Optimal Policies for Sin Goods and Health Care: Tax or Subsidy?

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Abstract

In this paper we examine the optimal policies for sin goods and health care in a two-period economy. Individuals are myopic in the sense that they undervalue the utilities of future consumption and health quality. When investing in health care in the second period, individuals who have previously made myopic decisions may persist in their shortsighted consumption plans (persistent error) or recognize their mistakes (dual self). We show that, for persistent-error myopes, the first-best policy mix requires a subsidy on savings and a tax on sin goods. The health care should be taxed (subsidized) if the degree of myopia concerning future consumption is larger (smaller) than that concerning health quality. For dual-self myopes, the optimal policy for sin goods can be either a tax or a subsidy, depending on the relative degrees of myopia and the property of the health quality function.

Keywords: sin goods; health care; myopic behaviors

JEL classification: H21; I18

1 Introduction

Sin goods refer to those commodities that bring immediate gratification but at the cost of detrimental effects on future health. Common examples include alcohol, cigarettes, drugs, and junk foods. These goods are more or less regulated by countries the world over, justified by at least the following two rationales. First, sin goods usually involve negative externalities, such as alcohol-related violence and passive smoking. Second, sin goods are often immoderately consumed due to individuals' self-control or myopia problems, i.e., the problem of lacking the ability to fully recognize the delayed health costs.

In this study we concern how to regulate sin goods with the primary focus being on the second justification. The issue has been studied by O'Donoghue and Rabin (2003, 2006), who develop a comprehensive framework amenable to addressing optimal sin taxes that is characterized by population heterogeneity in self-control problems. These and many subsequent studies generally model self-control or myopia problems based on individuals who are shortsighted so that they undervalue the negative effects of sin goods on future health.[1] However, myopia can refer not only to shortsightedness regarding future health consequences. In the literature on social security, myopic individuals are often regarded as those who attach too little weight to the utility of future consumption (Feldstein, 1985). This kind of myopia problem has yet received little attention in the literature on optimal sin taxes. Given that shortsightedness is undoubtedly an important feature of the sin-good consumers, it seems reasonable to extend the debate to encompass individuals with multiple types of shortsightedness. This is what we attempt to do in this paper.

For that purpose, we borrow the two-period model of sin taxes from Cremer et al. (2012). Their study adds two interesting traits to the issue of sin taxes. First, they assume that individuals can invest in health care in the second period to mitigate the damage caused by sin-good consumption in the first period. Second, while investing in health care, individuals who have made shortsighted choices of sin-good consumption earlier may persist in their mistaken consumption plans or acknowledge their mistakes. Myopia in their model is primarily associated with future health quality. We extend their work by considering that individuals are myopic not only in terms of future health quality but also in terms of the utility of future consumption.

[1] Although both are features of sin-good consumers, self-control problems and myopia are not equivalent in concept. The existing literature takes quite different approaches on them. For the former, consumers with self-control problems have difficulty of reducing addictive sin-good consumption (e.g., quitting smoking). Thus, "precommitment" is a solution to constrain the later self to follow the plans favored by an earlier self (Gruber and Kőszegi, 2001). For the latter, in contrast, myopic consumers (with dual self) have problems measuring future benefits and costs. Thus, it requires that the early self's decisions being corrected to conform with the preferences of the later self (Cremer et al., 2012).

The key assumption of this analysis is that people have different subjective discount rates on different goods (i.e., consumption and health). This assumption is well supported by the empirical literature. Many studies have identified that discount rates do vary accross commodities. Most related to our paper is the stream of works that estimates the discount rates on health and money (see, e.g., Cairns, 1992; Chapman and Elstein, 1995; Baker et al., 2003).[2] These studies identify that people discount health and money at different rates, but results regarding which discount rate is higher are mixed; namely, money can be discounted at a higher or lower rate than health, depending on other factors considered in the experiments. More recently, Bickel et al. (2011) analyze intertemporal choices of two commodities, cocaine and money, and find that different menus of commodities lead to various discounting rates. Using a much broader set of commodities, Ubfal (2016) also finds that people are singnificantly more impatient about some goods and less impatient about the others. Our appraoch assuming that people have different degrees of myopia is in accordance with these empirical observations.

We focus on the optimal policies that decentralize the first-best allocations. For persistent-error myopes (those who stick to their mistaken consumption plans), the optimal policy mix requires a subsidy on savings and a tax on sin goods. As for health care, we find that if the degree of myopia concerning health quality is stronger than that concerning future consumption, health care investment should be subsidized as illustrated by Cremer et al. (2012). However, in particular, if the degree of myopia concerning future consumption is stronger, it may be necessary to tax health care. To state this intuitively, when myopia concerning future consumption is stronger, persistent-error individuals underestimate the utility of their second-period consumption more severely than underestimating the utility of health care. As a result, they will under-consume the commodity and over-invest in health care, which calls for a tax on health care to balance it.

For dual-self myopes (those who in the second period will regret their earlier myopic behavior), no treatment on health care is needed because these myopes will adjust their behavior to make the right decision on health investment. The optimal sin tax can be positive or negative, which depends upon the relative degrees of myopia and upon how sin goods and health care interact in the health quality function. Specifically, a negative sin tax may be favorable if (i) the degree of myopia concerning health quality is greater, together with the sin goods and health care being complements; or (ii) the degree of myopia concerning future consumption is greater, together with the sin goods and health care being substitutes. Intuitively, if myopia in relation to health quality is stronger, individuals will tend to plan

[2] In our model, discounting future consumption is similar to discounting future money, since future money is spent on consuming a single numeraire good.

a suboptimally low level of health investment in the first period (a plan they will not obey in the second period). At the same time, with this planned level they will tend to choose a "too low" amount of sin-good consumption, supposing that sin goods and health care are complements. If this effect is very strong, sin goods will be under-consumed instead of being over-consumed. This provides a reasoning for subsidizing sin goods.

Given that our model is essentially a generalization of the work by Cremer et al. (2012), it is worthwhile to briefly summarize the similarities and differences between our results and their findings. For persistent-error myopes, both papers indicate that sin goods should be taxed at a positive rate. However, in their paper it is optimal to subsidize health care, while our analysis finds that the first-best policy for health care can be either a tax or a subsidy. In addition, they show that savings should be untaxed, whereas in our paper it is necessary to subsidize savings due to myopia concerning future health. For dual-self myopes, both papers suggest that health care should be untaxed. Nonetheless, their paper proposes a positive sin tax, while our analysis shows that, under certain conditions, it may be optimal to subsidize sin goods.

1.1 Related Literature

Our study belongs to the literature on optimal sin taxes. Gruber and Kőszegi (2001) establish a "rational addiction" model to study the regulation on addictive bads for time-inconsistent agents, and use the model to quantify the optimal taxation on cigarettes. The tax incidence of cigarette taxation among different income groups is examined later in Gruber and Kőszegi (2004). O'Donoghue and Rabin (2003, 2006) study optimal sin taxes when individuals are heterogeneous in self-control problems. They demonstrate that a (positive) sin tax can be Pareto-improving as it achieves the goals of redistribution and correcting the self-control problems. Aronsson and Thunstrőm (2008) assume that the instantaneous utility from sin goods not only depends on current consumption but also on the stock of health capital, which is negatively related to the accumulated consumption of unhealthy goods. Within such a setting, they show that the optimal policy would be a subsidy for health capital, while no tax on sin goods is needed. Yaniv et al. (2009) address the obesity problem. They find that a tax on junk-foods, known as the "fat tax", will unambiguously reduce obesity, while a "thin subsidy" for healthy foods may lead to an increase in obesity. By using a political framework where individuals vote on the determination of sin taxes, Haavio and Kotakorpi (2011) compare the equilibrium tax rate with the socially optimal level.

Two recent papers that introduce the issue of regret into the literature are closely related to the present paper. Cremer et al. (2012) consider one type of consumers who regret their past consumption plans (dual-self) and the other type of consumers who never regret them (persistent-error). They also introduce the role of health investment that can mitigate the damage caused by sin goods. Absent from health expenditures, Pestieau and Ponthiere (2012) consider three types of consumers: type-1 agents who are farsighted; type-2 agents who are myopes with dual selves; type-3 agents who are impatient and simply forego the future. Both studies provide important insights in regard to the interplay between regret behaviors and optimal sin taxes. None of the aforementioned studies, however, distinguishes between myopia concerning the harmful effect of sin goods and myopia regarding the utility of future consumption. This present paper thus contributes to the literature by showing that the relative degrees of the two types of myopia play a relevant role in the design of optimal policies on sin goods and health care.

The myopic behaviors under consideration are also related to the literature on social security with myopic agents.[3] Some of the contributions consider myopic agents as those who forego the future and thus do not save at all (e.g., Feldstein, 1985; Docquier, 2002; Cremer et al., 2007, 2008), while others allow individuals to be characterized by a partial myopia which leads to positive but inadequate savings (e.g., Feldstein, 1985; Cremer et al., 2009, Andersen and Bhattacharya, 2011). Another group of papers, including Pecchenino and Pollard (2005), Findley and Caliendo (2009), Caliendo (2011), and Caliendo and Gahramanov (2013), model myopic individuals as those who in facing uncertainty cannot perfectly foresee the length of their lifetime. Our analysis adopts the second approach involving partially myopic individuals for the convenience of examining the interaction between second-period consumption and health investment.

Finally, some of our results are in accord with those in Pestieau et al. (2008) and Leroux et al. (2011), who examine whether the government should subsidize health spending, and find that under certain conditions it may be optimal to tax health spending instead of subsidizing it. In these papers, however, the issue of sin goods is absent, and health investment affects welfare by enhancing longevity, while in our present paper health investment is used to mitigate the negative effects of unhealthy goods.

The remainder of this paper proceeds as follows. Section 2 describes the model and characterizes the first-best optimum. Section 3 and Section 4, respectively, examine the optimal policies for individuals with persistent errors and with dual selves. Section 5 compares the optimal sin taxes under the two cases. Section 6 concludes the paper.

[3] See Cremer and Pestieau (2011) for a recent survey.

2 The Model

We use a simplified version of the Cremer et al. (2012) model and extend it to additionally consider the myopia that is concerned with the utility of future consumption. Our model is kept as close to that of Cremer et al. (2012) as possible in order to highlight the pure effect of introducing the myopia regarding future consumption. The economy is inhabited by a number of individuals who are homogeneous except in regard to their types of myopia (to be described later).[4] Each individual lives for two periods. In the first period, he allocates an exogenous income y among the current consumption of a numeraire good c, the consumption of a sin good x, and savings s for future expenses. Consuming sin goods brings immediate utility, but at the cost of a delayed negative effect on health. In the second period, he consumes the numeraire good at the level d, and also invests e to improve his health quality. The individual's "true" welfare is given by:

$$W = u(c) + v(x) + \beta[u(d) + h(x, e)], \tag{1}$$

where $u(c)$ and $v(x)$ are strictly concave in c and x, and β is the true discount factor that individuals will actually experience in the second period.[5] The function $h(x, e)$ reflects the individual's state of health quality that is decreasing in sin goods consumed and increasing in the health investment, i.e., $\partial h/\partial x < 0$ and $\partial h/\partial e > 0$. We also assume that $h(x, e)$ is strictly concave in e. In the absence of policy intervention, the budget constraints are:

$$y = c + x + s, \tag{2}$$

$$s = d + e. \tag{3}$$

Note that in (3) a zero interest rate is assumed for simplicity.

2.1 The first-best optimum

As in Cremer et al. (2012), we first characterize the optimal allocations that are chosen by a paternalistic social planner, who maximizes (1) subject to (2) and (3). This yields the

[4] We do not consider heterogeneous earnings for simplicity. The first-best allocations are identical for all regardless of whether earnings differ across individuals or not if we adopt a uniform true discount factor. But the first-best allocation is not attainable with a common tax rate levied on all consumers. See the discussion in Cremer et al. (2012).

[5] For simplicity we assume a uniform discount factor. All of our results are robust to a more general setting under which the true discount factors for second-period consumption and for health quality are different.

following Lagrangian function:

$$\mathcal{L}^* = u(c) + v(x) + \beta u(d) + \beta h(x,e) + \mu(y - c - x - d - e), \tag{4}$$

where μ is the Lagrangian multiplier associated with the resource constraints.

The optimal conditions for this problem are easily derived as:

$$u'(c) = \mu \tag{5a}$$
$$v'(x) = -\beta \frac{\partial h(x,e)}{\partial x} + \mu \tag{5b}$$
$$\beta u'(d) = \mu \tag{5c}$$
$$\beta \frac{\partial h}{\partial e}(x,e) = \mu. \tag{5d}$$

The social planner equalizes the discounted marginal utilities (the left-hand sides) to the marginal costs in terms of utility (the right-hand sides). The set of equations (5a)-(5d) determines the first-best allocations (denoted by "$*$") c^*, x^*, d^*, e^*, and $s^*(= d^* + e^*)$.

2.2 Decentralized economy with myopic individuals

In this subsection we describe the decentralized decision-making by myopic individuals, who are shortsighted in the following two facets. First, as proposed by Cremer et al. (2012), they may undervalue the importance of their health quality in the second period. Secondly, they may also undervalue the utility of future consumption (Feldstein, 1985; Cremer et al., 2009; Cremer and Pestieau, 2011; Andersen and Bhattacharya, 2011). We allow both types of myopia as well as their degrees to be different across individuals. We also follow Cremer et al. (2012) to contrast two personal characteristics: "persistent error" and "dual self". Now let us introduce each of them in detail.

2.2.1 Persistent error

The characteristic "persistent error" refers to the case where myopic individuals make all decisions in the first period according to their shortsighted preferences, and in the second period they stick to their incorrect consumption plans. The objective functions with which they make decisions are:

$$U_i = u(c_i) + v(x_i) + \alpha_i^C u(d_i) + \alpha_i^H h(x_i, e_i), \tag{6}$$

where subscript i indexes the types of individuals (classified by their degrees of myopia). The parameter $\alpha_i^C \in (0, \beta]$ is the degree of myopia concerning the second-period consumption, and $\alpha_i^H \in (0, \beta]$ is the degree of myopia concerning the health quality.[6]

The government imposes taxes/subsidies on individuals in order to correct the problems of myopia. Let τ_s, τ_x, and τ_e denote the tax rates (subsidy rates in negative cases) levied on savings, sin goods, and health expenditure, respectively. Accordingly, the budget constraints can be written as:

$$y + a_i = (1 + \tau_{s,i})s_i + (1 + \tau_{x,i})x_i + c_i, \tag{7}$$

$$s_i = d_i + (1 + \tau_{e,i})e_i. \tag{8}$$

where a_i is a lump-sum transfer.

For myopes with persistent errors, all decisions are made at the start of the first period and remain unchanged afterwards. They maximize (6) subject to (7) and (8), which yields the following first-order conditions:

$$u'(c_i) = \lambda_i^P, \tag{9a}$$

$$v'(x_i) = -\alpha_i^H \frac{\partial h}{\partial x}(x_i, e_i) + (1 + \tau_{x,i})\lambda_i^P, \tag{9b}$$

$$\alpha_i^C u'(d_i) = (1 + \tau_{s,i})\lambda_i^P, \tag{9c}$$

$$\alpha_i^H \frac{\partial h}{\partial e}(x_i, e_i) = (1 + \tau_{s,i})(1 + \tau_{e,i})\lambda_i^P, \tag{9d}$$

where λ_i^P is the Lagrangian multiplier associated with the individual's budget constraints, and the superscript P denotes the case of persistent error. Again, the left-hand sides of equations (9a)-(9d) are marginal utilities and the right-hand sides are marginal costs in terms of utility with respect to c_i, x_i, d_i, and e_i. Notice that if the degrees of myopia are the same among individuals, $\alpha_i^C = \alpha^C$ and $\alpha_i^H = \alpha^H$, then the decentralized allocations are also identical for all individuals.

2.2.2 Dual self

Alternatively, individuals behaving as "dual selves" will recognize their previous mistakes when they choose how much to invest in health quality. In other words, they make myopic health-care plans in the first period, but later in the second period they will make the correct

[6] We have mentioned that myopic individuals are sometimes modeled as those who totally forego the future, which means that α_i^C and α_i^H are equal to zero. In this case, however, it is not possible to invest in health care and thus the first-best optimum is unreachable. Our analysis omits this case given that our main focus is on the first-best policies.

health-care decisions according to the true discount factor.[7]

In the first period, the "myopic self" makes his consumption plans using the shortsighted preference. The first-order conditions are similar as in the case of persistent error:

$$u'(c_i) = \lambda_i^D, \tag{10a}$$

$$v'(x_i) = -\alpha_i^H \frac{\partial h}{\partial x}(x_i, e_i^m) + (1+\tau_{x,i})\lambda_i^D, \tag{10b}$$

$$\alpha_i^C u'[s_i - (1+\tau_{e,i})e_i^m] = (1+\tau_{s,i})\lambda_i^D, \tag{10c}$$

$$\alpha_i^H \frac{\partial h}{\partial e}(x_i, e_i^m) = (1+\tau_{s,i})(1+\tau_{e,i})\lambda_i^D. \tag{10d}$$

Here, λ_i^D is the Lagrangian multiplier with the superscript D denoting the case of the dual self. e_i^m denotes the health expenditures originally planned in the first period.

Equations (10a)-(10d) determine the levels of c_i, x_i, and s_i, but not the level of e_i. This is because (10d) is the first-order condition with which the "myopic self" made the incorrect health investment in the first period. However, in the second period, the "rational self" appears. The rational selves realize that they have made a mistake earlier, so that they will no longer choose the level e_i^m now. Instead, they alter the health investment choice and redecide it according to the true welfare. The optimization condition for health care becomes:

$$(1+\tau_{e,i})u'[s_i - (1+\tau_{e,i})e_i] = \frac{\partial h}{\partial e}(x_i, e_i). \tag{11}$$

By inserting the levels of c_i, x_i, and s_i derived in the first period into (11), we can then obtain the final choices e_i and d_i made by the rational self in the second period.

3 Optimal Policies with Persistent Errors

We are now ready to investigate the optimal policies. In this section we study the case of persistent errors. We will demonstrate that the first-best allocations can be decentralized with an individualized policy mix. By comparing equations (5a)-(5d) with equations (9a)-(9d), we can obtain the optimal policies, which are elucidated by the following lemma:

Lemma 1 *In the case of persistent errors, an optimal policy mix that decentralizes the first-*

[7] O'Donoghue and Rabin (1999) separate dual-self individuals into two types: naive people (i.e., those who do not foresee that they will have self-control problems in the future) and sophisticated people (i.e., those who can foresee their self-control problems). In our dual-self model, individuals behave more like the case of naivete.

best allocations is given by:

$$\tau_{s,i}^P = \frac{\alpha_i^C - \beta}{\beta}, \tag{12a}$$

$$\tau_{x,i}^P = \frac{\alpha_i^H - \beta}{u'(c_i)} \frac{\partial h}{\partial x}(x^*, e^*), \tag{12b}$$

$$\tau_{e,i}^P = \frac{\alpha_i^H - \alpha_i^C}{\alpha_i^C}. \tag{12c}$$

Proof. Letting $\lambda_i^P = \mu$ and by comparing equations (5a)-(5d) with equations (9a)-(9d) complete the proof. ■

Obviously, without any myopia problems, i.e., $\alpha_i^C = \alpha_i^H = \beta$, there is no reason for the government to intervene in the economy. Therefore, in this case all tax rates are equal to zero. As for those who are shortsighted only in health quality, i.e., $\alpha_i^H < \alpha_i^C = \beta$, which is the scenario considered in Cremer et al. (2012), the optimal policy mix requires $\tau_{s,i}^P = 0$, $\tau_{x,i}^P > 0$, and $\tau_{e,i}^P < 0$. This result is quite intuitive. Myopia in relation to health quality induces two distortions: underestimating the damage caused by sin goods and underestimating the benefit of health investment. To correct both distortions, the government should tax sin goods and subsidize health care. The savings decision-making, by contrast, is not distorted in the absence of the type of myopia concerning future consumption, so that the government should simply leave savings uninfluenced.

Now we discuss the policy implications arising from the inclusive case where individuals are myopic in both health quality and future consumption, i.e., $\alpha_i^H, \alpha_i^C < \beta$. First, individuals subject to myopia regarding future consumption do not save enough to provide for their old age. Thus, savings should be subsidized. Secondly, sin goods should be taxed regardless of the extent of α_i^C, as long as myopia concerning health quality is present. Thirdly, perhaps interestingly, when individuals suffer more from the myopia problem regarding future consumption than health quality, i.e., $\alpha_i^C < \alpha_i^H$, to reach the first-best optimum, it is required that the government taxes health care rather than subsidizes it. The underlying intuition can be explained as follows. Suppose that the level of savings has been corrected to its optimal level since the government adopts policy $\tau_{s,i}^P$. This means that the individual has taken an optimal amount of resources to the second period, i.e., $s_i = s^*$. Accordingly, the target of the tax on health expenditures is then to equalize the marginal utility of second-period consumption with the marginal utility of health investment. In the previous case where $\alpha_i^H < \alpha_i^C = \beta$, only the marginal utility of health care is undervalued; therefore the government should adopt a subsidy policy to correct it. On the contrary, if $\alpha_i^C < \alpha_i^H$, the marginal utility of second-period consumption is undervalued even more than the marginal utility of health care. In this case, as a result, the optimal policy mix entails taxing the health investment. Finally, it is also straightforward to see that, with an identical degree of myopia being attached to the whole of the second period, i.e., $\alpha_i^C = \alpha_i^H$, neither a tax nor a subsidy on health investment is needed.

We outline the above discussions by the following proposition:

Proposition 1 *With persistent errors, and in the presence of both myopia concerning health care and future consumption, the optimal policy mix to reach the first-best optimum requires a subsidy on savings and a tax on sin goods. In particular, the optimal tax on health care is positive (negative) if $\alpha_i^H > \alpha_i^C$ ($\alpha_i^H < \alpha_i^C$).*

Proof. A direct result from Lemma 1. ■

To sum up, there are three distortions in this economy: myopia regarding health quality distorts the choices on (i) sin goods and (ii) health investment, and myopia regarding future consumption distorts the choice on (iii) savings (or equivalently, on the second-period consumption). For persistent-error myopes, it is necessary to correct for these distortions with three policy instruments: by taxing sin goods, taxing/subsidizing health care, and subsidizing savings.

By contrast, for dual-self myopes, since distortion (ii) will be corrected by their "rational selves", only two policy instruments are required to achieve the social optimum, which we will illustrate in the next section.

4 Optimal Policies with Dual Selves

In this section we go further to study the optimal policies for myopes with dual selves. As mentioned above, the "rational selves" will amend their own health-care choices in the second period. Accordingly, the main objective of the policy-maker is to correct the decisions made by the "myopic selves" in the first period, which are determined by equations (10a)-(10c). By comparing equations (10a)-(10c) with (5a)-(5c), we show that the first-best optimum can be attained by implementing a policy mix reported by the following lemma:

Lemma 2 *In the case of dual selves, an optimal policy mix that decentralizes the first-best* *allocations is given by:*

$$\tau_{s,i}^{D} = \frac{\alpha_i^C u'(s^* - e_i^{m*}) - \beta u'(s^* - e_i^*)}{u'(c^*)}, \tag{13a}$$

$$\tau_{x,i}^{D} = \frac{\alpha_i^H \frac{\partial h}{\partial x}(x^*, e_i^{m*}) - \beta \frac{\partial h}{\partial x}(x^*, e^*)}{u'(c^*)}, \tag{13b}$$

$$\tau_{e,i}^{D} = 0. \tag{13c}$$

Proof. Inserting $\lambda_i^D = \mu$, $\tau_{e,i}^D = 0$, and comparing equations (5a)-(5c) with equations (10a)-(10c) complete the proof. ■

In Lemma 2 we denote e_i^{m*} as the level of health investment planned by the "myopic self" with the presence of first-best policies in the first period. Notice that e_i^{m*} is not equivalent to e^* unless in a special case (which we will detail later). Analogous to Cremer et al. (2012), the optimal policy for myopes with dual selves is neither to tax nor to subsidize health care. The intuition is that individuals with dual selves are capable of making the optimal health-care decision as long as they take a correct amount of savings to the second period. In other words, once other policies can successfully induce individuals to save correctly, no further treatment on health care is needed.

Before examining the optimal policy for sin goods, it is useful to first compare the levels of e_i^{m*} with e^*. The following lemma reports the relationship between myopia and the relative magnitude of e_i^{m*} and e^*.

Lemma 3 *For dual-self myopes, we have:*

$$e_i^{m*} \gtreqless e^* \ if \ \alpha_i^H \gtreqless \alpha_i^C. \tag{14}$$

Proof. See Appendix A. ■

The intuition is clear. If dual-self individuals suffer more from the myopic problem regarding future consumption than health quality, i.e., $\alpha_i^H > \alpha_i^C$, the myopic selves undervalue the marginal utility of second-period consumption more than the marginal utility of health care. Therefore, in the first period, they will choose a higher amount of health investment than that amended by their rational selves in the second period. The opposite case $\alpha_i^H < \alpha_i^C$ follows a similar interpretation.

We are now in a position to deal with optimal sin taxes. An insightful understanding from Cremer et al. (2012) is that the property of the health quality function plays an important role in the design of optimal sin taxes. According to the nature of the sin goods, the health quality function can exhibit different properties. The property $\partial^2 h/\partial x \partial e > 0$ refers to the case where the marginal benefit of health care increases with the consumption of sin goods.

Sin goods of this type can be thought of as fatty foods. When you consume more fatty foods, you are more likely to develop diabetes or hypertension. In this case, the modern medicine capable of dealing with these diseases becomes more helpful to you. On the contrary, the property $\partial^2 h/\partial x \partial e < 0$ refers to the situation where the benefit of health care diminishes as more sin goods are consumed. An example of this type of sin goods is the cigarette. Smoking heavily will increase the risk of getting lung cancer and trachea cancer. For cancer patients, it is difficult to obtain much utility from consuming health care given that modern medicine could only help them in very limited ways. In other words, the marginal benefit of health care can be small for heavy smokers.[8]

We first discuss the implications of the case where $\partial^2 h/\partial x \partial e > 0$. With this property, Lemma 2 and Lemma 3, we can establish the following proposition:

Proposition 2 *Suppose that sin goods and health care are complements. If $\alpha_i^H \geq \alpha_i^C$, the optimal sin tax is always positive. If $\alpha_i^H < \alpha_i^C$, the optimal sin tax is uncertain in sign, which implies that it may be optimal to subsidize sin goods.*

Proof. If individuals suffer more from myopia concerning health quality, i.e., $\alpha_i^H < \alpha_i^C$, we have $e_i^{m*} < e^*$. Given that sin goods and health care are complements, i.e., $\partial^2 h/\partial x \partial e > 0$, we can further infer that $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) < \frac{\partial h}{\partial x}(x^*, e^*)$. Thus the sign of (13b) is ambiguous (notice that $\partial h/\partial x$ is negative). By contrast, if $\alpha_i^H \geq \alpha_i^C$ then $e_i^{m*} \geq e^*$, meaning that $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) \geq \frac{\partial h}{\partial x}(x^*, e^*)$ in the case of complements. Thus, given that $\alpha_i^H \in (0, \beta]$, the optimal sin tax is always positive. ■

We will illustrate the validity of Proposition 2 in Section 4.1 using a numerical example. The intuition behind the possible optimality of a negative sin tax is interpreted as follows. A greater degree of myopia regarding health quality has two opposite effects on the choice of sin-good consumption. On the one hand, when the degree of myopia concerning health quality is present, individuals underestimate the marginal damage caused by sin goods, leading to over-consumption of the sin goods. This *direct effect* entails a positive tax rate on sin goods. On the other hand, when the degree of myopia regarding health quality is stronger, individuals will plan a suboptimally low level of health expenditure in the first period (Lemma 3). At the same time, the choice of sin-good consumption is associated with the suboptimally low e_i^{m*}. Given that sin goods and health care are complements ($\partial^2 h/\partial x \partial e > 0$), individuals with a lower e_i^{m*} overestimate the marginal damage of sin goods. As a result, they tend to consume fewer sin goods compared to the optimal level. This *indirect effect* calls for a subsidy on sin goods. If the indirect effect dominates the direct effect, subsidizing sin goods is favorable.

[8] These cases are well discussed in Cremer et al. (2012).

We next investigate the implications of the case $\partial^2 h/\partial x\partial e < 0$. The result is stated in the next proposition:

Proposition 3 *Suppose that sin goods and health care are substitutes. If $\alpha_i^H \leq \alpha_i^C$, the optimal sin tax is always positive. If $\alpha_i^H > \alpha_i^C$, the optimal sin tax is uncertain in sign, which implies that it may be optimal to subsidize sin goods.*

Proof. If individuals suffer more from myopia concerning future consumption, i.e., $\alpha_i^H > \alpha_i^C$, we have $e_i^{m*} > e^*$. Given that sin goods and health care are substitutes, i.e., $\partial^2 h/\partial x\partial e < 0$, we can further infer that $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) < \frac{\partial h}{\partial x}(x^*, e^*)$. Thus the sign of (13b) is ambiguous. By contrast, if $\alpha_i^H \leq \alpha_i^C$ then $e_i^{m*} \leq e^*$, meaning that $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) \geq \frac{\partial h}{\partial x}(x^*, e^*)$ in the case of substitutes. Thus, given that $\alpha_i^H \in (0, \beta]$, the optimal sin tax is always positive. ∎

The intuition is parallel to the above discussion regarding Proposition 2. The direct effect is the same, while the indirect effect is opposite due to the different sign of the cross-derivative. When the degree of myopia concerning future consumption is stronger, Lemma 3 says that individuals plan to invest in a "too high" level of health care. In the case where sin goods and health care are substitutes ($\partial^2 h/\partial x\partial e < 0$), the synchronized choice of the level of sin-good consumption is reduced because individuals overestimate the marginal damage caused by sin goods with a too high e_i^{m*}. Again, if this indirect effect outweighs the direct effect, it is optimal to subsidize sin goods.

4.1 A numerical example

In this subsection we provide a simple numerical analysis to illustrate how the sign of the optimal sin tax hinges on the substitutability between x and e, and the degree of myopia. The main purpose here is not to provide a comprehensive quantitative evaluation on the level of optimal sin tax, but to highlight the possibility of a negative optimal sin tax by using a computational example. In doing so, we first assign an explicit form on equation (6), given by:

$$U_i = \ln c_i + \eta \ln x_i + \alpha_i^C \ln d_i + \alpha_i^H \gamma e^\theta x^{-\phi}. \tag{6'}$$

For simplicity, in equation (6') we consider a logarithmic utility function both for numeraire goods and sin goods. The health quality function is specified as $h(e, x) = \gamma e^\theta x^{-\phi}$. The parameters η and γ reflect respectively the preference for sin goods and health quality. We then consider the following parameter values. The true discount factor is set as $\beta = 0.95$, and the preference for sin goods is chosen as $\eta = 2$ based on the observation that sin goods usually give higher immediate utility than other goods. For the case of substitutes between sin goods and health care, we use the set of parameter values $(\gamma, \theta, \phi, y) = (0.5, 0.5, 1.5, 2)$; for the case of complements we use $(\gamma, \theta, \phi, y) = (-0.5, -1, -1.1, 1)$. As an illustrative example, we choose these parameter values such that the ratio of sinful consumption to income is around 25%.[9] These values satisfy the properties of the health quality function we mentioned in Section 2. Lastly, to highlight the role of myopia over future consumption, we fix the degree of myopia concerning health quality as $\alpha^H = 0.8$, and vary α^C to see how the optimal sin tax responds.

[Insert Figures 1 and 2 here]

Figures 1 and 2 show the effect of varying α^C on the optimal sin tax. In the case of substitutes, the optimal sin tax decreases when the problem of myopia concerning future consumption becomes more serious (i.e., with a smaller α^C). As α^C is smaller than 0.66, the optimal policy is to subsidize sin goods. By contrast, in the case of complements, the optimal sin tax decreases when the problem of myopia concerning future consumption is mild (i.e., with a larger α^C). The optimal sin tax is negative as α^C exceeds around 0.92. As is obvious, the numerical results manifest the validity of our analytical results reported in Propositions 2 and 3.

5 Comparison of Sin Taxes

In this section we compare the optimal sin taxes under the two characteristics, persistent error and dual self. In doing so we derive the difference between (12b) and (13b):

$$\tau_{x,i}^P - \tau_{x,i}^D = \frac{\alpha_i^H [\frac{\partial h}{\partial x}(x^*, e^*) - \frac{\partial h}{\partial x}(x^*, e_i^{m*})]}{u'(c^*)}. \tag{15}$$

Let us first suppose that the degree of myopia regarding future consumption is greater ($\alpha_i^H > \alpha_i^C$). We thus have $e_i^{m*} > e^*$ from Lemma 3. Accordingly, the term $\frac{\partial h}{\partial x}(x^*, e_i^{m*})$ will be larger (smaller) than $\frac{\partial h}{\partial x}(x^*, e^*)$ if sin goods and health care are complements (substitutes). We can then infer that the optimal sin tax with persistent errors should be lower (higher) than that with dual selves. The intuition is as follows. Due to the inconsistent levels of e_i^{m*} and e^*, dual-self myopes are mistaken in evaluating the marginal damage of sin goods. The case under consideration $e_i^{m*} > e^*$ means that dual-self myopes plan too high a level of health care. With this mistaken plan, they also underestimate the marginal damage caused by sin goods in the case of complements, and thus consume more sin goods. Persistent-error myopes, on

[9] We consider a much broader concept of sin goods including consumption of alcohol, cigarettes, junk foods, soft drinks, sugar, drugs, and so on.

the contrary, are not disturbed by such an effect, given that their first-period choice of health care has been corrected by the optimal $\tau^P_{e,i}$. Thus, to correct the additional underestimation of the marginal damage of sin goods for dual-self myopes, the government should levy a higher sin tax compared to that imposed on persistent-error myopes. Alternatively, in the case of substitutes between sin goods and health care, $e_i^{m*} > e^*$ implies an overestimation of the damage caused by sin goods. As a result, the government should adopt a lower sin tax.

The logic for the case where the degree of myopia regarding health quality is greater ($\alpha_i^H < \alpha_i^C$) is the other side of the coin of the previous discussion. To conserve space, we do not go through them again. The following proposition summarizes our findings in this section:

Proposition 4 *(i) If $\alpha_i^H > \alpha_i^C$, the optimal sin tax with dual selves is higher (lower) than that with persistent errors if sin goods and health care are complements (substitutes). (ii) If $\alpha_i^H < \alpha_i^C$, the optimal sin tax with dual selves is higher (lower) than that with persistent errors if sin goods and health care are substitutes (complements). (iii) If $\alpha_i^H = \alpha_i^C$, the optimal sin taxes under the two characteristics are equivalent.*

Proof. We first prove the case $\alpha_i^H > \alpha_i^C$, which implies $e_i^{m*} > e^*$. If sin goods and health care are complements, we can infer that $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) > \frac{\partial h}{\partial x}(x^*, e^*)$, and thus the sign of (15) is negative. If sin goods and health care are substitutes, we can infer that $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) < \frac{\partial h}{\partial x}(x^*, e^*)$, and thus the sign of (15) is positive. The case $\alpha_i^H < \alpha_i^C$ follows a similar inference. In the case where $\alpha_i^H = \alpha_i^C$, we have $\frac{\partial h}{\partial x}(x^*, e_i^{m*}) = \frac{\partial h}{\partial x}(x^*, e^*)$. Accordingly, we can obtain that $\tau^P_{x,i} = \tau^D_{x,i}$. ■

6 Discussions

For simplicity, our analysis has made some assumptions that may be debatable in terms of their realism. In this section, we provide extensive discussions on two crucial assumptions and their implications.

6.1 Individualized policy

This paper considers two types of myopic agents, and the first-best policies require individualized treatment for these two types of individuals. In reality, however, individualized policies face difficulties. First is about asymmetric information: the policymaker is usually difficult to distinguish between the two types of myopes. Moreover, even if the policymaker has full information, it would be too costly to implement specific policies on each individual.

Therefore, it can only impose a uniform policy that takes into consideration the behaviors of both individuals. In this case, the first-best optimum is not possible. To address this issue, one needs to consider the second-best setting where only uniform taxes/subsidies are usable, which is beyond the focus of this analysis. At this moment, the purpose of our theoretical model, as other multiple-self models, shall be best viewed as aiming at highlighting specific aspects of intertemporal choice (Frederick et al., 2002, p376) and understanding how policies restore the first-best optimum. A direct policy implication from our results is that the uniform policy should lean towards the individualized policy for one type of myope if such type is more empirically observed. This implication further calls for empirical evidence to guide us whether there are more persistent or dual-self individuals in the economy. However, the empirical evidence in this respect is scarce.[10] Future experiments can be designed to explore this issue.

6.2 Absent sin goods in the second period

While people consume sin goods at all times, our model, along with many studies in this literature, assumes that individuals only consume sin goods in their first period. In addition to technical simplicity, this setting has the advantage of sharpening our focus on the problem of myopia that arises as individuals undervalue the *delayed* health consequence of sin goods. A more general specification would be to consider sin goods consumed in both young and old periods. In this case, the individuals' objective function would be given by:

$$U_i = u(c_i) + v(x_i) + \alpha_i^C u(d_i) + \alpha_i^X v(z_i) + \alpha_i^H h(x_i, z_i, e_i). \tag{16}$$

Here z_i denotes the level of sin goods consumed in the second period, and α_i^X denotes the degree of myopia concerning future sin goods. Notice that z_i cannot have delayed health costs because there are only two periods in this model. Thus equation (16) assumes that the health cost of z_i is realized within the period when it is consumed. A possible interpretation of specification (16) is that the numeraire good and sin goods are consumed at the beginning of the second period, while health quality is realized at the end of the second period.

A critical feature of this extension is that the choices of x_i and z_i are subject to different myopia problems, i.e., α_i^H and α_i^X. Therefore, as long as the government imposes a flat rate of sin tax in both periods, the first-best optimum is virtually unreachable.[11] The intuition is

[10] The experiments designed for testing preferences with self-control problems mostly focus on exploring the degree of people's partial naivete; i.e., people are partially persistent-error and partially dual-self. Few (if not none) have distinguished two types of myopes and to examine which type of myope is more. See DellaVigna (2009) for a recent survey.

[11] A detailed proof is available from the authors upon request.

briefly explained as follows. In our basic model, there exist three distortions, and three policy instruments are sufficient to decentralize the first-best optimum (see our discussions below Proposition 1). Now introducing sin goods in the second period adds another distortion into the model. For persistent-error myopes, this implies that three policy instruments are not adequate for decentralizing the first-best optimum any more. For dual-self myopes, logically, it is optimal to tax x_i while leaving z_i untaxed because the "rational selves" will choose a correct level of z_i. Hence, a uniform sin tax on x_i and z_i makes it even harder to restore the first-best optimum. The comprehensive analysis of this extended model shall require modifying the model in other dimensions, which we leave for future research.

7 Conclusions

This paper has analyzed the first-best policies on sin goods and health care in an economy with myopic individuals. The previous literature on sin taxes mostly assumes that sin-good consumers are myopic in the sense that they underestimate the health costs of sin goods. We introduce another type of myopia into this literature; namely, individuals may underestimate the utility of future consumption, which is an assumption normally adopted in the literature on social security. Once this type of myopia is considered, the optimal policies could exhibit different properties from previous results. For myopes who never regret, if they suffer more from the myopia concerning future consumption, we find that it may be suboptimal to subsidize health care. For myopes who will regret their earlier shortsighted choices, the optimal sin tax depends on the interplay between the degrees of myopia and the property of the health quality function. In some cases, the optimal sin tax is negative.

Most literature on sin taxes, including our paper, has focused primarily on the aspect of "internalities" (Gruber and Kőszegi, 2001) imposed by sin-good consumers on themselves. However, sinful consumption is sometimes accompanied by negative externalities. Generally, if externalities are taken into account in the present framework, the social cost of sinful consumption would be greater. As a consequence, a higher tax on sin goods is needed, and therefore the conditions under which the optimal sin tax is negative would be more strict. Although coming at the cost of complexity, introducing externalities of sin goods can provide valuable insights to the literature.

Appendix A. Proof of Lemma 3

Combining (10c) and (10d), and inserting $\tau^D_{e,i} = 0$, we can rewrite the first-order conditions under the first-best policy mix as:

$$u^{'}[s^* - e_i^{m*}] = u^{'}[(d^*) + (e^* - e_i^{m*})] = \frac{\alpha_i^H}{\alpha_i^C}\frac{\partial h}{\partial e}(x^*, e_i^{m*}). \tag{A1}$$

Note that the first-best condition of health care is:

$$u^{'}(d^*) = \frac{\partial h}{\partial e}(x^*, e^*). \tag{A2}$$

Now let us first consider the case where $\alpha_i^H > \alpha_i^C$. According to (A1) we have $u^{'}[(d^*) + (e^* - e_i^{m*})] > \frac{\partial h}{\partial e}(x_i, e_i^{m*})$. Since $u(\cdot)$ and $h(\cdot)$ are strictly concave in d and e, it follows that if $e^* \geq e_i^{m*}$, then $u^{'}[(d^*) + (e^* - e_i^{m*})] \leq u^{'}(d^*)$ and $\frac{\partial h}{\partial e}(x^*, e^*) \leq \frac{\partial h}{\partial e}(x^*, e_i^{m*})$ are true. This means that $u^{'}[(d^*) + (e^* - e_i^{m*})] \leq u^{'}(d^*) = \frac{\partial h}{\partial e}(x^*, e^*) \leq \frac{\partial h}{\partial e}(x^*, e_i^{m*})$, which contradicts $u^{'}[(d^*) + (e^* - e_i^{m*})] > \frac{\partial h}{\partial e}(x^*, e_i^{m*})$. We can therefore conclude that if $\alpha_i^H > \alpha_i^C$, then $e^* < e_i^{m*}$ must hold.

Similarly, in the case where $\alpha_i^H < \alpha_i^C$, from (A1) we have $u^{'}[(d^*) + (e^* - e_i^{m*})] < \frac{\partial h}{\partial e}(x^*, e_i^{m*})$. If $e^* \leq e_i^{m*}$, then $u^{'}[(d^*) + (e^* - e_i^{m*})] \geq u^{'}(d^*)$ and $\frac{\partial h}{\partial e}(x^*, e^*) \geq \frac{\partial h}{\partial e}(x^*, e_i^{m*})$ are true, implying that $u^{'}[(d^*) + (e^* - e_i^{m*})] \geq u^{'}(d^*) = \frac{\partial h}{\partial e}(x^*, e^*) \geq \frac{\partial h}{\partial e}(x^*, e_i^{m*})$.This contradicts $u^{'}[(d^*) + (e^* - e_i^{m*})] < \frac{\partial h}{\partial e}(x^*, e_i^{m*})$. Thus we can infer that if $\alpha_i^H < \alpha_i^C$, then $e^* > e_i^{m*}$.

Lastly, in the case where $\alpha_i^H = \alpha_i^C$, it is straightforward to see that $u^{'}(d^*) = \frac{\partial h}{\partial e}(x^*, e_i^{m*})$. Thus the condition (A2) holds if and only if $\frac{\partial h}{\partial e}(x^*, e^*) = \frac{\partial h}{\partial e}(x^*, e_i^{m*})$, that is, $e^* = e_i^{m*}$. ■

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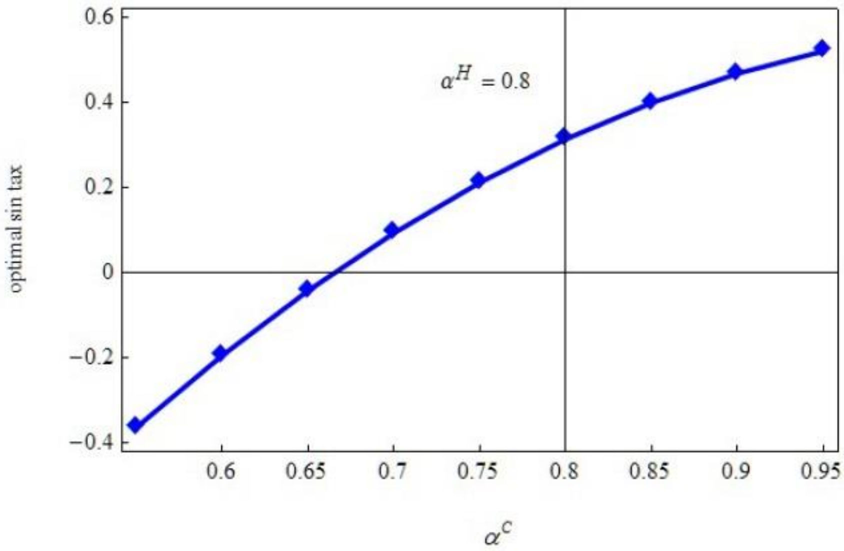

Figure 1: The case of substitutes between x and e

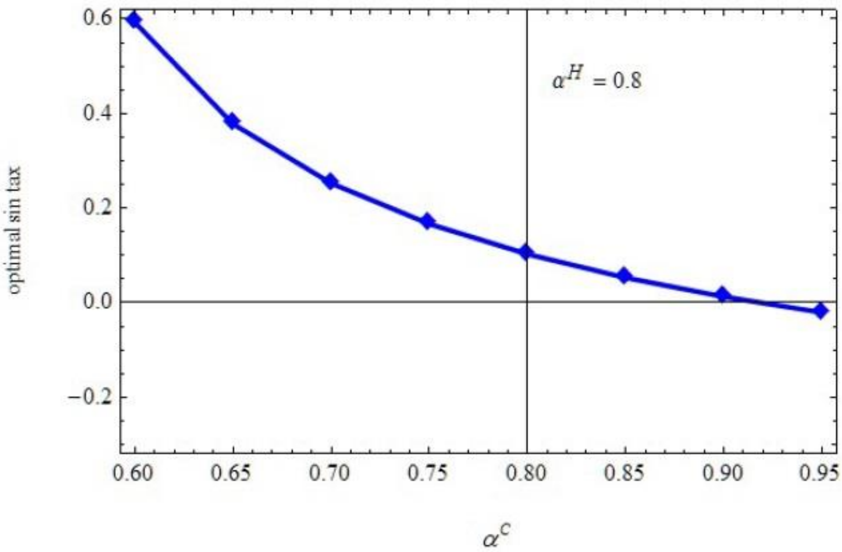

Figure 2: The case of complements between x and e