The Importance of Habit Formation for Environmental Taxation

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Abstract

We analyze how habit formation affects optimal environmental taxation, when consumption of a habitual good causes a negative external effect on the environment. In a simple two-period model, we show that optimal taxation is still Pigouvian, where tax rates equal marginal damage in each period. However, the magnitudes of the tax rates are affected by habit formation. Using simulations we show that since consumption of the habitual good increases over time, so does the optimal tax rate, implying a higher tax rate in period two than in period one. The discrepancy increases in habitual strength. Given the development of the tax rates over time we discuss the welfare loss from imposing a second-best environmental tax and its relation to habitual strength. Further, we analyze how optimal taxation changes if we relax the assumption of time-consistency.

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1 Introduction

Taxation of externalities has been scrutinized in innumerable papers, and conditions for Pigovian taxes have been studied in detail many times. However, little, if any, attention has been paid to how habit formation could affect this kind of taxation, although many phenomena that give rise to environmental damage actually are associated with habit formation. What we have in mind are ordinary consumption goods, where either the consumption, or the production of the good gives rise to an externality. Empirical evidence of habit formation in consumption goods is scarce,[1] but in Carrasco et.al. (2005) the authors successfully investigate the presence of habit formation in consumption, and find evidence of habit formation in consumption of food and services.

Most consumption goods give rise to negative externalities at varying degrees through the production process (e.g. through emissions), but one could also think of goods that are habitual and where the actual consumption gives rise to external effects. Examples are *sugar*, which causes an external effect on the public sector through higher medical costs, *smoking cigarettes*, which also overloads the medical service and creates another negative externality through passive smoking, and *alcohol*, where drunk driving generates an external effect through increased accidents. Hence, in many cases where correcting taxes are called for, habit formation plays a role, which in turn implies that when analyzing environmental taxation the effect of habit formation could be of significant importance.

One of the more cited papers on habit formation (in particular rational addiction) and policy is Gruber and Köszegi (2001). They find that:

"...there is no reason to take addictiveness per se as a call to government action, if individuals are pursuing these activities 'rationally'." (pp.1285)

Still, they don't explicitly account for externalities. In this paper we study how optimal environmental taxes are affected if there is habit formation asso-

[1] Mainly due to difficulties in isolating the effect of habit formation from other effects.

ciated with consumption of a good causing environmental damage.[2] We find that the optimal shape of corrective taxation is still the familiar Pigouvian tax (which is in line with Gruber and Köszegi, 2001), but where the size is certainly affected by habit formation. In Section 2 we set up a simple model to illustrate this result, which also helps us to clearly see the effect of habit formation on the *level* of the Pigouvian tax. Ballard et al. (2005) study the effects of non-homothetic preferences on environmental taxes. Their results show that given certain parameter values, an optimal environmental tax is larger than the Pigouvian tax. Our results corroborate the results in Ballard et al. (2005) in that we also find that the optimal environmental tax is different from the standard Pigouvian tax, although the direction is ambigious. There are two counteracting effects: on the one hand, the increased consumption of the habitual good induced by a stronger habit tends to increase the environmental damage and therefore the correcting tax; on the other hand, stronger habit implies higher marginal utility of the habitual good for the individual, an effect that goes in the opposite direction. The total effect therefore depends on which of the effects is greater.

There are no studies that we know of that explicitly consider habit formation in relation to environmental issues except for Wendner (2005). He considers efficient taxation (of income) when individuals are subject to habit formation and status seeking, given that they get utility from both consumption and environment, and concludes that an increase in importance of habit formation corresponds to an increase in the optimal income tax rate. We can conclude that habit formation also has an impact on optimal environmental taxes, and our simulation results suggest that the effects can be substantial.

The above mentioned studies assume time-consistent individuals. However, there have been objections to this assumption, where the critics have claimed that people are hardly rational when it comes to habit formation, but rather

[2] We want to clarify that in our model habit formation is equivalent to rational addiction as specified by e.g. Becker and Murphy (1988), but the term habit formation is used throughout the paper.

that people are time-inconsistent and do not have the ability to value the future correctly (see e.g. O'Donoghue and Rabin, 1999; and Frederick, Loewenstein, and O'Donoghue, 2002). When accounting for time-inconsistency we conclude that the optimal tax structure is no longer the Pigouvian. Optimal taxes then have to be corrected for time-inconsistency.

The paper is organized as follows. In Section 2, optimal corrective taxes are derived in the presence of habit formation. In Section 3 we relax the assumption of time-consistency and derive optimal taxation when a representative individual is not only affected by habit formation but is also time-inconsistent. A second-best tax is derived in Section 4, where we restrict the tax to be constant over time. Our analytical results are illustrated through simulations in Section 5.1, and Section 6 concludes the paper.

2 Optimal environmental taxation and habit formation

We choose to frame habit formation as utility that is dependent not only on current consumption but also on past consumption. The definition of a habitual good, which we use throughout the paper, is summarized succinctly by Pollak (1970). He defines a habit such that *(i)* past consumption influences current preferences and hence current demand, and *(ii)* a higher level of past consumption of a good implies, *ceteris paribus*, a higher level of present consumption of that good. In this paper, we expand this model by assuming that consumption of the habitual good also generates a negative external effect on the environment. Furthermore, we define a general utility function over two periods, which is quasiconcave and twice continuously differentiable. The model includes a social planner and a representative agent who consumes a habitual environmental bad (a_t) and a non-habitual good (n_t) that does not affect the environment. Subscripts denote in which period the good is consumed, $t = 1, 2$. We model the negative external effect on the environment as a convex damage function $D(a_t)$ (written in short as D_t), where $D'_t > 0$ and $D''_t \geq 0$.

In our model, habit formation implies that past consumption of a good increases the marginal utility of current consumption of the same good, i.e. $\frac{\partial^2 u_2}{\partial a_2 \partial a_1} > 0$.[3] In period two utility will depend not only on the two goods consumed during the period (a_2 and n_2) but also on the lagged consumption of a, i.e. (a_1), where $\frac{\partial u_2}{\partial a_1} > 0$ indicates a beneficial habitual good and $\frac{\partial u_2}{\partial a_1} < 0$ a harmful one (Stigler and Becker, 1977). The habitual property of the utility function is specifically captured by the effect $\frac{\partial^2 u_2}{\partial a_2 \partial a_1} > 0$, which we will hereafter simply assume is a constant, α.[4] Habit formation makes consumption of a greater in both periods irrespective of whether $\frac{\partial u_2}{\partial a_1} \gtreqless 0$.

The social planner maximizes total utility for a representative agent according to:

$$W_s = u_1(a_1, n_1) - D_1 + \frac{1}{1+\rho} u_2(a_1, a_2, n_2) - \frac{1}{1+\rho} D_2. \qquad (1)$$

Correspondingly, the total utility for a representative agent can be written as:

$$W_{ra} = u_1(a_1, n_1) - \bar{D}_1 + \frac{1}{1+\rho} u_2(a_1, a_2, n_2) - \frac{1}{1+\rho} \bar{D}_2. \qquad (2)$$

The social planner and the individual differ only in how they treat the effect of environmental damage. The representative agent treats environmental damage as a constant $\bar{D}_t$. Utility is hence defined as a function of the two consumption goods of which one is habitual and environmentally harmful, minus environmental damage.

To be able to concentrate on the effect of habit formation, and keep the model as tractable as possible, we assume an exogenously given, constant total production equal to y in both periods and prices normalized to unity. It is neither possible to save nor to borrow. The budget constraints for the social

[3] This implies that, in the words of Bowman et al. (1999), "For certain goods it seems reasonable to assume that people derive more satisfaction from a given level of consumption once they have developed a taste for it through past consumption."

[4] This assumption of a constant cross derivative would e.g. be the case with a quadratic utility function.

planner can then be written as:

$$a_t + n_t = y \text{ for } t = 1, 2. \tag{3}$$

Assuming that good a_t is taxed in each period, and that the tax revenue is returned to the individual via a lump sum transfer m_t, the representative agent's budget constraints can be written as:

$$p_t a_t + n_t = m_t + y \text{ for } t = 1, 2, \tag{4}$$

where the tax price $p_t = 1 + \tau_t$. τ_t is the tax rate of the environmentally harmful good in period t.

If we maximize (1) wrt a_1 and a_2 subject to the budget constraints (3), we get the following first order conditions for period one and two respectively:

$$\frac{\partial u_1}{\partial a_1} + \frac{1}{1+\rho}\frac{\partial u_2}{\partial a_1} - D_1' = \frac{\partial u_1}{\partial n_1}, \tag{5}$$

$$\frac{\partial u_2}{\partial a_2} - D_2' = \frac{\partial u_2}{\partial n_2}. \tag{6}$$

The corresponding first order conditions for the individual maximizing (2) subject to the budget constraints (4) are:

$$\frac{\partial u_1}{\partial a_1} + \frac{1}{1+\rho}\frac{\partial u_2}{\partial a_1} = p_1\frac{\partial u_1}{\partial n_1}, \tag{7}$$

$$\frac{\partial u_2}{\partial a_2} = p_2\frac{\partial u_2}{\partial n_2}. \tag{8}$$

The optimal environmental tax is found by equalizing the first order conditions for the social planner and the individual. Therefore, the socially optimal environmental tax rates in the two periods are:

$$\tau_1^* = \frac{D_1'}{\frac{\partial u_1}{\partial n_1}}, \tag{9}$$

$$\tau_2^* = \frac{D_2'}{\frac{\partial u_2}{\partial n_2}}. \tag{10}$$

Hence, the effect of habit formation on environmental taxation does not qualitatively affect the socially optimal taxation on consumption. The optimal environmental tax is still the Pigouvian tax, i.e. equal to the marginal damage. This means that an environmental externality should be taxed with the Pigouvian tax even if the consumption of the good that gives rise to the externality is subject to habit formation. Still, quantitatively, the size and time path of the Pigouvian tax is affected by the assumption of habit formation. The Pigouvian taxes in (9) and (10) depend on the marginal damage of a in the two periods.

By differentiating the individual's first-order conditions (7) and (8) (given the optimal taxes) with respect to habitual strength α, we see that:

$$\frac{\partial a_1}{\partial \alpha} = \frac{\alpha a_1 - \delta a_2}{\gamma \delta (1+\rho) - \alpha^2} > 0, \tag{11}$$

$$\frac{\partial a_2}{\partial \alpha} = -\frac{\alpha \frac{\partial a_1}{\partial \alpha} + a_1}{\delta} > 0, \tag{12}$$

where
$\gamma = \frac{\partial^2 u_1}{\partial a_1^2} - (1+p_1)\frac{\partial^2 u_1}{\partial a_1 \partial n_1} + p_1 \frac{\partial^2 u_1}{\partial n_1^2} + \frac{1}{1+\rho}\frac{\partial^2 u_2}{\partial a_1^2}$ and
$\delta = \frac{\partial^2 u_2}{\partial a_2^2} - (1+p_2)\frac{\partial^2 u_2}{\partial a_2 \partial n_2} + p_2 \frac{\partial^2 u_2}{\partial n_2^2}$.

Both these expressions are positive, implying that with optimal taxation consumption of a is greater in both periods the stronger the habit formation.

We have concluded that both a_1 and a_2 are increasing in habitual strength, but we cannot generally say whether the tax rates increase or decrease in habitual strength α.

$$\frac{\partial \tau_1^*}{\partial \alpha} = \left[\frac{D_1''}{D_1'} - \frac{\frac{\partial^2 u_1}{\partial a_1 \partial n_1} - p_1 \frac{\partial^2 u_1}{\partial n_1^2}}{\frac{\partial u_1}{\partial n_1}}\right] \frac{\frac{\partial a_1}{\partial \alpha}}{\frac{\partial u_1}{\partial n_1} D_1'} \tag{13}$$

$$\frac{\partial \tau_2^*}{\partial \alpha} = \left[\frac{D_2''}{D_2'} - \frac{\frac{\partial^2 u_2}{\partial a_2 \partial n_2} - p_2 \frac{\partial^2 u_2}{\partial n_2^2}}{\frac{\partial u_2}{\partial n_2}}\right] \frac{\frac{\partial a_2}{\partial \alpha}}{\frac{\partial u_2}{\partial n_2} D_2'} \tag{14}$$

The terms outside the brackets are all positive, so the signs of the derivatives depend solely on the relative convexity of the damage function and of the individual's utility function. There are two counteracting effects from increased habitual strength. On the one hand, the increased consumption of a induced by the stronger habit tends to increase the correcting tax. On the other hand, stronger habit implies higher marginal utility of the habitual good for the individual, an effect that goes in the opposite direction. The total effect therefore depends on which of the effects is greater. If the marginal environmental damage is constant, i.e. $D'' = 0$, the optimal tax rates are actually decreasing in habitual strength. The more convex the damage function is (i.e. the greater the $\frac{D''}{D'}$), the more likely it is that the tax actually increases in habitual strength.

3 Time-inconsistency and habit formation

In the model above individuals are assumed to be time-consistent, which has been criticized due to the overwhelming evidence (for an overview see Frederick, Loewenstein, and O'Donoghue, 2002) that individuals have problems anticipating future behavior correctly, i.e. behaving rationally. To account for this we add the parameter $0 < \beta < 1$ which illustrates how the individual fails to fully account for the utility in period two. This way of modeling time-inconsistency has been used previously by several authors (see p.106 in O'Donoghue and Rabin, 1999; and p.366 in Frederick, Loewenstein, and O'Donoghue, 2002). If the habit is beneficial, this means that the individual does not fully account for the (direct) positive effect of the consumption of the habitual good in period one on utility in period two, while if the habit is harmful, the individual does not fully account for the (direct) negative effect of the consumption of the good in period one on utility in period two. Further, the individual understates the indirect effect generated by the increased marginal utility from period one consumption on the habitual good in period two. The utility of the representative agent when we account for time-inconsistency can be written as:

$$W_{ra} = u_1(a_1, n_1) - \bar{D}_1 + \beta \frac{1}{1+\rho} \left[u_2(a_1, a_2, n_2) - \bar{D}_2 \right]. \tag{15}$$

The corresponding first order conditions for the individual are:

$$\frac{\partial u_1}{\partial a_1} + \beta \frac{1}{1+\rho} \frac{\partial u_2}{\partial a_1} = p_1 \frac{\partial u_1}{\partial n_1}, \tag{16}$$

$$\frac{\partial u_2}{\partial a_2} = p_2 \frac{\partial u_2}{\partial n_2}. \tag{17}$$

The difference between the time-consistent individual in Section 2 and the time-inconsistent in this section is the parameter β. Less weight is put on future utility, and this is reflected in the condition for the marginal rate of substitution where the stock effect, i.e. the discounted marginal utility of good a_1 in period two, is multiplied by β.

The social planner is not time-inconsistent so these first order conditions remain unchanged. The optimal environmental tax when individuals are time-inconsistent is therefore found by equalizing the first order conditions for the social planner (5) and (6) and the individual (16) and (17), respectively.

Therefore, the socially optimal environmental taxes when individuals are time-inconsistent are:

$$\tau_1^* = \frac{D_1'}{\frac{\partial u_1}{\partial n_1}} - \frac{1}{\frac{\partial u_1}{\partial n_1}(1+\rho)} \frac{\partial u_2}{\partial a_1}(1-\beta), \tag{18}$$

and

$$\tau_2^* = \frac{D_2'}{\frac{\partial u_2}{\partial n_2}}. \tag{19}$$

Hence, given habit formation and time-inconsistent individuals, the optimal environmental tax in period one is no longer equal to the Pigouvian tax. Since $\frac{\partial u_1}{\partial n_1} > 0$ and $0 < \beta < 1$, the sign of the deviation from the Pigouvian tax in period one is solely dependent on whether $\frac{\partial u_2}{\partial a_1}$ is negative or positive, i.e. if the habit is beneficial or harmful. Further, the expression for optimal taxation can be divided into two parts: one that corrects for the environmental damage (equal to the Pigouvian tax), and one that corrects for habit formation in combination with time-inconsistent behavior. If habit is beneficial $\left(\frac{\partial u_2}{\partial a_1} > 0\right)$, time-inconsistence makes the period-one tax rate lower than the Pigouvian tax. In this case, future benefits from a_1 are understated and the individual consumes less than optimal, which implies less need for corrective taxation. If $\left(\frac{\partial u_2}{\partial a_1} < 0\right)$ and habit is harmful, the effect is the opposite. Then the time-inconsistent individual consumes too much because he cannot fully foresee the negative future effects of consuming a_1, and the corrective tax rate should therefore be higher than in the time-consistent case. Also, the more time-inconsistent[5] an individual is (in a given society), the less the habit is internalized and the larger the deviation from the Pigouvian tax.[6] The tax in period two should be set equal to the Pigouvian tax (which is an artifact of the two-period model).

4 Habit formation and restricted environmental taxation

The optimal tax rates, calculated in previous sections, vary over time. Hence, when individuals are born in different periods, different tax rates should be simultaneously operative. The problem of having two different tax rates for two different groups of taxpayers is well known in the optimal tax literature. In this case, however, it would be difficult to find self-selection constraints that enable separate taxation. When we are dealing with consumption taxes the most realistic solution is to have one single tax rate that consumers of both generations face.[7] Such a tax would then be a "second-best" tax, assuming that

[5] i.e. the lower the β.

[6] Note that $\frac{\partial u_2}{\partial a_1}$ includes the direct as well as the indirect effect, where the indirect effect $\frac{\partial^2 u_2}{\partial a_2 \partial a_1}$ is always positive.

[7] Still, in our simple model, a possibility would be e.g. to let individuals show their identification and then depending on age pay different tax rates.

a social planner maximizes utility given that the tax rate must be equal in both periods, i.e. $\tau_1 = \tau_2 = \tau$.

Therefore, in order to find a more politically feasible solution, we now maximize the social planner's utility function (1) with respect to a common tax rate τ subject to the individual's time-inconsistent behavior presented in (15).[8]

Solving for the tax rate we arrive at the implicit expression

$$\tau = \frac{\frac{\partial a_1}{\partial \tau}\frac{\partial D}{\partial a_1} + \frac{1}{(1+\rho)}\frac{\partial a_2}{\partial \tau}\frac{\partial D}{\partial a_2} + (1-\beta)\frac{1}{(1+\rho)}\frac{\partial a_1}{\partial \tau}\frac{\partial u_2}{\partial a_1}}{\frac{\partial a_1}{\partial \tau}\frac{\partial u_1}{\partial n_1} + \frac{1}{(1+\rho)}\frac{\partial a_2}{\partial \tau}\frac{\partial u_2}{\partial n_2}}. \tag{20}$$

We can conclude that the common optimal tax rate is a weighted average of the two Pigouvian taxes that were obtained in (9) and (10) with adjustment for time-inconsistency.[9]

5 Applications

5.1 Simulations

To carry out our simulations, we apply a quadratic structure to the utility function $u(a,n)$ and assume that the damage function D also is quadratic. Hence, we write the social planner's welfare function as:

$$W_s = n_1 + \alpha_a a_1 - \alpha_{nn} n_1^2 - \alpha_{aa} a_1^2 - \delta a_1^2 + \frac{1}{1+\rho}\left[n_2 + \alpha_a a_2 - \alpha_{nn} n_2^2 - \alpha_{aa} a_2^2 + \alpha a_1 a_2 - \delta a_2^2\right]. \tag{21}$$

Note that we for simplicity have excluded possible cross effects between the habitual and the non-habitual goods in both periods. We also assume that a_1 enters period 2 utility purely through the habitual term $\alpha a_1 a_2$ so that we abstract from any direct lagged effect which may be positive or negative, indicating a beneficial or a harmful habitual good.

[8] An equivalent maximization could be done for the time-consistent case.

[9] The expressions for $\frac{\partial a_1}{\partial \tau} < 0$ and $\frac{\partial a_2}{\partial \tau} < 0$ are rather messy, but can be provided on request.

Just as in Section 2, the only difference between the social planner and the representative agent is that the representative agent does not take into account his effect on environmental damage, implying that the individual's utility function used for simulations is:

$$W_{ra} = n_1 + \alpha_a a_1 - \alpha_{nn} n_1^2 - \alpha_{aa} a_1^2 - \bar{D}_1 + \frac{1}{1+\rho}\left[n_2 + \alpha_a a_2 - \alpha_{nn} n_2^2 - \alpha_{aa} a_2^2 + \alpha a_1 a_2 - \bar{D}_2\right]. \tag{22}$$

When the social planner maximizes (21) wrt (3), the optimal levels of consumption in the two periods are:

$$a_1^* = \frac{(1 - 2\alpha_{nn} y - \alpha_a)\big(\alpha + 2(\alpha_{nn} + \alpha_{aa} + \delta)(1+\rho)\big)}{\alpha^2 - 4(\alpha_{nn} + \alpha_{aa} + \delta)^2 (1+\rho)} \tag{23}$$

and

$$a_2^* = \frac{(1 - 2\alpha_{nn} y - \alpha_a)\big(\alpha + 2(\alpha_{nn} + \alpha_{aa} + \delta)\big)(1+\rho)}{\alpha^2 - 4(\alpha_{nn} + \alpha_{aa} + \delta)^2 (1+\rho)}. \tag{24}$$

The representative agent maximizes (22) wrt (4) and, hence, the chosen levels of consumption will depend on the tax rates τ_1 and τ_2.

If both tax rates are zero, Figure 1 shows how the difference between the social planner's and the representative agent's choices of a_1 increases with habitual strength, α.[10]

[10] We assume the following parameter values:

$\alpha_a = 1$, $\alpha_{aa} = \alpha_{nn} = 0.4$, $\delta = 1$, $y = 1$, $\rho = 0.05$.

These parameters ensure that W_{ra} and W_s are strictly concave.

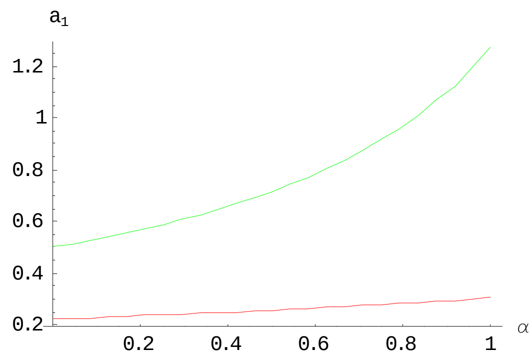

Figure 1. Optimal and individual consumption

The stronger the habit formation α, the more the individual will consume of the habitual good in both periods. As α increases, the individual's utility of the consumption good a increases, and hence the optimal consumption of a increases. However, environmental damage also increases, which implies that the increase is less for the social planner than for the individual. Further, without any habit formation (and no direct period 2 effect from a_1) the consumption is equal in both periods, but with habit formation $a_2 > a_1$ and the difference increases in α.

As always when the individual's consumption implies non-internalized environmental damage, there is a cause for public intervention, and we have simulated optimal Pigouvian taxes as functions of α. The difference between the individual's and the socially optimal consumption increases in α, which implies that also the tax rates increase in α. The stronger the habit formation, the higher the tax rates will be. In Figure 2 we show τ_1 as a function of α, but the same pattern holds for τ_2.[11]

[11] This positive relation between optimal tax rates and habitual strength holds also when we carry out a sensitivity analysis with respect to parameter values.

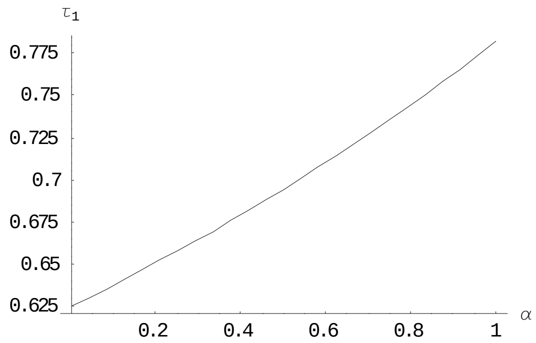

Figure 2. Pigouvian tax in period 1

Also, the correcting tax increases over time if there is habit formation, and it increases at a greater rate, the stronger the habit formation is. From this simple illustration we can conclude that when there is habit formation, the optimal correcting tax rate increases over time. In Figure 3 we illustrate this by plotting the difference between the tax in period one and in period two as a function of habitual strength (α).[12]

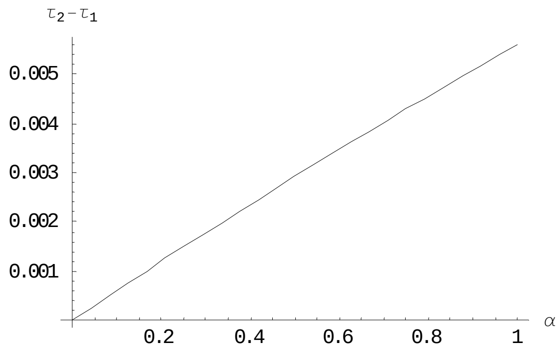

Figure 3. The difference $\tau_2 - \tau_1$

[12] When accounting for time-inconsistency we find that the optimal tax rates are increasing in time-inconsistency and habit formation (including direct effects of habit formation would strengthen the effect for a beneficial habit and mitigate the effect for a harmful habit).

5.2 Welfare loss of the second-best tax

The simulations reveal that the corrective taxes optimally increase not only in habitual strength but also over time. However, we discussed in Section 4 that it is more politically feasible to have one common tax rate. Then, what are the welfare losses from imposing such a common tax rate rather than the different Pigouvian taxes, and how is this welfare loss affected by the strength of habit?

With a constant tax rate equal to a weighted average of the two first-best, the tax is higher than the first-best in period one and lower than the first-best in period two. In period one, the consumption of the habitual good is then lower than in the first-best situation. In period two, the effects from the constant tax rate is ambigiuous. On the one hand, the tax rate is lower than in the first-best situation, which tends to increase the consumption. On the other hand, the marginal utility of a_2 decreases because a_1 is lower. The net of these two effects depends on α. A high α implies that the latter effect dominates, and a_2 is lower than in the first-best case.

The welfare loss of the (constant) second-best tax can be illustrated as in Figure 4 below.

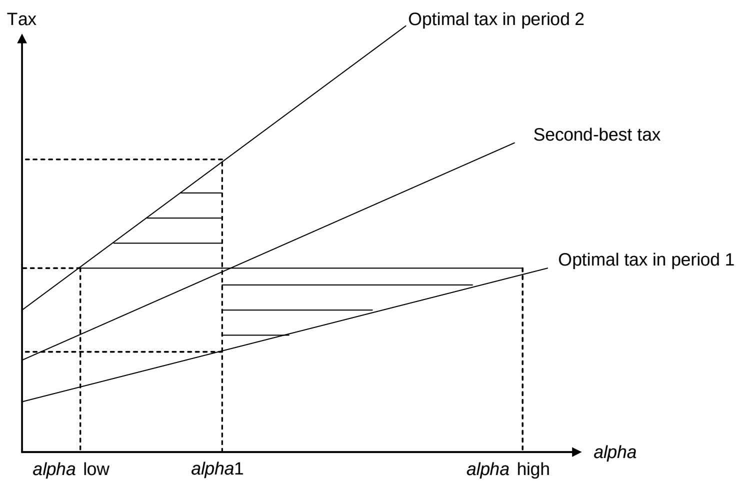

Figure 4. Welfare loss due to the second-best tax.

In Figure 4 the striped areas illustrate the welfare loss of the second-best tax due to a too high tax rate in period one and a too low tax rate in period two. The stronger the habit formation the larger the welfare loss. The intuition behind this is that the stronger the habit formation the larger the optimal difference between the tax rates in the two periods, as illustrated in Figure 3.

6 Concluding remarks

In this paper we have analyzed how habit formation affects optimal environmental taxation when consumption of a habitual good causes a negative external effect on the environment. In a simple two-period model, we have shown that optimal taxation is still Pigouvian, where tax rates equal marginal damage in each period. However, the magnitudes are affected by habit formation. On the one hand, a stronger habit tends to increase consumption and thereby the correcting tax. On the other hand it implies higher marginal utility of the habitual good for the individual, an effect that goes in the opposite direction. The total effect therefore depends on which of the effects is greater. In our simulations we have shown that the former effect is likely to be dominating, that stronger habit formation implies higher tax rates, and that the tax rate should increase over time.

We have also analyzed how optimal taxation changes if we relax the assumption of time-consistency. If individuals are time-inconsistent, the optimal tax rate in the first period is no longer equal to the Pigouvian, but has to be corrected for time-inconsistency. Whether this tax rate is higher or lower than the Pigouvian depends on the kind of habit − if it is beneficial or harmful. If habit is beneficial the optimal tax rate is lower than the Pigouvian because the individual, due to time-inconsistency, consumes less than optimal, which implies less environmental damage.

Since consumption of the habitual good increases over time, so does the optimal tax rate, implying a higher tax rate in period two than in period one and the discrepancy increases in habitual strength. In an economy where people of different generations and at different stages of habit formation live together, this would imply that different tax rates are used at the same time. It would be difficult to monitor that older (more habitual) people actually pay the higher and not the lower tax rate. There are no self-selection constraints that can be used here, so we analyzed what the solution would be if politicians were constrained to set one common second-best tax rate. We found that this common tax rate would be a weighted average of the two optimal rates and that there would be a welfare loss associated with this second-best tax, because it would be higher than optimal in period one and lower in period two. Since the difference between optimal tax rates increases in habitual strength, so does the welfare loss from imposing a second-best environmental tax.

Hence, we have shown that habit formation may have strong implications for environmental taxation. We have shown that the effects are both qualitative and quantitative. However, this is just a first step to understanding the issue of habit formation and the environment. The next step would naturally be to explore these connections empirically, to study to what extent environmental taxation would have to change due to these considerations.

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