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Kaisa Kotakorpi

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Paternalism and tax competition*

Kaisa Kotakorpi†
University of Tampere

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Abstract

When consumers make mistakes, the government may wish to use paternalistic taxation as a corrective measure. We examine a country whose government attempts to use taxation to reduce the consumption of a harmful good, and analyse the extent to which cross-border shopping and tax competition undermine the feasibility of paternalistic taxation. We show that the paternalistic component of a tax on a harmful good is reduced due to the possibility of cross-border shopping, but it does not disappear altogether. In a model with tax competition between two countries, only one of which has a paternalistic objective, we show that there exists an asymmetric Nash equilibrium, where the paternalistic country has the higher tax rate on the harmful good. We further show that despite the divergence in policy objectives, a minimum tax rate requirement can be Pareto improving. Tax harmonisation on the other hand always reduces welfare in the low-tax country.

Keywords: commodity taxation, tax competition, paternalism
JEL: H21, H73, H77, I18

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†Address: Department of Economics and Accounting, FI-33014 University of Tampere, Finland. Tel: +358-3-3551 6050. Fax: +358-3-3551 7214. E-mail: kaisa.kotakorpi@uta.fi

1 Introduction

When the government's and consumers' preferences differ, the government may wish to influence consumer choice through public policy. One particular example is a situation where consumers do not fully take into account the future negative effects caused by the consumption of certain goods, and therefore consume too much of such goods, even from the point of view of maximising their own lifetime utility. An important example is excessive consumption of goods with negative health effects (such as unhealthy food, cigarettes and alcohol) by consumers with self-control problems. It can be argued that market solutions to such self-control problems are unlikely to be effective (see Köszegi (2005)), and taxation is a potential tool for correcting the distortion in consumption. Taxation in such a context has been considered for example by O'Donoghue and Rabin (2003; 2006) and Gruber and Köszegi (2004). In general, policies of this kind are an example of paternalism, and their alleged purpose is to protect individuals in cases where they act against their own best self interest. Accordingly, we use the term "paternalistic taxation" to refer to taxation that is implemented so as to move private consumption closer to its optimal level (as evaluated according to the government's preferences)[1].

The objective of this paper is to analyse the feasibility of implementing paternalistic taxation in the presence of cross-border shopping and commodity tax competition. As is well known from previous literature, commodity tax competition between neighbouring countries can have the negative effect of eroding a country's tax base, when consumers take advantage of the opportunity of making cheaper purchases abroad. When governments wish to pursue paternalistic policies, tax competition causes a further externality which has thus far not been analysed in the literature: the possibility of cross-border shopping may undermine a government's attempts to control harmful consumption by relatively high taxation at home.

An interesting example is provided by recent developments in the Nordic countries. The excise duty on spirits was reduced by 45% in Denmark in October 2003. This change was at least in part prompted by relatively low prices of alcohol in Germany, and the desire to curtail cross-border shopping. Similarly, alcohol taxes were reduced in Finland on average by 33% in 2004, as a response to the lower alcohol taxes and prices in central Europe and in Estonia. A major motivation was that due to the removal of

[1] The possibility of government failure may reduce the effectiveness and desirability of paternalistic policies. Despite the importance of this consideration, we abstract from this issue in the current paper. See for example Thaler and Sunstein (2003) for arguments in favour of paternalism, and Glaeser (2006) for a critical view.

restrictions on alcohol purchases from Estonia, high taxes on alcohol were expected to become an inefficient tool for controlling alcohol consumption in Finland. In response to the new Danish and Finnish policies, also Sweden has been under considerable pressure to lower its taxes on alcohol, which are currently among the highest in the EU (European Commission, 2004).

In the current paper, we first consider a country whose government wishes to use taxation to reduce the consumption of a harmful good when consumers have an option to purchase the good more cheaply abroad. In this analysis we take the foreign price as exogenous. We show that the paternalistic component of the tax is reduced due to the possibility of cross-border shopping, but it does not disappear altogether. The intuition is that cross-border shopping causes taxes to be a less effective means for controlling harmful consumption, but not completely so: due to transportation costs, the increase in purchases made abroad caused by a domestic tax increase is smaller than the corresponding reduction in domestic purchases. Hence taxation can still be used to lower *total* consumption, albeit to a lesser extent than in the absence of cross-border shopping.

In addition to analysing how cross-border shopping affects the optimal tax on a harmful good when foreign prices can be taken as exogenous, we examine the implications of tax competition. We assume that consumer preferences are identical in the two countries, but one of the governments wishes to pursue paternalistic taxation whereas the other does not. Building on the model of Haufler (1996), we show that in this case an asymmetric Nash equilibrium exists, where the paternalistic country has a higher tax rate on the harmful good than the other country.

We further analyse whether policy coordination in the form of minimum tax rates or tax harmonisation can be used to alleviate problems arising from tax competition in this context. We show that the welfare effect of a binding minimum tax requirement on the low-tax country is in general ambiguous. However, a stronger paternalistic concern makes it more likely that the policy is Pareto improving. Our results indicate that for quadratic transport costs, the welfare effect on the high-tax country is unambiguously positive, and we show that there are relevant conditions under which the policy is beneficial also for the low-tax country. The two countries can both therefore benefit from a minimum tax rate requirement, despite the divergence in policy objectives. Tax rate harmonisation, on the other hand, is shown always to harm the low-tax country.

As a practical example of coordination in setting tax rates on harmful goods, the EU has minimum rates for excise duties on most types of alcohol. These were binding on a number of member states when the policy was adopted in 1992, but do not

seem to be so anymore. Accordingly, the European Commission has recommended an inflation adjustment of the minimum rates, but no further harmonisation is planned due to the differences in views on alcohol taxation between the member states. (European Commission, 2004).[2] However, the proposed adjustment to the minimum rates has recently faced opposition from some member countries that would be affected by the reform. Regarding the excise duty on tobacco products, a tightening of the EU minimum rate requirements was introduced in 2002, along with measures that lead to greater harmonisation in the rates. Health concerns are specifically mentioned as a motivation for the tightening of the minimum rates. (Directive 2002/10/EC; European Commission, 2001).

Our paper is closely related to previous literature on commodity tax competition[3], and in particular to the paper by Haufler (1996). Haufler considers commodity tax competition in a setting where governments of the two countries differ in their valuation for public goods. As in his model, we assume that producer trade is taxed under the destination principle (that is, taxes on the traded goods are levied in the destination country), whereas origin-based taxation is applied to cross-border purchases by consumers. Such a mixed tax system is currently in place in the EU (as a result of the abolition of border controls for consumer purchases), and the framework is therefore particularly well suited to analyse the issues that we are interested in. Haufler's paper also extends the earlier analysis of Kanbur and Keen (1993) by allowing governments to care not only about tax revenue but also about private consumption. Our paper differs from Haufler's analysis in that we allow the government's preferences to differ from those of consumers in one of the countries. Therefore, even though the government takes consumer surplus into account, increases in consumption are not always beneficial for social welfare. As was explained above, tax competition then has the further negative effect of undermining the government's ability to control harmful consumption.

Our analysis has particular similarities also with the analysis of commodity tax competition in the presence of externalities: negative health effects (in the case of consumers with self-control problems) as well as negative externalities are both harmful effects not taken into account by consumers, and governments might wish to alleviate these effects through taxation. Most of the literature on environmental taxation

[2] See also Cnossen (2006) for an analysis of alcohol taxation in Europe.

[3] We will not attempt to summarise this large literature here, but refer to the seminal contribution on commodity tax competition by Mintz and Tulkens (1986), to Haufler (2001) for a recent survey of the literature, and to Lockwood (2001) for a synthesis of various results from the previous literature.

in an international context has however concentrated on the analysis of cross-border environmental externalities (see for example Cremer and Gahvari (2005) and Aronsson and Blomquist (2003) and the references therein). In our context, the negative effects of consumption are local in the sense that they accrue only on the country whose consumers consume the harmful good. Further, when the issue is whether the government should adopt a paternalistic policy or not (rather than whether the government should engage in pollution abatement), it is perhaps more plausible to assume that governments of otherwise identical countries may have different policy objectives. Cooperation may thus be more difficult to achieve in our context than in the case of (global) environmental externalities.[4]

Christiansen (2003, 2006) analyses optimal commodity taxation in the presence of local externalities and cross-border shopping. Aronsson and Sjögren (2005) consider the particular problem of alcohol taxation when the local externalities of alcohol consumption are taken into account, and consumers can avoid domestic taxes either through cross-border shopping or illegal production. The focus in these papers is however distinctly different from ours, and they do not consider tax competition explicitly.[5]

The rest of the paper proceeds as follows. In Section 2, we present the model. In Section 3, we analyse paternalistic taxation when consumers can go cross-border shopping in a neighbouring country with an exogenously given, lower tax rate. In Section 4, we analyse the equilibrium with tax competition. In Sections 5 and 6 we consider the welfare effects of two coordination measures, a minimum tax rate requirement and tax harmonisation. Section 7 concludes.

2 The Model

We use a partial equilibrium model of cross-border shopping between two countries, A and B. Each country has a representative consumer who derives utility from consuming a good (c) that can be purchased either in the home country or abroad. Total consumption of this good by the citizen of country i, $i = A, B$, is denoted by c^i, which is the sum of the amount purchased at home (c_i^i) and the amount purchased abroad (c_j^i).[6]

[4] There is also literature on competition in setting environmental standards and capital taxation in the presence of local environmental externalities and capital mobility - see for example Oates and Schwab (1988) and Wilson (1996).

[5] Another related paper is Haaparanta (2006), who examines multilateral tariff reforms in the presence of merit goods.

[6] As we are primarily interested in trade in goods such as alcohol, concentrating on a single homoge-

If the good is purchased abroad, the consumer in country i incurs a transportation cost $\tau\left(c_j^i\right)$. As in previous literature, the transportation cost function is assumed to be continuously differentiable and to have the following properties: $\tau'\left(c_j^i\right) > 0$, $\tau''\left(c_j^i\right) > 0$ if $c_j^i > 0$; and $\tau(0) = \tau'(0) = 0$, $\tau''(0) > 0$. We therefore assume for simplicity that the transport cost functions are the same in both countries[7].

We assume that producer trade is taxed under the destination principle (that is, taxes on the traded goods are levied in the destination country). Under such a tax system, producer arbitrage equalises producer prices in the two countries, and we normalise these prices to 1. Consumer prices are denoted by $q^i = 1 + t^i$ and we assume that in the case of consumer trade, taxes are levied under the origin principle, so that consumers pay taxes in the country where they purchase the good. Consequently, if $t^i > t^j$, consumers in country i purchase part of their consumption in country j, until the point where $t^i = t^j + \tau'\left(c_j^i\right)$. We refer to this condition as the consumer arbitrage condition.

As in Haufler (1996), we distinguish between two different "regimes" according to whether country i has a higher tax rate than the other country. We thus refer to the high-tax country as being in regime I and to the low-tax country as being in regime II. This distinction is crucial in the model of tax competition, since a part of the tax revenues created by the consumption of the citizens of the high-tax country accrue on the low-tax country. If a country is in regime I, the budget constraint of its citizen is given by $\left(1 + t^i\right) c_i^i + \left(1 + t^j\right) c_j^i + \tau\left(c_j^i\right) = B^i$, where B^i is the consumer's income which we assume to be exogenous. If the country is in regime II, the budget constraint is $\left(1 + t^i\right) c^i = B^i$. Following Christiansen (1994), we find it useful to define $s^i = s^i\left(t^i, t^j\right) = \left(1 + t^i\right) c_i^i - \left(1 + t^j\right) c_j^i - \tau\left(c_j^i\right)$, which can be thought of as the income saved by the citizens of the high-tax country due to the possibility of cross-border shopping (i.e. due to buying the quantity c_j^i abroad rather than at home). Further, define $\left(1 + t^i\right) c^i = b^i$. The regime-specific budget constraints can then be rewritten as $b^i - s^i = B^i$ for regime I, and $b^i = B^i$ for regime II.

The consumer's utility function is $u\left(c^i\right)$, and this is maximised subject to the regime-specific budget constraint. This maximisation yields the regime-specific (total) demand functions $c_I^i\left(t^i, b^i - s^i\right)$ and $c_{II}^i\left(t^i, b^i\right)$, as well as the indirect utility functions

nous good seems appropriate. Tax competition with trade in differentiated goods has been analyzed for example in Lockwood (2001). See also Christiansen (2003, 2006) for analyses where some goods are cross-border traded while others are only purchased at home.

[7] This assumption is a sufficient condition for the existence of a Nash equilibrium in the tax setting game we set out below. Haufler (1996) has shown (in a model without paternalism) that this type of a game has a Nash equilibrium if the second derivatives of the transport cost functions are equal in the two countries.

$v_I^i\left(t^i, b^i - s^i\right)$ and $v_{II}^i\left(t^i, b^i\right)$. As in Haufler (1996), the comparative statics of the consumption levels with respect to each of the tax rates (or equivalently, consumer prices) are completely determined by the consumer arbitrage condition and regime-specific budget constraints. They are given by the following expressions:

$$\begin{array}{rcl} R\ I & : & \dfrac{\partial c_j^i}{\partial q^i} = \dfrac{1}{\tau''} > 0, \quad \dfrac{\partial c_i^i}{\partial q^i} = \dfrac{-c_i^i}{q^i} - \dfrac{1}{\tau''} < 0, \quad \dfrac{\partial c^i}{\partial q^i} = \dfrac{-c_i^i}{q^i} < 0 \\ \dfrac{\partial c_j^i}{\partial q^j} & = & \dfrac{-1}{\tau''} < 0, \quad \dfrac{\partial c_i^i}{\partial q^j} = \dfrac{-c_j^i}{q^i} + \dfrac{1}{\tau''} <> 0, \quad \dfrac{\partial c^i}{\partial q^j} = \dfrac{-c_j^i}{q^i} < 0 \\ R\ II & : & \dfrac{\partial c^i}{\partial q^i} = \dfrac{-c^i}{q^i} < 0, \quad \dfrac{\partial c^i}{\partial q^j} = 0 \end{array} \tag{1}$$

We allow the government's valuation of private consumption to differ from the citizen's valuation: specifically, we assume that the government values consumption according to[8] $\bar{u}(c^i) = u\left(c^i\right) - h(c^i)$. The function $h(c^i)$ denotes harm caused by consumption that is not taken into account by the consumer, with $h' > 0$, and h can be either concave or convex as long as $u'' - h'' < 0$. For example in the case of alcohol consumption, h is most likely to be either convex or linear (see for example Johansen *et al* (2005), White *et al* (2002)). Our formulation captures the example of self-control problems mentioned in the introduction.[9]

Our choice of $\bar{u}(c^i)$ implies that private consumption is excessive from the government's point of view. There is then scope for paternalism in policy making: the government can aim to influence private consumption decisions towards its favoured outcome through its choice of the tax rate.

Total social welfare is taken to be the sum of the utility from private consumption and from public funds. Let γ denote the marginal social value of tax revenue from the tax on the cross-border traded good (or the marginal cost of raising revenue from other tax bases).[10] Using the notation $\bar{v}(.) = v\left(.\right) - h(.)$, the government therefore chooses

[8] Racionero (2001) uses a similar functional form to examine optimal taxation in the presence of merit goods.

[9] To see this, assume that consumption has delayed utility costs equal to $\bar{h}\left(c^i\right)$ that accrue in the period following consumption, and let $h(c^i) = (1-\beta)\,\delta\bar{h}\left(c^i\right)$,where δ is the standard exponential discount factor. This formulation then captures the case where the government wants to maximise the lifetime utility of an individual who uses a quasi-hyperbolic discount function with parameter β (see for example Laibson (1997)).

[10] We use a partial equilibrium set-up where demands for other goods are assumed to be independent of the demand for the good under consideration and consequently, other tax bases are unaffected by the taxes in question. A similar assumption is (often implicitly) made in most of the cross-border shopping literature. It is therefore also natural to assume that γ is constant with respect to t^i, as for example in Christiansen (1994).

the tax rate to maximise $W_I^i = \bar{v}_I^i\left(t^i, b^i - s^i\right) + \gamma t^i c_i^i$ if it is in regime I. In regime II, the total welfare function to be maximised is $W_{II}^i = \bar{v}_{II}^i\left(t^i, b^i\right) + \gamma t^i\left(c^i + c_i^j\right)$.

3 Paternalistic taxation with cross-border shopping

3.1 Closed-economy benchmark

As a benchmark, let us first consider the policy that would be chosen by the government of a country (say country A) with a paternalistic objective, when there is no cross-border shopping. The government's objective function is then given by $W^A = \bar{v}^A\left(t^A, b^A\right) + \gamma t^A c^A\left(t^A, b^A\right)$.Denoting the consumer's marginal utility of income by α, the first-order condition is

$$-\alpha c^A - h'(c^A)\frac{\partial c^A}{\partial q^A} + \gamma\left(c^A + t^A\frac{\partial c^A}{\partial q^A}\right) = 0. \tag{2}$$

The optimal tax is given implicitly by the rule

$$t^A = \frac{h'(c^A)}{\gamma} - \frac{\left(1 - \alpha/\gamma\right)q^A}{\eta^A}, \tag{3}$$

where $\eta^A = \frac{\partial c^A}{\partial q^A}\frac{q^A}{c^A}$ is the elasticity of demand. The first term in this expression reflects paternalistic concerns and it enters the optimal tax formula additively, in accordance with the additivity principle familiar from the context of environmental taxation (Sandmo 1975). Since $h'(c^A) > 0$, this term is positive and if the harm function is convex, it is the larger the higher is consumption (and therefore, the further away equilibrium consumption is from optimal consumption). Paternalistic concerns therefore lead to higher taxation, as expected.

The second term in (3) reflects the standard public finance argument for taxation, and indicates that the magnitude of the tax depends on how sensitive demand is to price changes. The role of the term $1 - \alpha/\gamma$ merits some discussion, as it appears several times in the analysis. The parameter α is the marginal utility of income, γ is the shadow price of tax revenues, and α/γ is therefore the inverse of the shadow cost of public funds.

When taxation is distortive, we know that $1 - \alpha/\gamma > 0$. However, in the case of paternalistic taxation, taxes have also a corrective role and it is not clear a priori, whether α/γ is larger or smaller than unity. The difference between the paternalistic and standard cases is clear from (2): in the absence of paternalism, the first-order

condition implies that $1 - \alpha/\gamma > 0$, but when the government has a paternalistic objective, the sign of $1 - \alpha/\gamma$ is in general ambiguous. In what follows we assume that taxation is distortive - that is, at the optimum, taxation is used in excess of what would be required to correct the distortion in the consumption of the harmful good. This seems to be a reasonable assumption, since it is unlikely that a corrective tax on tobacco, say, will be sufficient to satisfy a modern government's revenue requirement. We therefore assume throughout the paper that $1 - \alpha/\gamma > 0$.

Consequently, we can also note that in the presence of distortionary taxation, the paternalistic part of the tax is lower than in the first-best case where taxation is not distortionary. In the first-best situation, the optimal tax would be given by $t^A = \frac{h'(c^A)}{\alpha} > \frac{h'(c^A)}{\gamma}$. This result is analogous to the principle of incomplete internalisation of environmental externalities in the presence of distortive taxation (Bovenberg and de Mooij 1994), and it can be explained by the fact that the marginal costs of harm reduction increase with the marginal cost of public funds.

3.2 The effect of cross-border shopping

Let us next consider how the optimal tax is affected when cross-border shopping is possible. Let country A be the home country whose tax decision we are interested in, and assume that there exists a neighbouring country B with a lower, exogenously given level of taxes. Country A is then in regime I: consumers in country A purchase part of their consumption in country B, until the point where $t^B = t^A + \tau'\left(c_B^A\right)$ and their consumption is such that the budget constraint $b^A - s^A = B^A$ is satisfied.

The government's objective function is now given by $W_I^A = \bar{v}^A\left(t^A, b^A - s^A\right) + \gamma t^A c_A^A$ and the first-order condition is $-\alpha c_A^A - h'(c^A)\frac{\partial c^A}{\partial q^A} + \gamma\left(c_A^A + t^A\frac{\partial c_A^A}{\partial q^A}\right) = 0$. Rearranging this condition yields the optimal tax rule in the case of cross-border shopping, which is given by

$$t^A = \frac{h'(c^A)}{\gamma}\frac{\eta^A}{\eta_A^A}\frac{c^A}{c_A^A} - \frac{(1-\alpha/\gamma)\,q^A}{\eta_A^A}, \tag{4}$$

where $\eta_A^A = \frac{\partial c_A^A}{\partial q^A}\frac{q^A}{c_A^A}$ and $\eta^A = \frac{\partial c^A}{\partial q^A}\frac{q^A}{c^A}$. Looking at the public finance part of the tax rule (the last term), the demand elasticity that is relevant from the public finance point of view is now the elasticity of *domestic* demand, since this is the quantity that determines the tax base in the case of cross-border shopping[11]. Using the comparative statics results in (1), it is easy to show that $\left|\eta_A^A\right| > \left|\eta^A\right|$. Therefore the public finance

[11] Christiansen (1994) obtains a similar result in a model without paternalism (see Proposition 1 in his paper).

part of the tax rule is scaled down due to the increased elasticity of the domestic tax base in the presence of cross-border shopping.

Further, comparing equations (3) and (4), the paternalistic term in the tax rule is multiplied by $\frac{\eta^A}{\eta^A_A}\frac{c^A}{c^A_A}$: in the presence of cross-border shopping, the paternalistic component of the tax is increasing in the ratio of the elasticity of total demand to the elasticity of domestic demand. This finding has an intuitive explanation: since the harmfulness of consumption is determined by total demand, this ratio of elasticities describes the effectiveness of tax policy as a means of reducing harmful consumption in an open economy.

Recalling that $c^A = c^A_A + c^A_B$, we can derive another useful formulation of the optimal tax rule, which enables us to evaluate the magnitude of the multiplier on the paternalistic term. Equation (4) can be written as

$$t^A = \frac{h'(c^A)}{\gamma}\left(1 + \frac{\eta^A_B}{\eta^A_A}\frac{c^A_B}{c^A_A}\right) - \frac{(1-\alpha/\gamma)\,q^A}{\eta^A_A}, \tag{5}$$

where $\eta^A_B = \frac{\partial c^A_B}{\partial q^A}\frac{q^A}{c^A_B}$. The paternalistic term is now multiplied by $1 + \frac{\eta^A_B}{\eta^A_A}\frac{c^A_B}{c^A_A}$. Using the comparative statics results given in (1), it can be seen that $-1 < \frac{\eta^A_B}{\eta^A_A}\frac{c^A_B}{c^A_A} < 0$. Our results therefore show that as a response to cross-border shopping, the paternalistic component of the tax is scaled down[12]. The intuition for this result is that taxation has now become a less efficient means for controlling harmful consumption, since the benefit from harm-abatement must now be traded off against inducing costly cross-border shopping.

However, it is interesting to note that the paternalistic component is not reduced to zero, and paternalistic concerns therefore continue to play a role in optimal tax policy even with cross-border shopping. It is worth stressing that this result does not depend for example on the strength of the paternalistic objective, or on the magnitude of transport costs.

The intuition for the result that paternalism continues to play a role in tax policy despite cross-border shopping is the following: even if there is extensive cross-border shopping, changes in the domestic tax rate cause larger changes in domestic demand (c^A_A) than in the amount of cross-border shopping (c^A_B) (see (1)); this is because transport costs imply that cross-border shopping is an imperfect substitute for domestic

[12]It should be noted that the discussion in this section suffers from the common problem that the "scaling down" refers to the components of the (implicit) tax rule, and not necessarily to the level of taxes when the economy moves between the two different equilibria considered. Limitations of this type are very common in the optimal taxation literature, and have recently been discussed for example by Gaube (2005).

consumption. Increases in the domestic tax rate will therefore reduce overall consumption regardless of the level of transport costs. As the level of total consumption determines the amount of harm from consumption, a paternalistic consideration will always be present in the optimal tax formula. The magnitude of the adjustment to the paternalistic component of the optimal commodity tax does, however, depend on the shape of the transport cost function: $\frac{\eta_B^A}{\eta_A^A}\frac{c_B^A}{c_A^A} \to -1$ when $\tau'' \to 0$ and $\frac{\eta_B^A}{\eta_A^A}\frac{c_B^A}{c_A^A} \to 0$ when $\tau'' \to \infty$. Therefore, as expected, the paternalistic part of the tax is high when transport costs are highly convex, and low when transport costs are close to linear (and cross-border shopping is therefore more sensitive to changes in the domestic tax rate).

Our results on how cross-border shopping affects paternalistic commodity taxation are summarised in the following proposition:

Proposition 1 *Assume that a government wishes to use paternalistic taxation to affect the consumption of a commodity. When this commodity is subject to cross-border shopping, the paternalistic component of the tax on the commodity is scaled down, but it is not reduced to zero. The paternalistic component of the tax is the higher the more elastic total demand is relative to domestic demand.*

4 Tax competition

4.1 Existence of a symmetric equilibrium

Let us next analyse the equilibrium under tax competition in a symmetric setting. In addition to assuming that individuals in the two countries have the same preferences, in the following analysis we will further assume that incomes in the two countries are identical ($b^i = b^j = b$). In the current subsection we further assume that the two government's have identical preferences; this assumption will subsequently be relaxed.

As a first step, we need to derive the reaction function of country i, taking into account that it can in principle be either the high-tax or the low-tax country, depending on the policy chosen by its neighbour. As in Haufler (1996), we therefore first derive separate reaction functions for the cases where the country is in either regime, taking into account that in regime I, the tax rate of country i has to be at least as high as the tax rate of country j, and vice versa in regime II. We then show that the reaction function is continuous at the point where the country switches regime (that is, at the point $t^{i*} = t^j$). This guarantees the existence of equilibrium in the tax setting game[13].

[13] The second-order conditions are reported in the appendix.

The first-order conditions for the government's optimisation problem in the two regimes are given by

$$R\ I: \begin{cases} \frac{\partial W_I^i}{\partial t^i} = -\alpha c_i^i - h'(c^i)\frac{\partial c^i}{\partial q^{i*}} + \gamma\left(c_i^i + t^{i*}\frac{\partial c_i^i}{\partial q^i}\right) = 0 \text{ if } t^{i*} \geq t^j \\ t^{i*} = t^j \text{ otherwise.} \end{cases} \tag{6}$$

$$R\ II: \begin{cases} \frac{\partial W_{II}^i}{\partial t^i} = -\alpha c^i - h'(c^i)\frac{\partial c^i}{\partial q^{i*}} + \gamma\left(c^i + t^{i*}\frac{\partial c^i}{\partial q^{i*}} + c_i^j + t^{i*}\frac{\partial c_i^j}{\partial q^{i*}}\right) = 0 \text{ if } t^{i*} \leq t^j \\ t^{i*} = t^j \text{ otherwise.} \end{cases} \tag{7}$$

Substituting in the expressions for the partial derivatives in (6) and (7), we obtain

$$R\ I: \begin{cases} \frac{\partial W_I^i}{\partial t^i} = -\alpha c_i^i + h'(c^i)\frac{c_i^i}{q^{i*}} + \gamma\left(\frac{c_i^i}{q^{i*}} - \frac{t^{i*}}{\tau''}\right) = 0 \text{ if } t^{i*} \geq t^j \\ t^{i*} = t^j \text{ otherwise.} \end{cases} \tag{8}$$

$$R\ II: \begin{cases} \frac{\partial W_{II}^i}{\partial t^i} = -\alpha c^i + h'(c^i)\frac{c^i}{q^{i*}} + \gamma\left(\frac{c^i}{q^{i*}} + c_i^j - \frac{t^{i*}}{\tau''}\right) = 0 \text{ if } t^{i*} \leq t^j \\ t^{i*} = t^j \text{ otherwise.} \end{cases} \tag{9}$$

The above equations define the reaction function $t^{i*}(t^j)$ of country i. Since $c_j^i \to 0$ and $c_i^i \to c^i$ as $t^i \to t^j$, the reaction function is continuous. If both countries have the same objective function, there therefore exists a symmetric Nash equilibrium where $t^{i*} = t^{j*}$.

4.2 Asymmetric equilibrium when one country has a paternalistic objective

Consider as a starting point a symmetric case where neither country has a paternalistic objective. In this case, the term $h'(c^i)\frac{\partial c^i}{\partial q^{i*}}$ in the above reaction functions is zero for both countries and there is a symmetric equilibrium. Now consider a change where in one of the countries, say in country A, a government with a paternalistic objective comes into power, whereas in the other country the situation remains unchanged. We know from equation (5), that this causes an increase in the tax rate in country A (corresponding to an outward shift in country A's reaction function).

In order to determine what happens in country B, we need to analyse the slope of its reaction function. Country B is now in regime II and has no paternalistic objective,

and its reaction function is therefore given by

$$\frac{\partial W_{II}^{B}}{\partial t^{B}} = R^{B}\left(t^{B}, t^{A}\right) = -\alpha c^{B} + \gamma\left(c^{B} + t^{B*}\frac{\partial c^{B}}{\partial q^{B*}} + c_{B}^{A} + t^{B*}\frac{\partial c_{B}^{A}}{\partial q^{B*}}\right) = 0. \tag{10}$$

Totally differentiating (10), the slope of country B's reaction function is given by $\frac{dt^B}{dt^A} = -\frac{\partial R^B\left(t^B,t^A\right)\,/\,\partial t^A}{\partial R^B(t^B,t^A)\,/\,\partial t^B} = -\frac{\partial^2 W_{II}^B\left(t^B,t^A\right)\,/\,\partial t^B\;\partial t^A}{\partial^2 W_{II}^B(t^B,t^A)\,/\,(\partial t^B)^2}$. The denominator of this expression is the second-order condition for country B, and is therefore negative. The numerator is given by

$$\frac{\partial R^{B}\left(t^{B}, t^{A}\right)}{\partial t^{A}} = \gamma\left(\frac{\partial c_{B}^{A}}{\partial q^{A}} + t^{B*}\frac{\partial^{2} c_{B}^{A}}{\partial q^{B}\partial q^{A}}\right)$$

This expression is simplified by assuming that the total transport cost function is quadratic, which is a common simplifying assumption in the literature on commodity tax competition (see for example Kanbur and Keen (1993) and Haufler (1996, 2001)). We therefore assume from now on that the transport cost function is $\tau = 1/2\theta\left(c_j^i\right)^2$, $\theta > 0$. In this case the amount of cross-border shopping is linear in the difference in tax rates ($c_B^A = \frac{q^A - q^B}{\theta}$), and we therefore have that $\frac{\partial^2 c_B^A}{\partial q^B \partial q^A} = 0$. Using this together with (1), we find that $\frac{\partial R^B\left(t^B,t^A\right)}{\partial t^A} > 0$ and hence that $\frac{dt^B}{dt^A} > 0$.Therefore, the two tax rates are strategic complements from the point of view of country B, and the policy shift in country A causes country B's tax rate also to increase.

To determine the relative magnitude of the increase in country B's tax rate, we substitute the comparative statics results from (1), as well as the transport cost function into the expression for $\frac{dt^B}{dt^A}$. After some manipulations, we obtain

$$\frac{dt^{B}}{dt^{A}} = \frac{1}{2 + \theta\left(\frac{2}{q^{B*}} - \frac{\alpha}{\gamma}\right)\frac{c^{B}}{q^{B*}}} \tag{11}$$

Since we have assumed that $1 - \alpha/\gamma > 0$, this expression is smaller than 1 (in fact, smaller than 1/2). Therefore the tax rate in country B increases by less than the tax rate in country A.[14] Therefore, there exists an asymmetric Nash equilibrium, where the paternalistic country has the higher tax rate. We can state the following proposition:

Proposition 2 *Starting from a symmetric equilibrium where neither government has a paternalistic objective, consider a small change whereby one country adopts paternalistic taxation to reduce the consumption of a harmful good. Both countries' tax rates*

[14]The original equilibrium therefore satisfies the "stability" conditions of Nash equilibrium (see Dixit (1986)), which are equivalent with $\left|\frac{dt^B}{dt^A}\right| < 1$.

increase, and there is an asymmetric equilibrium where the paternalistic country has the higher tax rate.

5 Minimum tax rates

Let us next turn to the question whether policy coordination can be beneficial when the starting point is the equilibrium examined in the previous section. In the current section, we examine whether welfare can be increased by setting a binding minimum tax rate requirement. In the following section, we will analyse the effects of tax rate harmonisation. Both are key measures that have been proposed in the EU to curtail excessive cross-border shopping.

5.1 Welfare effect on the high-tax country

In order to examine whether a binding minimum tax rate requirement on the low-tax country would improve welfare in the high-tax country, we differentiate the welfare function of country A with respect to country B's tax rate. As country A is in regime I and has a paternalistic objective, its welfare function is $W_I^A = \bar{v}_I^A\left(t^A, b^A - s^A\right) + \gamma t^A c_A^A$. The derivative with respect to country B's tax rate is given by

$$\begin{aligned} \frac{\partial W_I^A}{\partial t^B} &= -\alpha c_B^A - h'(c^A)\frac{\partial c^A}{\partial q^B} + \gamma t^A \frac{\partial c_A^A}{\partial q^B} \\ &= \left(-\alpha + \frac{h'(c^A)}{q^A}\right) c_B^A + \gamma t^A \left(\frac{-c_B^A}{q^A} + \frac{1}{\tau''}\right) \end{aligned} \tag{12}$$

From this expression, we can isolate two effects, identified in previous literature (see Mintz and Tulkens (1986) and Haufler (1996)), of an increase in the low-tax country's tax rate on the high-tax country's welfare: firstly, the private consumption effect, which is given by the two first terms in (12), is the direct welfare effect of the reduction in private consumption, caused by the increased cost of cross-border shopping. Secondly, the public consumption effect, given by the last term in (12), gives the effect of the increase in the low-tax country's tax rate on government revenue in the high-tax country[15].

[15] These effects have been aggregated into the "consumer price spillover" in Lockwood (2001). Lockwood further discusses two other tax spillovers, namely producer price spillovers and rent spillovers.

Consider first the private consumption effect. The nature of this effect is in our context very different from the standard case: in our setting, high consumption is not necessarily beneficial for welfare, and a tax increase in the low-tax country therefore generates a positive spillover on the high-tax country not analysed in previous literature. In the standard case without paternalism, the private consumption effect is always negative, and consists only of the very first term in (12), $-\alpha c_B^A$: this is a terms of trade effect, as consumers experience a loss due to more expensive cross-border shopping. However, the paternalistic objective implies that the sign of the private consumption effect may be reversed: in the case with paternalism, the reduction in consumption has an additional positive effect (given by the term $-h'(c^A)\frac{\partial c^A}{\partial q^B}$), as the harm caused by consumption is thereby reduced[16]. In net, the sign of the private consumption effect is thus in our case ambiguous. From (12), it is positive if $q^A < \frac{h'(c^A)}{\alpha}$. The high-tax country is therefore more likely to benefit from the tax increase in the low-tax country when the marginal harm created by consumption is high and the paternalistic objective therefore plays a stronger role.

The last term in (12) refers to the public consumption effect. This effect is identical to the standard case, as presented in Haufler (1996). The public consumption effect can be either positive or negative, depending on whether an increase in the low-tax country's tax rate increases or reduces domestic demand. The latter case, which may seem paradoxical, can be explained by the fact that a tax increase in the low-tax country reduces not only cross-border shopping, but also *total* demand c^A due to an income effect. Whether the domestic tax base increases or decreases when the foreign tax rate is increased, depends on how responsive cross-border shopping is to changes in the tax rate differential; this in turn depends on the shape of the transport cost function. Let us again consider the special case of quadratic transport costs. As in Haufler (1996), the public consumption effect is then unambiguously positive: domestic demand is then given by $c_A^A = \frac{1}{q^A}\left(1 - \frac{q^A - q^B}{\theta} - \frac{\left(t^A\right)^2 - \left(t^B\right)^2}{2\theta}\right)$ and therefore $\frac{\partial c_A^A}{\partial q^B} = \frac{q^B}{\theta q^A} > 0$.

However, the ambiguity about the sign of the private consumption effect is not resolved by assuming quadratic transport costs, as it depends primarily on the extent of harm from consumption. Further analysis is therefore needed to determine whether the overall effect in (12) is positive or negative. Noting again that with quadratic

These effects however are only present when there is imperfect factor mobility or imperfect competition, respectively, and therefore do not arise in our model.

[16] Christiansen (2006) has independently obtained similar results in a context where there are negative externalities from the consumption of a cross-border traded good (see Proposition 4 in his paper). The emphasis in his paper - the effect of cross-border shopping on the optimal commodity tax structure - is distinctly different from ours.

transport costs $c_B^A = \frac{q^A - q^B}{\theta}$, the expression for $\frac{\partial W_I^A}{\partial t^B}$ becomes

$$\frac{\partial W_I^A}{\partial t^B} = \left[-\alpha + \frac{h'\left(c^A\right)}{q^{A*}} + \frac{\gamma}{q^{A*}} \frac{\left(q^{A*} - 1\right) q^{B*}}{\left(q^{A*} - q^{B*}\right)} \right] > 0.$$

This expression can easily be shown to be positive by comparing it with the high-tax country's first-order condition (8). Therefore, if transport costs are quadratic, the sum of the private and public consumption effects is positive, and the paternalistic country benefits from a binding minimum tax rate requirement on the low-tax country.

5.2 Welfare effect on the low-tax country

Let us next consider the effect of a binding minimum tax rate requirement on welfare in the low-tax country. If the required increase in the tax rate of the low-tax country is small, then the welfare effect of a binding minimum tax rate on the low-tax country itself depends only on the reaction of the high-tax country. We therefore need to examine firstly, how country B's welfare is affected by changes in country A's tax rate, and secondly, how country A's tax rate reacts to a (small) increase in country B's tax rate.

The effect of a change in country A's tax rate on welfare in country B is given by $\frac{\partial W_{II}^B}{\partial t^A} = \gamma t^B \frac{\partial c_B^A}{\partial q^A} > 0$: an increase in the high-tax country's tax rate would unambiguously increase the amount of cross-border shopping, and it thus only has a positive public consumption effect on the low-tax country. Therefore, if the tax rates are strategic complements also from the point of view of country A, and an increase in country B's own tax rate therefore induces country A also to increase its tax rate, then the minimum tax rate requirement increases welfare in country B.

To examine how country A's tax rate reacts to an increase in country B's tax rate, we need to find the slope of country A's reaction function. Country A is in regime I and has a paternalistic objective, and its reaction function (from (8)) is therefore given by

$$\frac{\partial W_I^A}{\partial t^A} = R^A\left(t^B, t^A\right) = -\alpha c_A^A + h'(c^A)\frac{c_A^A}{q^{A*}} + \gamma\left(\frac{c_A^A}{q^{A*}} - \frac{t^{A*}}{\tau''}\right) = 0 \qquad (13)$$

By a similar argument as in the previous section, $sign\left(\frac{dt^A}{dt^B}\right) = sign\left(\frac{\partial R^A}{\partial t^B}\right)$. Differentiating (13) yields

$$\frac{\partial R^A\left(t^B,t^A\right)}{\partial t^B}=\left(-\alpha+\frac{h'(c^A)}{q^{A*}}+\frac{\gamma}{q^{A*}}\right)\frac{\partial c_A^A}{\partial q^B}+h''(c^A)\frac{\partial c^A}{\partial q^B}\frac{c_A^A}{q^{A*}}. \tag{14}$$

The sign of this expression is in general ambiguous. We can however again analyse the special case of quadratic transport costs. In this case we know that $\frac{\partial c_A^A}{\partial q^B}>0$. It can also be observed from country A's first-order condition (13) that $-\alpha+\frac{h'(c^A)}{q^{A*}}+\frac{\gamma}{q^{A*}}>0$. With quadratic transport costs, the first half of (14) is therefore positive.

However, the sign of the latter part, $h''(c^A)\frac{\partial c^A}{\partial q^B}\frac{c_A^A}{q^{A*}}$, hinges on whether the harm function is concave or convex. The sign of $\frac{\partial R^A\left(t^B,t^A\right)}{\partial t^B}$ therefore remains ambiguous even with quadratic transport costs, and it is guaranteed to be positive only if the harm function is not too convex. When the harm function is very convex, the reduction in consumption caused by higher taxation in country B already causes a large reduction in harm, and the case for domestic tax increases in country A is therefore weakened.

It is interesting to note that with quadratic transport costs, a stronger paternalistic concern in country A makes it more likely that (14) is positive: the stronger the paternalistic concern, the more likely it is that country A increases its tax rate in response to a tax increase in country B. In the previous subsection we concluded that a stronger paternalistic concern also makes it more likely that the high-tax country benefits from the minimum tax rate requirement. Therefore, a stronger paternalistic concern - implying that there is more divergence in the policy objectives of the two countries - makes it more likely that a binding minimum tax rate on the low-tax country is Pareto improving.

Further, if we consider the example of alcohol, recent medical research has provided evidence that the harm function from alcohol consumption may in fact be linear (Johansen *et al* 2005). If this is the case, the last term in (14) vanishes, and a policy of minimum tax rate requirement will be Pareto improving.

We summarise the results of this section in the following proposition:

Proposition 3 *Starting from a symmetric equilibrium where neither government has a paternalistic objective, consider a small change whereby one country adopts paternalistic taxation to reduce the consumption of a harmful good. In the resulting asymmetric equilibrium, the welfare effect of a binding minimum tax rate requirement is in general ambiguous. With quadratic transport costs, the following results hold:*

(i) the welfare effect on the high-tax country is positive.

(ii) the welfare effect on the low-tax country is positive if the harm function is not too convex.

(iii) a stronger paternalistic objective makes it more likely that the policy is Pareto improving.

Our analysis has therefore shown that even when countries have very different views about the proper role of alcohol taxation - whether it should be used for revenue raising purposes only, or as part of national health policy - they can benefit from policy coordination. The different views about alcohol taxation held for example by different member states of the EU should therefore not be an obstacle to policy coordination aimed at eliminating harmful tax competition.

6 Tax harmonisation

Let us finally analyse another possible coordination measure which has been discussed by European policy makers, namely tax rate harmonisation. Our argument in this section is most closely related to the analysis of tax harmonisation in Kanbur and Keen (1993). However, Kanbur and Keen as well as various authors building on their analysis (see Nielsen (2001) and Ohsawa (1999)) assume that the governments' objective is to maximise tax revenue. We analyse also the effects on private consumption, taking into account the fact that in our context, increases in private consumption are not always welfare improving[17].

As in previous literature, we take harmonisation to mean that taxes in the two countries are set at a common, intermediate level between the initial tax rates. Such a reform eliminates all cross-border shopping, and might therefore at first sight seem like an attractive remedy for the problems stemming from cross-border shopping and tax competition. However, it is easy to show that in our model the low-tax country would lose from harmonisation to any tax rate $t \in \left(t^{B*}, t^{A*}\right)$.[18] The objective function in the (previously) low-tax country, country B, is now given simply by $W^B = v\left(t\right) + tc^B\left(t\right)$. Consumption depends only on the country's own tax rate, as in the previous equilibrium. Since the harmonised tax rate $t > t^{B*}$, private consumption must fall in country B after harmonisation. Further, government revenue must also fall: the country

[17] See also Keen (1987, 1989) for seminal contributions to the literature on tax harmonisation (looking at destination-based taxes) and Lopez-Garcia (1996) and Kotsogiannis *et al* (2005) for analyses with origin-based taxation. These papers consider tax harmonisation in a setting with differentiated goods, and do not model cross-border shopping or transport costs explicitly. Lockwood (2001) provides a synthesis of many results from the previous literature, but he does not consider harmonisation of origin-based taxes.

[18] As in Kanbur and Keen (1993), we do not consider the possibility of transfers between countries, but look at each country separately and concentrate on whether actual Pareto improvements could be obtained by harmonisation.

loses all tax revenue from cross-border shopping, whereas domestic revenue remains constant, as consumption falls one-for-one with the increased tax rate. Therefore, tax rate harmonisation is certain to reduce welfare in country B.

Turning next to effects in the high-tax country, we can gain useful insights by examining the effects of harmonisation at either of the original tax rates, $t^{B*}$and t^{A*}. Firstly, harmonisation at t^{B*} would be certain to reduce welfare in the high-tax country, since we know that $W^A\left(t^{A*}(t^B), t^B\right) > W^A\left(t^B, t^B\right)$. Secondly, let us consider harmonisation at t^{A*}. We know that total private consumption will necessarily fall: consumers were maximising their consumption at the original equilibrium by doing some cross-border shopping, and therefore private consumption must fall in the new situation where there is no cross-border shopping but domestic consumption is as expensive as before. Government revenue, on the other hand, will increase due to an increase in the tax base: using the consumer budget constraint, we know that in the original equilibrium, government revenue is given by $\frac{b-\tau(c_B^A)-q^{B*}c_B^A}{q^{A*}}t^{A*}$, whereas in the new situation it is simply $\frac{b}{q^{A*}}t^{A*}$.

Thus we have established that in the (previously) high-tax country, private consumption falls and government revenue increases after harmonisation at t^{A*}. In our context, it is not clear whether reductions in consumption are harmful from the social point of view, due to the harm generated by consumption but not taken into account by consumers - see the previous section, where we argued that the private consumption effect may be either positive or negative in the high-tax country in the original equilibrium. In principle, there would therefore be two cases to consider - the one where consumption is too high in the original equilibrium, and the one where consumption is too low. However, since the government's objective function is not monotonic in the level of consumption, it is not possible to derive unambiguous results for the welfare effect on country A in either of these cases[19].

As an aside, it is interesting to note that the result in Kanbur and Keen (1993), that harmonisation to t^A (or any tax rate sufficiently close to it) would always be welfare improving in the high-tax country, does not seem to be robust - in the conventional setting where increases in consumption are beneficial - to extending the government's welfare function beyond simple revenue maximisation. When increases in consumption are beneficial, country A might either benefit or lose out from harmonisation to t^{A*}, depending on the relative weights given to private and public consumption in the social

[19]Even in the case where consumption was inititally too high and a marginal reduction in consumption would therefore be beneficial, we cannot conclude that welfare would be increased by a discrete increase in country B's tax rate from t^{B*} to t^{A*}, as consumption in county A might then be reduced too much.

welfare function.

How about the welfare effects in country A of harmonisation at some tax rate $t \in \left(t^{B*}, t^{A*}\right)$? Since harmonisation at t^{B*} strictly lowers welfare in country A, by continuity, there is another threshold tax rate $\hat{t} \in \left(t^{B*}, t^{A*}\right)$ below which harmonisation will still certainly be welfare reducing for country A. However, harmonisation above $\hat{t}$ will have an ambiguous effect on welfare in country A.

We summarise our findings on the welfare effects of tax harmonisation in the following proposition:

Proposition 4 *There exists a tax rate $\hat{t}$, such that tax harmonisation at any $t \in \left(t^{B*}, \hat{t}\right)$ is welfare reducing for both countries. The welfare effect of harmonisation at $t \in \left(\hat{t}, t^{A*}\right)$ is negative for country B and ambiguous for country A.*

Based on our analysis we can therefore say that even though the two countries with different policy objectives can benefit from coordination as shown in Proposition 3, the coordination should be done through minimum tax rate requirements rather than through tax rate harmonisation. Welfare is not reduced by cross-border shopping per se, but by tax rates being too low. The more effective remedy is therefore to implement mandatory increases in tax rates, rather than to eliminate cross-border shopping by tax harmonisation.

7 Conclusions

In this paper we have analysed how the possibility of using taxation as a tool to control the consumption of a harmful good is affected by cross-border shopping and commodity tax competition. In a context where a paternalistic country has a neighbour with an exogenously given, lower tax rate, we showed that cross-border shopping leads to a reduction of the paternalistic component of the tax on the harmful good: with the possibility of cross-border shopping, domestic taxation is an inefficient instrument for reducing harmful consumption. However, paternalism still continues to play a role in tax policy.

We also analysed explicitly the outcome of tax competition between two countries, one of which has a paternalistic objective whereas the other one does not. In such a situation, the paternalistic country has the higher tax rate. We further examined whether welfare could be improved by policy coordination, and showed that the welfare effects of tax harmonisation would be negative on the low-tax country and ambiguous on the high-tax country.

However, the prospects for welfare gains from minimum tax rate requirements seem more promising. It was shown that in a model with quadratic transport costs, the paternalistic country would benefit from a small increase in the other country's tax rate. The low-tax country would also benefit, if the harm function from consumption is not too convex.

Further, it is interesting to note that a stronger paternalistic objective makes it more likely that the policy of a minimum tax rate requirement is Pareto improving: firstly, the paternalistic country is then more likely to benefit from the reduction in consumption caused by a higher foreign tax rate; and secondly, the paternalistic country is then more likely to respond to the minimum tax rate requirement by increasing its tax rate in turn, which is beneficial for the low-tax country as it alleviates the negative externality caused by tax competition.

Our analysis therefore indicates that even countries with very different attitudes towards paternalism can benefit from policy coordination. The divergent views about alcohol taxation held for example by different member states of the EU should therefore not be an obstacle to policy coordination aimed at eliminating harmful tax competition.

Appendix

The second-order condition in the tax competition game for regime I (the high-tax country) is given by

$$\frac{\partial^2 W_I^i\left(t^i,t^j\right)}{\partial t^{i2}}=\left(-\alpha+\frac{h'(c^i)}{q^{i*}}+\frac{\gamma}{q^{i*}}\right)\frac{\partial c_i^i}{\partial q^i}-\left(\gamma+h'\left(c^i\right)\right)\frac{c_i^i}{\left(q^{i*}\right)^2}+h''\left(c^i\right)\frac{\partial c^i}{\partial q^i}\frac{c_i^i}{q^{i*}}-\frac{\tau''-\frac{\tau'''}{\tau''}t^{i*}}{\left(\tau''\right)^2}<0.$$

The first term is negative by (1) and the first-order condition (8). The second term is also negative. The third term is non-positive if the harm function is convex or linear, which we have argued to be the most likely case. Finally, the last term is negative for example if the transport cost function is quadratic (this is a sufficient, though not a necessary condition).

In the case of regime II (the low-tax country), the second-order condition is given by

$$\frac{\partial^2 W_{II}^i\left(t^i,t^j\right)}{\partial t^{i2}}=\left(-\alpha+\frac{2h'(c^i)}{q^{i*}}+\frac{2\gamma}{q^{i*}}\right)\frac{\partial c^i}{\partial q^i}+h''\left(c^i\right)\frac{\partial c^i}{\partial q^i}\frac{c^i}{q^{i*}}-\frac{\left(1+\gamma\right)\tau''+\frac{\tau'''}{\tau''}t^{i*}}{\left(\tau''\right)^2}<0.$$

The first term is guaranteed to be negative given our assumption that $\gamma > \alpha$ and if the tax rate in the low-tax country is less than 100% of the producer price (a sufficient but not a necessary condition). As above, the second term is negative if the harm function is convex or linear, and the last term is negative for example if the transport cost function is quadratic (again a sufficient but not a necessary condition).

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