1 Introduction

A common perspective is that sin taxes can correct individual ignorance toward detrimental effects on health (e.g. O'Donoghue and Rabin, 2006), the so-called paternalistic view. However, an important aspect is the presence of fiscal externalities. Sin goods affect not only individual health but also public funds. Excessive demand for alcohol causes injuries and chronic diseases, raising hospitalization and the visits to emergency departments which ultimately increase the fiscal burden (e.g. Bouchery et al., 2011). Thus, sin taxes can be motivated even if individuals recognize the adverse effects of unhealthy goods. We take a unified approach allowing for both paternalistic and non-paternalistic motivation for sin taxes. The paternalistic view associates with individual ignorance toward the detrimental impacts of sin goods on health. The non-paternalistic view is based on fiscal externalities: if individuals do not fully internalize (1) the crowding-out effect on health care resources while tackling short-term health problems (short-term externalities), and (2) the relationship between individuals' long-term health and the effectiveness of health care services (long-term externalities).

2 The economy

The individual maximizes

$$U = \int_0^\infty e^{-\rho t} u(c, x, L) dt, \tag{1}$$

where ρ denotes the rate of time preference, c denotes numeraire goods, x denotes sin goods, and L denotes leisure. L is

$$L \equiv (1 - l)H(h), \tag{2}$$

where l is the fraction of healthy time allocated to labor supply, and h is the stock of health. h generates healthy time through a concave H function as in Grossman (1972). Individuals own assets a and face the budget constraint and the law of motion of h respectively:

$$\dot{a} = (1 - \tau_k)ra + (1 - \tau_l)wlH - c - (1 + \tau_x)x - T, \tag{3}$$

$$\dot{h} = M(m, \epsilon_x x, \epsilon_h h) - \epsilon_\eta \eta(x) - \delta h, \tag{4}$$

where $M_m > 0$, $M_x < 0$, $\eta_x > 0$, $\eta_{xx} \leq 0$, and $\delta > 0$. τ_k, τ_l, and τ_x represent taxes on capital income, labor income, and sin goods, r and w are the prices of capital and labor, and T is a lump-sum tax. We normalize the after-tax price of c to unity without affecting the results. Health can be accumulated (equation (4)) through effective health care M but deteriorates in x via the η function and natural depreciation δ. M is affected by the provision of public health-care spending m, consumption of x, and the level of h. The inclusion of x and h captures the short- and long-term externalities on M. Short-term: although individuals can use m to recover from short-term problems caused by x, they simultaneously crowd out the resources available for other health problems and the opportunities to further improve h. Long-term: as suggested by Grossman (1972), the marginal efficiency of m decreases in h, implying that $d\dot{h}/dh < 0$. Hence, M_h can be either positive or negative as long as it is less than δ. We include $0 \le \epsilon_x \le 1$ and $0 \le \epsilon_h \le 1$ to represent the degree to which individuals internalize the effects of x and h on M respectively. We further include ϵ_η to allow for a paternalistic aspect of sin taxes. When $\epsilon_\eta < 1$, individuals do not fully understand the detrimental effect on own health when consuming x (thus having limited cognitive ability).

The economy is constituted by two sectors: goods y and health m, which both require capital k and labor lH as inputs. We assume that y has constant returns to scale.

$$y = f(sk, vlH), \tag{5}$$
$$m = m((1-s)k, (1-v)lH), \tag{6}$$

where s and v are the fractions of capital and labor devoted to the goods sector.

m is funded through taxes and government debt b:

$$\tau_k ra + \tau_l wlH + \tau_x x + T + \dot{b} = m + rb, \tag{7}$$

Furthermore, $a = k + b$.

We employ the primal approach, choosing allocations directly subject to the implementability constraint

$$\lambda_0 a_0 = \int_0^\infty e^{-\rho t}[u_c c - u_L lH + u_x x + q(M_x \epsilon_x - \epsilon_\eta \eta_x)x + u_c T]dt, \tag{8}$$

where λ and q are the co-states (to $\dot{a}$ and $\dot{h}$), the feasibility constraint

$$\dot{k} = f(sk, vlH) - c - x, \tag{9}$$

and the law of motion

$$\dot{h} = M(m((1-s)k,(1-v)lH),x,h) - \eta(x) - \delta h. \tag{10}$$

To focus on the second-best case, we set $T = 0$.

We compare the marginal rates of substitution derived from the individual problem and the Ramsey problem and obtain the optimal taxes[1]:

$$\tau_k = 0, \tag{11}$$

$$\tau_l = \frac{u_L}{\gamma f_2}\left[\Omega\left(\Delta_L - \Delta_c\right) + \psi H_h\left(\frac{u_{cL}}{u_c} - \frac{u_{LL}}{u_L}\right)\right], \tag{12}$$

$$\begin{aligned}\tau_x = {} & \frac{q}{u_c}\left(M_x\epsilon_x - \epsilon_\eta\eta_x\right) + \frac{u_x}{\gamma}\Big\{\Omega\left[\Delta_c - \Delta_x - \frac{q}{u_x}\left(M_x\epsilon_x - \epsilon_\eta\eta_x + \left(M_{xx}\epsilon_x - \epsilon_\eta\eta_{xx}\right)x\right)\right] \\ & - \frac{\omega}{u_x}\left(M_x - \eta_x\right) + \psi\left(\frac{q}{u_x}M_{xh}\epsilon_h + \left(\frac{u_{xL}}{u_x} - \frac{u_{cL}}{u_c}\right)H_h\right)\Big\},\end{aligned} \tag{13}$$

where

$$\Delta_c \equiv 1 + \frac{u_{cc}}{u_c}c - \frac{u_{cL}}{u_c}lH + \frac{u_{cx}}{u_c}x, \tag{14}$$

$$\Delta_x \equiv 1 + \frac{u_{cx}}{u_x}c - \frac{u_{xL}}{u_x}lH + \frac{u_{xx}}{u_x}x, \tag{15}$$

$$\Delta_L \equiv 1 + \frac{u_{cL}}{u_L}c - \frac{u_{LL}}{u_L}lH + \frac{u_{xL}}{u_L}x. \tag{16}$$

Ω is the multiplier on the implementability constraint, ψ is the co-state on the private shadow price of health, and ω is he social shadow price of health (equal to q in the first-best). f_2 denotes the derivative of $f(sk, vlH)$ with respect to its second element. The zero capital income tax result is well discussed in the existing studies (e.g. Judd, 1985; Chamley, 1986), and we will not elaborate further. In the first-best, where T is implementable, the implementability constraint is nonbinding and $\Omega = \psi = 0$; therefore, by equation (12), $\tau_l = 0$ in the first-best. τ_x is not necessarily zero in the first-best. A further exploration of the structure of τ_x is provided in Section 3.

[1] Detailed derivations are provided in the Online Appendix

3 Optimal sin taxes

We decompose equation (13) as

$$\tau_x = \tau_x^p + \tau_x^e, \tag{17}$$

where

$$\begin{aligned}\tau_x^p = \frac{u_L}{u_c} \times \frac{H_h}{(\rho+\delta-M_h\epsilon_h)(\rho+\delta-M_h)}&[-M_x(\rho+\delta-M_h)(1-\epsilon_x)+M_h(\eta_x-M_x)(1-\epsilon_h)\\ &+\eta_x(\rho+\delta-M_h)(1-\epsilon_\eta)],\end{aligned} \tag{18}$$

and

$$\begin{aligned}\tau_x^e = \frac{M_x-\eta_x}{\gamma}&\left[\frac{u_L H_h}{\rho+\delta-M_h}\left(\frac{\gamma}{u_c}-1\right)-\omega+\frac{u_L H_h}{\rho+\delta-M_h}\right]+\frac{u_x}{\gamma}\left\{\Omega\left[\Delta_c-\Delta_x-\frac{q}{u_x}(M_x\epsilon_x-\epsilon_\eta\eta_x\right.\right.\\ &\left.\left.+(M_{xx}\epsilon_x-\epsilon_\eta\eta_{xx})x)\right]+\psi\left[\frac{q}{u_x}M_{xh}\epsilon_h+\left(\frac{u_{xL}}{u_x}-\frac{u_{cL}}{u_c}\right)H_h\right]\right\}.\end{aligned} \tag{19}$$

Proposition 1. *The optimal sin tax is additively composed of an efficiency term τ_x^e and a Pigouvian term τ_x^p, where the latter is additive in the externality components.*

Thus, the additivity result by Sandmo (1975) is found in our setting. τ_x^e in the first-best, when T is available ($\Omega = 0$). Equation (18) shows the corrective role of τ_x when individuals do not fully internalize the fiscal externalities, or are aware of their own health consequences. τ_x takes an additive structure in three non-negative terms. The first term is related to the short-term fiscal externality in health care $(1-\epsilon_x)$, the second term to the long-term fiscal externality $(1-\epsilon_h)$, and the third to the paternalistic aspect $(1-\epsilon_\eta)$. Thus, even in absence of paternalism ($\epsilon_\eta = 1$), τ_x^p would be positive as long as either ϵ_x or ϵ_h is below unity.

4 Calibration

We calibrate the model on the UK economy 2005-2015, using the following functions:

$$u = \ln c + \theta \ln x + \phi \ln L, \tag{20}$$

$$H = h^\mu, \tag{21}$$

$$\eta(x) = \eta x, \tag{22}$$

$$y = A(sk)^\alpha (vlH)^{(1-\alpha)}, \tag{23}$$

$$m = B((1-s)k)^{\beta}((1-v)lH)^{1-\beta}, \tag{24}$$

$$M = Em^{\kappa_m}x^{-\kappa_x}h^{\kappa_h}. \tag{25}$$

As a benchmark in the calibration, we take the non-paternalistic case ($\epsilon_\eta = 1$). The parameters are calculated by using the first-order conditions of the individual maximization problem. The results of the benchmark calibration are summarized in Table 1.

Table 1: Calibration

Parameters in the Literature		Targeted Ratio		Calibrated Parameters	
α	0.3000^a	dm/dx	0.0430^f	s_0	0.9324
β	0.2200^a	$m_0/(y_0+m_0)$	0.0900^g	v_0	0.9007
κ_m	0.8000^a	$x_0/(y_0+m_0)$	0.0400^g	k_0	5.7112
κ_h	0.0500^b	l_0	0.2500^a	h_0	6.9256
ρ	0.0400^a	y_0	1^*	B	1.1912
δ	0.0430^a	A	1^*	E	2.0994
θ	0.2000^c			ϵ_x	0.5000
μ	0.4000^d			ϵ_h	0.4830
τ_k	0.2900^e			η	1.8947
τ_l	0.2600^e				
τ_x	0.1600^e				

[a]: Wang et al. (2017); [b]: Galama et al. (2012); [c]: Chen et al. (2017); [d]: Hall and Jones (2007); [e]: McDaniel (2007); [f]: Scarborough et al. (2011); [g]: OECD Statistics; $*$: normalization to 1.

Subscripts 0 in Table 1 denote the initial values for calibration. Most calibrated parameters are uniquely determined (to match the target ratios). However, E and η are determined by ϵ_x and ϵ_h. Without data on those we proceed as follows. ϵ_x and ϵ_h lie in a range $0-1$, and we compute the lowest possible E (=2.0756) and largest possible E (=2.1231). Approaching this agnostically, we take E as the mean of these values. The value of E then give the values of $\epsilon_x = 0.5$, $\epsilon_h = 0.4830$ and $\eta = 1.8947$.

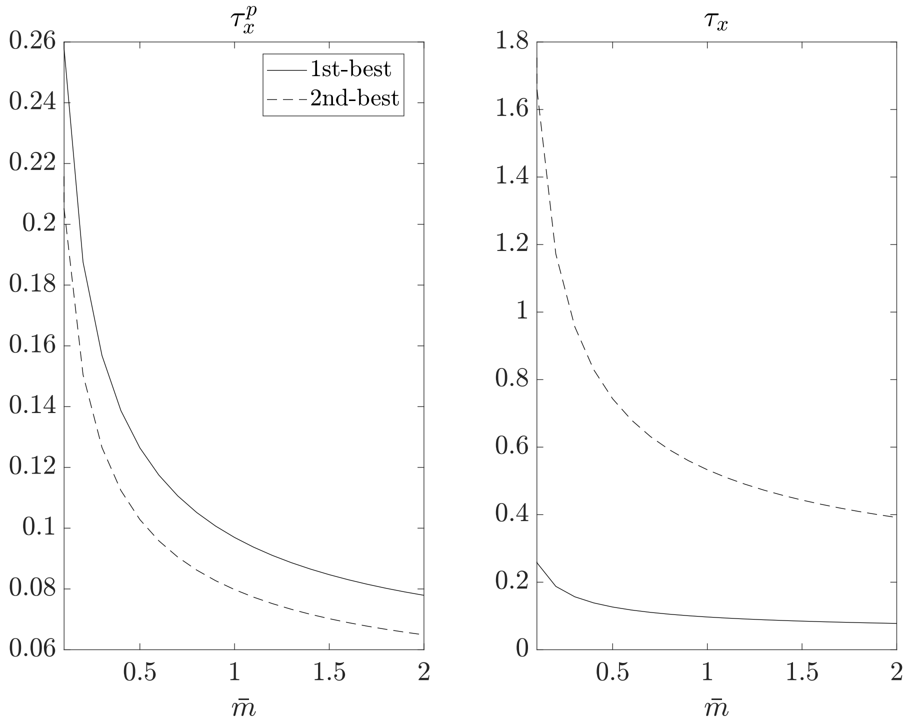

Figure 1: τ_x^p and τ_x with different levels of $\bar{m}$

The left panel in Figure 1 shows the first- and the second-best Pigouvian elements with different levels of $\bar{m}$. The second-best τ_x^p are generally lower than those in the first-best. The reason is that individuals value public goods less in the presence of τ_l, so they can tolerate higher levels of externalities. This finding accords to Bovenberg and Goulder (1996) in that the implementation of income taxes distorts the corrective taxes downward. However, as shown in the right panel, lower levels of Pigouvian elements in the second-best do not mean that the second-best τ_x are also lower. Referring to (19), the efficiency elements could be non-zero in the second-best. Therefore, optimal sin taxes in the second-best can still be higher than those in the first-best.

5 Sin tax reform

We further explore the property of sin taxes by computing changes in economic variables in response to revenue-neutral "sin tax reforms" which replaces τ_l and T with τ_x respectively. Apart from the benchmark parameters (labeled NP, for non-paternalistic), we also use an alternative parameter set with $\epsilon_\eta = 0.1$ and $\eta = 17.2121$ (labeled P, for paternalistic). The latter is calibrated to yield the same initial steady states as the benchmark.

Thus we are able to compare the effects of tax reforms in two different economies, one where the initial equilibrium is generated by rational individuals ($\epsilon_\eta = 1$), and one where the initial equilibrium is generated by non-rational individuals ($\epsilon_\eta = 0.1$).

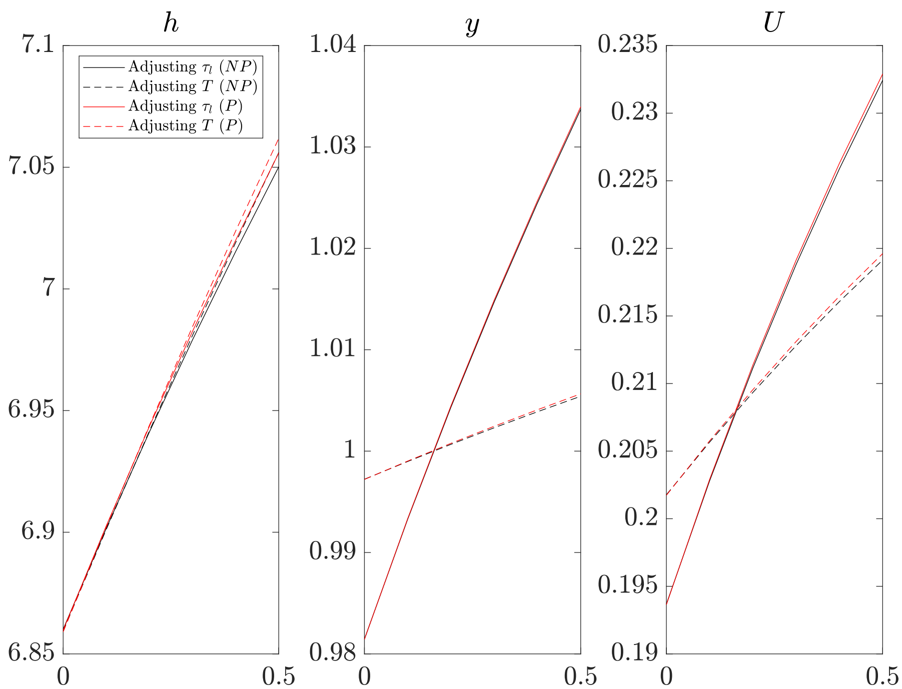

Figure 2: The impacts of sin tax reforms on h, y and U

As seen in Figure 2, h, y and U all increase in τ_x. The reason is that τ_x discourages x, and thereby improves h, which in turn increases productivity and output. There is a larger response in output and welfare to the tax reform in the paternalistic case, though quantitatively the difference is small. Thus we expect, quantitatively, close responses for paternalistic and non-paternalistic economies due to an increase in the sin tax. Furthermore, there is a larger response when τ_l is lowered (as opposed to T), also in magnitude. In this sense, sin taxes contribute to double-dividends in terms of not only improving population health but also enhancing both economic output and welfare.

6 Conclusion

This paper explores the structure of optimal sin taxes in the presence of income taxes and the provision of health care in a dynamic general equilibrium model. We contribute to the literature with the following findings. First, we allow for both non-paternalistic (in the presence of fiscal externalities) and paternalistic motivations to justify the role of sin taxes. Second, we show the additive property between the Pigouvian elements and the efficiency element in the optimal sin taxes in our dynamic setting. The overall Pigouvian element can be further decomposed additively into a crowding-out and a paternalistic component. In addition, our simulation shows that the Pigouvian taxes would be distorted downward in the second-best. The reason behind this finding is that individuals can tolerate more externalities since they value public goods less in the second-best. However, with the presence of the efficiency element, the second-best optimal sin taxes are not necessarily lower than those in the first-best. Third, we find that the implementation of sin taxes has double-dividends which improve not only population health but also economic performance and welfare in the UK.

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