Myopia, Regrets and Risky Behaviors*

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Abstract

This paper examines how a government should intervene when agents make choices having long-term detrimental effects on their life expectancy. For that purpose, we consider an economy where some agents consume a sin good (reducing their survival chances) out of myopia, and regret their choices later on, whereas other agents make, because of their impatience, the same risky choices, which they never regret. We argue that, in the first-best, a government should only interfere with behaviors that agents will regret, but not with other behaviors. In the second-best, asymmetric information and redistributive concerns imply interferences not only with myopic behaviors, but also with impatience-based (rational) behaviors. Finally, we introduce heterogeneity in individual earnings, and show that the optimal tax on the sin good depends on the size of the myopic group, on the reactivity of sin good consumption to tax changes, and on the extent to which sin good consumption is correlated with labor earnings.

Keywords: sin goods, optimal taxation, myopia, regrets, self-control.

JEL codes: I18, J18, H21, H31.

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1 Introduction

Undoubtedly, the consumption of "sin goods" - i.e. goods that generate instantaneous satisfaction at the cost of worse future living conditions - is an old practice, probably as old as religions, morals or State laws regulating such activities. Drinking, smoking, or taking drugs are as ancient as mankind. But sin goods consumption still prevails today, as illustrated by Figure 1, which shows alcohol and tobacco uses around the world.[1] Although there exists a significant inter-country variation, the consumption of alcohol and tobacco is a widespread phenomenon, which takes place in most areas of the world. True, those data are national averages, which may hide a large heterogeneity within countries. It is also clear that sin goods consumption is low in several countries.[2] But apart from few exceptions, sin goods consumption is a sizeable phenomenon, in particular in European countries, which lie in the upper-right corner.[3]

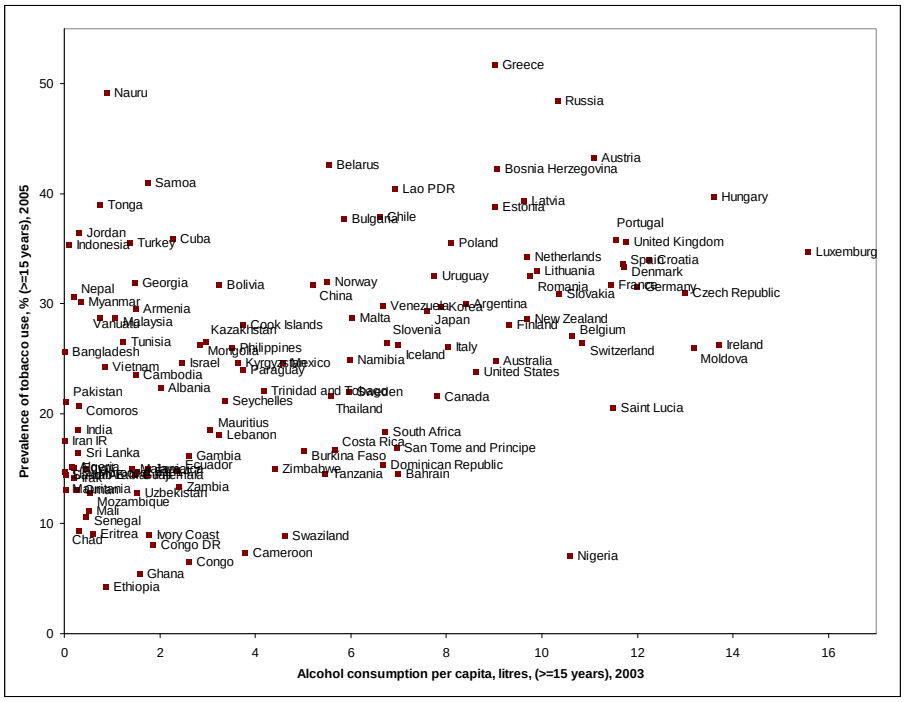

Figure 1: Tobacco and alcohol consumptions in the world

[1] Sources: World Health Organization, WHO Statistical Information System, retrived on 01/12/2008 at http://www.who.int/whosis/data/. The sample includes 123 countries.

[2] Those exceptions include some sub-Saharian economies (e.g. Ethiopia, Chad, Eritrea), where the consumption of alcohol and tobacco is very low, as well as some Middle-East countries, where alcohol consumption is close to zero (e.g. Iran, Saudi Arabia, Oman).

[3] On the relation between alcohol and tobacco uses, see Decker and Schwartz (2000).

Such a widespread consumption of alcohol and tobacco is a somewhat surprising fact, since it is now widely acknowledged, among scientists, that both alcohol and tobacco consumptions have a negative effect on survival. Empirical evidence on the negative impact of cigarettes on health dates back to the 1950s (see Doll and Hill 1950), and the negative influence of excess alcohol consumption is also widely documented (see Poikolainen 1982).[4] To give an idea of the size of the effects at work, let us briefly refer to the longitudinal study by Kaplan *et al.* (1987). That study showed that individuals above age 60 who were current smokers in 1965 faced, during the next 17 years, an overall mortality risk that is 1.47 times the risk of those who never smoked.

In the light of their sizeable effects on health and survival, sin goods constitute an obvious subject of concerns for governments. The fiscal treatment of sin goods is a true challenge for policy makers. Various aspects of the problem have been examined in the recent years.[5] In particular, a large attention has been paid to the normative issue of the optimal fiscal treatment of sin goods, in lines with the recent behavioral public economics, which supports public intervention as a way to prevent agents with behavioral imperfections from making mistakes. Gruber and Koszegi (2000, 2001) derive optimal taxes of addictive bads in the presence of time-inconsistent agents, i.e. agents who are impatient when they face a choice between today and tomorrow, but who would like to become patient in the future, so that there is an internal conflict between the current and the future selves. They argue that taxing sin goods can serve as a self-control device for time-inconsistent agents with hyperbolic preferences *à la* Laibson (1997), and solve the optimal tax problem for three types of agents taken 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.[6] Optimal sin taxes are also studied by O'Donoghue and Rabin (2003, 2006), who consider an economy where agents differ in their taste for the sin good and in their degree of time-inconsistency (still modelled by hyperbolic preferences). They highlight the trade-off 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.[7] Finally, Cremer *et al.* (2008) study optimal sin taxes when agents, who have self-control problems, can mitigate the

[4] Note that demographic studies on the impact of sin goods focused also recently on the impact of excessive or inadequate eating (Bender *et al,* 1998; Stamler, 1973).

[5] Those aspects include the reactivity of sin goods consumption to taxes (see, for cigarettes: Chaloupka and Wechsler, 1997; Grignon, 2007; Chaloupka *et al.*, 2010; Forster and Jones, 2010), the impact of international differentials in sin taxes on purchasing behaviours (Beatty *et al.*, 2009), and the regressiveness of sin taxes (Lyon *et al.*, 1995). Other topics include the addictive nature of sin goods (see Orphanides and Zervos, 1995; Suranovic *et al.*, 1999; Kenkel *et al.* 2002), and the size of the negative externalities due to sin goods (see Viscusi 1995, Chaloupka and Warner 2000, Cnossen and Smart 2005, Cnossen 2007).

[6] On the regressivity of sin taxes in that framework, see Gruber and Koszegi (2004).

[7] That trade-off is also examined by Haavio and Kotakorpi (2009), who consider how individuals would vote on sin goods taxes.

current impact of past consumption decisions thanks to curative expenditures. When deriving the optimal tax policy, they distinguish between the case where all time-inconsistent agents realize their mistakes and try to correct them, and the case where all time-inconsistent agents never realize their mistakes.

The goal of the present paper is to re-examine the optimal taxation of sin goods, by paying attention to other dimensions of heterogeneity among agents. Our contribution to the existing literature is twofold. First, we allow for a diversity of sin goods consumers regarding their attitude towards past consumption. Some consumers will *regret* their past decisions, whereas others will have no regret, and we characterize the optimal tax policy when all those types of sin goods consumers coexist within the population.[8] Second, we also consider another source of heterogeneity: differences in individual *earnings*, and examine how that heterogeneity affects the optimal fiscal treatment of sin goods.[9]

The relevancy, for optimal policy-making, of heterogeneity among sin goods consumers can hardly be overemphasized.[10] Actually, a vast empirical literature shows that some sin goods consumers exhibit regrets later on in their life (i.e. they would like to come back earlier in life and act differently), whereas other sin goods users do not regret their past choices. The coexistence of regretting and non-regretting sin good consumers was emphasized, for instance, by Slovic (2001), who found, on the basis of a telephone survey of a representative sample of U.S. respondents, that 85 % of adult smokers stated that they would not start smoking if they had to do it over again.[11] Note that the coexistence of regretting and non-regretting sin goods consumers is crucial for optimal policy. Sin goods consumers who regret *ex post* can be regarded as having suffered from a *myopia* at the time of making their decision, in the sense that those agents underestimated, at that time, the negative effects of sin goods on future health. That myopia can be regarded as involving some kind of limited rationality, and, as such, this requires a public intervention. Myopic agents would welcome a government that would force them to behave differently (i.e. with a balanced concern for both short-run and long-term interests). On the contrary, regretless sin goods consumers do not need any governmental intervention: those risk-takers are rational, and the principle of consumer sovereignty recommends not to interfere with their choices. The need for correcting the myopia of *some* sin good consumers while letting others unaffected raises particular difficulties under asymmetric information on agents' type, which are examined in this paper.

Moreover, when designing the optimal taxation of sin goods, another dimension to be taken into account is the heterogeneity in terms of earnings. Actually,

[8] As such, we depart from Gruber and Koszegi (2000, 2001) and Cremer *et al* (2008), who only consider one type of sin good consumers at a time.

[9] Hence we complement O'Donoghue and Rabin (2003, 2006).

[10] Note that there exists also strong differences between those who consume sin goods and those who do not. See for instance Khwaja *et al.* (2009) on how these value health.

[11] That result is robust to various countries. In the U.K., Jarvis *et al* (2002) showed that about 83 % of smokers "would not start smoking if they had their time again". Finally, Fong *et al* (2004) showed, on the basis of a telephone survey in Canada, the U.S., the U.K. and Australia, that about 90 % of smokers agree with the statement "if you had to do it over again, you would not have started smoking"

when the consumption of sin goods concerns individuals with lower incomes, taxing sin goods consumption may have quite regressive effects, which may be undesirable from a social perspective. Therefore it is important to take earnings differentials into account. Various studies support the existence of significant correlations between income and sin goods consumption. Levine *et al.* (1997), Heineck and Schwarze (2003), Van Ours (2004), Auld (2005) and Braakmann (2008) all report the existence of a wage penalty attached to smoking, ranging from 2 % to 24 %. More recently, Anger and Kvasnicka (2010) confirm the existence of a 4 to 10 % wage penalty for current smokers in comparison to never-smokers. Regarding alcohol consumption, empirical studies point also to a correlation, but of a positive sign (see Van Ours 2004; Lye and Hirschberg 2004; Auld 2005). Those studies justify the introduction of heterogeneity in individual earnings as an essential aspect of the design of optimal sin taxes.

In order to re-examine the optimal taxation of sin goods when agents differ in *ex post* regrets and in individual earnings, we develop a two-period model where the probability of survival from the first period (young adulthood) to the second period (old age) depends on sin good consumption when being young. The population is composed of three types of agents: (1) farsighted agents, (2) myopic risk-takers (with regrets *ex post*) and (3) rational risk-takers, who are guided by their impatience (but without any regrets *ex post*).[12] In a first stage, we assume uniform earnings and study the optimal tax policy, under a perfect observability of types (i.e. first-best) and asymmetric information (i.e. second-best). Then, in a second stage, we introduce earnings inequalities, and characterize the optimal linear taxation policy in that context.

Anticipating our results, we show that, at the first-best, the government should interfere only with myopic risky behaviors (to avoid regrets), but not with rational risky behaviors. Hence, it is optimal to tax sin goods consumption for myopic agents (but not for others), in such a way as to induce the myopics into behaving with concern for the long-term. However, in the second-best, particularly when agents differ not only in terms of myopia but also of income, asymmetric information and redistributive concerns may imply interferences with rational risky behaviors as well. We also examine the determinants of optimal sin taxes, and argue for a differentiated fiscal treatment of sin goods.

The rest of this paper is organized as follows. Section 2 develops the basic model, where agents of three types - farsighted, myopic and impatient - choose their consumption of a sin good (impatience being taken as a proxy for risk taking behavior). Section 3 characterizes the first-best optimum, and studies its decentralization. The second-best problem is examined in Section 4. Finally, Section 5 adds a second source of heterogeneity - earnings - and studies the optimal linear taxation problem. Conclusions are drawn in Section 6.

[12] We are well aware that having a high impatience and having a low risk-aversion are two distinct aspects of human personality. While these two traits can be both regarded as implying risk-taking behaviors, we shall here use the former rather than the latter, as this is more convenient for analytical purposes. But note that assuming agents with distinct risk-aversions would not affect our conclusions, as these only presuppose that a given risky behavior causes regrets among some people (type-2 agents), and no regret among others (type-3 agents).

2 The basic model

2.1 Environment

We consider a population of agents who live, at best, two periods. The first period (i.e. young age) is lived with certainty, whereas the second period (i.e. old age) is lived with a probability π. That probability of survival depends negatively on the consumption of a sin good at the young age, denoted y, through the survival function

$$\pi = \pi(y)$$

with $\pi'(y) < 0$ and $\pi''(y) > 0$.

At the beginning of the first period, agents allocate their (fixed) earnings between current consumption c, savings s, and the sin good y. Sin goods consumption involves an immediate satisfaction, but at the cost of future inconveniencies, which take here the form of a lower survival probability π.

Time preferences playing a crucial role when weighting gains and losses associated with sin goods consumption, it makes sense to assume that sin goods consumption differentials are due to heterogeneity regarding time preferences. However, as stated above, the population who consumes sin goods is heterogeneous in terms of *ex post* regrets, in the sense that some sin goods consumers will regret their decisions in the future, whereas other consumers will not.[13] Therefore we assume that the population is composed of three types of agents:[14]

- Type-1 agents are *farsighted*;
- Type-2 agents are *myopic*, but with a dual self: they would like, *ex post*, to have been forced to behave as farsighted (i.e. regrets *ex post*);
- Type-3 agents are *impatient*; they do not care about the future (without any regret *ex post*).

A first, major difference between our three types is that, whereas type-1 agents care significantly about the future, type-2 and type-3 agents care less about the future. As we shall see, that difference is a key driver of the sin goods consumption decision, in the sense that type-1 agents consume sin goods moderately, whereas type-2 and type-3 agents consume more sin goods, since they assign a lower weight to future welfare losses due to sin good consumption.

Despite their common tendency to consume sin goods, type-2 and type-3 agents differ from each others, since type-2 agents will have regrets about their past consumption decision, contrary to type-3 agents, who will never have any regret.[15] By "regretting" their past consumption, we mean that type-2 agents

[13] On the prevalence of regrets among smokers, see Slovic (2001), Jarvis *et al* (2002) and Fong *et al* (2004).

[14] We shall denote by n_i the number of agents of type $i = 1, 2, 3$.

[15] Myopic agents are, in some sense, characterized by a tension between their two selves, that of instant gratification and that of long term welfare. *Ex post*, when facing the negative effect of their past sin good consumption, they regret their past decisions, in the sense that they would like to come back to the past, to change these. Hence they would be grateful to a public intervention acting as a self-control device.

will, at the end of the young age, consider that they made a mistake when choosing how much sin goods to consume.[16] In other words, type-2 agents will, at the end of the young age, realize that their past decision was wrong, and will thus regret their past choices. There are various ways to make mistakes, but here we consider that the source of mistake and regrets by type-2 agents is a myopia, in the sense that those agents made their sin good consumption decision without taking into account the effect it will have on their future.[17] Type-3 agents, on the contrary, will not have any regret, and will thus not consider that their past sin good consumption was a mistake.[18]

The heterogeneity of agents in terms of time preferences and in terms of regrets with respect to past choices is modelled here by means of pairs of time preference parameters (α_i, β_i), where α_i denotes the time preference factor that governed the agent's decisions at the beginning of young adulthood, whereas β_i denotes the time preference factor that *should* have governed past decisions, from the perspective of the agent arrived at the end of young adulthood. For type-1 and type-3 agents, there is an equality between α_i and β_i, whereas the same is not true for type-2 agents, for whom α_2 differs from β_2, explaining regrets about past decisions. The following table summarizes our notations.

Types	*ex ante* time preferences	*ex post* time preferences	regrets
1: farsighted	α_1	β_1	no, as $\alpha_1 = \beta_1$
2: myopic	α_2	β_2	yes, as $\alpha_2 \neq \beta_2$
3: impatient	α_3	β_3	no, as $\alpha_3 = \beta_3$

Note that, in terms of sin good consumptions, type-2 and type-3 cannot be distinguished (as they all consume the same amount of sin good). Hence, in terms of the time preference factor α_i weighting the second-period utility of agents, there is an equality of time preference parameters for types 2 and 3, that is, between α_2 and α_3. We also know that type-1 agents care more about the future, so that $\alpha_1 > \alpha_2 = \alpha_3$. Throughout this paper, we shall, for the simplicity of presentation, assume that type-2 and type-3 agents act in such a way that they do not assign any weight to the second period: $\alpha_2 = \alpha_3 = 0$.[19] That assumption simplifies the analysis significantly, which will be most useful when introducing additional sources of heterogeneity latter on (see Section 5).

[16] Note that in a two-period model with possible death after period 1, there cannot be regrets in period 2 (as one may be dead), so that regrets must take place at the end of period 1.

[17] The widespread feeling of invulnerability among young adults and adolescents (see Quadrel *et al*, 1993) can be regarded as a form of myopia.

[18] A good way to sort out those two types of sin good consumers would be to observe their behavior in case of vote on a tax (or even a prohibition) on the sin good. The regretless consumers would vote for a tax equal to zero. In contrast, the regretful myopics, assuming that they are sophisticated, would vote for the tax (or even the prohibition), which they perceive as a commitment device (see Cremer *et al*, 2007).

[19] Assuming $\alpha_2 = \alpha_3 > 0$ would not change our results fundamentally. Only the extent of myopia for type-2 agents would be reduced, but no major qualitative change would occur.

Finally, it should be stressed that, regrets, modelled as a differential between α_2 and β_2, could take several forms: one could, *ex post*, turn out to care more about the old age than initially, i.e. $\beta_2 > \alpha_2$, or the opposite, that is, one could turn out, *ex post*, to care less about the old age than initially, i.e. $\beta_2 < \alpha_2$. Given that the empirical literature on regrets among smokers suggests that regretting smokers would prefer not to have started smoking or to have smoked less, we will assume, throughout the paper, that the regrets take the form of $\beta_2 > \alpha_2$. In other words, regretting sin goods consumers will, at the end of young adulthood, look at their past life differently, and consider that their past sin good consumption was excessive in comparison to what is the best for them.

2.2 The laissez-faire

An agent of type $i = 1, 2, 3$ chooses the first-period and second-period consumptions of the normal good c_i and d_i, as well as the consumption of the sin good y_i, in such a way as to maximize his expected lifetime utility subject to his budget constraint, the utility of death being normalized to zero. It is assumed, for simplicity, that a perfect annuity market exists, and that there is a zero interest rate, so that the return on savings is $1/\pi_i$. Moreover, individual utility is assumed to be quasi linear in first-period consumption for convenience.

Hence, the problem of each agent of type i can be written as

$$\max_{c_i, d_i, y_i} \; c_i + v(y_i) + \alpha_i \pi\left(y_i\right) u(d_i)$$

subject to the budget constraint

$$c_i + y_i + d_i \pi(y_i) \leq w$$

where $v(y_i)$ is the utility derived from the consumption of the sin good, while w is the income endowment of the agent.

The first-order conditions yield

$$\begin{aligned} 1 &= \mu \\ \alpha_i u'(d_i) &= \mu \\ v'(y_i) + \alpha_i \pi'\left(y_i\right) u(d_i) &= \mu(1 + \pi'\left(y_i\right) d_i) \end{aligned}$$

Given that $\alpha_2 = \alpha_3 = 0$, we have

$$\begin{aligned} u'(d_1) &= \frac{1}{\alpha_1} \\ d_2 &= d_3 = 0 \\ v'(y_1) &= 1 - \pi'\left(y_1\right) \alpha_1 \left[u(d_1) - u'(d_1) d_1\right] > 1 \\ v'(y_2) &= v'(y_3) = 1 \end{aligned}$$

From this, it is not difficult to see that agents of types 2 and 3 save nothing, as the second period does not matter for them, contrary to type-1 agents, who

save some resources. Moreover, agents of types 2 and 3 consume also the same amount of sin good $y_2 = y_3$, which is higher than the one consumed by type-1 agents. The reason why $y_1 < y_2 = y_3$ is that type-1 agents care about the negative impact of the sin good on the probability of survival, unlike type-2 and type-3 agents, who do not care, *ex ante*, about the old age. As a consequence, agents of type 1, by choosing a lower consumption of sin good, have also a higher survival probability than type-2 and type-3 agents, who have a low and identical survival probability: $\pi_1 > \pi_2 = \pi_3$.

Note, however, that although agents of types 2 and 3 make, under $\alpha_2 = \alpha_3$, exactly the same choices, the motivations underlying those choices differ. Agents of type 3 are fully rational and consistent: at the end of period 1, when they face the level of the survival probability $\pi_3 < \pi_1$, they express no regret: this is the mere result of their choice and their impatience, to which they still adhere.[20] On the contrary, agents of type 2, when facing $\pi_2 = \pi_3 < \pi_1$, express regrets: their myopia did not allow them to see the impact of sin good consumption on the survival probability, and, *if they could go back to their youth* (i.e. the beginning of period 1), they would act differently from what they did, and would opt for a lower sin good consumption.

In our framework, the occurrence of regrets takes the form of a differential between the time preference parameter that governed the choices of agents, i.e. α_i, and the time preference that they use when they evaluate their welfare at the end of young adulthood, i.e. β_i. For agents of types 1 and 3, α_i and β_i are equal, so that there is no regret. Thus, for those agents, the levels of c_i, d_i and y_i chosen at the beginning of young adulthood maximize their welfare as evaluated at the end of young adulthood, which can be written as:

$$c_i + v(y_i) + \beta_i \pi(y_i)\, u(d_i)$$

However, the same is not true for type-2 agents. The levels of c_2, d_2 and y_2 that were chosen at the beginning of young adulthood do not maximize the above expression, because these were chosen on the basis of α_2, which is lower than β_2. To see this, it suffices to notice that the optimal level of sin good, computed *ex post*, satisfies the FOC:

$$v'(y_2) + \beta_2 \pi'(y_2)\, u(d_2) = 1 + \pi'(y_2)\, d_2$$

whereas, at the beginning of young adulthood, type-2 agents choose, given $\alpha_2 = 0$, a level of y_2 such that:

$$v'(y_2) = 1 + \pi'(y_2)\, d_2$$

Hence, under $\beta_2 \pi'(y_2)\, u(d_2) < 0$, the optimal amount of sin good is strictly *lower* than what was actually chosen at the beginning of young adulthood. This explains the occurrence of regrets for type-2 agents once they reach the end of young adulthood (i.e. the end of period 1).

[20] In other words, they would be willing to act again in the same way if some time-traveling machine existed.

3 The first-best problem

The design of an optimal public policy requires first to select a social objective. For that purpose, we shall assume that the social planner is utilitarian, that is, that his goal is to maximize the sum of all agents' welfare, each agent being assigned an equal weight in the social welfare function.

Note, however, that an adherence to utilitarianism does not suffice, in the present context, to fully describe the social objective to be pursued by the government. The reason has to do with the existence of a tension between how type-2 agents behave *ex ante* and how they evaluate their past choices *ex post*. As we just saw, type-2 agents do not have the same preferences at the beginning and at the end of young adulthood. This raises the question of the selection of the preferences to be taken into account in the utilitarian calculus.

Throughout this paper, we assume that the preferences to be taken into account are the *ex post* ones, i.e. the ones represented by the β_i parameters, and not the α_i parameters. This choice does not make any difference for type-1 and type-3 agents (for whom $\alpha_i = \beta_i$), but this is not the case regarding type-2 agents, for whom $\alpha_2 < \beta_2$. Actually, the utilitarian social planner will solve his social welfare maximization problem while taking the *ex post* preferences of type-2 agents into account (i.e. β_2), in such a way as to avoid the occurrence of regrets. Thus, the social planner will take into account how type-2 agents, once they are at the end of young adulthood, will look at their life, and not how these have considered their life *ex ante* (i.e. at the beginning of young adulthood).

Our normative approach can be justified by referring to what is called the "new paternalism". The idea is that the government has, as a function, to intervene in order to help agents who suffer from behavioral imperfections, in such a way as to avoid the occurrence of frustrations, regrets or inconsistencies. According to that approach, the government should ideally interfere with agents having behavioral imperfections, but not with other agents, whose decisions have to be respected, in the name of the principle of consumer sovereignty.[21] That kind of paternalism is defended, among others, by Rabin and O'Donoghue (2003), under the name of "cautious" paternalism, and by Camerer *et al* (2003), under the name of "asymmetric" paternalism. In each case, the government faces a trade-off between, on the one hand, the benefits from a public intervention preventing some agents from making mistakes, and, on the other hand, the costs implied by that intervention for fully rational agents.[22]

Note that, in the context of sin goods consumption, adopting a "new" paternalism differs strongly from adopting an "old" paternalistic perspective. Indeed, whereas it could be argued, from an "old" paternalistic perspective, that both myopic and impatient sin good consumers do not behave in their best interests, we consider here that the different attitudes of agents *ex post* (i.e. occurrence of

[21] Note that, in the presence of externalities, then there could be a motivation for interfering with agents's choices, but here there is no externality, so that we should not interfere with rational decision-makers.

[22] On the new paternalism and its translation into optimal policies, see also Thaler and Sunstein (2003) and Cremer *et al* (2008).

regrets for type-2 agents and not for type-3 agents) invite a distinct treatment of those types by the government, even though their behavior is exactly the same. By doing so, we are opposed to the "old" paternalism, which would recommend a similar treatment of rational risk-takers and myopics, on the grounds that sin goods consumption is "bad", whatever the underlying motivations are.[23]

Finally, one should notice that our choice to rely on the *ex post* preferences of agents as a basis for the utilitarian calculus needs also to be justified. Given that type-2 agents have a dual self, it is inevitable that a government will have to make a choice between the two selves, that is, will have to select *one* set of preferences as a basis for making his calculations. Instead of our reliance on β_i parameters, one could have, for instance, taken the *ex ante* preferences as a basis (i.e. the α_i parameters).[24] The reason why the social planner takes here the *ex post* preferences into account has to do with an early utilitarian tradition, which regards preferences based on past experience as superior to other, less experienced, preferences. That tradition dates back to the refinement of utilitarianism by Mill (1863). According to Mill, utilitarianism should rely on well-formed preferences, that is, preferences that have a constant support over time, and not preferences that turn out to be questioned.[25] Thus, from that perspective, the fact that type-2 agents end up regretting their past choices is a good reason for taking their *ex post* preferences into account and not their *ex ante* preferences.

3.1 The first-best optimum

The problem faced by the utilitarian social planner can be written as the choice of first- and second-period consumptions c_i, d_i and sin good consumption y_i for the three types of agents. As stated above, the social planner does not want to interfere with the choices of agents of types 1 and 3, as those agents are acting in a consistent way, that is, without any regret. On the contrary, the planner would like to correct the myopia of type-2 agents. The social planner can achieve those goals by using, in his social objective function, the *ex post* preference parameters β_i. Given that those parameters coincide with the α_i parameters for agents of types 1 and 3, the social planner's solution will be in conformity with the principle of consumer sovereignty for those agents. However, for type-2 agents, using β_2 instead of α_2 in the social welfare function will also allow the planner to prevent type-2 agents from regretting their choices *ex post*.

The Lagrangian of the social planner's problem can be written as

$$\pounds = \sum_{i=1,2,3} n_i \left\{ V\left[c_i + v(y_i) + \beta_i \pi\left(y_i\right) u(d_i)\right] - \mu\left[c_i + y_i + \pi(y_i) d_i - w\right] \right\}$$

[23] Note that such an old-style paternalism seems hardly justifiable, as this relies on a questionable set of "good" and "bad" things established *independently* from what people think.

[24] One could also take a convex combination of parameters α_i and β_i.

[25] In Mill's terms, such well-formed preferences are associated with "high quality" pleasures, in contrast with "low quality" pleasures. The Principle of Utility has to be refined accordingly, as the promotion of the largest happiness - in quantity *and* quality - for the largest number (see Mill 1863, on pages 262-263).

where $V(.)$ is a strictly concave transform, while μ is the Lagrange multiplier associated with the budget constraint.

The FOCs yield

$$\begin{aligned} V'(x_i) &= \mu \\ V'(x_i)\beta_i\pi\left(y_i\right)u'(d_i) &= \mu\pi(y_i) \\ V'(x_i)\left[v'(y_i)+\beta_i\pi'(y_i)u(d_i)\right] &= \mu(1+\pi'(y_i)d_i) \end{aligned}$$

where $x_i \equiv c_i + v(y_i) + \beta_i\pi\left(y_i\right)u(d_i)$ denotes the argument of the transform $V(.)$, that is, the welfare of an agent of type i. It should be stressed here that the variable x_i depends on the *ex post* preferences of agents, that is, on the parameters β_i (and not on the parameters α_i). Hence one can refer to the variable x_i as the *ex post* welfare of agents of type i.[26]

From the FOCs, we have, given $\beta_3 = 0$, that:

$$\begin{aligned} u'(d_i) &= \frac{1}{\beta_i},\ i=1,2 \\ d_3 &= 0 \\ v'(y_i) &= 1-\beta_i\pi'(y_i)\left[u(d_i)-u'(d_i)d_i\right],\ i=1,2 \\ v'(y_3) &= 1 \end{aligned}$$

so that, given $\beta_1 = \beta_2 > 0$, we can deduce

$$\begin{aligned} d_1 &= d_2 > d_3 = 0 \\ y_1 &= y_2 < y_3 \end{aligned}$$

Thus, in the first-best optimum, type-3 agents do not consume anything in the second period, contrary to agents of types 1 and 2. Agents of types 1 and 2 consume a small amount of sin goods, while type-3 agents consume a higher amount. But resources are distributed in such a way that the expected lifetime welfare is, from the point of view of the social planner, equalized across all types, as we have $x_1 = x_2 = x_3$.

3.2 Decentralization

To see how the social optimum can be decentralized, let us now compare the FOCs under the laissez-faire with the ones under the first-best, and try to identify fiscal instruments that will make those FOCs coincide with each others, implying that these instruments allow for the decentralization of the social optimum. Clearly, the social planner does not need to interfere with the choices of agents of type 1, as there is a perfect identity between the FOCs under laissez-faire and at the first-best for that type of agents. The same is also true for

[26] To be more precise, the variable x_i is a measure of the *average ex post* lifetime welfare for agents of type i, since a group of agents of type i involves long-lived and short-lived persons, with proportions equal to respectively π_i and $1-\pi_i$. Hence x_i is a measure of the average *ex post* welfare in the group i.

agents of type 3. However, the planner must interfere with the choice of type-2 agents, and at two levels: the savings decision and the sin goods consumption.

Actually, the laissez-faire level of second-period consumption, equal to zero, is inferior to the first-best level, which is strictly positive, because $\beta_2 > \alpha_2 = 0$. Thus, in order to decentralize the first-best optimum, the government must force type-2 agents to pay a tax T_2 in the first period, and uses this to finance a pension P_2 in the second period, which is given only in case of survival. Provided T_2 and P_2 are equal to:[27]

$$\begin{aligned} T_2 &= \pi(y_2)\, d_2 \\ P_2 &= d_2 \end{aligned}$$

this forced pension system for type-2 agents induces the first-best consumption path. Indeed, type-2 agents still choose to have no savings under that system, but their second-period consumption is now equal to the pension P_2. At this stage, it should be stressed that this forced savings system is here necessary, and cannot be replaced by any standard linear subsidy on savings. The reason is that the savings of type-2 agents at the laissez-faire is, given $\alpha_2 = 0$, a corner solution, and equal to 0, so that no linear subsidy could ever make type-2 agents save.[28] Note that, if we had assumed $0 < \alpha_2 < \beta_2$ instead, then the laissez-faire savings would have been an interior solution, and thus a saving subsidy could have been used to decentralize the optimum savings level for type-2 agents.

Note, however, that the pension system $\{T_2, P_2\}$ does not affect the consumption of the sin good, as we have quasi-linear utility in y_2. Therefore the pension system $\{T_2, P_2\}$ is necessary but not sufficient for the decentralization of the social optimum. This requires also another instrument insuring that type-2 agents choose the optimal level of sin good consumption y_2.

Regarding the decentralization of the first-best optimum of sin goods consumption, let us notice that the FOC for the first-best level of y_2 is

$$v'(y_2) = 1 - \pi'(y_2)\, \beta_2 \left[u(d_2) - u'(d_2) d_2\right]$$

whereas, under a tax θ_2 on y_2, the laissez-faire level of y_2 is characterized by

$$v'(y_2) = 1 + \theta_2$$

Hence, the first-best level of sin good consumption can be decentralized by means of a tax θ_2 equal to

$$\theta_2 = -\pi'(y_2)\, \beta_2 \left[u(d_2) - u'(d_2) d_2\right] > 0$$

where d_2 and y_2 take their first-best levels. This tax depends positively on β_2, and is thus increasing in the degree of myopia of the agent. The tax depends also on the sensitivity of the survival probability to the consumption of y_2.

[27] Note that d_2 and y_2 take here their first-best levels.

[28] Even a 100 % subsidy of savings would not make type-2 agents save under $\alpha_2 = 0$.

Thus, under the pension system $\{T_2, P_2\}$ and the tax θ_2, type-1 and type-2 agents have exactly the same bundles. This will also prevent type-2 agents from regretting their choices, and from envying type-1 agents *ex post*.

Finally, note that, in order to achieve the equality of marginal social utilities, the implementation of the first-best may also require some lump sum transfers across groups 1, 2 and 3. However, given that those three types of agents have the same endowment, one could argue that the role of the government should be restricted to the (forced) pension system $\{T_2, P_2\}$ and the Pigouvian tax θ_2 on the sin good, in the name of responsibility.

4 The second-best problem

Let us now consider the second-best problem, in which the social planner cannot observe the types of agents. Under such a limited observability of types, it is likely that myopic agents (i.e. type-2 agents) will pretend to be impatient agents (i.e. type-3 agents), in order to escape from the forced savings system proposed by the planner at the first-best. Indeed, even though this forced pension system is built for the good of type-2 agents, those agents, being myopic, cannot realize, *ex ante*, that such a system would be good for them. As a consequence, type-2 agents might prefer pretending to be of type-3, in such a way as to receive from the social planner the bundle designed for type-3 agents.

Note also that such "mimicking behaviors" are not restricted to type-2 agents. For instance, farsighted agents (i.e. type-1 agents) may also be tempted to lie on their type, in such a way as to benefit from a more favorable bundle. Clearly, type-1 agents could be tempted to pretend to be myopic agents (i.e. type-2 agents). The reason is that once we refine the bundles of type-2 agents to prevent the mimicking of type-3 agents, type-1 agents might then be tempted to pretend to be of type-2, in order to benefit from a more attractive bundle.

4.1 The second-best optimum

As a consequence of those mimicking possibilities, the imperfect observability of types requires the addition of two self-selection constraints. Hence the Lagrangian of the second-best problem can be written as

$$\begin{aligned}\mathcal{L} \quad = \quad & \sum_{i=1,2,3} n_i \left\{ V\left[c_i + v(y_i) + \beta_i \pi\left(y_i\right) u(d_i)\right] - \mu\left[c_i + y_i + \pi(y_i) d_i - w\right] \right\} \\ & + \lambda_1 \left[c_1 + v(y_1) + \alpha_1 \pi\left(y_1\right) u(d_1) - c_2 - v(y_2) - \alpha_1 \pi\left(y_2\right) u(d_2)\right] \\ & + \lambda_2 \left[c_2 + v(y_2) + \alpha_2 \pi\left(y_2\right) u(d_2) - c_3 - v(y_3) - \alpha_2 \pi\left(y_3\right) u(d_3)\right]\end{aligned}$$

where λ_i is the Lagrange multiplier associated with the incentive compatibility constraint preventing an agent of type i from mimicking an agent of type $i+1$.

As above, the social planner's objective function relies on the *ex post* preference parameters β_i, rather than on the *ex ante* preference parameters α_i, in such a way as to avoid the prevalence of regrets. On the contrary, the self-selection

constraints rely on the *ex ante* preference parameters α_i. The intuition behind this is that agents's will to mimic other agents depends on their *ex ante* perspectives. For instance, type-2 agents, when deciding whether they will pretend to be of type 3 or not, are subject to their myopia when making that decision.

Note that our assumptions on preference parameters allow us to simplify the above Lagrangian significantly. Given that we assume $\alpha_2 = 0$, the second self-selection constraint, which concerns myopic agents, only includes the comparison of first-period consumption and sin good, so that we can simplify the terms related to the second period. Regarding the first incentive compatibility constraint, it is clear that, given that type-1 agents do not have any regret, we have $\alpha_1 = \beta_1 > 0$. Therefore one can substitute for β_1 instead of α_1 in that constraint. Hence the Lagrangian becomes:

$$\begin{aligned}\mathcal{L} &= \sum_{i=1,2,3} n_i \left\{V\left[c_i + v(y_i) + \beta_i \pi\left(y_i\right) u(d_i)\right] - \mu\left[c_i + y_i + \pi(y_i) d_i - w\right]\right\} \\ &\quad + \lambda_1\left[c_1 + v(y_1) + \beta\pi\left(y_1\right) u(d_1) - c_2 - v(y_2) - \beta\pi\left(y_2\right) u(d_2)\right] \\ &\quad + \lambda_2\left[c_2 + v(y_2) - c_3 - v(y_3)\right]\end{aligned}$$

where we use, for simplicity, the notation $\beta \equiv \beta_1 = \beta_2 > 0$.

The FOCs yield

$$\begin{aligned}\left(V'(x_1) - \mu\right) n_1 + \lambda_1 &= 0 \\ \left(V'(x_2) - \mu\right) n_2 + \lambda_2 - \lambda_1 &= 0 \\ \left(V'(x_3) - \mu\right) n_3 - \lambda_2 &= 0 \\ \left(V'(x_1)\beta u'(d_1) - \mu\right) n_1 + \lambda_1 \beta u'(d_1) &= 0 \\ \left(V'(x_2)\beta u'(d_2) - \mu\right) n_2 - \lambda_1 \beta u'(d_2) &= 0 \\ d_3 &= 0 \\ \left[V'(x_1)\left[v'(y_1) + \beta\pi'(y_1)u(d_1)\right] - \mu(1 + \pi'(y_1)d_1)\right] n_1 & \\ \quad + \lambda_1\left[v'(y_1) + \beta\pi'(y_1)u(d_1)\right] &= 0 \\ \left[V'(x_2)\left[v'(y_2) + \beta\pi'(y_2)u(d_2)\right] - \mu(1 + \pi'(y_2)d_2)\right] n_2 & \\ \quad - \lambda_1\left[v'(y_2) + \beta\pi'(y_2)u(d_2)\right] + \lambda_2 v'(y_2) &= 0 \\ \left[V'(x_3)v'(y_3) - \mu\right] n_3 - \lambda_2 v'(y_3) &= 0\end{aligned}$$

From the first three FOCs, we have:

$$\begin{aligned}V'(x_1) &= \mu - \frac{\lambda_1}{n_1} \\ V'(x_2) &= \mu - \frac{\lambda_2 - \lambda_1}{n_2} \\ V'(x_3) &= \mu + \frac{\lambda_2}{n_3}\end{aligned}$$

Those equalities imply that $x_3 < x_1 = x_2$.[29] Hence, type-1 and type-2

[29] The inequality $x_3 < x_1$ follows from the first and the third conditions. Regarding the equality $x_1 = x_2$, this comes from the first self-selection constraint: the *ex post* welfare of type-1 agents mimicking type-2 agents equals the one of type-2 agents.

agents have, at the second-best, a higher *ex post* welfare than type-3 agents. Given that this was not the case at the first-best, where $x_3 = x_1 = x_2$, it follows that type-1 and type-2 agents tend to benefit from asymmetric information at the expense of type-3 agents. Substituting those expressions in the FOCs for savings yields

$$\begin{aligned} u'(d_1) &= \frac{1}{\beta} \\ u'(d_2) &= \frac{1}{\left(1 - \frac{\lambda_2}{\mu n_2}\right)\beta} \\ d_3 &= 0 \end{aligned}$$

From which we have: $d_3 < d_2 < d_1$. Note that type-2 agents have here a lower second-period consumption than under the first-best, to an extent that depends on the curvature of the temporal utility function. This change with respect to the first-best comes from the second incentive compatibility constraint. Given that type-2 agents do not see, *ex ante*, the relevancy of second-period consumption, the social planner proposes a lower d_2 than at the first-best, to prevent them from pretending to be of type 3.

Regarding the consumption of sin goods, we have

$$\begin{aligned} v'(y_1) &= 1 - \beta\pi'(y_1)\left[u(d_1) - u'(d_1)d_1\right] \\ v'(y_2) &= 1 - \beta\pi'(y_2)\left(1 - \frac{\lambda_2}{\mu n_2}\right)\left[u(d_2) - u'(d_2)d_2\right] \\ v'(y_3) &= 1 \end{aligned}$$

Thus we obtain $y_1 < y_2 < y_3$. Hence, whereas, at the first-best, type-1 and type-2 agents were treated similarly, this is no longer the case here, as type-2 agents enjoy a higher level of sin good consumption than type-1 agents. Here again, this change is due to the introduction of incentive compatibility constraints.

Comparing these FOCs with the first-best FOCs, we can see that

$$\begin{aligned} y_1^{FB} &= y_1^{SB} \\ y_2^{FB} &< y_2^{SB} \\ y_3^{FB} &= y_3^{SB} \end{aligned}$$

Type-1 agents consume, at the second-best optimum, the same sin good quantity as in the first-best. However, the second-best optimum involves a higher consumption of sin goods for type-2 agents, in such a way as to prevent them from pretending to be of type 3. Note that the sin good consumption of type-3 agents is the same as in the first-best.

But this does not imply that type-3 agents are not affected by the introduction of self-selection constraints. Actually, in comparison with the first-best,

type-3 are worse off, while type-1 and -2 agents have a higher level of welfare:

$$\begin{aligned} x_1^{FB} &< x_1^{SB} \\ x_2^{FB} &< x_2^{SB} \\ x_3^{FB} &> x_3^{SB} \end{aligned}$$

Thus the social planner, by preventing type-2 agents from pretending to be of type 3, offers them a basket that will, at the end of the day, make these better off than type-3 agents. The latter are the victims of this, as type-3 agents see their welfare falling in comparison with the first-best optimum. Actually, given that type-3 agents have a lower utility, but keep the same sin good consumption and the same second-period consumption as in the first-best, it must be the case that these enjoy a lower first-period consumption than at the first-best. Hence reducing the first-period consumption of type-3 agents appears to be the strategy adopted by the social planner to solve the incentive problem.

Moreover, type-1 agents are also better off at the second-best than at the first-best, since the social planner offers them a better basket, which includes the same sin good quantity and second-period consumption as in the first-best, but with more first-period consumption, in such a way as to prevent them from pretending to be myopic. All in all, the introduction of incentive compatibility constraints benefits to farsighted and to myopic agents, but at the cost of a lower welfare for impatient agents.

Finally, it should be noted that our second-best optimum induces, by construction, the self-selection of agents of *all* types, since no agent has, under that allocation of resources, any incentive to lie on his type. Indeed, it is obvious from the second incentive compatibility constraint that myopic agents (i.e. type-2 agents) will not want to mimic impatient agents (i.e. type-3 agents). Moreover, it is clear from the first incentive compatibility constraint that farsighted agents (i.e. type-1 agents) will not want to pretend to be myopic (i.e. of type 2). But it is also easy to check that no agent has, under those two incentive compatibility constraints, any temptation to mimic another agent. For instance, one can show from the two incentive compatibility constraints that type-3 agents will not pretend to be of type 1.[30]

4.2 Implementation

Let us now study how the above second-best optimum can be decentralized. For that purpose, we shall follow the same method as in the first-best problem, and look for fiscal instruments such that, if imposed on the agents, their laissez-faire decisions will coincide exactly with the second-best optimum.

[30] Indeed, combining the two self-selection constraints yields:

$$c_3 + v(y_3) - c_1 - v(y_1) = \pi(y_1)\, u(d_1) - \pi(y_2)\, u(d_2)$$

Note that, as $d_1 > d_2$ and $y_1 < y_2$, the RHS of that expression is necessarily non-negative, implying that type-3 agents do not want to pretend to be of type 1.

Note first that, as in the first-best problem, the decentralization of the second-best involves a forced savings system for type-2 agents, that is, a first period tax T_2 and a second-period pension P_2 such that

$$\begin{aligned} T_2 &= \pi(y_2)\, d_2 \\ P_2 &= d_2 \end{aligned}$$

where d_2 and y_2 take their second-best levels. Given that $y_2^{SB} > y_2^{FB}$ and $d_2^{SB} < d_2^{FB}$, it is not difficult to see that the tax and the pension will be here of smaller size in comparison with the first-best levels:

$$\begin{aligned} T_2^{SB} &< T_2^{FB} \\ P_2^{SB} &< P_2^{FB} \end{aligned}$$

The decentralization of the second-best requires also a tax on the sin good for type-2 agents, but this tax will now take a lower level than under the first-best. Indeed, the FOC for optimal second-best y_2 is

$$v'(y_2) = 1 - \beta\pi'(y_2)\left(1 - \frac{\lambda_2}{\mu n_2}\right)[u(d_2) - u'(d_2)d_2]$$

Comparing this with the FOC under laissez-faire yields an optimal tax θ_2^{SB}:

$$\theta_2^{SB} = -\pi'(y_2)\,\beta\left(1 - \frac{\lambda_2}{\mu n_2}\right)(u(d_2) - u'(d_2)d_2) > 0$$

Given that $1 - \frac{\lambda_2}{\mu n_2} < 1$, we have

$$\theta_2^{SB} < \theta_2^{FB}$$

Thus the second-best tax on the sin good is smaller than the first-best tax, as the (second) incentive-compatibility constraint tends to counteract the correction of the myopia: in order to prevent type-2 agents from pretending to be of type-3, we have to weaken the tax on the sin good.

Finally, as in the first-best, those policies $\{T_2, P_2, \theta_2\}$ do not suffice to decentralize the social optimum. Some lump sum transfers across agents are also needed, to satisfy the above FOCs. We shall not explore here those transfers in details, but it is clear that, in the light of what was stressed above, type-3 agents tend, in comparison with the first-best, to transfer more resources to type-2 agents, as their first-period consumption is reduced with respect to the first-best, whereas the opposite holds for type-2 agents.

5 Double heterogeneity and linear taxation

In the previous sections, we studied the optimal taxation policy when the population includes different types of agents, some agents being farsighted, whereas

others are myopic or impatient. In order to characterize the optimal policy under perfect information (Section 3) and imperfect information (Section 4), we assumed, for simplicity, that individual earnings were uniform, in such a way as to keep only one dimension of heterogeneity. This assumption allowed us to derive a simple formula for the optimal sin tax.

However, in the real world, agents differ in individual earnings, and a large empirical literature identified the existence of statistically significant correlations between sin goods consumption and earnings. Regarding smoking behavior, Levine *et al.* (1997), Heineck and Schwarze (2003), Van Ours (2004), Auld (2005), Braakmann (2008) and Anger and Kvasnicka (2010) report the existence of a wage penalty attached to smoking, ranging from 2 % to 24 %. As far as alcohol consumption is concerned, empirical studies point also to a correlation, but of a positive sign (see Van Ours, 2004; Lye and Hirschberg, 2004; Auld, 2005). Hence, in the light of those studies, one can hardly consider that the different types considered so far are homogeneous in terms of earnings. On the contrary, agents consuming more sin goods (i.e. types 2 and 3), are also characterized by a lower or a higher level of earnings, depending on the sin good. Taking this dimension of heterogeneity into account is thus most relevant for the design of optimal sin taxes. Moreover, introducing heterogeneity in earnings gives us also the opportunity to examine the regressiveness of sin taxes, which depends on whether sin goods consumers earn less or more than non-consumers.

In order to study the impact of earnings inequality on the optimal sin tax, we will concentrate here on *linear* taxation instruments. Note that, ideally we should deal with this enriched setting by means of non-linear taxes or subsidies. Unfortunately, even in the simplest case (two levels of wages and three types of agents), the number of binding self-selection constraints would make the problem intractable. Therefore we will restrict ourselves here to non-individualized linear taxation instruments. This is not as general as a non-linear taxation framework, but this is analytically more convenient, and it is also somewhat more realistic, since tax instruments are, in the real world, most often linear.[31]

Note, however, that the use of linear fiscal instruments has also its own costs. First of all, this restriction of the set of available taxation instruments consists of nothing else than a kind of second-best approach to taxation. But another well-known problem raised by linear instruments is that if an agent's choice coincides with a corner solution at the laissez-faire, a linear subsidy cannot induce him to change his behavior. In the present context, we face that problem with the savings of myopic agents. As we showed in Section 2, type-2 agents, being myopic, do not save at all at the laissez-faire. Hence, a standard linear subsidy on savings cannot help decentralizing the social optimum, as it is ineffective in the context of a corner solution at the laissez-faire. Thus, to induce type-2 agents to have some resources in the second period, a linear subsidy cannot do the job. What we need to introduce is a flat pension benefit.

As a consequence of all this, we will, throughout this section, use the fol-

[31] Besides realism concerns, our reliance on non-individualized linear taxation instruments can also be defended on the grounds of the too large administrative costs induced by the use of finer fiscal instruments.

lowing non-individualized taxation instruments: a flat tax τ on earnings, a demogrant a, a tax θ on the sin good, and a pension benefit P.

5.1 The agents' decisions

The introduction of heterogeneity in earnings requires new notations. Throughout this section, we shall denote the wage of agents of type i by w_i. Thus, each individual variable will now be indexed by the letter i for the wage rate w_i, and by letters $j = 1, 2, 3$ for the three types of behaviors present in the baseline model: farsightedness, myopia (with regrets) and impatience (without regrets).

Under a quadratic disutility of labor, the problem of an agent of type ij is to maximize:

$$w_i \ell_{ij} (1 - \tau) + a - s_{ij} - y_{ij} (1 + \theta) - \frac{\ell_{ij}^2}{2} + v(y_{ij}) + \alpha_{ij} \pi(y_{ij}) u\left(\frac{s_{ij}}{\pi(y_{ij})} + P\right)$$

where ℓ_{ij} denotes the labor of agents of type ij, while α_{ij} denotes the time preference parameter governing the decision of an agent of type ij. As above, we shall assume that $\alpha_{i1} > 0$ and $\alpha_{i2} = \alpha_{i3} = 0$.

From individual optimization, we have

$$\begin{aligned} \ell_{ij} &= w_i(1 - \tau),\ j = 1, 2, 3 \\ s_{i1} &= s_{i1}(\tau, a, \theta, P) \\ s_{ij} &= 0,\ j = 2, 3 \\ y_{ij} &= y_{ij}(\tau, a, \theta, P),\ j = 1, 2, 3 \end{aligned}$$

Note that the labour supply decision does not depend on whether the agent is farsighted, myopic or impatient, but depends only on the wage level and on the tax rate. Here again, type-2 and type-3 agents do not save, whereas the savings of type-1 agents is a function of the policy instruments.

5.2 The planner's problem

Let us now consider the social planner's problem. As above, we distinguish here between α_{ij}, i.e. the *ex ante* time preference parameter of agents of type ij, and β_{ij}, which consists of the *ex post* time preference parameter of agents of type ij. As in the basic model, farsighted agents and impatient agents do not exhibit any regret, that is, there is a perfect coincidence between their *ex ante* preferences and their *ex post* preferences: $\alpha_{i1} = \beta_{i1} > 0$ and $\alpha_{i3} = \beta_{i3} = 0$. However, type-2 agents exhibit some regrets, in the sense that there is a gap between how they value their old-age when making their decisions at the beginning of young adulthood and how they value their old-age at the end of young adulthood. This discrepancy, which is at the origin of regrets, is formalized by a difference between *ex ante* and *ex post* preferences: $\alpha_{i2} = 0 < \beta_{i2}$. Moreover, for the ease of presentation, we also assume that $\beta_{i1} = \beta_{i2}$.

As in the baseline model, the social planner, when solving the problem of the optimal allocation of resources, will base his calculations on the *ex post*

time preference parameters β_{ij}, and not on the *ex ante* preferences α_{ij}, in such a way as to avoid the occurrence of regrets among type-2 agents. Hence the problem of the social planner can be written as the maximization of the following Lagrangian:

$$\begin{aligned}\mathcal{L} &= \sum n_{ij} V\left[\frac{w_i^2\left(1-\tau\right)^2}{2}+a-s_{ij}-y_{ij}\left(1+\theta\right)+v\left(y_{ij}\right)\right. \\ &\left.+\beta_{ij}\pi\left(y_{ij}\right)u\left(\frac{s_{ij}}{\pi_{ij}}+P\right)\right]+\mu\sum n_{ij}\left(\tau\left(1-\tau\right)w_i^2+\theta y_{ij}-a-\pi\left(y_{ij}\right)P\right)\end{aligned}$$

where n_{ij} is the proportion of individuals of type j with productivity w_i, the optimal labor supply $\ell_{ij}=w_i\left(1-\tau\right)$ is substituted in, and μ is the Lagrange multiplier associated with the revenue constraint.

From the FOCs for an interior maximum and using the envelope theorem, we obtain the following FOCs, for respectively a, τ, P and θ:

$$\sum n_{ij}V'\left(x_{ij}\right)+\sum n_{i2}V'\left(x_{i2}\right)\upsilon_{i2}\frac{\partial y_{i2}}{\partial a}+\mu\sum n_{ij}\left(\theta\frac{\partial y_{ij}}{\partial a}-1-\pi'\left(y_{ij}\right)\frac{\partial y_{ij}}{\partial a}P\right)=0$$

$$\begin{aligned}-\sum n_{ij}V'\left(x_{ij}\right)w_i^2(1-\tau)+\sum n_{i2}V'\left(x_{i2}\right)\upsilon_{i2}\tfrac{\partial y_{i2}}{\partial\tau} \\ +\mu\sum n_{ij}\left[\left(1-2\tau\right)w_i^2+\theta\tfrac{\partial y_{ij}}{\partial\tau}-\pi'\left(y_{ij}\right)\tfrac{\partial y_{ij}}{\partial\tau}P\right]\end{aligned}=0$$

$$\begin{aligned}\sum n_{ij}V'\left(x_{ij}\right)\beta_{ij}\pi\left(y_{ij}\right)u'(d_{ij})+\sum n_{i2}V'\left(x_{i2}\right)\upsilon_{i2}\tfrac{\partial y_{i2}}{\partial P} \\ +\mu\sum n_{ij}\left[\theta\tfrac{\partial y_{ij}}{\partial P}-\pi'\left(y_{ij}\right)\tfrac{\partial y_{ij}}{\partial P}P-\pi\left(y_{ij}\right)\right]\end{aligned}=0$$

$$-\sum n_{ij}V'\left(x_{ij}\right)y_{ij}+\sum n_{i2}V'\left(x_{i2}\right)\upsilon_{i2}\frac{\partial y_{i2}}{\partial\theta}+\mu\sum n_{ij}\left(y_{ij}+\theta\frac{\partial y_{ij}}{\partial\theta}-\pi'\left(y_{ij}\right)\frac{\partial y_{ij}}{\partial\theta}P\right)=0$$

where $\upsilon_{i2}\equiv\beta_{i2}\pi'(y_{i2})u(d_{i2})<0$ denotes the utility loss that is due to the myopia of type-2 agents.

Those optimality conditions allow us to characterize the optimal values of our policy instruments a, τ, P and θ. Note, however, that the simultaneous study of the optimal levels of the four taxation tools would be quite laborious, as their values are all related to each others through the government's budget constraint. Therefore, in order to keep the analysis simple, we will proceed as follows. To interpret those optimality conditions, we will consider alternative pairs of fiscal instruments, holding the other instruments equal to 0. Hence, we will here focus on the pairs (τ,a), (P,a) and (θ,a), while keeping, each time, the other fiscal tools set to 0. This simplification will allow us to derive, *in fine*, closed-form solutions for the optimal levels of our instruments.

Let us start with the pair (τ,a), composed of the tax rate on labour earnings and the first-period demogrant. Regarding the optimal level of τ, the second FOC does not allow us, on its own, to characterize the optimal level of τ, as a rise in τ must, under the government's budget constraint, imply a change in the demogrant a, in such a way as to maintain the budget equilibrium. Hence the first FOC must also be considered in the analysis. Therefore, in order to

characterize the optimal level of τ on the basis of the above optimality conditions, we will use a compensated Lagrangian expression, whose derivative with respect to the policy instrument τ gives us the effect of a variation of τ on the Lagrangian when that change is compensated by a variation of the demogrant a that keeps the government's budget equilibrium. Using the optimality conditions, the derivative of the compensated Lagrangian can be defined as:

$$\frac{\partial \tilde{\pounds}}{\partial \tau} \equiv \frac{\partial \pounds}{\partial \tau} + \frac{\partial \pounds}{\partial a}\frac{da}{d\tau} = \frac{\partial \pounds}{\partial \tau} + \frac{\partial \pounds}{\partial a}(1-2\tau)\sum n_{ij}w_i^2$$

where $\tilde{\pounds}$ denotes the compensated Lagrangian, and where the second term accounts for the effect of a change in the tax rate τ on the first-period demogrant, under the government's budget equilibrium constraint.

Substituting for the above FOCs and equalizing to zero yields

$$\begin{aligned}\frac{\partial \tilde{\pounds}}{\partial \tau} &= -(1-\tau)\sum n_{ij}V'(x_{ij})\left[w_i^2 - \sum n_{ij}w_i^2\right] \\ &\quad -\tau\sum n_{ij}V'(x_{ij})\sum n_{ij}w_i^2 + \sum n_{i2}V'(x_{i2})\,\upsilon_{i2}\frac{\partial \tilde{y}_{i2}}{\partial \tau} \\ &= 0\end{aligned}$$

where $\partial \tilde{y}_{i2}/\partial \tau$ denotes the effect of a change of τ on the sin good consumption of type-2 agents, when that change is compensated by a change of the demogrant a in such a way as to maintain the government's budget equilibrium.

Regarding the pair (P, a), on can proceed in the same way as with the pair (τ, a), and define the derivative of the compensated Lagrangian as follows:

$$\frac{\partial \tilde{\pounds}}{\partial P} \equiv \frac{\partial \pounds}{\partial P} + \frac{\partial \pounds}{\partial a}\frac{da}{dP} = \frac{\partial \pounds}{\partial P} - \frac{\partial \pounds}{\partial a}\sum n_{ij}\pi(y_{ij})$$

where the second term accounts for the effect of a change in the pension P on the first-period demogrant, under the government's budget equilibrium.

Substituting for the above FOCs and equalizing to zero yields

$$\begin{aligned}\frac{\partial \tilde{\pounds}}{\partial P} &= \sum n_{ij}V'(x_{ij})\,\beta_{ij}\pi(y_{ij})\,u'(d_{ij}) - \sum n_{ij}V'(x_{ij})\sum n_{ij}\pi(y_{ij}) \\ &\quad + \sum n_{i2}V'(x_{i2})\,\upsilon_{i2}\frac{\partial \tilde{y}_{i2}}{\partial P} - \mu\sum n_{ij}\pi'(y_{ij})\,P\frac{\partial \tilde{y}_{ij}}{\partial P} \\ &= 0\end{aligned}$$

where $\partial \tilde{y}_{ij}/\partial P$ denotes the effect of a change of P on the sin good consumption of agents of type ij, when that change is compensated by a change of the demogrant a in such a way as to maintain the government's budget equilibrium.

Finally, in the case of the pair (θ, a), the derivative of compensated Lagrangian can be defined as:

$$\frac{\partial \tilde{\pounds}}{\partial \theta} \equiv \frac{\partial \pounds}{\partial \theta} + \frac{\partial \pounds}{\partial a}\frac{da}{d\theta} = \frac{\partial \pounds}{\partial \theta} + \frac{\partial \pounds}{\partial a}\sum n_{ij}y_{ij}$$

where the second term accounts for the effect of a change in the tax θ on the first-period demogrant, under the government's budget constraint.

Substituting for the above FOCs and equalizing to zero yields

$$\begin{aligned}\frac{\partial \tilde{\pounds}}{\partial \theta} &= -\sum n_{ij} V'(x_{ij})\, y_{ij} + \sum n_{ij} V'(x_{ij}) \sum n_{ij} y_{ij} \\ &\quad + \sum n_{ij} V'(x_{ij})\, \upsilon_{i2} \frac{\partial \tilde{y}_{i2}}{\partial \theta} + \mu\theta \sum n_{ij} \frac{\partial \tilde{y}_{ij}}{\partial \theta} \\ &= 0\end{aligned}$$

where $\partial \tilde{y}_{ij}/\partial\theta$ denotes the effect of a change of θ on the sin good consumption of type-2 agents, when that change is compensated by a change of the demogrant a in such a way as to maintain the government's budget equilibrium.

With those simplifications, we can now obtain, from each of the above compensated Lagrangian expression, a formula for each tax instrument, keeping in mind that the other instruments are, in each case (except the demogrant), set equal to zero.[32]

$$\tau^* = \frac{-cov\left(V'(x), w^2\right) + \sum n_{i2} V'(x_{i2})\, \upsilon_{i2} \frac{\partial \tilde{y}_{i2}}{\partial \tau}}{-cov\left(V'(x), w^2\right) + EV'(x) Ew^2}$$

$$P^* = \frac{-cov\left(V'(x), \pi\right) - \sum_{2,3} n_{ij} V'(x_{ij}) \pi(y_{ij}) \left(1 - \beta_{ij} u'(P)\right) + \sum n_{i2} V'(x_{i2})\, \upsilon_{i2} \frac{\partial \tilde{y}_{i2}}{\partial P}}{-\mu E \pi'(y) \frac{\partial \tilde{y}}{\partial P}}$$

$$\theta^* = \frac{-cov\left(V'(x), y\right) + \sum n_{i2} V'(x_{i2})\, \upsilon_{i2} \frac{\partial \tilde{y}_{i2}}{\partial \theta}}{-\mu E \frac{\partial \tilde{y}}{\partial \theta}}$$

In order to interpret the formulae of the optimal tax instruments τ^*, P^* and θ^*, let us first examine the structure that is common to all those expressions.

The denominators of those expressions reflect the efficiency effect of the tax instrument: for τ^*, the effect of τ on aggregate labor supply; for P^*, the effect of pensions on longevity, and, for θ^*, the effect of the tax on the sin good consumption. The larger those effects are, the lower the tax instruments should be *ceteris paribus*.

In the numerators, the covariance terms reflect the equity effect of the tax instrument. The covariance terms are likely to be negative, and are closely linked to the concavity of $V(x)$. Actually, we expect agents with a higher x to be also more productive, to live longer, and to consume more sin good (even though this latter point is more debatable). This leads to negative covariance terms, which tend, in the present framework, to raise the optimal levels of the tax instruments. The higher the covariance terms are in absolute value, and the larger the optimal values of tax instruments are, everything else being unchanged. Note, however, that things could be different with a more general functional form for individual utility. For example, it is not impossible to have a sin good consumption which

[32] We use here the E operator for expected values.

decreases as income increases. In that case, $cov\left(V'\left(x\right),y\right)$ could be positive, thus pushing for a lower sin tax.

The terms including υ_{i2} - the utility loss due to myopia - at the numerators indicate how the tax instruments induce myopic agents to choose the right amount of sin good y. Those terms depend on the effect of a rise in the instrument on sin good consumption when this is compensated by a change in the transfer a in such a way as to maintain the budget equilibrium. The sign of those compensated changes $\partial\tilde{y}_{i2}/\partial\theta$, $\partial\tilde{y}_{i2}/\partial\tau$ and $\partial\tilde{y}_{i2}/\partial P$ is likely to be negative, but it is not easy to see how large those compensated changes are. Note that the size of the terms including υ_{i2} depends also on how sizeable the type-2 group is: the larger that group is, the larger the social planner's concern for those agents is, and thus the more the optimal tax instruments will reflect the correction of type-2 agents' myopia.

Finally, note that there is the second term of the numerator of the P^* formula, which has to be distinguished between types 2 and 3. For type-3 agents, $\beta_{i3}=0$, and thus this term is positive, pushing P^* down. For type-2, it is negative ($\beta_{i2}>0$), and pushes P^* up.

All in all, the above tax formulas allow us to identify the major determinants of the optimal fiscal instruments τ^*, P^*, and θ^*. As usual with this type of problem, the optimal taxes result from a trade-off between efficiency and equity concerns. However, in the present framework, the correction for myopia is another key determinant of the optimal fiscal instruments, whose size depends on how large the group of myopic agents is.

Undoubtedly, the above tax formulas are quite abstract, and, in order to interpret these further, we need to have a look at what the existing empirical literature can say about the various determinants at work. For that purpose, we will, in the rest of this section, focus on the optimal sin tax θ^*, since the goal of this paper is to cast a new light on the optimal fiscal treatment of sin goods.

5.3 The determinants of the optimal sin tax

Let us now investigate what the above analysis can tell us about the optimal taxation of sin goods in real market economies. For that purpose, remind first that the optimal sin tax θ^* depends on three determinants: (1) how reactive average sin good consumption is to the tax (i.e. the denominator); (2) how large the correction of the myopia induced by the tax is (i.e. the terms including υ_{i2}); (3) how correlated sin good consumption and individual welfare are (i.e. the covariance term). We will here discuss what policy recommendations can be drawn from this, on the basis of empirical studies on sin goods consumption.

Regarding point (1), sin good consumption seems, in general, relatively little elastic to changes in the tax, implying a low denominator, which would support the necessity of a large sin tax θ. This intuition for a low elasticity is confirmed by the literature on the price elasticity of the demand for cigarettes, which yields estimations ranging between -0.3 and -0.5. For instance, Lewit and Coate (1982) estimated an (uncompensated) price elasticity of -0.42, while Chaloupka

and Wechsler (1997) estimated an (uncompensated) price elasticity of -0.58.[33] Regarding alcohol, existing studies, such as Saffer and Dhaval (2002, 2006), report even lower estimates for the price elasticity, between -0.2 and -0.3, whereas Selvanathan (2006) estimates a price elasticity of -0.6. Those relatively low elasticity values support, from the point of view of efficiency, a large taxation of the sin good. Note, however, that if myopic agents are also little sensitive to sin good taxation, then, by point (2), it would not make sense to tax sin good too much, which reduces the optimal θ *ceteris paribus*. The little reactivity of sin good consumption to taxation seems thus to yield ambiguous results in terms of sin good taxation: on the one hand, the low elasticity makes the taxation of that good efficient, but, on the other hand, the perspectives of lowering, through the tax, the welfare loss due to myopia are also reduced.

Moreover, regarding the second term of the numerator of θ [i.e. point (2)], it appears that the optimal tax on the sin good is also larger if a large proportion of the population suffers from myopia (i.e. a large n_{i2}). In other words, the extent to which sin good consumers formulate regrets or not affects the optimal tax to a large extent. As stressed in Section 1, the proportion of regret-makers is, in the light of various studies, especially large among smokers - about 80 to 90 % of the smokers population - (see Slovic, 2001; Jarvis *et al*, 2002; Fong *et al*, 2004). Such a large proportion of smokers with regrets supports a large n_{i2}, and, thus, as far as cigarettes are concerned, a large sin tax. Under such a high proportion of regret-makers (i.e. type-2 agents), the tax on cigarettes would be mainly driven by the task of reducing the welfare burden from myopia.[34]

Finally, it should be stressed that, with a more general utility function, point (3) could play in the opposite direction, that is, towards a *lower* taxation of the sin good. Clearly, if sin goods were mainly consumed by agents with a low productivity (i.e. if sin goods were inferior goods), then the term $cov\left(V'\left(x\right),y\right)$ would be positive, which would support a subsidization rather than a taxation of sin goods in the name of equity concerns, and would play against the other concerns defended above. This would be consistent with the example of cigarettes, as the existing literature supports that smoking prevalence is clearly decreasing with the education level, and, thus, with productivity. For instance, in the U.S. (2007), the lowest rates of smoking prevalence are found among undergraduates (11.4 %) and graduates (6.2 %).[35] Moreover, independently from education, the individuals whose earnings are below the federal poverty lines exhibit also a larger average smoking prevalence than the ones whose earnings are above the poverty line (28.8 % against 20.3 %).[36] Furthermore, numerous studies including Levine *et al.* (1997), Heineck and Schwarze (2003), Van Ours (2004), Auld (2005), Braakmann (2008) and Anger and Kvasnicka (2010) all report the

[33] More recently, Grignon (2007) finds, in France, a price elasticity of starting smoking equal to 0.203, meaning that higher prices tend to delay smoking initiation less than proportionally. The population having hyperbolic time preferences exhibits a slightly larger price elasticity of staring smoking, equal to 0.347.

[34] Note that, unfortunately, we do not have similar studies available for alcohol users.

[35] Data: the *National Health Interview Survey 2007*.

[36] Data: the *National Health Interview Survey 2007*.

existence of a wage penalty attached to smoking, ranging from 2 % to 24 %. All this suggests that $cov\left(V'\left(x\right),y\right)$ might be, in the case of cigarettes, positive, which would tend to lower, *ceteris paribus*, the optimal tax on cigarettes.

Note, however, that this third determinant of the optimal sin tax does not necessarily go in the direction of less taxation. This depends on how productivity and sin good consumption are correlated, which may vary with the sin good at stake. Take, for instance, the case of alcohol consumption. As mentioned in Section 1, Van Ours (2004), Lye and Hirschberg (2004), and Auld (2005) all report the existence of *positive* correlation between (moderate) alcohol consumption and individual earnings. Given the existence of such an alcohol premium, the sign of $cov\left(V'\left(x\right),y\right)$ is likely to be negative, which supports, *ceteris paribus*, a larger tax on alcohol. Hence it appears that, from the point of view of covariance term present in the optimal sin tax formula, not all sin goods should be treated equally. A differentiated treatment of sin goods seems to be required, since some sin goods, like cigarettes, are associated with lower earnings, whereas this is the opposite for other sin goods, such as alcohol.

All in all, the design of the optimal uniform tax on sin goods is not trivial, as there seem to exist tensions between, on the one hand, efficiency concerns and myopia reduction, which support a heavy taxation of the sin good, and, on the other hand, equity concerns, which tend, for some sin goods, to lower the optimal tax rate. The large proportion of regretting sin goods consumers - at least among smokers - seems, on the contrary, to support a high corrective tax.

6 Conclusions

Whereas sin goods consumption is widespread around the world, it is unquestionable that each population is, on its own, far from uniform in its attitude towards sin goods. Some people consume sin goods, others do not. Some sin goods consumers regret their choices later on, whereas others do not regret.

The goal of this paper was to study the optimal taxation of sin goods in an economy where agents differ in how much sin good they consume, and in their attitude towards past sin good consumption (regrets or not). Can we defend, in that economy, a uniform treatment of sin goods consumers by the government?

In the absence of externalities, there exist at least three justifications for such a uniform treatment of sin good consumers: (1) old paternalism (sin goods are "bad" for everyone); (2) Good Samaritan effect (the State anticipates that it will have, *in fine*, to help the persons in need, whatever their responsibility is); (3) informational imperfection at the government's level (impossibility for policy-makers to distinguish between different motivations behind a given choice). The present study focused on the third justification only.

We showed that informational imperfection does not suffice to justify a uniform treatment of sin goods consumers. For that purpose, we first considered a model where all agents have equal earnings, and where some - but not all - sin good users have regrets later on. We argued in Section 3 that, if the government wants to protect myopic agents against future regrets, the decentralization of

the social optimum requires a type-specific taxation on sin goods. It was also shown, in Section 4, that the second-best optimum, although introducing distortions with respect to the first-best (to avoid pooling equilibria), still recommends a differentiated treatment of sin goods consumers, depending on the (more or less) myopic nature of their choices.[37]

Hence, if some theoretical support is to be found for the existing uniform treatment, by the governments, of sin goods consumers of all kinds, this cannot be in the informational constraints faced by governments. On the contrary, this support must lie either in old paternalism, or in the Good Samaritan effect. Whereas the former is hardly defendable, the latter does not provide a strong support for a uniform treatment of all sin goods consumers, but invites further research on how a government could make its commitments more plausible, making thus a differentiated treatment possible again.

Those conclusions, which support the need for a differentiated treatment of sin good consumers, were drawn under the assumption of a full homogeneity of earnings in the population, which is a strong simplification. This is the reason why we introduced, in Section 5, unequal earnings, and examined the design of optimal linear, non-individualized tax instruments, which better coincide with the taxation tools available in the real world. As we showed, heterogeneity in individual earnings complexifies the optimal intervention of the government, because of the potential conflicts between, on the one hand, efficiency concerns and myopia correction, and, on the other hand, equity concerns, when sin goods are more consumed by agents with lower earnings. The former concerns support a high taxation of sin goods, while the latter support the opposite, so that the optimal sign and level of the uniform tax on sin good is ambiguous.

Therefore, this paper emphasizes not only that the existing uniform taxation of sin goods cannot be justified on the grounds of informational imperfection, but, also, that such a uniform treatment is likely to be quite costly in terms of social justice. Actually, if the correlation between earnings and risk-taking behaviors is negative rather than positive, correcting uniformly for a myopia may be in strong opposition with basic equity concerns. Hence the limitation of the government's tools to a uniform tax may not only penalize non-myopic risk-takers, but may also penalize the myopic ones. Heterogeneity in earnings consists thus of an additional reason for a differentiated treatment of risk-takers.

Our paper also highlighted the necessity to treat the various sin goods differently, depending on their properties. For instance, given empirical studies showing that the sign of the correlation between sin good consumption and earnings varies across sin goods (for instance for cigarettes and alcohol), such differences need to be taken into account when designing the optimal sin taxes. As a consequence, our results would tend to support a differentiated treatment of sin goods, on the basis of their different correlations with earnings, which affect the equity component of the optimal sin taxes in various directions.

In sum, the present study emphasizes major difficulties raised by the design

[37] Another interesting feature of the second-best optimum is that it does not only interfere with myopics' choices, but, also, brings lower utility to rational risk-takers, to insure incentive compatibility.

of optimal sin taxes. Note, however, that this study does not have the pretension to provide a complete answer to the question at stake. Actually, we had, for the sake of simplicity, to abstract from some important aspects of sin goods consumption, which may affect optimal sin taxes. Firstly, we left aside *externalities* associated with the consumption of sin goods. This is an obvious simplification, as most sin goods involve externalities, whose internalization would invite Pigouvian taxes. Secondly, this study did not consider the problem of *addiction*, which would require a more detailed time structure than our two-period setting.[38] Thirdly, we limited the set of governmental instruments to pure *fiscal instruments*, and left aside other forms of intervention.[39] Fourthly, this study presupposed a *fixed partition* of the population into different types of agents, whereas that partition is the outcome of various socialization processes at work in the economy, in which the government can play a significant role. Optimal sin taxes should ideally take also that endogeneity into account.[40] Hence much work remains to be done to provide a complete theory of optimal public intervention in the context of sin goods consumption.

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[38] On this, see Orphanides and Zervos (1995), Gruber and Koszegi (2000, 2002) and Suranovic *et al* (1999). Note, however, that the addiction motive - past choices being irreversible - can be interpreted as a kind of myopia, because the anticipation of future addiction would probably, for a farsighted agent, prevent him from consuming addictive sin goods.

[39] Alternative interventions include: education, information campaigns, age restrictions, etc.

[40] On optimal fiscal policy under an endogenous partition of the population into healthy and unhealthy lifestyles, see Ponthiere (2010).

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