Addiction and The Role of Commitment Devices*

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Abstract

This paper studies the role of commitment devices as instruments that reduce the consumption of addictive goods (alcohol, cigarettes, drugs, fatty foods etc.), under the assumption that individuals are sophisticated hyperbolic discounters. The model shows that helping individuals by making easier the access to instruments that may mitigate addictive behavior has positive and negative effects on individuals' welfare. First, hyperbolic agents purchase commitment devices less often that they wish to. Third, the availability of such instrument has ambiguous effect on limiting the consumption of addictive goods. For mild level of addiction, commitment devices reduce consumption and improve health status. For severe level of addiction, consumption increases, and the availability of commitment devices worsens the addictive problem. Finally, policy implications are derived.

JEL Classification: A12, D91, E21, H55

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1 Introduction

Many of the habits of our everyday life, such as smoking, drinking, taking drugs, eating fatty foods etc, can be described as addictive. According to Becker and Murphy (1988), two conditions are necessary to define a good as addictive. One is *Reinforcement*: the more you partake of the activity, the more you want to partake. The second is *Tolerance*: the more that you partake of the activity, the lower future utility will be. The literature on addiction (Kenkel et al. 2002, for instance) modeled these two effects by assuming that consuming today the addictive good, from one hand, raises the marginal utility of consumption both in the present and in future periods (addiction effect) but, from the other hand, it lowers overall utility in the future due to a detrimental health effect.

Health care professionals often view addiction as a disease that impedes the agents' decision-making ability. The economic literature has shown a growing interest for this topic, motivated, from the one side, by the interest in discovering the determinants behind the consumption of such goods and, from the other side, by the necessity to develop adequate policy measure that mitigate the harmful effects of addiction, both for individuals and for the collectivity.

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Indeed, the abuse of addictive goods generates costs in addition to the value of resources used to produce and distribute them (Rabin and O'Donogue, 2009). More precisely, the abuse of addictive goods generates enormous costs, not only at the individual but also at the social level, which have effects in the short-term and the long-term. Examples of internal costs are lost income, increased insurance premiums, emotional and physical stress, whereas external costs include: health care costs, justice costs, injures to others, violences and damage to properties. To better quantify the damages created by overconsumption of addictive goods, I present data about three typical examples of addictive behavior: smoking, alcohol and obesity.

Alcool: Twenty-five to forty percent of all patients in U.S. are being treated for alcohol-related problems, with an annual costs of \$22.5 billion. Untreated alcohol problems waste \$184.6 billion per year in health care, criminal justice costs, and cause more than 100,000 deaths. Alcohol abuse by underage results in \$3.7 billion a year in medical care costs (traffic crashes, violent crime, suicide attempts). Alcohol use is also associated with homicides, suicides, domestic violences, and drownings. The total annual cost of alcohol use by underage youth is \$ 52.8 billion (Cook and Moore, 1999, U.S. Center for Disease Control, 2004).

Smoking: Besides the negative health costs that smokers have to bear, tobaccos consumption generates also external cost to governments, to employers and to the environment. These costs includes social, welfare and health care spending, loss of foreign exchange in importing cigarettes; loss of land that could grow food; costs of fires and damage to buildings caused by careless smoking; environmental costs ranging from deforestation to collection of smokers litter, absenteeism, decreased productivity, higher numbers of accidents and higher insurance premiums. The U.S. Center for Disease Control estimates that 2,400 deaths occur each year due to the consumption of second-hand smoke. Manning et al. (1989, 1991) find that there are significant external costs from smoking because of property loss. In particular, they estimate the property loss from smoking-related fires was approximately \$340 million (Cook and Moore, 1999, U.S. Center for Disease Control, 2004).

Obesity: the fraction of adults suffering of overweighting or obesity has increased in the past years. In the US, for instance, the proportion has risen form 12% in 1990 to 21% in 2001 (Mokdad et al. 1999). Health care and other costs associated with obesity are enormous (Bhattacharya et al. 2009): at the individual level, overconsumption of fatty foods increases the risk of diabetes hypertension, stroke and other chronic conditions. Socially, obesity increases expenditures in health care. In the US, according to Finkelstein et al. (2005), the average taxpayer spends \$175 to finance obesity related medical expenditures for Medicaid and Medicare.

Once that the external effects of consumption of addictive goods have been highlighted, it is become natural to ask what determines, from an economic point of view, the individual decision to consume such goods.

2 Literature Review

The literature on addiction has a long tradition. Until the 80s, the leading paradigm on the topic has focused on the aspect of habit formation, or reinforcement, of addictive processes. In other words, current consumption of the addictive good depends on past consumption: agents (Chaloupka and Warner, 1998) have a backward-looking attitude for goods that create addiction.

Papers by Stigler and Becker (1977) and Becker and Murphy (1988) modify the approach for modeling the addictive process. In these works, agents are rational, forward-looking, maximizers, who recognize *ex-ante* the addictive nature of the good, both in terms of current monetary price and in terms of future addictions and future health costs. Therefore, if the gains from such consumption activity are greater than the costs induced by future addiction, it becomes optimal to make this choice. In other words, these models put the consumption of such goods into a standard rationally optimizing framework in which agents choosing the appropriate level of consumption of the addictive goods make a trade-off between current utility, which increases with consumption, and long-run utility, which decreases with the quantity consumed today, via the stock effect. Given that consumption today affects future utility, rational individuals should increase it, in order to enjoy more utility tomorrow. The key prediction of this approach is that consumption today is dependent on consumption tomorrow.

This model of rational addiction has been widely tested (see, for instance, Becker, Grossman and Murphy, 1994, which focuses on cigarettes consumption), and the data support the conclusions of the theoretical model: consumption of addictive goods today depends not only on past consumption but on future consumption as well. In particular, as shown by announcing an increase of future price of cigarettes lowers consumption today.

The Becker Murphy (1988) approach have been challenged, among others, by Orphanides and Zervos (1995) and Gruber and Koszegi (2001).

The criticisms involve the behavioral aspects of the Becker and Murphy paper. First, the model seems to be inconsistent with the observed regret among addicts: agents choose consciously to become addicted (Akerlof, 1991). Therefore, there is no need for information and public policies that illustrates the potential danger of addiction (Orphanides and Zervos, 1995). Second, the assumption that individuals can appropriately forecast prices far in advance (one year, in BGM simulations) is hard to justify. Moreover, price increases, at least for cigarettes, are usually announced without such advance. Third, from a theoretical point of view, agents' forward-looking behavior toward consumption of addictive goods may not imply time consistency of their choices. Indeed, a key assumption in the Becker-Murphy model is that agents' future decisions coincide with their current choices regarding this behavior (Gruber and Koszegi, 2001).

A first departure from Becker and Murphy is Orphanides and Zervos (1995): This paper stresses the role of information in forming individuals' beliefs about the risk of addiction. In particular, it removes the assumption of perfect foresight that it is incorporated in the BM framework. Agents are rational utility maximizers, but are also inexperienced, in the sense that they do not know exactly the cost that addiction will impose on themselves (addiction is not equally harmful to all agents). By consuming the good, they receive information about these costs. Addiction is thus voluntary, but unintentional: once the stock of past consumption reaches some critical level, then the consumer is hooked into addiction and she can do nothing to avoid it. In this way, the model captures the regret that often characterizes addicted agents, and stresses the role of education, public policies, and peer effects in increasing the information about the cost of addiction that are available ex-ante to individuals.

However, in spite the massive investment in educational and informational campaigns by authorities, the number of smokers, drinkers, especially among young, seems not to be decreased in the past years.

The second criticism of the rational approach to addiction comes from the literature on behavioral economics. Recent developments in this field show that models with time inconsistent preferences (although forward-looking behavior is implied) a la Laibson (1997) appear to be more appropriate in describing the consumption of addictive goods. Given that this activities are characterized by immediate costs and delayed rewards, it is reasonable to expect that these actions will be severely affected by time inconsistency (Gruber and Koszegi, 2004, and Rabin and O'Donoghue, 2009). In particular, Gruber and Koszegi (and the subsequent literature: see Gruber and Koszegi (2004) and O'Donoghue and Rabin (2003, 2006 and 2009) model addiction as an endogenous, rational, consumption choice. Goods for which preferences display time inconsistency are defined as sin goods.

The role of bounded rationality in the consumption of addictive goods is stressed in several studies of attitudes towards smoking, which are an important source of evidence that agents are subject to limited foresight, with their foresight horizons differing depending on how experienced they are. For example, if agents were rational and there were no material shocks affecting the average tendency to smoke, then people's expectations of their likelihood of being smokers in future years should, on average, correspond to the numbers of these individuals that actually are smokers. Yet, according to US DHHS 1994 data, as reported in Loewenstein et al. (2003), only 15 percent of high school students that were occasional smokers (whom we interpret as less experienced people) predicted that they might be smoking in five years, when in fact 42 percent were still smoking five years later. By comparison, 68 percent of high school students that were heavy smokers (whom we interpret as more experienced people) predicted that they would still smoking be smoking in five years, while 80 percent were still smoking five years later. Assuming that there were no material shocks increasing the aggregate tendency to smoke in the period of this study, these results constitute evidence for limited foresight among young smokers, with the foresight error being far less severe for heavy (more experienced) young smokers than for light (less experienced) young smokers.

In other words, with time inconsistent preferences, consumers optimally choose to consume more today and less in the future. However, the next period, consumers also optimally choose to consume more today and less in the future. Agents are rational, but over-consume in the sense that their welfare would increase if the they would have been able to commit themselves to the "time-zero" consumption plan.

3 Fighting Addiction

The natural policy approach to the addiction problem is the introduction of a (Pigouvian) tax that discourages consumption of such goods, and help individuals to internalize the negative effects of addiction. The tax is justified because it takes into account that consuming such goods not only impose an externality on the society, but also an "internality"on themselves, in terms of future health costs. Rising future taxes on consumption of such goods increase not only the future costs of addiction but also the present ones, as addiction makes the latter be dependent on the former. Individuals rationally anticipate the they will not be able to sustain high future levels of consumption, an reduce consequently present consumption as well.

Therefore, imposing taxes on addictive goods can create Pareto-improvements, provided that the proceeds of such taxes are returned lump sum to consumers, as shown by O'Donoghue and Rabin (2009). Sin taxes have two effects: from one hand, they help individuals to counteract the over-consumption of addictive goods. From the other hand, given that individuals with self-control problems consume more addictive goods, taxation redistributes income from individuals with self control problem to individuals with no such problems.

Gruber and Koszegi (2001) compute that, to take into account agents' time inconsistency, the optimal tax on cigarettes should be at least a dollar higher. O'Donoghue and Rabin (2006), on the other hand, find that the optimal tax on unhealthy goods ranges from 1-72% when time inconsistent preferences are considered.

However, taxation is not the only way that may help individuals to overcome their addiction problems. A substantial amount of resources are spent to reduce the availability and the unhealthy effects of sin goods. These efforts in counteracting addiction are justified by the belief that such behavior represents a serious health and social problem. The role of these interventions are either to cure (*i.e.* induce abstinence) or at least to control (*i.e.* reducing consumption) the addictive behavior.

In particular, Gul and Pesendorfer (2007) compare the welfare effects of two policies aimed at reducing the consumption of sin goods, with a focus on drugs abuse. The first policy increases the price of the sin good (for instance, because a tax is introduced) and a prohibitionist policy. Within a model of self control/temptation (slightly different from the multi-selves model adopted by Gruber and Koszegi (2004)), they show that the second policy is always Pareto superior to the first one. The intuition for the result is that a price policy makes more costly to consume the addictive good, but it does not change the tempting alternative. Individuals will respond to the price change by reducing consumption and exerting more self-control effort. However, given that the cost of self-control is higher than the utility gain from reduced consumption, such policy reduces welfare. With a prohibitive policy, the tempting alternative, namely the consumption of the sin good, is eliminated, Therefore, a prohibitive policy, by not distorting agents' choices, and by eliminating the tempting alternative, increases welfare.

Not always, however, it is feasible to prohibit the consumption of a sin good; once that a such good has been banned, black markets can arises, and the tempting alternative is restored (for instance, that is what happened in the United States between 1919 and 1934 when alcohol consumption was prohibited due to the Eighteenth Amendment and the Volstead Act). In this case, welfare improvements are not possible.

Does it mean that only taxation can help addicted consumers? Not exactly: sometimes, individuals realize by themselves that they are over-consuming, and consequently look for an instrument that either forces them to reduce autonomously the consumption of the addictive good, or to reduce the health costs associated with the unhealthy activity. Examples of such personal commitment devices are given by exercising, patches for smokers, dieting, or buying supplementary voluntary health insurance that provides additional health care assistance.

This tendency has favored a recent policy approach: combining taxation of addictive goods with promotion of more healthy lifestyles (in the spirit of a soft paternalistic approach): education, promotion of quitting aids, subsidies for gym subscription, to complementary health insurances (that includes addiction treatments).

How do these policies affect consumption of addictive goods? No papers, to my knowledge, have tried to study the interplay between personal/private commitment devices and the consumption of sin goods. This paper plans to investigate how the consumption of sin goods affect individual's decision to purchase Voluntary Private Health Insurance (VPHI) and/or to invest in health-preserving activities.

Two critical assumptions will be introduced: first, the decision to buy an insurance or to exercise reduce the costs of addiction in the subsequent period; second, that I follow Gruber and Koszegi (2004) by assuming that some consumers may have some degree of self-control problems. In particular, I consider individuals with time inconsistent preferences la Laibson (1997). The main innovation with respect to Gruber and Koszegi is that individuals have an external source which may help them to fight their addiction problem. This source may take the form of a private insurance plan, that mitigates the health costs related to the addictive behavior, or simply some physical activity (subscribing to a gym, jogging etc.) that has the same aim.

4 The Economic Environment

I first analyze a basic three-period model, the minimal length that generates time inconsistency. Periods are labeled 0,1,2, and the subscript on the variables refer to the period in question. The economy consists of two goods: an addictive good, whose consumed quantity is denoted x_t, and an ordinary good (a "composite" good), denoted z_t. Prices for the two commodities are normalized to 1.

Similarly to Becker and Murphy (1988), Orphanides and Zervos (1995) and Gruber and Koszegi (2001), the long-lasting effect of post consumption of the addictive good are captured by the stock variable S_t, which evolves according to:

$$S_t = (1 - d)(S_{t-1} + x_t) \tag{1}$$

where d is the depreciation rate of the stock. The instantaneous utility function consists of three parts:

$$U_t = U(x_t, z_t, S_t) = v(x_t, S_t; \rho) + u(z_t) - c_t(x_t, S_t; \gamma) \tag{2}$$

Here, the function $v(x_t, S_t); \rho)$ denotes the immediate benefits from current consumption of the addictive good and $u(z_t)$ is the utility obtained from the consumption of the ordinary, non-addictive, good. The function $c_t(x_t, S_t; \gamma)$ captures the detrimental side effects associated to past and present consumption of the addictive good. Notice that $c(.)$ is time-dependent, since it is very natural to consider that health problems due to addiction develop more often in old ages relative to young ages. To simplify notation, I moreover assume that $c_0(.) = c_1(.) = 0$ and only $c_2(.)$ is positive. However, the assumptions of time dependent costs and zero cost at $t = 0, 1$ could be easily relaxed, and all the results of the paper continue to hold. The parameters ρ and γ capture heterogeneity in, respectively, preferences for the addictive good and health damages.

The peculiarity of consuming an addictive good instead of the ordinary good comes from equation (2): current utility is not affected only by current consumption of the addictive good, but also by past consumption, via the effect of the stock S_t: the more an agent has consumed in the past, the more she wants to consume today. However, the stock of past consumption also affects the costs of being addicted, as captured by the dependence of $c(.)$ from S_t.

To account for time inconsistent preferences in intertemporal choices, I adopt the following form for the discounted utility (Laibson, 1997):

$$W = U_0 + \beta\delta U_1 + \beta\delta^2 U_2 \tag{3}$$

where $\beta \in (0, 1)$ and $\delta \in (0, 1)$ denote, respectively, the short-term and the long-term discount factor. In particular, β capture the fact that, from the perspective of an individual at time $t = 0$, the discount factor between two consecutive periods in the future (δ, the discount factor between period 2 and 3), is larger than between the current period and the next one ($\beta\delta$). Therefore, the problem faced by any individual in the population with initial stock S_{-1} is:

$$\max \quad v(x_0, S_0; \rho) + u(z_0) + \beta\delta \left[v(x_1, S_1\rho) + u(z_1)\right] + \beta\delta^2 \left[v(x_2, S_2; \rho) + u(z_1) - c(x, S, \gamma^s)\right] \tag{4}$$

$$x_1 + z_1 \leq I_1 \tag{5}$$

$$x_t, z_t \geq \tag{6}$$

Individual decisions are modeled as a subgame-perfect equilibrium of the game played by the different selves. Notice that I assume that time inconsistent agents are sophisticated, in the sense that they are aware of the change of preferences that occurs between period two and three, are anticipate that present plans concerning the consumption of the addictive goods will be changed by their future selves.[1]

I make the following basic assumptions:

[1] An alternative assumption concerning time inconsistent preferences is *naivete*, according to which each self believes that future selves will follow her decisions.

A1: *Smoothness* The functions $v(x, S; \rho)$, $u(z)$ and $c(x, S; \gamma)$ are twice continuously differentiable for $x, z, S \geq 0$.

A2: *Concavity* The function $v(x, S; \rho)$ is increasing and concave in x and the function $u(z)$ is increasing and concave in z. The function cx, S is increasing in x, while no restrictions are imposed on the sign of the second derivative: $c_{xx} > 0, c_{xx} < 0 or c_{xx} = 0$ are all possible. Overall, the function $U(x_t, z_t, S_t)$ is strictly concave, that is the Hessian is negative definite.

A3: *Complementarity*] $v_{xS} > 0$, because consumption of the addictive goods generally increases future marginal utility.

A4: *Harmful Addiction* The function $c_{x,S}$ is increasing in S, and $cx, S = 0$ iff $S = 0$. No restrictions are imposed on the sign of the second derivative: $c_{SS} > 0, c_{SS} < 0 or c_{SS} = 0$ are all possible.

A5: *Commitment* Commitment to future consumption levels of the addictive good is not possible.

Assumptions A1 and A2 are standard, and ensure that the solution is well-behaved. Complementarity is the key assumption to capture the peculiarity of addictive behavior. It means that if one agent had done more addictive goods in the past, she will crave more in the present (*Reinforcement*). In the same way, $c_{xS} > 0$ implies that the more addictive good has been consumed, the higher is the current marginal health cost. Taken together, the assumptions of complementarity and harmful addiction introduce the elements of tolerance and withdrawal that characterize addiction (Becker and Murphy, 1998). Tolerance implies that larger quantities of the addictive good x are necessary to achieve a certain utility level when the stock is larger. Withdrawal, instead, implies that the utility loss form a reduction in the consumption of x is larger when S_t is larger.

Assumption A5 justifies the existence of the external health insurance. If 'personal'commitment to future consumption levels would be possible, no one will be willing to look for an external commitment device, and time inconsistency would not represent an issue.

The timing of the model is the following:

$t = 0$: The representative agent has to allocate her exogenous income, I_0, between the addictive and the composite good.

$t = 1$: At the beginning of period 1, the agent allocate again her income, I_1, between the addictive and the composite good. Moreover, since the costs associated with the consumption of the addictive good are common knowledge, she can decide whether to fight the negative effects of addiction by purchasing a commitment device. The expense for the purchase of the commitment device can be interpreted in several ways: it can be a supplementary health insurance, a subscription to a gym, performing healthy activities, buying a self-help book, anti-smoking patches etc. The commitment device costs a units of income, and the advantage of having it is that the negative costs of addiction are reduced: formally,

$\gamma^i > \gamma^u$, where the superscripts denote the insurance condition: those who have it are the "insured "and those who have not as the "uninsured ".

$t = 2$: The agent allocates her income I_2 between addictive and non addictive good, taking into account that, if insured, she has also to pay the fixed amount a. Only in this period the detrimental effects of addiction arise, and the cost function $c(.)$ reduces agent's utility at time $t = 2$.

4.1 Solving The Model

The subgame perfect equilibrium of the game is obtained by solving the model backwards. In period 2, the representative agent who has insured herself in the previous period solves:

$$\max_{x_2, z_2} \quad U_2 = v(x_2, S_2; \rho) + u(z_2) - c(x_2, S_2; \gamma^i)$$

subject to:

$$x_2 + z_2 + a = I_2$$

Consumption levels are labeled by $x_2^{*i}(I_2, a, S_2; \rho, \gamma^i)$ and z_2^{*i}, while the associated utility level is:

$$U_2^i = v(x_2^{*i}, S_2; \rho) + u(I_2 - a - x_2^{*i}) - c(x_2^{*i}, S_2, \gamma^i) \quad (7)$$

On the other hand, if the insurance is not purchased, the problem becomes:

$$\max_{x_2, z_2} \quad U_2 = v(x_2, S_2; \rho) + u(z_2) - c(x_2, S_2; \gamma^u)$$

subject to:

$$x_2 + z_2 = I_2$$

with solutions x_2^{*u} and $z_2^{*u} = I_2 - x_2^{*u}$ and associated indirect utility function:

$$U_2^u = v(x_2^{*u}, S_2; \rho) + u(I_2 - x_2^{*u}) - c(x_2^{*u}, S_2, \gamma^u) \quad (8)$$

In period 1, the agent decides whether to buy the health insurance and how much addictive good to consume. The agent takes also into account that her choice of x_1 affects also the consumption of the addictive good in period 2, via the stock S_2. Therefore, consumption of the addictive good in period 2 can be written as $x_2(x_1)$. Under the assumption that the insurance is purchased, the agent solves:

$$\max_{x_2, z_2} \quad U_1 = v(x_1, S_1; \rho) + u(z_1) + \beta\delta \left[v(x_2(x_1), S_2(x_1); \rho) + u(I_2 - a - x_2(x_1)) - c(x_2(x_1), S_2(x_1); \gamma^i) \right]$$

subject to:

$$x_1 + a + z_1 = I_1$$

$$x_2 + a + z_2 = I_2$$

with equilibrium choices $x_1^{*i}(I_1, a, S_1; \rho, \gamma^i)$ and $z_1^{*i} = I_1 - a - x_1^{*i}$. The agent's associated utility level is:

$$U_1^i = v(x_1^{*i}, S_1; \rho) + u(I_1 - a - x_1^{*i}) + \beta\delta \left[v(x_2(x_1^{*i}), S_2(x_1^{*i}); \rho) + u(I_2 - a - x_2(x_1^{*i})) - c(x_2(x_1^{*i}), S_2(x_1^{*i}), \gamma^i) \right] \tag{9}$$

If, on the other hand, the insurance is not purchased, the problem is:

$$\max_{x_2, z_2} \quad U_1 = v(x_1, S_1; \rho) + u(z_1) + \beta\delta \left[v(x_2(x_1), S_2(x_1); \rho) + u(z_2)) - c(x_2(x_1), S_2(x_1); \gamma^i) \right]$$

subject to:

$$x_1 + z_1 = I_1$$
$$x_2 + z_2 = I_2$$

with solutions $x_1^{*u}(I_1, S_1; \rho, \gamma^u)$ and $z_1^{*u} = I_1 - x_1^{*u}$ and associated indirect utility function:

$$U_1^u = v(x_1^{*u}, S_1; \rho) + u(I_1 - x_1^{*u}) + \beta\delta \left[v(x_2(x_1^{*u}), S_2(x_1^{*u}); \rho) + u(I_2 - x_2(x_1^{*u})) - c(x_2(x_1^{*u}), S_2(x_1^{*u}), \gamma^u) \right] \tag{10}$$

Therefore, the device will be purchased if and only if:

$$U_1^i \geq U_1^u \tag{11}$$

or, equivalently:

$$v(x_1^{*i}, S_1; \rho) - v(x_1^{*u}, S_1; \rho) + u(I_1 - a - x_1^{*i}) - u(I_1 - x_1^{*u}) \geq \beta\delta \left[c(x_2(x_1^{*i}), S_2(x_1^{*i}), \gamma^i) - c(x_2(x_1^{*u}), S_2(x_1^{*u}), \gamma^u) \right] +$$
$$\beta\delta \left[v(x_2(x_1^{*u}), S_2(x_1^{*u}); \rho) - v(x_2(x_1^{*i}), S_2(x_1^{*i}); \rho) + u(I_2 - x_2(x_1^{*u})) - u(I_2 - a - x_2(x_1^{*i})) \right] \tag{12}$$

The concavity of the objective function U guarantees that there exists a value for the stock of past consumption, denoted S_1^*, such that the agent prefers to buy the insurance for any value $S_1 > \bar{S}_1$. Otherwise, she prefers to remain uninsured.

The intuition for this result is rather simple: if the stock of addictive goods consumed in the past is above a critical threshold S_1^*, the agent becomes a "compulsive"addicted. By consequence, the associated health damages are very high, and even a sophisticated hyperbolic discounters anticipates it. However, given that addicted agents are hooked into the consumption of the addictive good, they can not reduce autonomously their consumption level, even if they would to. The possibility of purchasing the insurance represents an external instrument that, in principle, would soften the health damages. Purchasing the insurance reduces available income, and provided that the addictive good is normal, consumption is also reduced.

Figure 1 displays the continuation utility from the perspective of self 1 as a function of S_1, the stock of past addictive consumption that self 0 leaves to her, for a specification of the utility function (2) similar to Becker and Murphy (1988) and Gruber and Koszegi (2003) (See the appendix for further details). The solid line denotes the continuation utility of the agent assuming that self 1 is uninsured, while the dashed line

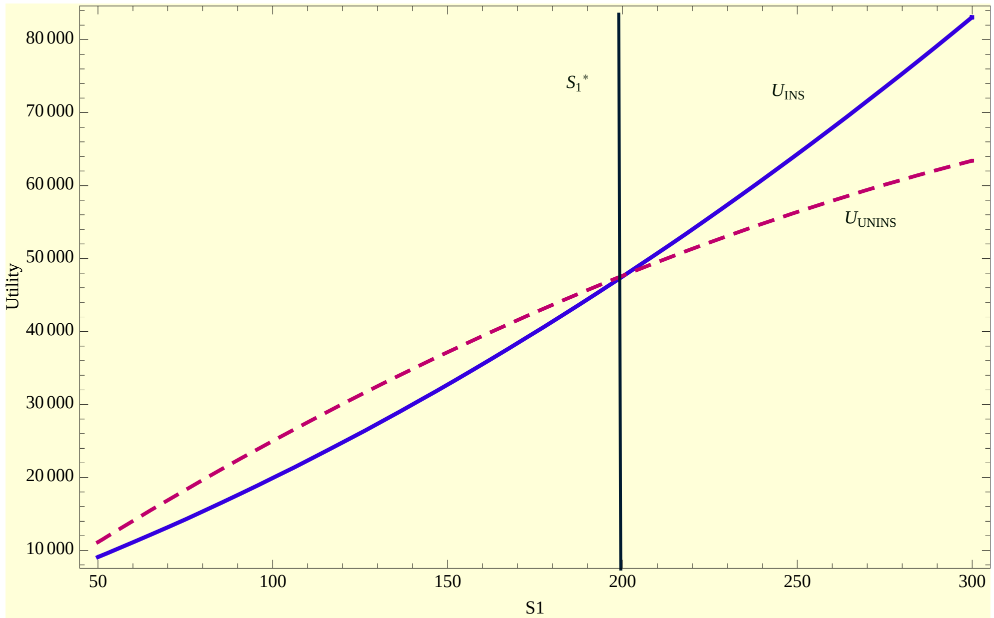

Figure 1: Utility of Self 1 from periods 1 and 2, with and without insurance in period 1

represents her continuation utility assuming that the insurance is purchased. The threshold S_1^* represents the stock of past consumption that makes the agent indifferent between paying a or not. Notice that, for values of S_1 below S_1^*, only the dashed line is available to the individual, while for values above it, only the solid line is available.

The previous result, however, changes if one observes the decision of purchasing the insurance or not from the perspective of self 0. In fact, the agent will insure herself if and only if:

$$\widetilde{U_1}^i \geq \widetilde{U_1}^u \tag{13}$$

where:

$$\widetilde{U_1}^i = \beta\delta\left[v(x_1^{*i}, S_1; \rho) + u(I_1 - a - x_1^{*i})\right] + \beta\delta^2\left[v(x_2(x_1^{*i}), S_2(x_1^{*i}); \rho) + u(I_2 - a - x_2(x_1^{*i})) - c(x_2(x_1^{*i}), S_2(x_1^{*i}), \gamma^i)\right]$$
$$\widetilde{U_1}^u = \beta\delta\left[v(x_1^{*u}, S_1; \rho) + u(I_1 - x_1^{*u})\right] + \beta\delta^2\left[v(x_2(x_1^{*u}), S_2(x_1^{*u}); \rho) + u(I_2 - x_2(x_1^{*u})) - c(x_2(x_1^{*u}), S_2(x_1^{*u}), \gamma^u)\right]$$

Condition (13) can be written as follows:

$$v(x_1^{*i}, S_1; \rho) - v(x_1^{*u}, S_1; \rho) + u(I_1 - a - x_1^{*i}) - u(I_1 - x_1^{*u}) \geq \delta\left[c(x_2(x_1^{*i}), S_2(x_1^{*i}), \gamma^i) - c(x_2(x_1^{*u}), S_2(x_1^{*u}), \gamma^u)\right] +$$
$$\delta\left[v(x_2(x_1^{*u}), S_2(x_1^{*u}); \rho) - v(x_2(x_1^{*i}), S_2(x_1^{*i}); \rho) + u(I_2 - x_2(x_1^{*u})) - u(I_2 - a - x_2(x_1^{*i}))\right] \tag{14}$$

and it is immediate to see that the left hand side of (14) is higher than the left hand side of (12): therefore, it exists an interval of values of S_1 such that self 0 would prefer to purchase the insurance, but self 1 does not want to.[2]

[2]I assume that, if indifferent, *i.e.* $S_1 = S_1^*$, the individual chooses to buy the insurance.

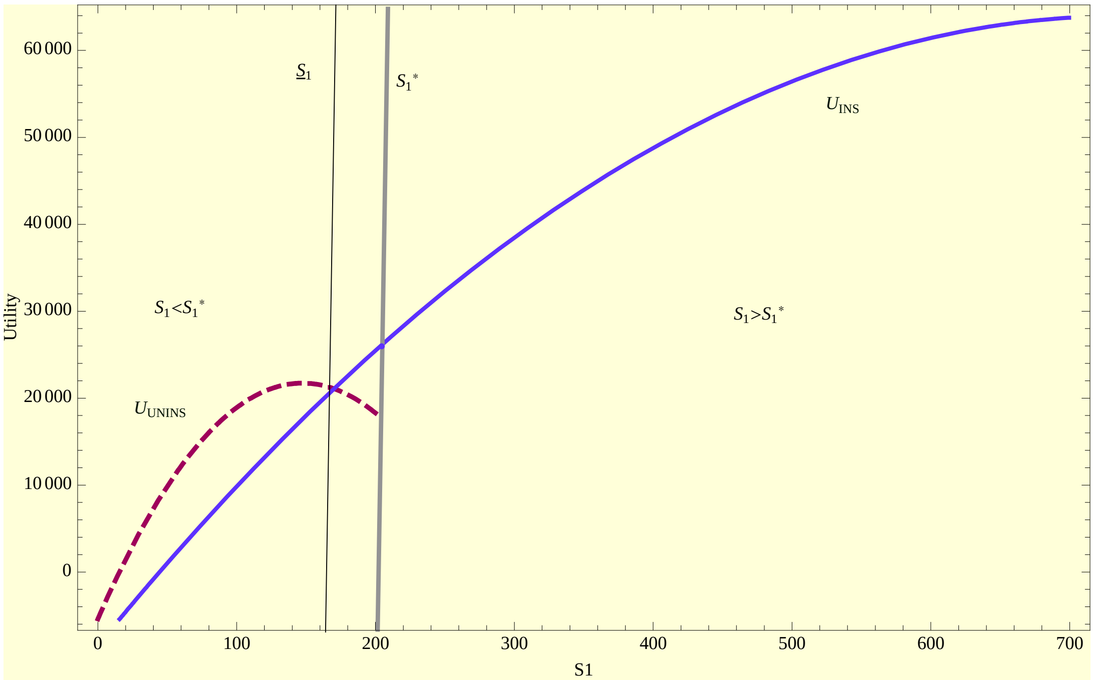

Figure 2: Utility of Self 0 from periods 1 and 2, with and without insurance in period 1

Notice that, if $S_1 = S_1^*$, self 1 is indifferent between insuring herself or not, but self 0 would strictly prefer her to insure. This result is quite intuitive and follows from the change of preferences that occurs between period 1 and 2. The health costs of addiction are weighted now at the increased rate of δ: therefore, self 0 places a higher weight on them, thus making more likely the purchase of insurance.

Figure 2 illustrates this result: the two curves represent the continuation utility of periods 1 and 2 from the perspective of self 0, as a function of S_1, for the same specification of figure 1. The dashed line U_{UNINS} denotes self 0's continuation utility between $t = 1$ and $t = 2$ assuming the individual is not insured, while the solid line U_{INS} is self 0's continuation utility between $t = 1$ and $t = 2$ assuming the individual is not insured. Notice that only the dashed curve below S_1^* and on the solid line above S_1^* are available to self 0, as she has to consider self 1's insurance decision, on the basis of S_1^* and S_1. It follows that there is an interval of values for the stock of past consumption of the addictive good, between S_1^* and $\underline{S}_1$, in which self 1 chooses to be uninsured, but self 0 would prefer to be insured.

I move now to the analysis of the maximization problem of self 0. Define U_{UNINS} and U_{INS} as continuation utilities of periods one and two, respectively with and without insurance. Moreover, let me define x_0^{*j}, for $j = i, u$ as the demand function of the addictive good at time 0. This demand function which determines the stock of addiction received by self 1, S_1, together with that at time 0, S_0. In other words:

$$S_0 = S_{-1} + x_0^{*j} \qquad j = i, u$$

Assume that the decison to insure herself is exogenous for the agent. Self 0 solves the following problem:

$$\max_{x_0, z_0} \quad U_1 = v(x_0, S_0; \rho) + u(z_0) + U_j \quad j = INS, UNINS$$

Note that a more intense taste for the addictive good, measured by ρ, leads to greater consumption levels for the addictive good in period 0. Moreover, since purchasing the insurance reduces disposable income in period 1 and 2, an insured individual necessarily will consume less addictive good relative to an uninsured agent (under the reasonable assumption that the addictive good is normal): therefore, $x_0^{*i} < x_0^{*u}$. If the hyperbolic agent could commit to a decision on insuring or not, she would choose one of these two consumption levels.

In the rest of this paragraph, I will compare decision to consume addictive goods with endogenous decision on insurance to that with exogenous insurance and to the consumption that would result if self 0 could commit to self 1's insurance decision. As said before, denote the consumption level of addictive goods with endogenous by x_0^*.

Graphically, the above problem is depicted in Figure 3, for the same numerical example of Figures 1 and 2. Lifetime discounted utilities available to self 0 are expressed as a function of the stock S_1. The consumption level x_0^{*i} maximizes the insurance curve U_{INS} while x_0^{*u} maximizes the curve U_{UNINS}. The concavity of the two curves ensures that the optimal choice of the agent will be one among x_0^{*u}, x_0^{*i} and the consumption level that makes the agent indifferent between insurance or not. I define this consumption level $\bar{x}_0$; notice that $\bar{x}_0$ is the consumption level that makes the stock of the addictive good equal to S_1^*.

To study individuals' optimal behavior in such an environment, I consider two comparisons.

In the first one, I assume that health insurance is mandatory (or alternatively, that smoking more than x_0^{*i} is forbidden by law). Therefore, all individuals will consume x_0^{*i}. Suppose now that the mandatory insurance is removed (or there is the possibility to drop out from it and consume any amount of the addictive good). Two strategies are available to agents: some will drop out form the insurance policy and start to consume x_0^{*u}. Other agents will continue to buy the insurance, without changing their consumption levels. What is peculiar to hyperbolic discounting is that some individuals will remain insured, but they will change their consumption from x_0^{*i} to $\bar{x}_0$.

The second comparison assumes that there is no possibility to buy health insurance: consumption of the addictive good at time 0 is x_0^{*u}. Suppose that the possibility of insure themselves against the risk of addiction is introduced: two things can happen in this case. Some individuals would remain uninsured (meaning that their strategy does not change after the introduction of insurance), and their consumption level remains x_0^{*u}. However, others may change their behavior, and decide to purchase the insurance: their consumption level moves either to x_0^{*i} or to a quantity $\bar{x}_0$ such that $S_1 = S_1^*$, depending on the one that gives the highest discounted utility.

So far I have analyzed only a situation of no commitment on the decision to buy insurance (remember that commitment on future consumption levels is ruled out). To better understand the interaction of the absence of such commitment devices and hyperbolic preferences, I have to compare the no commitment

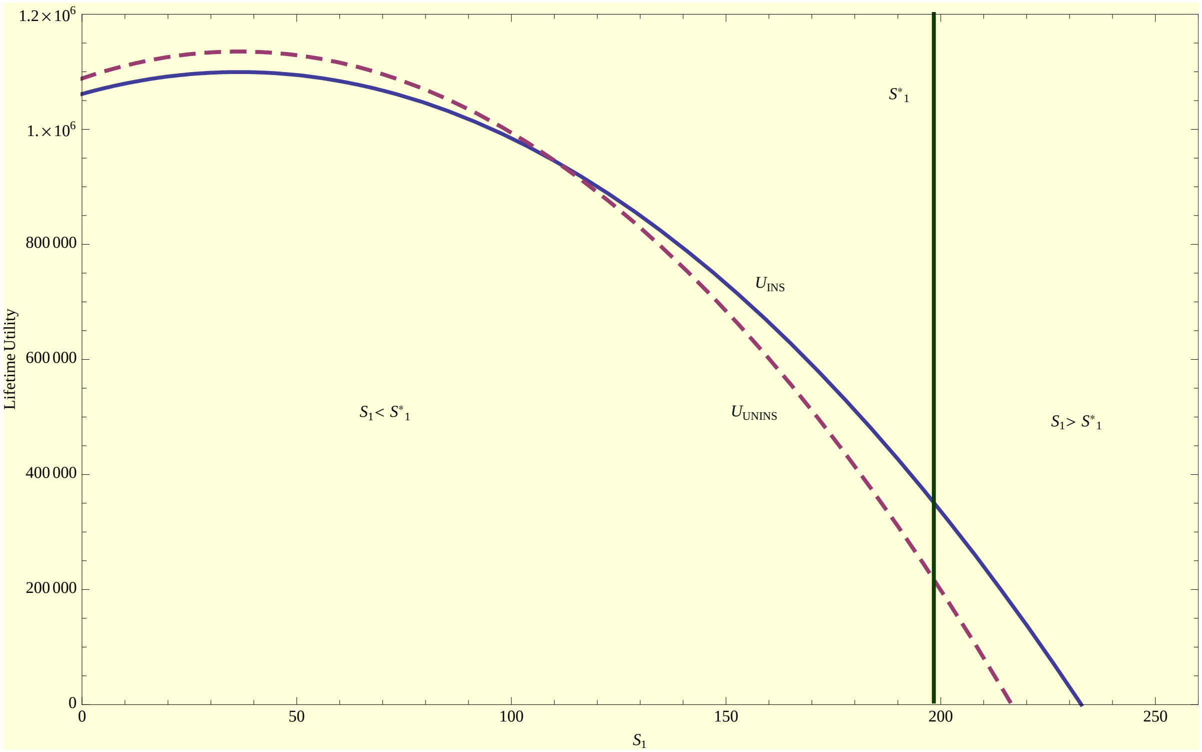

Figure 3: Lifetime Utility

solution presented above with the one with commitment: first, if with commitment the agent is not insured and consumption is x_0^{*u}, then also the no commitment decision would be the same. In the same way, if the solution to the problem with commitment is to buy the insurance and smoke an amount x_0^{*i}, then the availability of a commitment device does not change anything. However, if without commitment the agent decide to purchase the insurance and consume $\bar{x}_0$, it is possible that the commitment solution entails insurance and consumption level x_0^{*i}.

To summarize, if with a commitment mechanism self 0 wants self 1 to insure, then removing the commitment device can have three effects: first, it may have no effects on the decision to be insured and on consumption levels. Second, it may induce the agent to give up the insurance and to change consumption levels from x_0^{*i} to x_0^{*u}. Finally, it may not change the insurance decision, but could modify consumption levels from x_0^{*i} to $\bar{x}_0$.

4.2 Comparative Statics

This section analyzes the effects on the equilibrium values when the key parameters of the model are changed. First, I consider a change in the relative preferences for the addictive good, measured by a change in the parameter ρ.[3]

4.2.1 Changing ρ

For low values of ρ, the agent prefers to consume more the composite good relative to the addictive good. In particular, if ρ is such that $x_0 < S_1^*$, the individual is not willing to buy the insurance. In this case, the inability to commit to future choices induced by hyperbolic discounting does not affect the agent's decision to reduce smoking. In any case, this agent would have never bought any insurance policy

For higher values of ρ, in particular those such that $x_0 = S_1^*$, the individual consumes more addictive good. However, as stressed before, addiction is lower than it would be if self 0 would have the possibility to commit to a decision to be insured in period 1. Therefore, the agent consume prefers to consume less of the addictive good. I refer to this equilibrium as *strategic underinsurance.*

If ρ is high enough, in particular such that $x_0^{*i} > S_1^*$, the agent accommodates her preferences for the addictive good and buy the insurance even if self 0 would have consumed less and would have not bought the insurance if it were possible. I refer to this equilibrium as *resigned overinsurance.*

Finally, for very high values of ρ, self 0 prefers that self 1 buy the insurance: the inability to commit does not affect agent's behavior.

Therefore, in equilibrium, the behavior of a sophisticated hyperbolic individual differs according to her taste for the addictive good, measured by ρ.

The following proposition summarizes the result of the hyperbolic game and compares them with the equilibrium in a time consistent economy.

Proposition 1 *Consumption of the addictive good at time 0 is such that:*

i. For $0 < \rho < \bar{\rho}_1$, $x_0^{*u} < S_1^*$ and insurance is not purchased. A time consistent agent will the same ρ (or an hyperbolic with commitment) adopts the same strategy;

ii. For $\bar{\rho}_2 < \rho < \bar{\rho}_3$, $\bar{x}_0 = S_1^*$ and the agent does not purchase the insurance. Consumption of the addictive good is lower for a sophisticated hyperbolic agent than for a time consistent one with the same ρ (Strategic Underinsurance);

iii. For $\bar{\rho}_3 < \rho < \bar{\rho}_4$ the agent consumes $x_0^{*i} > S_1^*$, and the agent purchases insurance. Consumption of the addictive good is higher for a sophisticated agent than for a time consistent one with the same ρ (Resigned Overinsurance);

iv. For $\rho > \bar{\rho}_4$ the agent purchases the insurance. A time consistent agent with the same ρ (or an hyperbolic with commitment power) adopts the same strategy.

[3] Changing ρ is equivalent to change the stock of past consumption in period 0, S_{-1}. However, since I restrict my attention to a simple three period model, assuming changes in the initial stock of addictive good may appear strange. Instead, it seems more reasonable to assume that the preference parameter ρ changes.

The proposition extends the results of Gruber and Koszegi (2000): their paper, for the quadratic utility function I adopt in my simulations, shows that sophisticated hyperbolic individuals always consume more addictive good than time consistent agents. The intuition for their result is the following: exponential individuals understand that consuming the addictive good today has also an impact both on their future consumption levels (through the effect of S) and on their health status, and are able to limit their consumption. On the other hand, time inconsistent preferences does not allow individuals to internalize these effects, and consumption levels are higher.

The key assumption for this result is clearly the awareness of the self-control problem: indeed, knowing in advance about the change of preferences that occurs between period 1 and 2, a sophisticated will partially internalize the overconsumption problem with respect to a naive individual, who also display hyperbolic discounting but is not aware of it. As a result, the latter will consume even more addictive good. Moreover, the higher is the level of ρ (which represents the "propensity" to be addicted), the worse the situation becomes for naifs relative to sophisticated. Naifs do not realize that their future self will not (at least partially) adjust their decision, as they wish. On the other hand, sophisticates' knowledge that things are effectively bad limits their desire of consuming the addictive good.

Instead, this model shows that, if sophisticates are given the possibility to insure themselves against the health costs related to addiction, it is possible that the level of the addictive good consumed by them is actually *lower* than that of exponential/time consistent. The two results are not in contradiction: in Gruber and Koszegi, the absence of an external commitment device does not allow sophisticated hyperbolic agents to implement an optimal strategy that allows them to reduce the negative effects of addiction. However, being aware of their self-control problem, they are still able to soften their addiction problem relative to naive agents.

In our model, the availability of the insurance mechanism (or any other external device that attenuate the negative effects of addiction) make possible for the hyperbolic agent the adoption of two different strategies. In one case, if they are not "too much" addicted (if $\bar{\rho}_2 < \rho < \bar{\rho}_3$), sophisticated consume less than far-sighted, and buy less often the health insurance. The intuition for this behavior is subtle. They prefer not to consume too much, addictive good at $t = 0$, in order to limit their addiction. In some sense, however, reducing consumption today allows them to consume more tomorrow: by consuming a quantity just below the threshold S_1^*, not only they do not buy the insurance and do not have to pay the cost a, but also they are able to consume more in the future.

For high level of "potential" addiction ($\rho > \bar{\rho}_3$), the strategy is reversed: given the high taste for the addictive good that it is too costly, in terms of current utility, to reduce the level of present consumption below $\bar{x}_0$ in order to not purchase the insurance and consume more addictive good in the future. The optimal strategy consists instead in consuming *more* than a far-sighted today, as to reconcile agent's choices with her preferences. Since the level of addiction is such that the insurance will be purchased in any case, it is better from the point of view of an hyperbolic consumers to become more addicted today, in order to consume also more tomorrow, but benefiting, at the same time, and exactly because of this resigned overconsumption strategy, from the insurance that reduces health costs. Being both the health costs and the effects of the insurance increasing in the stock of past consumption, this strategy increases hyperbolic agents' utility.

4.3 Changing γ

To be added

5 a is increasing in S_t

To be added

6 Insurance/exercising can be accumulated

To be added

7 Conclusions

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Appendix

Numerical Example

For the numerical simulations of the model, I adopt the utility specification of Gruber and Koszegi and Becker and Murphy. More precisely, the instantaneous utility function has the following form:

$$U_t = U(x_t, z_t, S_t) = \rho_x x_t - \rho_{xx}\frac{x_t^2}{2} + \rho_{xs}x_tS_t + c_z z_t - c_{zz}\frac{z_t^2}{2} - \gamma_g^j(S_t + x_t) - \gamma_{gg}^j\frac{(S_t + x_t)^2}{2}$$

for $j = INS, UNINS$ and for $t = 0, 1, 2$.

Let me assume, for simplicity, that the marginal costs of addiction, measured by the parameters γ_g^j and γ_{gg}^j are equal to zero in periods 0 and 1. The parameters of the utility function are all positive. The parameter ρ_{xs} is the one of major interest: it measures the effect of past consumption on the marginal utility of current consumption. If ρ_{xs} is positive, it means that if you consumed more addictive goods in the past, you will crave them more in the present, and this gives rise to addictive behavior. The evidence that ρ_{xs} is positive is in Becker and Murphy (1988)

In the numerical simulations, the parameters take the following values:

Parameter	ρ_x	ρ_{xx}	ρ_{xs}	c_z	c_{zz}	I_0	I_1	I_2	a	β	δ	γ_g^i	γ_{gg}^i	γ_g^u	γ_{gg}^u
Values	40	7	10	32	25	40	40	40	25	2/3	2/3	2	3	3	5