Washington	$4.04
Kansas	$1.80	New Mexico	$2.67	Rhode Island	$4.47
Nevada	$1.81	Montana	$2.71	New York	$5.36

State and federal excise taxes range from $1.18 in Missouri to $5.36 in New York (New York City has an additional local cigarette tax of $1.50, bringing total taxes per pack to $6.86). The median per pack is $2.35 and the average is $2.46. The average price for a pack of cigarettes in the United States including state and federal cigarette taxes, but ignoring local cigarette taxes and sales taxes, is $5.51. The average federal and state excise tax calculated by Gruber (2001) was $0.76 so taxes have increased tremendously in the United States in the past decade.

Concluding, there is no considerable difference between the median cigarette taxes per pack in the European Union (2.43€) and the United States ($2.35) if the U.S. numbers are adjusted with sales taxes and local cigarette taxes. The comparatively

high tax levels of \$5.36 in the state of New York and €6.71 in Ireland are clearly exceptions in both groups. Cigarette taxes seem to systematically exceed the estimated value of smoking's externalities of \$0.40 per pack by a margin.

Figures 5 and 6, adapted from the World Health Organization (2008) exhibit the tax proportions of cigarette prices and average retail prices and tax amounts, respectively, in 204 countries.

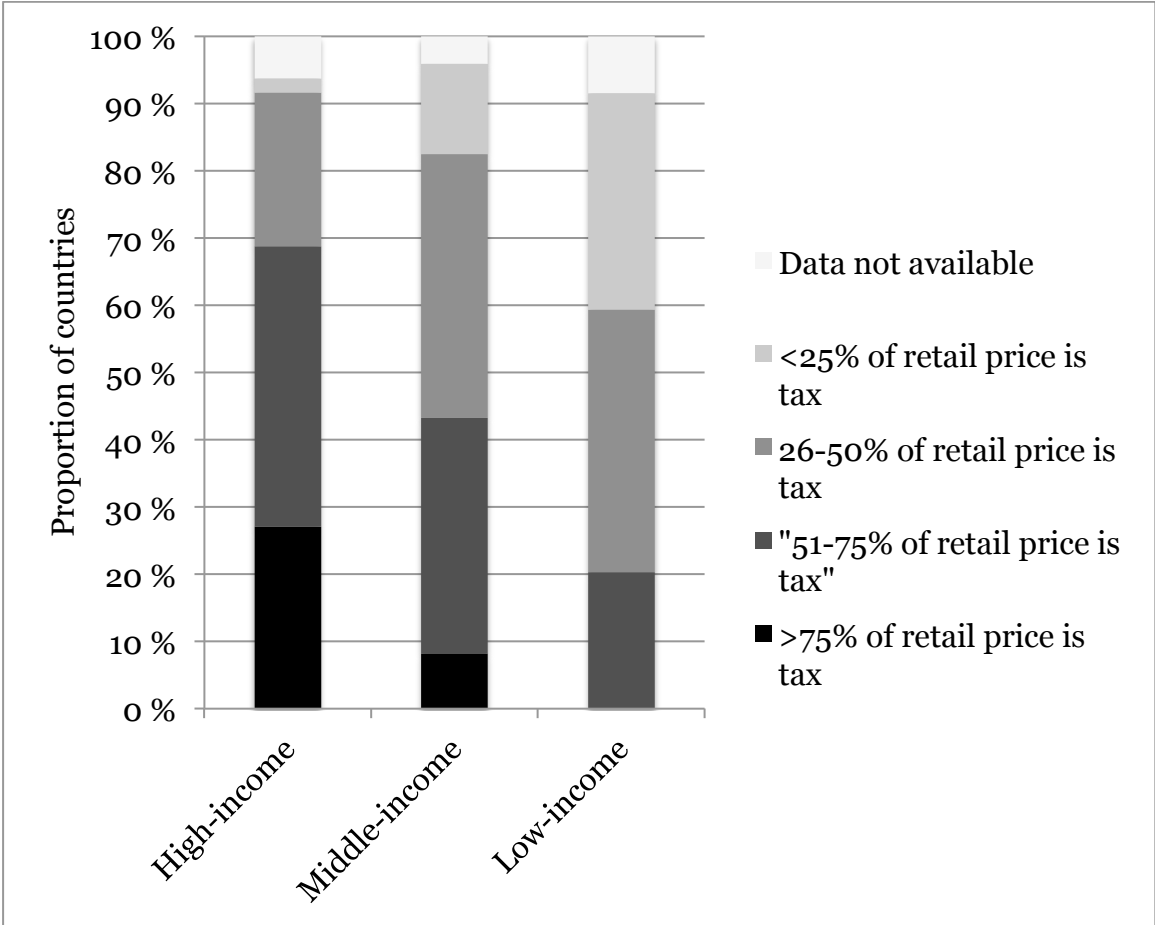### FIGURE 5: Tax proportions of cigarette retail prices, 2008

Figure 5 shows how a country's income level and the heaviness of cigarette taxes go hand in hand. Tax percentages are notably higher in high-income countries. Less than half of the retail price consists of taxes in 80 percent of low-income countries.

Tax proportions of over 75 percent, quite common in the developed world, are virtually non-existent in the developing world.

FIGURE 6: Average retail price and taxation (excise and total) of most sold brands of cigarettes, 2008
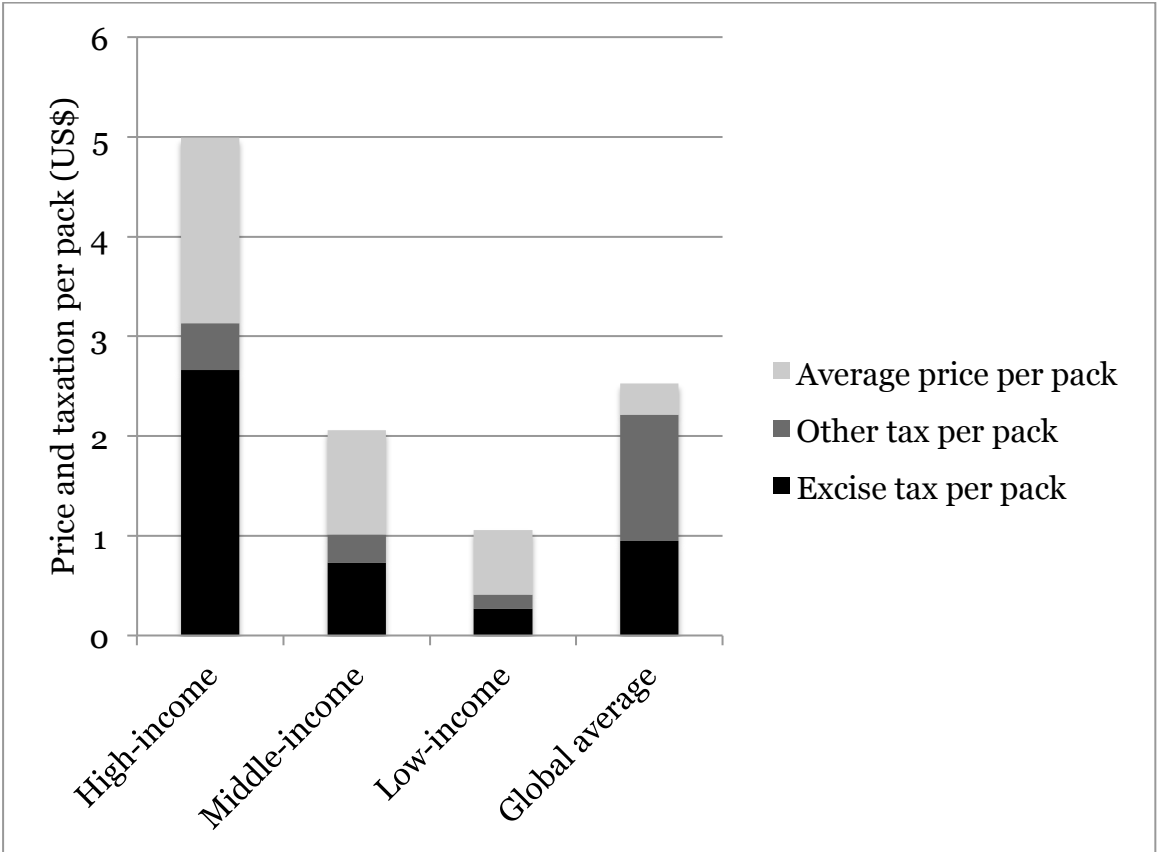
As seen in Figure 6, cigarettes are more than twice as expensive in high-income countries as in middle-income countries, and nearly five times as expensive as in low-income countries.

8. Private market solutions to self-control problems

As allowing agents to operate in a free market is traditionally considered to be the ideal setting in economics, the question arises as to whether the private market could be able to provide a more efficient solution to self-control problems than the government.

A well-known example of a privately provided self-control device is the chronic alcoholism treatment aid Antabus. The drug causes immediate unpleasant symptoms (comparable to a hangover) as a result of drinking alcohol, for up to two weeks after taking a dose. Although a drug that would provide a temporary relief from these symptoms is not to my knowledge available to the general public (perhaps due to ethical reasons), a google search for 'Antabus antidote' reveals that there would definitely be demand for such a product.

With the example above my attempt is to illustrate the main problem with market solutions to self-control problems: Although firms have a financial incentive to provide self-control to consumers, other firms have a corresponding incentive to break it down.

As has been argued by Koszegi (2005), market solutions to self- control problems are unlikely to be effective: Even though both consumers and firms would have the incentive, ex ante, to sign contracts that implement the optimal level of consumption, in a competitive market consumers cannot be prevented from purchasing from other firms ex post.

Gruber and Koszegi (2001) point out that "problems arise in contracting setups. If there are ex post gains to be made, the future self might want to renegotiate today's contract. But even if there are none, there is an ex post incentive to cheat on the contract: Smoking is hard to verify in court. This leaves us with privately provided self-control mechanisms like betting with others or becoming involved in situations where it is very difficult to smoke, but these mechanisms are likely to run into similar enforcement problems to those discussed above."

Koszegi (2005) concludes that "a government or social planner, which is in a unique position to impose rules that apply to all market transactions, may typically be necessary to bring the consumption of harmful and beneficial goods closer to optimal." The special role of the government is that a government-imposed per-unit tax requires all firms to charge the higher price.

O'Donoghue and Rabin (2006) suggest that another reason to be cautious in presuming that the private market will solve self-control problems is that people may be unaware of their own need for commitment. It may be hard to sell people a service they don't think they need.

Although in theory they should not, in practice private market self-control devices nevertheless do exist. In addition to drugs such as Antabus, real-world self-control tools provided by the private market include, among others, the Stickk.com commitment contract service. In the service the user sets a goal and commits to it. Even though money is at stake because credit card information is given upfront, the Stickk service takes the users word (or the word of a referee chosen by the user) on whether or not she has accomplished her goal. It is therefore far from a very effective self-control device. The existence of such self-control devices is nevertheless another piece of empirical evidence of time-inconsistency in preferences.

9. Tax incidence: Distributional effects of cigarette tax increases

In this section I investigate how time-inconsistency in preferences affects the issue of tax incidence. A principal argument against cigarette tax increases is that they are unfair to the poor because the tax is considered to be regressive, as lower income groups spend a much larger share of their income on cigarettes than do higher income groups. According to Evans et al. (1999) cigarette expenditures as a share of income are 3.2 percent in the bottom quartile of the income distribution and 0.4 percent of income in the top quartile. Therefore, a tax increase presumably hurts the poor more than the rich.

Gruber and Koszegi (2004) show that when the theory of hyperbolic discounting is applied to incidence analysis the unfairness argument is no longer as strong. The self-control function of taxation benefits lower income groups more, since they have a significantly higher price sensitivity of smoking. Gruber and Koszegi claim that the effect is considerable, making cigarette taxes much less regressive than previously assumed, possibly even progressive.

Tax incidence analysis measures utility. In the traditional view, the utility effect of a cigarette tax increase is equal to the product of the price increase, the quantity consumed, and the marginal utility of wealth. Regressive forms of taxation are unpopular because lower-income individuals have a higher marginal utility of wealth. The inverse of income is generally used as a proxy for people's marginal utility of wealth. Therefore, measuring expenditures divided by income is typically the way to assess the distributional impacts of tax policies.

As seen in section 5, time-inconsistency means that consumers can behave suboptimally. Because of this, the impact of a tax increase no longer comes solely from the increased expenditures on the product. The following model is adapted from Gruber and Koszegi (2008).

Let N_t be the number of smokers in the population, q_t the number of smokers who decide to quit because of the tax increase, b_i the pleasure that quitters previously enjoyed from smoking, and h the harm from smoking. δ and β denote the long-term and short-term discount factors, respectively. The utility impact of a price change is then

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

Smokers who quit in response to a marginal change in taxes must be approximately indifferent between smoking and not smoking at this price, so that $b_i = p_t + \beta\delta h$ turning the above into

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

The standard incidence term $-N_t\beta p_t$ shows that a price hike hurts smokers' utility. The second term (that equals zero if there is perfect time-consistency, $\beta = 1$) shows that the price change increases the utility of the individuals who end up quitting. As it was individually suboptimal for these individuals to consume cigarettes, the price change – acting as a self-control device - helped them to achieve their goal of quitting. Incidence is thus lower than for a time-consistent individual. Another form of expressing the above is

$$-N_t \Delta p_t(1 - [(q_t/N_t)/(\Delta p_t/p_t)](1 - \beta)\delta h/p_t)$$

or by denoting the price elasticity of demand $(q_t/N_t)/(\Delta p_t/p_t)$ by e_t

$$-N_t \Delta p_t [1 - e_t(1 - \beta)\delta h/p_t].$$

Gruber and Koszegi refer to the term in brackets as the 'incidence adjustment factor'. For $\beta < 1$, the factor equals less than one, leading to a lower incidence than in the traditional model.

The adjustment factor depends on the discounted harm from smoking, δh, normalized by the price of cigarettes. Intuitively, the higher is the harm from smoking, the more costly are the individual's self-control problems and the more beneficial is a price-induced decrease in smoking. The normalization by p_t is necessary because if a person still smokes when the price is high, then the same price increase will be less effective in getting her to quit. In addition, the lower is β, the greater is the individual's time inconsistency and again the more beneficial is a price-induced decrease in smoking.

The adjustment factor also depends on the short-term discount factor β. Whether or not the reason that lower-income groups tend to smoke more is because they have more severe self-control problems - a lower β - is not known, so it is assumed that they do not.

What is most important is that the adjustment factor is decreasing in the price elasticity of demand. Because a time-inconsistent individual smokes too much in each period, the price hike increases utility by restraining the overconsumption. The effectiveness of the self-control device increases with one's responsiveness to price incentives.

As discussed earlier in section 4, lower-income individuals have a much higher price-elasticity of demand for cigarettes than higher-income individuals. This in itself may reverse the regressivity of taxation in the model that incorporates time-inconsistency.

Table 3 shows how different levels of time-inconsistency affect the incidence of cigarette taxes. It is assumed that the value of life is equal across income groups (the conclusions hold as long as there is not a radical difference) and that the price of a

pack of cigarettes is $4.54. The figures represent the incidence of a $1 tax per pack of cigarettes, as a percentage of income.

TABLE 5: The effect of time-inconsistency on the incidence of cigarette taxes

Income quartile	Incidence (percent of income)			
	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

As the first column confirms, the traditional view suggests that cigarette taxes are regressive. When calculated proportional to income, smokers in the lowest income quartile spend almost ten times as much on cigarettes as smokers in the highest income quartile.

When time-inconsistency is incorporated the picture changes radically. Even for a mild level of self-control problems the incidence on the poor is only twice the incidence on the rich. Switching to a short-term discount factor of 0.8 cigarette taxes become progressive. With a factor of 0.6 all income groups are better off from taxation, most notably the lowest income group. Because of higher price elasticity, low-income smokers will cut their smoking more and gain more of the benefits from reduced smoking.

10. Alternative approaches

In this section I will briefly discuss two other notable recent studies of individual decision-making concerning addictive goods: Bernheim and Rangel (2004) and Gul and Pesendorfer (2007). Both of the studies reach conclusions that have different policy implications than the ones above. They suggest that attempting to correct overconsumption of addictive goods through taxation may in fact be socially counterproductive.

10.1 Cue-triggered decision processes

Bernheim and Rangel (2004) suggest a model of cue-triggered redicivism. In the model individuals are at each moment in one of two states, switching between them according to a random process. In the cold state standard rational utility-maximizing decision making holds, in the hot state it short-circuits.

Cues from environment increase the likelihood of entering the hot state. Likelihood of encountering such a cue increases in past consumption of the addictive good (the size of the addiction stock). In the hot state, when the individual overconsumes the drug, she is not price-sensitive at all. Thus higher prices serve no self-control purpose, and can only make addicts worse off by making them pay more for the addictive good they will consume no matter what.

The model suggests a formulation of time-inconsistency in which taxation will not be of any assistance. The idea is that sometimes the drive to consume an addictive good is so strong that it overshadows all rational optimization. Bernheim and Rangel in fact show that, because of such effects, in some circumstances it could conceivably be optimal to subsidize an addictive good.

Gruber and Koszegi (2004) comment on the Bernheim and Rangel model: "This may be true for drugs like cocaine and heroin, but probably not for cigarettes."

10.2 Temptation utility model

Most models of intertemporal choice, all of the ones above included, assume that options not chosen are irrelevant to an individual's well-being. Gul and Pesendorfer (2007) present a model of 'temptation preferences'. In their model total utility is not only affected by the utility from an outcome actually chosen, but also by the disutility experienced when the most tempting option is not chosen.

Gul and Pesendorfer motivate their model as an alternative explanation for people making ex-ante commitments. The individual suffers disutility from exercising costly self-control in order to choose something else than the most tempting alternative. From a prior perspective, commitments can be valuable if they alter the most tempting option that will be available when it is time to consume.

The theory implies that a person might be better off if some particularly tempting option were not available, even if she doesn't choose that option in the end. As a result, she may be willing to pay in advance to eliminate that option.

According to this model individuals always behave in a time-consistent manner. The model is driven by disutility from temptation. Gul and Pesendorfer assume that the agent is tempted equally strongly by the addictive good for all possible prices, as long as she has enough wealth to pay for it. Therefore increasing taxes will only make her worse off. The model does, however, predict that a complete ban on smoking might enhance the well-being of smokers.

10.3 Critique and empirical evidence

As discussed in section 4, the demand for cigarettes is undeniably and consistently price-sensitive. In addition, the strong evidence on the effect of cigarette tax increases on well-being in Gruber and Mullainathan (2005) is inconsistent with these two models.

I believe that these two models do not describe cigarette consumption well at all, but rather the consumption of drugs that have extremely strong withdrawal symptoms such as heroin. Gruber and Koszegi (2004) suggest that addictive consumption behavior in general might best be modeled by a combination of their own model and these two, while the best model in any one particular case depends on the good in question.

11. Conclusions

Traditional economics suggests that only the externalities of smoking should be considered when setting the cigarette tax level, as smokers take fully into account the harm caused to themselves when making the decision to smoke. According to this view, attempting to reduce smoking with taxes above this level would be unnecessary welfare-reducing paternalism, and it would only bring the consumption of cigarettes below the social optimum.

In this thesis I set out to find out whether smokers' self-control problems should be another factor to consider when setting the cigarette tax level. Research in the field of behavioral economics and psychology suggests that smokers may not fully internalize all of the future harm smoking causes them, because of the human tendency to pursue immediate gratification. This would imply that part of the costs to the smoker herself should be treated similarly to externalities, and corrected through taxation of tobacco products.

Studies of optimal cigarette taxes face many challenges. Calculating the full amount of external and internal costs of smoking is in many cases extremely difficult if not impossible. Compromises have to be made, estimates are often very rough, and many potentially important costs have to be ignored.

There is a lag of decades between the time the significant health costs are realised and the time the smoking that causes them is conducted. All the same, the relevant tax level should be set at the time the smoking occurs. The long lag also makes the choice of discount rate extremely important, as a small change in discount rate may turn net externalities from positive to negative.

On the one hand, when ignoring the costs to the smoker's family as internal and considering the economic benefits to society from the earlier deaths of smokers, the net external costs of smoking are probably quite close to zero. They are possibly even below zero, which would mean that smoking is economically beneficial to the society. On the other hand, mostly because of the fact that one in two smokers die from

smoking-related diseases, the value of the internal costs is very high. This figure is further increased by all of the other harm (that is often difficult to quantify) to the smoker, and the significant costs from environmental tobacco smoke to the smoker's family. The estimated discounted cost of lost life-years of $35.64 per pack speaks for itself.

Taxation is the most effective government policy tool for correcting cigarette consumption distortions. It is an excellent provider of self-control because it can not be avoided. Taxation nevertheless has some tricky properties that need to be factored in when adjusting the tax level. The change in actual retail price will probably differ from the change in taxes, due to the oligopolistic nature of the tobacco industry. Uniform per-pack rate taxation will lead to over-taxation of some smokers, and under-taxation of others. Like all specific excise taxes, cigarette taxes need to keep up with inflation and incomes to remain effective. Due to compensating behavior, taxes need to be consistent throughout all tobacco products, and they should be preferably be based on tar and nicotine content.

It is clear that the basic laws behind the demand for cigarettes are not different from other goods, and the downward-sloping demand curve also applies to cigarettes. The average price-elasticity of cigarettes for rising prices is approximately -0.40 to -0.50 in high- and medium-income countries. Sensitivity to falling prices is twice as high. Smokers in developing countries, smokers belonging to the lowest income groups in developed countries, and young smokers are significantly more price-sensitive. Individuals who have smoked more in the past are less sensitive to prices. Among young people the effect of price falls mostly on smoking participation, reducing smoking initiation.

The rational addiction model is the first modern addictive good consumption model. Unlike others before it, it models smoking as rational behavior, wherein the smoker correctly evaluates the present and future benefits and costs of smoking, and makes the decision of whether or not to smoke. Although the forward-lookingness assumption implied by the model is supported by empirical evidence, the assumption of time-consistent preferences is not.

When the model is adjusted for time-inconsistency in preferences through hyperbolic discounting, smokers no longer fully internalize the future costs of smoking to themselves. Because of the tendency to pursue immediate gratification, the self of today disagrees with all future selves on how much to smoke. This conflict creates the self-control problem and results in suboptimal consumption of cigarettes from the smoker's own point of view.

Empirical evidence for time-inconsistency in preferences in general is overwhelming, consisting of both laboratory experiments and observed real-world behavior. The shown positive effect of cigarette tax increases to smokers' well-being is the most interesting empirical evidence for the purposes of this thesis, as the study tests my hypothesis directly.

Prevailing taxes are on average 2.43€ per pack of cigarettes in the European Union and roughly at the same level in the United States. The tax levels have risen tremendously in the past decade, and they are many times higher than the estimated net externalities of smoking. They are, however, much lower than they should be – even when calibrating with careful estimates - if smokers' self-control problems are taken into account.

Although they exist, private market solutions to self-control problems are unlikely to be effective. Firms have the financial incentive to provide self-control to consumers, but other firms have the incentive to break it down. Unlike the government, firms are unable to force consumers into reducing smoking. Smokers may also be unaware of their need for a self-control device.

Cigarette taxes have traditionally been viewed as regressive, hurting the poor disproportionately because their cigarette expenditures are much higher as a share of income. When self-control problems are considered, the impact of a tax increase no longer comes solely from the increased expenditures on the product. The self-control function of taxation benefits lower income groups more because of their higher sensitivity to price. This reduces the regressiveness of cigarette taxes, and may even turn them progressive.

The cue-triggered decision process model and the temptation utility model, with their different tax policy implications, are probably better suited for other addictive products than cigarettes.

As I discussed in the introduction, I have assumed that the health risks and addictiveness of cigarettes are correctly anticipated by the smoker when making the decision to smoke. In addition to present-bias, a growing literature identifies another possible reason that cigarette taxes should be higher: projection-bias.

According to Levy (2010), when first starting a smoking habit, inexperienced smokers do not appreciate the degree to which they will become addicted to nicotine. Conversely, experienced smokers fail to fully appreciate how refraining from smoking would eventually make them un-addicted. There are not yet many estimates on how large the projection-bias effect is. Levy estimates that taking into account both biases would imply an optimal corrective tax of $8-11 per pack.

For reasons discussed in section 5.3.1, I consider the long-run preferences of smokers relevant for welfare maximization. Naturally, if short-run preferences were instead considered relevant and the utility of today's self would be prioritized over the utility of all future selves, then the policy implications of this thesis would no longer hold.

Understanding the impacts of cigarette taxes on well-being and the implications of time-inconsistency in preferences is not simply a matter of intellectual curiosity. A thesis such as this necessarily makes a normative statement about government policy.

The standard view in line with the rational addiction model suggests that there is no reason for government regulation of addictive goods other than interpersonal externalities. Addictiveness per se should not be taken as a call to government action, if individuals are acting rationally. According to this view the optimal tax rate for cigarettes is fairly low, since the net external costs of smoking are quite small according to most estimates.

The government policy implications of the time-inconsistency model are radically different. The self-control benefits to time-inconsistent individuals place the optimal

cigarette tax high above zero even absent externalities. The radical difference is a result of the huge amount of damage smokers inflict on themselves, and the very modest level of time-inconsistency required for it to have a large distorting effect.

I find it highly likely that the prevailing levels of cigarette taxes are not socially optimal, and that raising them would increase both the well-being of smokers and the well-being of the society as a whole.

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