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Lifestyle taxes in the presence of profit shifting

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Abstract

The consumption of unhealthy products generates significant externalities in terms of increased future health care costs to society. Lifestyle taxes are attracting increasing attention as a measure by which to discourage over-consumption and correct such externalities. This paper focuses on the trade-off that governments face in setting a lifestyle tax when the producer of the taxed good is a multinational which may engage in profit-shifting activities. In the absence of profit shifting, if governments do care about corporate tax revenue, the optimal lifestyle tax is always lower than the marginal health care cost. We show that, by shrinking the corporate tax base, profit shifting has the interesting side effect of helping to close the gap between the lifestyle tax and the marginal health care cost.

Keywords Lifestyle tax · Multinational firm · Profit shifting · Health care costs

JEL Classification H21 · H32 · D11 · D62 · I18

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1 Introduction

Noncommunicable diseases (NCDs)–which include cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes–kill more than 40 million people each year, equivalent to about 70% of all deaths globally (WHO 2017). NCDs disproportionately affect people in low- and middle-income countries where more than three quarters of global NCD deaths occur, but represent a significant share of total health care spending also in developed countries. In the EU, for example, NCDs account for approximately 25% of total health care costs (Vandenberghe and Albrecht 2019). Modifiable behaviours, such as tobacco use, physical inactivity, the abuse of alcohol, and unhealthy diets, all significantly increase the risk of NCDs.[1] In an attempt to tackle some of the key behavioural determinants of NCDs, countries around the world have been introducing policies ranging from information and education measures to policies designed to widen choices (e.g. the EU school fruit, vegetable and milk scheme), workplace health policies, and price instruments in the form of "lifestyle taxes". Lifestyle taxes, which are the focus of the present work, aim at discouraging the consumption of unhealthy products (or products high in unhealthy content) by increasing their price. Examples of applications of such policies are taxes on cigarettes and alchool, which are widely used in both OECD and non-OECD countries; taxes on food high in saturated fats (e.g., taxes on ready-to-eat meals in Hungary (Bíró 2015)); and taxes on sugar-sweetened beverages, such as "soda taxes" in France (Berardi et al. 2016), Chile (Nakamura et al. 2018; Caro et al. 2017), Mexico (Colchero et al. 2016), the United Kingdom (Pell et al. 2019), the city of Berkeley, (Falbe et al. 2016) and the State of Pennsylvania in the United States (Zhong et al. 2018).

The use of lifestyle taxes poses a number of important questions and challenges. These include how effective these policies are in significantly modifying purchasing patterns (see, for instance, Colchero et al. 2016); whether there is any potential substitution effect (Jou and Techakehakij 2012; Sassi et al. 2013; Quirmbach et al. 2018); whether lifestyle taxes have adverse economic impacts on low-income groups, due to the disproportionately higher consumption of cigarettes, junk food and sugary drinks among poor households (Goldin and Homonoff 2013; Allcott et al. 2015, 2019; Gruber and Köszegi 2001).

In addition to these aspects, which largely pertain to the consumption side of the problem, there are features of the supply side, as well as potential trade-offs for governments, that may affect the design of lifestyle taxes and should therefore be carefully taken into account. For example, the contraction in consumption induced by a lifestyle tax may reduce firms' profit and, consequently, the corporate tax base, thus posing a potential trade-off for governments between internalizing the health-related externality and raising revenue. Moreover, for many "sin" goods the supply side of the market is predominantly controlled by multinational companies, with market

[1] According to recent estimates, tobacco accounts for over 7.2 million deaths every year and is projected to increase markedly over the coming years; 4.1 million annual deaths have been attributed to excess salt/sodium intake; and more than half of the 3.3 million annual deaths attributable to alcohol use are from NCDs, including cancer ((WHO 2017); and https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases).

power. In the market for soda drinks, for example, Coca-Cola Co. and Pepsi Co. control, respectively, 50% and 20% of the global carbonated beverage market, while the remaining share is only partially controlled by nationally-based companies Statista (2020). In the global fast food market, one of the leading sources of junk food, brands such as Burger King, McDonald's, Domino's Pizza, KFC, Jack in the Box and Yum! are the major players and are all multinationals.

In a recent paper, Cremer et al. (2019) have shown that, while under perfect competition a Pigouvian tax proportional to sugar content is sufficient to achieve a first best solution, under imperfect competition the appropriate tax rule is more complex. In particular, market power affects both output and sugar content and these effects have to be balanced against Pigouvuan considerations. O'Connell and Smith (2021), on the other hand, have highlighted how market power impacts not only the efficiency but also the redistributive properties of sin taxation. In particular, allocative distortions from the exercise of market power lead optimal sin tax policy to depend on the extent of equilibrium price-cost margins on sin products, relative to alternatives. The concentration of profit holdings in the hands of the wealthy leads policy to be more progressive than if no profits were realized, thereby counteracting the regressive incidence of the tax based on consumption patterns. The authors quantify these effects within the context of an application to sugar-sweetened beverage taxation in the UK market, and show that ignoring the impact of market power on optimal policy leads to substantial unrealized welfare gains.

In the present work, we focus on another relevant feature of the supply side, which has not been considered by previous literature; that is, the fact that multinational companies, in the attempt to minimize their tax burden, typically engage in profit-shifting activities. In other words, they reallocate profit among countries so as to exploit corporate tax differences. Our principal aim is to examine whether and how this could affect the tradeoffs that governments face when setting a life style tax and therefore the resulting level of the tax.

To this end, we propose a stylized two-country model, whose basic elements are presented in Sect. 2. Consumers in each country derive utility from the consumption of an unhealthy good, which is produced by a multinational company (MNC). The MNC's productive activities are subject to source-based corporation taxes. When making their consumption decisions, consumers do not take into account the negative externality in terms of increased future health care costs, associated with the consumption of the unhealthy good. Within this context, we consider the possibility that national governments introduce a lifestyle tax. The problem is modelled as a two-stage game: in the first stage, governments independently and simultaneously set their lifestyle tax rates; in the second stage, demand and supply meet on the market and the market equilibrium forms. The game is solved by backward induction.

We first work, in Sect. 3, under the assumption that the multinational company cannot engage in profit shifting activities and show that the optimal lifestyle tax is always lower than the marginal health care cost, reflecting the trade-off that governments face between internalizing the health-related externality and raising revenues. In Sect. 4, we allow for the possibility that the MNC reallocates profit across countries so as to exploit corporate tax differences, and analyze whether and how profit shifting affects governments' choices. We find that profit shifting has no

effect on the level of the lifestyle tax set by the country *towards* which the MNC shifts profit. By contrast, the optimal lifestyle tax of the country *from* which profit is shifted is higher than in the absence of profit shifting and gets closer to the marginal health care cost the higher the equilibrium profit-shifting share. In Sect. 5 we discuss the results and conclude.

2 Basic setup

We consider two countries, 1 and 2. Consumers in each country derive utility from the consumption of a good g. Inverse demand in country i is $p(Q_i^d) = a_i - b_i Q_i^d$, which implies

$$Q_i^d = \frac{a_i - p}{b_i}. \tag{1}$$

Good g is an unhealthy good; in other words, its consumption reduces the health stock, which in turn causes an increase in health care costs at some later stage. The discounted expected value of these costs is proportional to the quantity demanded and given by $h_i Q_i^d$, with $h_i > 0$. When making their consumption decisions, individuals do not take this cost into account. As a result, a negative externality arises.[2]

Good g is produced by a profit-maximising multinational company (MNC), whose marginal cost of production is equal to c, independently of where the good is produced. The price p of the good is set at the international level. For simplicity, we assume that the company takes the international price as given.[3] If the marginal cost is lower than the international price, the company produces up to covering the internal demand of each country. The MNC faces convex transport costs. Specifically, these costs increase in the difference between local supply and local demand according to the following functional specification: $\frac{\beta}{2}(Q_i^s - Q_i^d)^2$, with $\beta > 0$.

The firm's productive activities are subject to source-based corporation taxes. We denote by τ_1 and τ_2 the corporate tax rates in country 1 and 2, respectively. Without loss of generality, we assume that $\tau_1 > \tau_2 > 0$.

The MNC's net profit is given by:

$$\Pi_N = (p - c)\left[(1 - \tau_1)Q_1^s + (1 - \tau_2)Q_2^s\right] - \frac{\beta}{2}\left(Q_1^s - Q_1^d\right)^2 \tag{2}$$

The multinational firm maximises (2) subject to market-clearing conditions:

$$Q_1^s + Q_2^s = Q_1^d + Q_2^d. \tag{3}$$

Using (1) and (3), we can rewrite the MNC's net profit as:

[2] The negative effects that consumers impose on themselves by consuming unhealthy products are often called internality. Yet, if the health care system is publicly funded (as it is the case for example in many European countries), the individual consumption of unhealthy products has negative effects also on others by increasing health care expenses, hence the externality.

[3] In Appendix A.4 we extend the analysis to the case of a monopolist and show that the qualitative nature of the results continues to hold.

$$\Pi_N = (p-c)\left[(1-\tau_1)Q_1^s + (1-\tau_2)\left(\frac{a_1-p}{b_1} + \frac{a_2-p}{b_2} - Q_1^s\right)\right] - \frac{\beta}{2}\left(Q_1^s - \frac{a_1-p}{b_1}\right)^2.$$

Differentiating this expression with respect to Q_1^s and equating to zero, we have:

$$(p-c)[(1-\tau_1)-(1-\tau_2)] - \beta\left(Q_1^s - \frac{a_1-p}{b_1}\right) = 0$$

from which

$$Q_1^s = \frac{a_1-p}{b_1} - \frac{(p-c)}{\beta}(\tau_1-\tau_2) \tag{4}$$

and, by substituing (4) into (3)

$$Q_2^s = \frac{a_2-p}{b_2} + \frac{(p-c)}{\beta}(\tau_1-\tau_2). \tag{5}$$

Note that, for $\tau_1 > \tau_2$, this implies that the MNC optimally relocates production from country 1 to country 2.

Each country is represented by a government, which cares about the consumer surplus realized by its citizens, the external health care cost associated with the consumption of good g, and the revenues derived from the corporate tax. Given the demand specification, the consumer surplus realized by the citizens of country i is given by $\frac{(a_i-p)^2}{2b_i}$. Government i's welfare function can therefore be written as

$$W_i = \frac{(a_i-p)^2}{2b_i} - h_i\frac{a_i-p}{b_i} + \tau_i(p-c)Q_i^s. \tag{6}$$

3 The introduction of a lifestyle tax

We now consider the possibility that countries introduce a per unit tax on the consumption of good g. The problem can be modelled as a two stage game: in the first stage, governments independently and simultaneously set their lifestyle tax rates; in the second stage, demand and supply meet on the market and the market equilibrium forms. The game is solved by backward induction.

3.1 Second stage

If an arbitrary per unit tax t_i is introduced, the unit price paid by consumers in i becomes $p + t_i$. From (1), aggregate demand in country i is then given by $Q_i^d = \frac{a_i - p - t_i}{b_i}$.

The MNC's net profit becomes

$$\begin{aligned}\Pi_N =&(p-c)(1-\tau_1)Q_1^s \\ &+(p-c)(1-\tau_2)\left(\frac{a_1-p-t_1}{b_1}+\frac{a_2-p-t_2}{b_2}-Q_1^s\right) \\ &+-\frac{\beta}{2}\left(Q_1^s-\frac{a_1-p-t_1}{b_1}\right)^2.\end{aligned} \tag{7}$$

Profit maximization leads to the following second stage equilibrium production choices:[4]

$$Q_1^{s^*}(t_1)=\frac{a_1-p-t_1}{b_1}-\frac{(p-c)}{\beta}(\tau_1-\tau_2) \tag{8}$$

and

$$Q_2^{s^*}(t_2)=\frac{a_2-p-t_2}{b_2}+\frac{(p-c)}{\beta}(\tau_1-\tau_2) \tag{9}$$

3.2 First stage

For an arbitrary tax rate t_i, Government i's revenue from the lifestyle tax is $t_i\frac{a_i-p-t_i}{b_i}$. By modifying Eq. (6) so as to take the lifestyle tax revenue into account, and substituting into the resulting expression the second stage equilibrium solutions, we have

$$\begin{aligned}W_i =&\frac{(a_i-p-t_i)^2}{2b_i}-h_i\frac{a_i-p-t_i}{b_i} \\ &+\tau_i(p-c)\left[\frac{a_i-p-t_i}{b_i}-\frac{(p-c)}{\beta}(\tau_i-\tau_j)\right] \\ &+t_i\frac{a_i-p-t_i}{b_i}\end{aligned} \tag{10}$$

with $i=1,2$. Note that, for each government, the first-stage welfare function is independent of the lifestyle tax chosen by the other government. In other words, there is no strategic interaction.

Differentiating (10) with respect to t_i and equating to zero, gives:

$$-\frac{2(a_i-p-t_i)}{2b_i}+\frac{h_i}{b_i}-\frac{\tau_i(p-c)}{b_i}+\frac{(a_i-p-t_i)}{b_i}-\frac{t_i}{b_i}=0$$

from which

[4] See Appendix A.1.

$$t_i^* = h_i - \tau_i(p-c) \tag{11}$$

with $i = 1, 2$. Note that, country i's optimal tax rate is given by the difference between the marginal health care cost and the marginal corporate tax revenue, reflecting the trade-off that governments face between internalizing the health-related externality and raising revenues.

4 On the effects of profit-shifting

4.1 Introducing profit-shifting

In order to minimize their tax burden, multinational companies typically engage in profit-shifting activities. We now take this into consideration by allowing for the possibility that the firm shifts a share $\gamma \in [0, 1]$ of the profit generated in the high-tax country (country 1) to the low-tax country (country 2). The gross saving (in terms of avoided taxes) that the firm can make by engaging in profit shifting is then given by $(\tau_1 - \tau_2)[\gamma(p-c)Q_1^s]$, where $\gamma(p-c)Q_1^s$ is the amount of shifted profit. Profit shifting is assumed to be costly. In particular, following (Hines and Rice 1994), we hypothesize that the *marginal* cost of shifting profit is very small at first, but rises in proportion to the ratio of shifted profit to total profit generated in country 1, $\frac{\gamma(p-c)Q_1^s}{(p-c)Q_1^s}$. Letting α denote this factor of proportionality, the total cost associated with profit-shifting is given by $\frac{\alpha}{2}\frac{[\gamma(p-c)Q_1^s]^2}{(p-c)Q_1^s}$, with $\alpha > 0$.

The MNC's net profit can then be written as:

$$\begin{aligned}\Pi_N =& (p-c)\left[(1-\tau_1)Q_1^s + (1-\tau_2)Q_2^s\right] \\ &+ \frac{\beta}{2}\left(Q_1^s - Q_1^d\right)^2 + (\tau_1 - \tau_2)\left[\gamma(p-c)Q_1^s\right] - \frac{\alpha}{2}\gamma^2(p-c)Q_1^s\end{aligned} \tag{12}$$

and governments' welfare functions are, respectively:

$$W_1 = \frac{(a_1-p)^2}{2b_1} - h_1\frac{a_1-p}{b_1} + \tau_1(p-c)\left[Q_1^s - \gamma Q_1^s\right] \tag{13}$$

$$W_2 = \frac{(a_2-p)^2}{2b_2} - h_2\frac{a_2-p}{b_2} + \tau_2(p-c)\left[Q_2^s - \gamma Q_1^s\right] \tag{14}$$

4.2 Solving for the equilibrium with profit shifting

As before, we now consider the possibility that countries introduce a tax on the consumption of the unhealthy good. With a per unit tax t_i, aggregate demand in i is $Q_i^d = \frac{a_i - p - t_i}{b_i}$ and the MNC's net profit becomes

$$\begin{aligned}\Pi_N =&(p-c)(1-\tau_1)Q_1^s+\\&+(p-c)(1-\tau_2)\left(\frac{a_1-p-t_1}{b_1}+\frac{a_2-p-t_2}{b_2}-Q_1^s\right)\\&+-\frac{\beta}{2}\left(Q_1^s-\frac{a_1-p-t_1}{b_1}\right)^2\\&+(\tau_1-\tau_2)(p-c)\gamma Q_1^s-\frac{\alpha}{2}\gamma^2(p-c)Q_1^s\end{aligned} \tag{15}$$

Profit maximization leads to the following second-stage equilibrium solutions in terms of production location and profit-shifting decisions[5]:

$$Q_1^{s^*}(t_1)=\frac{a_1-p-t_1}{b_1}-\frac{(p-c)}{\beta}(\tau_1-\tau_2)+\frac{(p-c)}{2\alpha\beta}(\tau_1-\tau_2)^2 \tag{16}$$

$$Q_2^{s^*}(t_2)=\frac{a_2-p-t_2}{b_2}+\frac{(p-c)}{\beta}(\tau_1-\tau_2)-\frac{(p-c)}{2\alpha\beta}(\tau_1-\tau_2)^2 \tag{17}$$

$$\gamma^*=\frac{\tau_1-\tau_2}{\alpha} \tag{18}$$

By comparing Eqs. (16) and (17) with Eqs. (8) and (9), we can see that–for *given* levels of t_1 and t_2–the amount of production shifted from country 1 to country 2 is higher in the absence of profit shifting. This can be explained by the fact that when profit shifting is not allowed–e.g. because of the implementation of anti-BEPS (Base Erosion Profit Shifting) measures - production relocation is the only way through which the multinational company can try to reduce its tax burden.

In line with intuition, the optimal profit-shifting share in Eq. (18) is increasing in the corporation tax differential.

Let us now turn to the first stage of the game. For an arbitrary tax rate t_i, Government i's revenue from the lifestyle tax is $t_i\frac{a_i-p-t_i}{b_i}$. By taking this into account in Eqs. (13) and (14) and substituting the second stage equilibrium solutions into the resulting expressions, we have

$$\begin{aligned}W_1=&\frac{(a_1-p-t_1)^2}{2b_1}-h_1\frac{a_1-p-t_1}{b_1}\\&+\tau_1(p-c)(1-\gamma^*)Q_1^{s^*}(t_1)+t_1\frac{a_1-p-t_1}{b_1}\end{aligned} \tag{19}$$

$$\begin{aligned}W_2=&\frac{(a_2-p-t_2)^2}{2b_2}-h_2\frac{a_2-p-t_2}{b_2}\\&+\tau_2(p-c)[Q_2^{s^*}(t_2)+\gamma^*Q_1^{s^*}(t_1)]+t_2\frac{a_2-p-t_2}{b_2}\end{aligned} \tag{20}$$

Note that, while W_1 depends only on t_1, W_2 is a function of both t_1 and t_2. In

[5] See Appendix A.2.

Appendix A.3, we solve governments' optimization problem and obtain the following first-stage equilibrium solutions

$$t_1^{*PS} = h_1 - \tau_1(p-c)(1-\gamma^*) \tag{21}$$

$$t_2^{*PS} = h_2 - \tau_2(p-c) \tag{22}$$

By comparing these solutions with the equilibrium tax rates in the absence of profit shifting (see Eq. 11), we can see that profit shifting has no effect on the tax rate optimally set by country 2 (i.e., the low tax country enjoing profit inflow). Mathematically, this comes from the fact that, although in the setting with profit-shifting Government 2's welfare function is no longer independent of t_1, its marginal decision remains unchanged because t_1 enters W_2 in a separate manner (see Eqs. 20 and 16). Conceptually, from the point of view of Government 2, the amount of profit that the MNC decides to shift is just a lump-sum transfer, and is therefore independent of the lifestyle tax set by 2.

By contrast, Government 1's marginal decision (and consequently its equilibrium tax rate) is affected by profit shifting since there is an interaction between t_1 and γ^* in Eq. (19), and t_1 is a decision variable for Government 1. Precisely, by comparing Eqs. (21) and (11), we can see that the equilibrium lifestyle tax set by Government 1 is higher in the presence of profit shifting, and gets closer to the marginal health care cost, h_1, the higher the equilibrium profit-shifting share γ^*. In the limit case where $\gamma^* = 1$, which implies that the whole profit generated in 1 is shifted to country 2, $t_1^{*PS} = h_1$. The intuition behind this result is that, by reducing the corporate tax base, profit-shifting weakens the trade-off that Government 1 faces between internalizing the health care cost externality and raising revenue.

5 Conclusions

The consumption of unhealthy products such as junk food, sugar-sweetend beverages, tobacco and alcohol, generates a negative externality in terms of increased future health care costs to society. Increasing the price of unhealthy products through taxes is a potential policy measure by which to discourage overconsumption and correct the externality. The effectiveness of this measure, however, crucially depends on whether the tax is set at an appropriate level. The corrective logic dating to Pigou (1920) and Diamond (1973) tells us that the externality can be fully internalized by setting the tax equal to the marginal health care cost associated with the consumption of the unhealthy good. Yet, this principle abstracts from important considerations about the trade-offs that Governments may face when implementing a lifestyle tax. One such trade-off comes from the fact that, by discouraging consumption, a lifestyle tax may lead to a reduction in firm's profit and, consequently, a contraction of the corporate tax base for the country that introduces the tax.

We modelled this trade-off and examined its effects in terms of Governments' choices. We then considered the possibility that the producer of the taxed good

engages in profit-shifting activities and analyzed whether and how this affects the optimal level of the lifestyle tax. This latter aspect is particularly relevant in the context of the analysis because the goods that are subject to lifestyle taxes are predominantly produced by multinational companies and it is among multinationals that the practice of profit-shifting is particularly widespread.

If governments do care about corporate tax revenue, the optimal lifestyle tax in the absence of profit shifting is always lower than the marginal health care cost; consequently it never leads to the full internalization of the health-related externality. Moreover, the effectiveness of the lifestyle tax in internalizing the health care cost externality is inversely related to the magnitude of country i's corporate tax rate, τ_i.

When the company producing the unhealthy good can reallocate profit across countries, it optimally does so if countries differ in their corporate tax rates. Profit shifting has no effect on the lifestyle tax set by the country *towards* which the company shifts profits. By contrast, the country *from* which profits are shifted will optimally set a lifestyle tax closer to the marginal health care cost. In this case, by reducing the corporate tax base, profit shifting weakens the trade-off that the country faces between internalizing the health care cost externality and raising revenues.

The analysis confirms the importance of taking these aspects into account when thinking about possible solutions to the over-consumption of unhealthy products, and imposes a reflection about the opportunity to adopt an international perspective to the problem, even in the absence of strategic considerations among countries. Indeed, being less influenced by corporate tax revenues, a supranational body could be more effective in correcting the externalities associated with the consumption of unhealthy products.

Appendix

A.1: Derivation of the second-stage equilibrium solutions in the absence of profit shifting

The MNC solves the following optimization problem

$$\begin{aligned}\text{Max}_{Q_1^s} \quad & (p-c)(1-\tau_1)Q_1^s \\ & + (p-c)(1-\tau_2)\left(\frac{a_1-p-t_1}{b_1}+\frac{a_2-p-t_2}{b_2}-Q_1^s\right) \\ & -\frac{\beta}{2}\left(Q_1^s-\frac{a_1-p-t_1}{b_1}\right)^2.\end{aligned}$$

The F.O.C. for the above problem is

$$-(p-c)(\tau_1-\tau_2)-\beta Q_1^s+\beta\frac{a_1-p-t_1}{b_1}=0. \tag{23}$$

Provided that $\beta(a_1-p-t_1) > b_1(p-c)(\tau_1-\tau_2)$, the following internal solution can be defined

$$Q_1^{s^*} = \frac{a_1 - p - t_1}{b_1} - \frac{(p-c)}{\beta}(\tau_1 - \tau_2). \tag{24}$$

From Eq. (23) it is immediate to see that the second derivative of the profit function with respect to Q_1^s is negative, which guarantees that the solution identifies a maximum.

By substituting $Q_1^{s^*}$ into the market clearing condition defined in Eq. (3) and solving for $Q_2^{s^*}$, we obtain

$$Q_2^{s^*} = \frac{a_2 - p - t_2}{b_2} + \frac{(p-c)}{\beta}(\tau_1 - \tau_2). \tag{25}$$

A.2: Derivation of the second-stage equilibrium solutions with profit shifting

The MNC solves the following optimization problem

$$\begin{aligned}\text{Max}_{Q_1^s,\gamma} \quad & (p-c)(1-\tau_1)Q_1^s \\ & + (p-c)(1-\tau_2)\left(\frac{a_1 - p - t_1}{b_1} + \frac{a_2 - p - t_2}{b_2} - Q_1^s\right) \\ & - \frac{\beta}{2}\left(Q_1^s - \frac{a_1 - p - t_1}{b_1}\right)^2 \\ & + (\tau_1 - \tau_2)(p-c)\gamma Q_1^s - \frac{\alpha}{2}\gamma^2(p-c)Q_1^s.\end{aligned}$$

The F.O.C. for the above problem are

$$-(p-c)(\tau_1 - \tau_2) - \beta Q_1^s + \beta\frac{a_1 - p - t_1}{b_1} + (p-c)(\tau_1 - \tau_2)\gamma - \frac{\alpha}{2}(p-c)\gamma^2 = 0 \tag{26}$$

and

$$(p-c)(\tau_1 - \tau_2)Q_1^s - \alpha(p-c)Q_1^s\gamma = 0. \tag{27}$$

From Eq. 27, we have

$$\gamma^* = \frac{\tau_1 - \tau_2}{\alpha}. \tag{28}$$

Substituting (28) into (26) and solving for Q_1^s, we obtain

$$Q_1^{s^*}(t_1) = \frac{a_1 - p - t_1}{b_1} - \frac{(p-c)}{\beta}(\tau_1 - \tau_2) + \frac{(p-c)}{2\alpha\beta}(\tau_1 - \tau_2)^2. \tag{29}$$

Using (29) into the market clearing condition, we find

$$Q_2^{s^*}(t_2) = \frac{a_2 - p - t_2}{b_2} + \frac{(p-c)}{\beta}(\tau_1 - \tau_2) - \frac{(p-c)}{2\alpha\beta}(\tau_1 - \tau_2)^2. \tag{30}$$

A.3: Derivation of the optimal life-style tax with profit shifting

In the first stage of the game, Government 1 chooses t_1 so as to maximize its welfare function. Formally:

$$\begin{aligned}\text{Max}_{t_1} \quad & \frac{(a_1-p-t_1)^2}{2b_1}-h_1\frac{a_1-p-t_1}{b_1}\\ & +\tau_1(p-c)\left(1-\frac{\tau_1-\tau_2}{\alpha}\right)\left[\frac{a_1-p-t_1}{b_1}-\frac{(p-c)}{\beta}(\tau_1-\tau_2)+\frac{(p-c)}{2\alpha\beta}(\tau_1-\tau_2)^2\right]\\ & +t_1\frac{a_1-p-t_1}{b_1}.\end{aligned}$$

The F.O.C. for the above problem is

$$-\frac{a_1-p-t_1}{b_1}+\frac{h_1}{b_1}-\frac{\tau_1(p-c)}{b_1}\left(1-\frac{\tau_1-\tau_2}{\alpha}\right)+\frac{a_1-p-t_1}{b_1}-\frac{t_1}{b_1}=0, \qquad (31)$$

from which

$$t_1^{*PS}=h_1-\tau_1(p-c)\left(1-\frac{\tau_1-\tau_2}{\alpha}\right)$$

Substituting (16), (17) and (18) into Eq. (20), we can write Government 2's welfare function as follows

$$\begin{aligned}W_2=&\frac{(a_2-p-t_2)^2}{2b_2}-h_2\frac{a_2-p-t_2}{b_2}+t_2\frac{a_2-p-t_2}{b_2}\\ &+\tau_2(p-c)\left[\frac{a_2-p-t_2}{b_2}+\frac{(p-c)}{\beta}(\tau_1-\tau_2)-\frac{(p-c)}{2\alpha\beta}(\tau_1-\tau_2)^2\right]\\ &+\tau_2(p-c)\left(\frac{\tau_1-\tau_2}{\alpha}\right)\left[\frac{a_1-p-t_1}{b_1}-\frac{(p-c)}{\beta}(\tau_1-\tau_2)+\frac{(p-c)}{2\alpha\beta}(\tau_1-\tau_2)^2\right].\end{aligned}$$

Welfare maximization leads to the following F.O.C.

$$-\frac{a_2-p-t_2}{b_2}+\frac{h_2}{b_2}+\frac{a_2-p-t_2}{b_2}-\frac{t_2}{b_2}-\frac{1}{b_2}\tau_2(p-c)=0. \qquad (32)$$

Note that, although W_2 depends on both t_1 and t_2, the F.O.C. is independent of the tax rate set by the other country since t_1 enters W_2 in a linear manner. From (32), we have

$$t_2^{*PS}=h_2-\tau_2(p-c).$$

A.4: The case of a monopolist

In sections 2 to 4, we worked under the assumption that the price of the unhealthy good is set at the international level and that the multinational company (MNC) takes

the international price as given. We now consider the case in which the MNC is instead a monopolist who can sell on two different markets (country 1 and country 2).[6] The analysis will show that the qualitative nature of our results about the effect of profit shifting on the optimal life-style tax does not change.

A.4.1: Derivation of the optimal life-style tax in the absence of profit shifting

In the second stage, the MNC solves the following optimization problem

$$\text{Max}_{Q_1,Q_2} \quad (1-\tau_1)(p_1(Q_1)-c)Q_1+(1-\tau_2)(p_2(Q_2)-c)Q_2 \tag{33}$$

where $p_1(Q_1)=(a_1-b_1Q_1-t_1)$ and $p_2(Q_2)=(a_2-b_2Q_2-t_2)$ are the inverse demand functions in country 1 and 2, respectively.

The F.O.C. for the above problem are

$$(1-\tau_1)(a_1-2b_1Q_1-t_1-c)=0$$
$$(1-\tau_2)(a_2-2b_2Q_2-t_2-c)=0$$

which lead to

$$Q_1^m=\frac{a_1-t_1-c}{2b_1}$$
$$Q_2^m=\frac{a_2-t_2-c}{2b_2}$$

Substituting the above solutions into the inverse demand functions of country 1 and 2, we obtain

$$p_1^m=\frac{a_1-t_1+c}{2}$$
$$p_2^m=\frac{a_2-t_2+c}{2}$$

In the first stage, Government i chooses t_i so as to maximize welfare. Formally:

$$\text{Max}_{\ t_i} \quad \frac{(a_i-t_i-c)^2}{8b_i}-h_i\frac{a_i-t_i-c}{2b_i}+\tau_i\frac{(a_i-t_i-c)^2}{4b_i}+t_i\frac{a_i-t_i-c}{2b_i}.$$

The F.O.C. is

$$\frac{a_i-t_i-c}{4b_i}-\frac{\tau_i(a_i-t_i-c)}{2b_i}+\frac{h_i-t_i}{2b_i}=0$$

from which

$$t_i^m=\left[h_i-\tau_i(a_i-c)-\frac{a_i-c}{2}+(a_i-c)\right]\frac{2}{3-2\tau_i} \tag{34}$$

The optimal life-style tax in Eq. (34) is the sum of four elements, which represent the

[6] For simplicity, in analysing the monopolist case, we will assume that transport costs are infinite

marginal effect of the tax on: (i) health damage; (ii) corporate tax revenues; (iii) consumer surplus; and (iv) life-style tax revenues. Note that, under perfect competition, the last two effects cancel out and the only relevant trade-off for the government is between internalizing the consumption externality and raising corporate tax revenues [see Eq. (11)].

A.4.2: Derivation of the optimal life-style tax with profit shifting

In the second stage, the MNC solves the following optimization problem

$$\begin{aligned}\text{Max}_{Q_1,Q_2,\gamma} \quad & (1-\tau_1)(p_1(Q_1)-c)Q_1+(1-\tau_2)(p_2(Q_2)-c)Q_2 \\ & +\gamma(\tau_1-\tau_2)(p_1(Q_1)-c)Q_1-\frac{\alpha}{2}\gamma^2(p_1(Q_1)-c)Q_1.\end{aligned}$$

where $p_1(Q_1)=(a_1-b_1Q_1-t_1)$ and $p_2(Q_2)=(a_2-b_2Q_2-t_2)$ are the inverse demand functions in country 1 and 2, respectively.

The F.O.C. for the above problem are

$$\begin{aligned}\left(1-\tau_1+\gamma(\tau_1-\tau_2)-\frac{\alpha\gamma^2}{2}\right)(a_1-2b_1Q_1-t_1-c)&=0\\ (1-\tau_2)(a_2-2b_2Q_2-t_2-c)&=0\\ (\tau_1-\tau_2-\alpha\gamma)(a_1-b_1Q_1-t_1-c)Q_1&=0\end{aligned}$$

From which we have

$$\begin{aligned}Q_1^m&=\frac{a_1-t_1-c}{2b_1}\\ Q_2^m&=\frac{a_2-t_2-c}{2b_2}\\ \gamma^m&=\frac{\tau_1-\tau_2}{\alpha}\end{aligned}$$

and, by substituting Q_1^m and Q_2^m into country 1 and 2's inverse demand functions

$$\begin{aligned}p_1^m&=\frac{a_1-t_1+c}{2}\\ p_2^m&=\frac{a_2-t_2+c}{2}\end{aligned}$$

In the first stage, Government 1 chooses t_1 so as to maximize the following welfare function

$$\begin{aligned}\text{Max}_{t_1} \quad & \frac{(a_1-t_1-c)^2}{8b_1}-h_1\frac{a_1-t_1-c}{2b_1}+\tau_1(1-\gamma^m)\frac{(a_1-t_1-c)^2}{4b_1} \\ & +t_1\frac{a_1-t_1-c}{2b_1}.\end{aligned}$$

The F.O.C. for the above problem is

$$\frac{a_1 - t_1 - c}{4b_1} + \frac{h_1 - t_1}{2b_1} - \tau_1(1 - \gamma^m)\frac{a_1 - t_1 - c}{2b_1} = 0,$$

which leads to the following optimal life-style tax

$$t_1^{m,PS} = \left[h_1 - \tau_1(1 - \gamma^m)(a_1 - c) - \frac{a_1 - c}{2} + (a_1 - c)\right]\frac{2}{3 - 2\tau_1(1 - \gamma^m)} \quad (35)$$

Government 2's optimization problem is as follow

$$\begin{aligned}\text{Max}_{\,t_2} \quad & \frac{(a_2 - t_2 - c)^2}{8b_2} - h_2\frac{a_2 - t_2 - c}{2b_2} \\ & + \tau_2\frac{(a_2 - t_2 - c)^2}{4b_2} + \tau_2\gamma^m\frac{(a_1 - t_1 - c)^2}{4b_1} \\ & + t_2\frac{a_2 - t_2 - c}{2b_2}.\end{aligned}$$

The FOC is

$$\frac{a_2 - t_2 - c}{4b_2} - \frac{\tau_2(a_2 - t_2 - c)}{2b_2} + \frac{h_2 - t_2}{2b_2} = 0$$

from which

$$t_2^{m,PS} = \left[h_2 - \tau_2(a_2 - c) - \frac{a_2 - c}{2} + (a_2 - c)\right]\frac{2}{3 - 2\tau_2} \quad (36)$$

By comparing $t_1^{m,PS}$ and $t_2^{m,PS}$ with the equilibrium tax rates in the absence of profit shifting [Eq. (34)], we can see that profit shifting has no effect on the tax rate optimally set by country 2 (i.e., the country *towards* which the MNC shifts profit). By contrast, the equilibrium lifestyle tax set by country 1 is higher in the presence of profit shifting. From a qualitative point of view, this result is consistent with what we found in the case of perfect competition.

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Declarations

Conflict of interest None

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