

Tacit Collusion and International Commodity Taxation*

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Abstract

The paper employs a model of dynamic price competition to study how international commodity taxation affects the stability of collusive agreements when producers in an international duopoly agree not to export into each other's home market. We consider both the choice of international tax principle and the harmonization of tax rates and differentiate between a setting where production costs differ between countries, and a setting where exogenous tax rate differentials are the only asymmetry. The conclusions derived from this model differ strongly from those obtained under the assumption of competitive product markets.

Keywords: commodity taxation, dynamic price competition

JEL classification: H7, L1

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1 Introduction

Taxes on goods and services are among the most important sources of tax revenue in the OECD and the single most important tax base in the European Union. The deepening of economic integration, as signified by cross-border trade and the free movement of goods, has put on the political agenda the issues of tax rate harmonization and the choice of international tax principle. The European Union has agreed on a common minimum rate for value-added taxation (VAT) in order to limit the extent of private cross-border shopping, and a complete harmonization of VAT rates has been proposed (European Commission, 1996). As for the choice of tax principle, there is still widespread discussion within the EU as to whether one should abolish the present system of consumption-based taxation (the destination principle) and switch to taxes on production (the origin principle). This switch would allow to eliminate border tax adjustments that are difficult to maintain in the absence of physical border controls, but it also implies that international VAT differentials would affect the competitiveness of firms. Given the rapid spread of value-added taxation worldwide (see Cnossen, 1998) similar issues may soon be faced by other integrating regions, such as the Commonwealth of Independent States, or by federal countries that introduce VAT at subnational levels.¹

The issues of tax rate harmonization and the choice of commodity tax principle have been discussed in a large literature which can be grouped into three different branches.² With few exceptions, however, these contributions have assumed perfectly competitive product markets. A first strand in the literature analyzes the choice of tax principle. A basic result here is that the destination and origin principles are equivalent, if either exchange rates or producer prices are fully flexible, and if the commodity tax can be levied on all goods at the same rate (see Lockwood, de Meza and Myles, 1994). If there is some selectivity in commodity taxation, then an important distinction arises as to whether tax rates are set in cooperative or non-cooperative ways. With cooperative tax setting, the production efficiency theorem leads to a general argument in favour of the destination principle, since the latter implies that relative price distortions fall on consumer rather than producer prices and international trade remains based on the principle of comparative advantage

¹An example of the latter is India, where policy efforts are under way to replace existing sales taxes, levied under the origin principle, by a state-level VAT (Purohit, 2001).

²See Lockwood (2001) for a recent and thorough synthesis of this literature.

(see, e.g., Keen and Smith, 1996).³ When taxes are set non-cooperatively, however, and countries can affect their terms of trade, then no clear argument emerges in favour of one or the other tax principle (Lockwood, 1993; 2001, sec. 6).

A second set of papers deals with origin-based commodity tax competition in the presence of cross-border shopping. Fundamental results here are that non-cooperative tax rates will be set too low in at least one of the trading countries (Mintz and Tulkens, 1986) and a minimum rate policy – such as that pursued in the EU – leads to a strict Pareto improvement when revenue maximization is the policy objective (Kanbur and Keen, 1993). Finally, a third branch in the literature is concerned with tax rate harmonization when governments can levy differentiated taxes under either the origin or the destination principle. If competition in the goods market is perfect, and the government faces no revenue constraint, then an approximation of tax rates leads to aggregate welfare gains, as it improves exchange efficiency under the destination principle (Keen, 1987, 1989) and production efficiency under the origin principle (Lopez-Garcia, 1996). The conditions for tax harmonization to constitute a Pareto improvement become much more stringent, however, when tax revenues are needed to finance a public good (Delipalla, 1997; Lockwood, 1997; Lahiri and Raimondos-Møller, 1998; Lopez-Garcia, 1998).

In sum, despite a number of caveats, the literature on international commodity taxation in perfectly competitive product markets leads to qualified arguments (*i*) in favour of the destination principle (when countries can cooperate over tax rates), and (*ii*) in favour of tax rate harmonization. Given the policy relevance of these results, it is important to ask whether they continue to hold when the assumption of perfect competition is relaxed. In recent years a few papers have begun to analyze the choice of tax principle and tax rate harmonization in imperfectly competitive markets. Keen and Lahiri (1998) compare the destination and origin principles in a duopoly model where cost structures of the two firms differ. In this setting, they show for a variety of cases under both coordinated and non-coordinated tax setting that the origin principle is likely to dominate from a global efficiency perspective.⁴

³One caveat to this result is that production efficiency may not be desirable from the perspective of world welfare maximization when the trading countries face separate budget constraints and lump-sum transfers between them are excluded (Keen and Wildasin, 2000).

⁴Haufler, Schjelderup and Stähler (2000) incorporate transport costs in the model of Keen and Lahiri (1998) and focus on non-cooperative tax setting. In this framework the welfare comparison between the destination and origin principles depends on the size of trade costs and the destination

With respect to tax rate harmonization, Keen and Lahiri (1993) and Lockwood (2001, sec. 5) have shown that the conditions for a harmonizing reform to be Pareto improving are analogous to their counterparts in the perfectly competitive case when taxes are levied under the destination principle. Under the origin principle, however, the same harmonizing reform unambiguously reduces welfare in each country (Keen, Lahiri and Raimondos-Møller, 2002). In sum, these analyses indicate that many of the policy conclusions for the design of international commodity taxation depend on the competitive conditions in product markets.

It is well known, however, that results derived in imperfectly competitive commodity markets often depend on the precise form that imperfect competition will take. Hence a relevant question is whether the conclusions reached in the above-mentioned literature – which have generally been derived in models of international duopoly – carry over to other settings of imperfect competition. The present paper explores the implications for international tax policy when imperfect competition takes the form of tacit collusion between firms that operate in different markets. The basic questions we ask are which role the choice of commodity tax principle on the one hand, and a policy of tax rate harmonization on the other, can play in undermining the stability of collusive agreements between firms.

The importance of implicit collusion in an international framework – which involves cooperation both within a country and across national boundaries – has recently been highlighted by the record fine of \$ 755 million (Euro 855 million) that the European Commission has imposed on an international group of eight chemical and pharmaceutical companies that have engaged in a vitamin price-fixing scheme for nearly a decade (Financial Times, November 21, 2001, p. 1). It is also documented in a number of empirical studies. Slade (1995) studies 10 industries and finds empirical evidence for international collusion in all but one of these industries. Strong evidence for collusion is found in industries such as diamonds, wood pulp, uranium yellowcake, canadian potash, and cement (see also Scherer, 1996). Detailed evidence for collusion at the national level exists for the telecommunications sector in New Zealand (see King, 1997) and for the Norwegian cement market (Steen and Sjørgard, 1999). The political importance of collusion is furthermore witnessed by the many allegations of collusion at an international level, only some of which are taken

principle dominates the origin principle when these costs are sufficiently high.

to court.⁵ These cases also reveal the difficulty of addressing collusion by means of conventional competition policy. The reason is that firms seldom go into explicit contractual agreements over price or quantity fixing, but instead rely on secret talks or signalling games in the market. These indirect ways of forming collusive agreements imply that public prosecutors must rely on circumstantial evidence, which is often insufficient as a basis for allegations.

Against this background, the present paper uses a standard model of dynamic price competition and tacit collusion, borrowed from the industrial organization literature. The theory of repeated games has been applied to a number of international policy contexts, including the comparison of tariffs and quotas (Rotemberg and Saloner, 1989) and the effects of trade liberalization (Lommerud and Sørsgard, 2001). Recently, it has also been used to study the effects of alternative loss offset provisions under the corporation tax in a closed-economy setting (Gendron, 2001). In this paper we aim to show that this approach can also be usefully applied to issues of international commodity taxation.

We employ a two-country, two-firm model of price competition where national product markets may differ in size and costs of production may vary across firms. In addition, we impose exogenous differences in national VAT rates in the home countries of the two firms. In this framework we consider the choice of an international tax principle and the effects of tax rate harmonization in two different cases. In the first scenario, differences in costs of production are systematically linked to international tax differentials. In the second scenario, tax rates are the only asymmetry between countries. Several of the propositions we derive in these settings strengthen the policy case for the origin principle when markets are imperfectly competitive. We also show that the argument *against* tax rate harmonization may be more general than the previous literature has established.

The remainder of the paper is set up as follows. In Section 2 we present the basic model of dynamic price competition as it applies in our setting. Section 3 asks how differences in market size, costs of production and tax rates affect the incentive of

⁵As a recent example, the competitive regulatory agencies in Denmark, Norway and Sweden have taken coordinated action in bringing to court firms in the plastic pipe and electronics industry for cooperating within national boundaries as well as colluding internationally by creating exclusive national territories. Similar coordinated actions have also been undertaken within the EU in the same industries (see Berlingske Tidende, 7 February, 1999, p.1).

firms to break a collusive agreement. Based on this analysis, Section 4 compares the stability of tacit collusion under the destination and origin principles. Section 5 analyzes the effects of tax rate harmonization and Section 6 concludes.

2 The analytical framework

We follow the standard set-up of infinitely repeated games and consider two firms, labelled $i \in \{1, 2\}$ and located in countries 1 and 2, respectively.⁶ The two firms produce amounts x_i of an identical and homogenous good. Our analysis is partial equilibrium in the sense that we focus on the imperfectly competitive market (or the two national markets) for good x . Implicitly there is an untaxed, tradeable numeraire good in the background which ensures that taxes have an effect on relative prices.

In our international framework, tacit collusion between the two firms implies that both firms refrain from exporting and each firm is thus a monopolist in its home market. In each period, either firm may find it profitable to defect from this implicit agreement and export to the other market, but it knows that this action will cause future retaliation by the other firm. It is well known that there are a large number of equilibria in this type of repeated game and we assume, as is usual in the literature, that the Pareto optimal equilibrium from the viewpoint of the two firms will be realized (see Tirole, 1988, p. 247).

It is a standard result under this set of assumptions that if firm i defects at all, it will do so in the first period ($t = 0$). If firm i deviates from the cartel solution at $t = 0$ and exports to country j , it will in this period catch firm j by surprise. We call this the ‘deviation phase’ of the game. In the following period(s), however, firm j retaliates by exporting to market i . This is the ‘punishment phase’ of the game. As in most of the policy-oriented literature on repeated games, we assume a *trigger strategy* which implies that firm j will retaliate by exporting to market i in *all* subsequent periods.⁷ Hence, if one of the firms defects in period $t = 0$, then duopoly competition will prevail in both markets in $t = 1, 2, \dots, \infty$. Finally, in line with the assumption that governments cannot effectively control the imperfectly competitive

⁶The assumption that there is only one firm in each market can either be interpreted in a strict sense, or in the sense that several firms in a national industry collude.

⁷It is shown in Abreu (1986) and Fudenberg and Maskin (1986) that the trigger strategy is subgame perfect.

market for good x , we assume that national markets are segmented, i.e., different producer prices can be set in the two national markets under both monopolistic and duopolistic market structures.

In the following, we denote by π_i^M the per-period profits of firm i if it acts as a monopolist in its domestic market, π_i^E are the extra profits in period 0 when the firm defects and exports into the other market, and π_i^D are firm i 's total duopoly profits per period (earned in both markets together) under mutual export competition. Denoting by δ_i the discount factor of firm i ($0 < \delta_i < 1$), defection from the cartel solution will be unprofitable when

$$\frac{\pi_i^M}{1 - \delta_i} \geq (\pi_i^M + \pi_i^E) + \left(\frac{\delta_i}{1 - \delta_i} \right) \pi_i^D \quad \forall i \in \{1, 2\},$$

where we have used the summation rules for infinite series starting at time $t = 0$ and $t = 1$, respectively. The LHS of this inequality gives the discounted sum of monopoly profits in all periods, whereas the RHS gives total profits in the defection period 0 (the sum of domestic monopoly profits and profits in the export market) and duopoly profits in both markets thereafter.

In general, it cannot be excluded in this type of model that $\pi_i^M < \pi_i^D$ for one of the two firms. In this case, it would always be profitable for this firm to leave the collusive agreement, since it will gain not only in the deviation phase but also in the punishment phase of the game. Since we focus only on conditions under which tax policy affects the stability of collusive arrangements, we disregard these cases in the following and assume that $\pi_i^M > \pi_i^D$ holds throughout the analysis. The above inequality can then be rearranged to give the following ‘stability condition’ for the collusive agreement:

$$\theta_i \geq \bar{\theta}_i^m = \frac{\pi_i^E}{\pi_i^M - \pi_i^D} \quad \forall i \in \{1, 2\}. \quad (1)$$

Here, we have introduced $\theta_i \equiv \delta_i/(1 - \delta_i)$ as the relative discount factor of firm i , and $\bar{\theta}_i^m$ denotes the critical value of this factor that just leaves the firm indifferent between staying in the secret cartel and defecting. These critical values depend on both the tax principle in operation (destination or origin principle, $m \in \{DP, OP\}$) and on the nature of duopoly competition. For brevity, we consider only price (Bertrand) competition between firms.⁸

⁸For isolated differences in tax rates, the case of quantity (Cournot) competition has been analyzed in a previous working paper version (Hauffer and Schjelderup, 2000) and leads to qualitatively similar results.

Since the gains from defecting accrue in $t = 0$, but the losses due to export competition are felt only later, it is intuitive that the cartel will be more stable, the higher are the firms' relative discount factors θ_i (i.e., the closer the absolute discount factor δ_i is to its maximum value of unity). We assume in the following that the relative discount factor is the same for both firms ($\theta_1 = \theta_2 = \theta$), an obvious interpretation being that both firms calculate their discount factors from the common market interest rate.⁹ The critical values of these discount factors ($\bar{\theta}_i$) will, however, differ between the two firms when the profit terms in eq. (1) differ due to an underlying asymmetry. The firm with the higher critical value of $\bar{\theta}_i$ will then be the one which is more likely to break the collusive arrangement and hence it is this firm's $\bar{\theta}_i$ that is binding for the stability of the secret cartel.¹⁰ In the following, we thus focus on the comparison of the binding critical values of $\bar{\theta}_i$ under different tax policies. The implication is that the higher is $\bar{\theta}_i$ under a given scenario, the lower is the likelihood that the collusive agreement will be stable, in the sense that only a smaller range of (common) relative discount factors θ sustains the cartel solution.

3 Determinants of cartel stability

In this section we focus on the different effects that consumption- versus production-based commodity taxes have on the stability of the collusive agreement. Consistent with the use of value-added taxation as the primary source of indirect tax revenue, we assume that each country levies an *ad valorem* tax rate t_i on good x , where $1 \geq t_i \geq 0$.¹¹ Tax rates remain exogenous in our analysis and, importantly, generally differ

⁹The important simplifying assumptions underlying our specification are that the discount factors are common knowledge and that they are time-invariant. See Martin (1993, ch. 5) for a discussion of the additional effects introduced by discount factors that vary over time.

¹⁰If firm j has the higher critical value of $\bar{\theta}$, then firm i ($i \neq j$) could improve the stability of the collusive agreement by offering firm j a new contract (for example a fifty-fifty split of the two markets). Such market sharing, however, poses a problem. The reason is that it is much easier to detect a breach of agreement if a firm exports (when it should not) than if it produces beyond the agreed export quota. The cost of monitoring, therefore, provides cartels with an incentive to set up exclusive territories (see Marvel 1982, and Tirole 1988, pp. 183 and 185).

¹¹It is well known that, in contrast to the competitive case, specific and *ad valorem* taxes are not equivalent under imperfect competition. Venables (1986) and, in more detail, Delipalla and Keen (1992) show that *ad valorem* taxes lead to lower consumer prices and profits in the oligopoly equilibrium as compared to specific taxes.

between countries. In addition to differences in tax rates, we allow for differences in the size of national markets and in the unit costs c_i of the competing firms.

Before we turn to the separate analyses of the destination and origin principles, we can compute each firm's monopoly profits π_i^M . These are unaffected by the international tax principle in operation because with two monopolies each serving the domestic market only, there is no trade in good x . We assume that demand functions in both markets are linear and given by $x_i = a_i - q_i = a_i - (1 + t_i)p_i$. The parameter $a_i > 0$ gives maximum sales at a price of zero and is thus an indicator of market size. Consumer and producer prices are denoted by q_i and p_i , respectively. The per-period profits of firm i in its home market are then

$$\pi_i = p_i x_i - c_i x_i = (p_i - c_i) [a_i - (1 + t_i)p_i] \quad \forall i \in \{1, 2\}. \quad (2)$$

The monopoly problem can be solved by choosing either the producer price p_i or the quantity sold x_i . In both cases it is straightforward to show that the solution to the maximization problem yields

$$p_i = \frac{1}{2} \left[\frac{a_i}{(1 + t_i)} + c_i \right], \quad q_i = \frac{1}{2} [a_i + (1 + t_i) c_i], \quad x_i = \frac{a_i - (1 + t_i) c_i}{2} \quad \forall i. \quad (3)$$

For positive costs of production, our model implies that taxes are partly shifted into consumer prices and partly fall on producers. Note, however, that in the special case of zero costs the commodity tax is fully shifted backwards into producer prices and effectively becomes a pure profit tax.

The prices and quantities given by (3) yield per-period monopoly profits of

$$\pi_i^M = \frac{\alpha_i^2}{4(1 + t_i)}, \quad \forall i \in \{1, 2\}, \quad (4)$$

$$\alpha_i \equiv a_i - (1 + t_i) c_i > 0 \quad \forall i \in \{1, 2\}. \quad (5)$$

Note that α_i must be positive for positive sales in country i [see eq. (3)]. The monopoly profits of each firm in its domestic market are thus positively related to market size and depend negatively on unit production costs and taxes.

In the following we derive explicit expressions for the remaining profit terms in eq. (1), i.e., exporting profits π_i^E and duopoly profits π_i^D . These terms depend on the underlying tax principle.

3.1 The destination principle

Under the destination principle commodity taxes are levied in the country where the good is consumed. This implies that firms located in countries with different tax rates will nevertheless compete in each market on an equal tax footing.

If firm i deviates from the cartel solution and exports to market j ($j \neq i$), firm j is initially unaware of the breach of agreement. Firm j will therefore continue to set its monopoly price as given by eq. (3). Under price competition, this implies that firm i can capture the whole market in country j by slightly undercutting this price. Firm i 's exports are taxed at the rate t_j under the destination principle, but its exporting profits will generally differ from firm j 's monopoly profits due to differences in production costs. Using eq. (3) and rewriting yields

$$\pi_i^{E(DP)} = (p_j - c_i) x_j = \frac{\alpha_j}{4(1+t_j)} [\alpha_j + 2(1+t_j)(c_j - c_i)] \quad \forall i \neq j. \quad (6)$$

Comparing this with (2) shows that firm i 's profits from exporting into country j exceed firm j 's monopoly profits if $c_j > c_i$, and fall below π_j^M otherwise.

In the following we adopt the convention that, if costs differ between firms, then firm j has the higher unit cost and $c_j > c_i$. We restrict cost differences between the two firms by assuming that the high-cost firm will still be able to make positive profits from exporting to market i . This implies the following condition:

$$\alpha_i - 2(1+t_i)(c_j - c_i) > 0. \quad (7)$$

When firm j observes that firm i has defected from the cartel, it will respond by exporting to market i and there will be export competition in both markets in all future periods. Firm i as, the low-cost firm, will then set its price just below c_j and sweep both markets, earning $(c_j - c_i) [a_i - (1+t_i)c_j]/2$ in market i and $(c_j - c_i) [a_j - (1+t_j)c_j]/2$ in market j . Firm j will earn zero profits in the punishment phase. Using (5), per-period duopoly profits of the two firms are

$$\pi_i^{D(DP)} = (c_j - c_i) [\alpha_i + \alpha_j - (1+t_i)(c_j - c_i)], \quad \pi_j^{D(DP)} = 0.$$

In the special case where both firms have equal costs, price competition under the destination principle implies that profits in the duopoly equilibrium fall to zero for *both* firms. It is this severe effect of competition in the later stages of the game which 'disciplines' the firms and gives an incentive to stick to the collusive agreement.

We can now substitute (4), (6) and (8) into (1). The critical discount factors at which each of the two firms is indifferent between defecting and remaining in the secret cartel are for firms i and j , respectively:

$$\bar{\theta}_i^{DP} = \frac{(1+t_i)\alpha_j[\alpha_j+2(1+t_j)(c_j-c_i)]}{(1+t_j)\{\alpha_i^2-2(1+t_i)(c_j-c_i)[\alpha_i+\alpha_j-(1+t_i)(c_j-c_i)]\}}, \quad (8a)$$

$$\bar{\theta}_j^{DP} = \frac{(1+t_j)\alpha_i[\alpha_i-2(1+t_i)(c_j-c_i)]}{(1+t_i)\alpha_j^2}. \quad (8b)$$

In the following, we consider three special cases of (8a)–(8b), corresponding to isolated differences in tax rates, market size, and production costs. In each case, we determine which firm is more likely to defect from the collusive agreement.¹²

Case A: $t_i \neq t_j$ ($a_i = a_j$, $c_i = c_j$)

When only destination-based tax rates differ between the two markets, then equation set (8a)–(8b) reduces to

$$\bar{\theta}_i^{DP} = \frac{(1+t_i)\alpha_j^2}{(1+t_j)\alpha_i^2} \quad \forall i \neq j. \quad (9)$$

Recalling (5), it is directly inferred from (9) that the firm in the *high-tax* country will be more likely to break the collusive agreement under the destination principle. If, for example, $t_i > t_j$, then the numerator in $\bar{\theta}_i^{DP}$ is larger and the denominator is smaller for firm i , as compared to firm j . Intuitively, firm i 's gains from defecting are given by the monopoly profits in the relatively profitable (low-tax) market j , while the losses occur in the less profitable home market i .

Case B: $a_i \neq a_j$ ($t_i = t_j$, $c_i = c_j$)

With isolated differences in market size, equation set (8a)–(8b) collapses to $\bar{\theta}_i^{DP} = \alpha_j^2/\alpha_i^2 \quad \forall i \neq j$. Hence the firm located in the *smaller* market will be more likely to defect from the cartel. The reasoning is very similar to the one given above: if, for example, $a_i < a_j$ then firm i 's exporting profits accrue in the larger market j , whereas the losses in the punishment phase fall in the smaller home market i .

¹²If countries and firms are symmetric in *all* respects, then the critical values of $\bar{\theta}$ reduce to 1 for both firms. From the definition $\theta \equiv \delta/(1-\delta)$ this implies a critical absolute discount factor of $\delta = 1/2$, thus reproducing a standard result in symmetric models of repeated price competition (see Tirole, 1988, p. 246).

Case C: $c_i \leq c_j$ ($t_i = t_j$, $a_i = a_j$)

In this case, we can simplify (8a)–(8b) with the help of (5) to get

$$\bar{\theta}_i^{DP} = \frac{\alpha_j[\alpha_i + (1+t)(c_j - c_i)]}{\alpha_i^2 - 4(1+t)(c_j - c_i)\alpha_j}, \quad (10a)$$

$$\bar{\theta}_j^{DP} = \frac{\alpha_i[\alpha_j - (1+t)(c_j - c_i)]}{\alpha_j^2}. \quad (10b)$$

Comparing first the numerators in (10a) and (10b), this is larger for the *low-cost* firm i , which has the higher gains from exporting to the foreign market. The comparison of the denominators is somewhat more complicated because the low-cost firm obtains the larger monopoly profits in its home market. It can be shown, however, that this effect is more than compensated by the higher profits of firm i in the duopoly equilibrium so that the denominator is smaller for the low-cost firm.¹³ Hence, firm i has the unambiguously higher value of $\bar{\theta}^{DP}$. Our results under the destination principle are summarized in

Lemma 1: *Under the destination principle, a firm is more likely to break the collusive agreement if it (i) operates in the high-tax country; (ii) has the smaller home market; (iii) has the lower costs of production.*

3.2 The origin principle

Under the origin principle, commodities are taxed in the country of production, but are exempted from tax in the importing country. Hence tax differentials affect the relative competitiveness of the two firms in each market.

If firm i breaks the collusive agreement and exports to market j it can again capture the entire market by slightly undercutting firm j . The difference to the destination principle is that firm i will now base its pricing decision on the monopoly *consumer* price charged by firm j . From (3), this equals $q_j = [a_j + (1+t_j)c_j]/2$. Given that the tax rate applicable to firm i 's sales to market j is t_i , the maximum

¹³From the comparison of the denominators in (10a) and (10b), the condition that has to be fulfilled is $\alpha_j^2 - \alpha_i^2 + 4(c_j - c_i)(1+t)\alpha_j > 0$. Using the binomial rules and (5) this reduces to $(1+t)(c_j - c_i)(3\alpha_j - \alpha_i) = 2\alpha_i - 3(1+t)(c_j - c_i)$, which is positive if the high-cost firm is to make positive exporting profits in the deviation phase [cf. (7)].

producer price that firm i can charge is $[a_j + (1 + t_j)c_j]/[2(1 + t_i)]$. From (3), demand in country j for the consumer price q_j is $\alpha_j/2$. Hence, using (5), maximum profits from exporting are equal to

$$\pi_i^{E(OP)} = \frac{\alpha_j}{4(1 + t_i)} \{ \alpha_j + 2[(1 + t_j)c_j - (1 + t_i)c_i] \} \quad \forall i \neq j. \quad (11)$$

Eq. (11) shows that under the origin principle the tax rate in the defecting firm's home country and this firm's unit costs have additive effects on the profitability of exporting. As before, we let firm j have the higher unit costs of production, grossed up by the origin-based ad valorem tax $[(1 + t_j)c_j > (1 + t_i)c_i]$. Hence, exporting profits are larger for firm i . A condition similar to (7) ensures that (11) will also be positive for the high-cost firm j .

In the duopoly equilibrium, price competition will lead firm j to charge a consumer price of $q_i = q_j = c_j(1 + t_j)$ in both markets and make zero profits. This allows firm i to charge a producer price of $(1 + t_j)c_j/(1 + t_i)$, leaving a profit margin of $[(1 + t_j)c_j - (1 + t_i)c_i]/(1 + t_i)$ per unit of output sold in either market. Since, for a consumer price of $(1 + t_j)c_j$, demand is $\alpha_j/2$ in *each* of the two markets, per-period duopoly profits under the origin principle are given by

$$\pi_i^{D(OP)} = \frac{[(1 + t_j)c_j - (1 + t_i)c_i]\alpha_j}{(1 + t_i)}, \quad \pi_j^{D(OP)} = 0. \quad (12)$$

Substituting (4), (11) and (12) into (1) gives critical values $\bar{\theta}^{OP}$ for firms i and j :

$$\bar{\theta}_i^{OP} = \frac{\alpha_j \{ \alpha_j + 2[(1 + t_j)c_j - (1 + t_i)c_i] \}}{\alpha_i^2 - 4\alpha_j[(1 + t_j)c_j - (1 + t_i)c_i]}, \quad (13a)$$

$$\bar{\theta}_j^{OP} = \frac{\alpha_i \{ \alpha_i - 2[(1 + t_j)c_j - (1 + t_i)c_i] \}}{\alpha_j^2}. \quad (13b)$$

Based on these general expressions, we again consider the three special cases of isolated differences in tax rates, market size, and production costs.

Case A: $t_i \leq t_j$ ($a_i = a_j$, $c_i = c_j$)

When costs are equal for the two firms, but firm j is located in the high-tax country, the critical values of $\bar{\theta}$ for the two firms are¹⁴

$$\bar{\theta}_i^{OP} = \frac{[\alpha_i + c(t_j - t_i)]\alpha_j}{[\alpha_j - c(t_j - t_i)]^2}, \quad \bar{\theta}_j^{OP} = \frac{[\alpha_j - c(t_j - t_i)]\alpha_i}{\alpha_j^2} \quad \text{for } t_j > t_i. \quad (14)$$

¹⁴The denominator of $\bar{\theta}_i^{OP}$ in (14) is obtained from $\alpha_i^2 - 4\alpha_j c(t_j - t_i)$ using $\alpha_i = \alpha_j + c(t_j - t_i)$ and the binomial rules.

Eq. (14) shows that if firm i is located in the *low-tax* country, then the numerator of $\bar{\theta}_i$ is larger, and the denominator is smaller, than for the rival firm j . Since firm i is faced with larger exporting profits and smaller losses from non-cooperation, it will impose the binding constraint on the stability of the collusive agreement.

Case B: $a_i \neq a_j$ ($t_i = t_j$, $c_i = c_j$)

With isolated differences in market size, equation set (13a)–(13b) reduces to $\bar{\theta}_i^{OP} = \alpha_j^2/\alpha_i^2 \forall i \neq j$, which is the same expression as under the destination principle. Hence the result that the firm in the *smaller* market is more likely to defect from the cartel holds under both tax principles.

Case C: $c_i \leq c_j$ ($t_i = t_j$, $a_i = a_j$)

When only costs of production differ between the two firms then the critical values for $\bar{\theta}$ derived from (13a)–(13b) are identical to those obtained under the destination principle [eqs. (10a)–(10b)]. Hence it is again the *low-cost* firm that is more likely to break the secret cartel. We summarize these results in

Lemma 2: *Under the origin principle, a firm is more likely to break the collusive agreement if it (i) operates in the low-tax country; (ii) has the smaller home market; (iii) has the lower costs of production.*

Comparing Lemmas 1 and 2 we find that the choice of tax principle is immaterial for the question which firm will break the collusive agreement when tax rates are equal across countries, but either the size of the home market or production costs differ between the two firms (Cases B and C). However, isolated differences in the rates of commodity tax have precisely the opposite effects under the destination and origin principles (Case A).

4 The choice of tax principle

In the previous section we have determined how isolated differences in market size, production costs and tax rates affect the stability of collusive agreements under each tax principle, and which of the two firms is more likely to defect in each of the different scenarios. Having laid this groundwork, we are now in a position to compare the stability of collusive agreements under the destination and origin

principles. We will do this in two different settings. First, we analyze the interaction of tax differentials with underlying – and dominating – differences in production costs.¹⁵ This allows us to link the results derived in our tacit collusion framework to the existing literature on commodity taxation in international duopoly markets. In a second step, we compare the destination and origin principles when tax differentials are the main and, for simplicity, the only source of asymmetry.

4.1 Differences in production costs

We consider the case where firm 1 is the low-cost firm while both markets are of equal size. Furthermore, we assume that differences in costs dominate tax differences under both tax principles. Under these assumptions, Lemmas 1 and 2 imply that firm 1 will impose the binding constraint on the stability of the collusive agreement.

Under the destination principle, we get from (8a) and $a_i = a_j$

$$\bar{\theta}_1^{DP} = \frac{[(1+t_1)/(1+t_2)]\alpha_2[\alpha_2 + 2(1+t_2)(c_2 - c_1)]}{\alpha_1^2 - 2(1+t_1)(c_2 - c_1)[2\alpha_2 - (t_1 - t_2)c_2]} . \quad (15)$$

Under the origin principle, we get from (13a) and $a_i = a_j$

$$\bar{\theta}_1^{OP} = \frac{\alpha_2\{\alpha_2 + 2[(1+t_2)c_2 - (1+t_1)c_1]\}}{\alpha_1^2 - 4\alpha_2[(1+t_2)c_2 - (1+t_1)c_1]} . \quad (16)$$

Comparing (15) and (16) gives

Proposition 1: *If the firm with the lower costs of production faces the lower (higher) tax rate, then tacit collusion is more likely (less likely) under the destination principle than under the origin principle.*

Proof: See the appendix.

The intuition for Proposition 1 is straightforward. Given that firm 1 imposes the binding constraint on the stability of the collusive agreement, we only have to ask whether tax differentials reinforce or counteract the incentive of this firm to leave the secret cartel. Under the destination principle, a low tax rate in country 1 makes the domestic market more profitable and thus counteracts the incentive for the low-cost firm 1 to defect from the collusive agreement. Under the origin principle, in

¹⁵As indicated by Lemmas 1 and 2, the framework set up in the previous section can also be used to analyze differences in market size. To save space, the analysis of this case is not carried out in detail in this paper, but a brief summary of the results is given (see footnote 16 below).

contrast, a low tax rate in country 1 gives the low-cost firm an additional competitive advantage, which raises its exporting profits and limits the losses in the punishment phase. Therefore, if $t_1 < t_2$, the incentive of the low-cost firm to defect from the collusive agreement is reinforced under the origin principle, but weakened under the destination principle. If $t_1 > t_2$ holds instead, the opposite conclusions follow.

Proposition 1 indicates that the view one takes on the choice of commodity tax principle and its impact on collusion depends very much on how cost levels and tax rates are correlated. Previous work on non-cooperative commodity taxation in the presence of cost differences between internationally operating firms has established that, other things being equal, the country hosting the low-cost firm will set the lower tax rate under both tax principles (Keen and Lahiri, 1993; Keen, Lahiri and Raimondos-Møller, 2002). The reason is that with equal demand conditions the country hosting the low-cost firm will export the good produced in the imperfectly competitive market. Hence, it will gain by strategically reducing the tax in order to raise domestic demand and increase the world price. Under the origin principle, an incentive to subsidize domestic output arises for both countries. This ‘rent shifting effect’, known from the literature on strategic trade policy (Brander and Spencer, 1985), is stronger for the country hosting the more efficient firm, which will therefore set the lower tax rate in the non-cooperative equilibrium. Thus, the literature provides a strong argument for that countries with low commodity tax rates play host to low-cost firms. Using this as a guidance for interpreting Proposition 1, we conclude that the origin principle is less likely to lead to a stable cartel.¹⁶

Summing up the results in this section, a collusive agreement is less likely to be sustained under the origin principle, if the firm with the larger incentive to defect (firm 1) faces a lower tax rate than its foreign rival. The literature on non-cooperative commodity taxation in open economies has established several arguments why such a relationship can indeed be expected. If these results are incorporated into our analysis, then Proposition 1 implies an argument in favour of origin-based commodity taxes under the presumption that a stable cartel is undesirable from a social welfare perspective. It is easily shown in our model that the equilibrium producer

¹⁶If market size differs between countries, instead of firms’ production costs, similar arguments as the ones given above apply. It emerges that tacit collusion will be more likely (less likely) under the destination principle, as compared to the origin principle, if the firm with the smaller home market faces the lower (higher) tax rate. The full analysis of this case is available from the authors.

price under duopoly competition is always below monopoly prices in both markets, even if costs differ across firms. To see this under the destination principle, compare the monopoly prices given in (3) with the duopoly price c_j (where $c_j > c_i$). It follows from condition (7) that even the monopoly price charged by the low-cost firm i exceeds the common duopoly price c_j . An analogous condition holds under the origin principle [see the discussion of eq. (11)]. With prices lower under duopoly than in each national monopoly, total output is larger, and hence closer to its efficient level, if the firms engage in duopoly competition. Thus, using a simple but conventional welfare measure by adding up consumer surplus, producer profits and tax revenue, a normative interpretation of our results is that we should prefer the tax policy that is more likely to induce duopoly competition.

In this sense, our results are complementary to the findings of Keen and Lahiri (1998) who show that the origin principle is likely to Pareto dominate the destination principle if firms engage in Cournot duopoly competition. In their framework, the market structure is given and the superiority of origin-based taxes derives from the property that they can be more directly targeted at the underlying production distortion. In contrast, the welfare argument for the origin principle in the present model is based on its greater ability to effect a change in market structure.

Recall, however, that the statement in Proposition 1 that one tax principle is “more likely” to maintain tacit collusion implies merely that a secret cartel is an equilibrium outcome for a larger range of common discount factors θ (cf. section 2). Depending on the actual values of the firms’ discount factors, it is also possible that collusion is stable under both tax principles considered, or under none of them.

4.2 Isolated differences in tax rates

In the previous section we have assumed that differences in tax rates are systematically linked to an underlying asymmetry in production costs. From an empirical perspective it is not clear, however, that production costs are a primary determinant of commodity tax rates. Instead, differences in commodity tax levels are often attributed to different preferences for public goods and redistribution. In addition, an important determinant of the direct-indirect tax mix in each country is the ability of national tax administrations to control income tax evasion (see Boadway, Marchand and Pestieau, 1994).

To incorporate the possibility that commodity tax differentials are caused by factors unrelated to firms' costs of production, we now consider a setting where exogenous differences in tax rates are the *only* source of asymmetry. This set-up implies that the (unmodelled) determinants of international tax differentials do not affect the profitability of firms.

From Lemmas 1 and 2 we know that if tax rates are the only difference between countries, then the firm in the high-tax country will be more likely to leave the collusive agreement under the destination principle, but the firm in the low-tax country is more likely to defect under the origin principle. We adopt the convention, with no loss of generality, that country 1 is the low-tax country and $t_1 < t_2$. With this assumption our previous findings in eqs. (9) and (14) imply that the following critical values are binding under the two tax principles:

$$\bar{\theta}_2^{DP} = \frac{(1+t_2)\alpha_1^2}{(1+t_1)\alpha_2^2}, \quad \bar{\theta}_1^{OP} = \frac{[\alpha_1 + c(t_2 - t_1)]\alpha_2}{[\alpha_2 - c(t_2 - t_1)]^2}. \quad (17)$$

We then obtain the following result:

Proposition 2: *When tax rates are the only asymmetry between countries, then a stable collusive agreement is less likely under the destination principle, as compared to the origin principle, if (i) market size is large and (ii) costs of production are low.*

Proof: See the appendix.

To interpret this result note first that if tax rates are the only asymmetry, then a larger international tax differential weakens the stability of the collusive agreement under both tax principles. It is seen from (17) that the critical values of $\bar{\theta}$ are always at a *minimum* when tax rates are equal. Next, recall that a tax differential has very different effects under the two tax principles. Under the destination principle it is the difference in the profitability of the two markets which is crucial for the incentive to leave the secret cartel. Other things equal, this difference will be magnified when the common market size parameter a is large. Under the origin principle, a tax differential changes the competitive position of the two firms. Since taxes are levied ad valorem, the absolute cost advantage of the low-tax firm becomes larger when costs of production are high. In the special case of zero production costs, taxes under the origin principle are essentially pure profit taxes and tacit collusion is unambiguously less likely under the destination principle.¹⁷

¹⁷To see this, note that if $c = 0$, then $\alpha_1 = \alpha_2 = a$ and the terms in (17) reduce to $\bar{\theta}_2^{DP} = (1+t_2)/(1+t_1)$ and $\bar{\theta}_1^{OP} = 1$. For $t_1 < t_2$, this implies $\bar{\theta}_2^{DP} > \bar{\theta}_1^{OP}$.

While no unambiguous result emerges for the comparison of destination and origin principles when tax differences are the only asymmetry, we can go one step further and relax the assumption that there are only two countries and two firms. What would happen if there were instead n countries each hosting a firm? To consider this case note that, irrespective of the tax principle in operation, profits in the deviation phase would go up since a cheating firm can export to $(n - 1)$ markets and earn profits in each of these markets. *Ceteris paribus* this destabilizes the cartel. In the deviation phase, however, there are now $(n - 1)$ firms that potentially can export into the home market of the cheating firm. This may lower profits in the punishment phase and, *ceteris paribus*, stabilize the cartel. The full effect on cartel stability must therefore take into account the benefit of cheating and the consequences of breaking out of the cartel in the noncooperative stages of the game. In general the inclusion of many countries allows for a wide range of different constellations of tax rates and cost and market asymmetries. It is therefore not possible to make a general statement as to the effect on cartel stability without making some restrictive assumptions.

However, it is straightforward to analyze this extension in the setting where an international tax difference is the only force affecting the stability of the cartel. Let us start with the destination principle. As before, it will be the firm in the country with the highest tax rate (firm 2) that has the greatest incentive to leave the collusive agreement. Assume now that there is only one high-tax country, in which firm 2 is located, while there are $(n - 1)$ low-tax countries, each hosting a firm of type 1.¹⁸ The total exporting profits of firm 2 from selling in all low-tax markets are given by $\Pi_2^{E(DP)} = (n - 1) \pi_2^{E(DP)}$.

In the duopoly equilibrium, profits are zero for all firms if the destination principle is applied. Thus, breaking out of the cartel does not affect the noncooperative phase of the game. We denote firm 2's critical discount value in this extended setting by $\bar{\Theta}_2^{DP}$. This value is given by

$$\bar{\Theta}_2^{DP} = \frac{\Pi_2^{E(DP)}}{\pi_2^M} = \frac{(n - 1) \pi_2^{E(DP)}}{\pi_2^M} = (n - 1) \bar{\theta}_2^{DP}. \quad (18)$$

Hence, under the destination principle, the critical value of the firm that is most likely to defect (firm 2) rises *in proportion to* the number of markets into which this firm can export in the deviation phase.

¹⁸All qualitative results would be unchanged (but the notation would be much more cumbersome), if we assumed instead that each of the n countries had a different tax rate.

Consider now the origin principle. Here, it is the firm in the country with the lowest tax rate (firm 1) that is most likely to break up the cartel. For symmetry, we assume now that there are one low-tax country and $(n - 1)$ high-tax countries. In the deviation phase, firm 1 sells to all high-tax markets, making exporting profits equal to $\Pi_1^{E(OP)} = (n - 1) \pi_1^{E(OP)}$. In contrast to the destination principle, however, the low-tax firm also earns positive profits in the non-cooperative phase of the game. These profits rise as the low-tax country can exploit its tax advantage to undercut firms in $(n - 1)$ markets, yielding $\Pi_1^{D(OP)} = (n - 1) \pi_1^{D(OP)}$. Firm 1's critical discount value, $\bar{\Theta}_1^{OP}$, is thus given by

$$\bar{\Theta}_1^{OP} = \frac{\Pi_1^{E(OP)}}{\pi_1^M - \Pi_1^{D(OP)}} = \frac{(n - 1) \pi_1^{E(OP)}}{\pi_1^M - (n - 1) \pi_1^{E(OP)}} = \left[(n - 1) + \frac{(n - 2) \pi_1^M}{\pi_1^M - (n - 1) \pi_1^D} \right] \bar{\theta}_1^{OP}. \quad (19)$$

Since the second term in the squared bracket is unambiguously rising in n , this result implies that the critical value of firm 1 rises *more than proportionally* as the number of countries increases. This is because the higher profits that firm 1 makes in the deviation phase have an additional destabilizing effect on the collusive agreement that is not present under the destination principle. We summarize these results in

Proposition 3: *When the number of countries (and firms) is increased, and tax rates are the only asymmetry between countries, a stable collusive agreement becomes less likely both tax principles. However, the destabilizing effect is stronger under the origin principle.*

The first part of the proposition is in line with previous findings in the literature, which show that cartels are destabilized by expanding the number of firms (see e.g., Abreu, 1986 and Bernheim and Whinston, 1990). The second part states that even in a setting where tax rates are the only asymmetry the origin principle has some merits in destabilizing collusive agreements when the model is extended to account for more than two countries and firms.

5 Tax rate harmonization

In this section we turn to the implications of tax rate harmonization for the stability of tacit collusion. The analysis is carried out in the same settings as in the previous section. Let $t_i < t_j$, $i \neq j$. We define a harmonizing reform in a broad sense

as any narrowing of the tax differential between the two countries. As a special case, this incorporates a unilateral increase in the tax rate of the low-tax country ($dt_i > 0$, $dt_j = 0$). This has been the approach to commodity tax harmonization in the European Union, and it is also a common definition in the literature (see, e.g., Kanbur and Keen, 1993). Alternatively, a narrowing of the tax differential can be brought about by an isolated reduction in the tax rate of the high-tax country ($dt_i = 0$, $dt_j < 0$) or by a simultaneous alignment of tax rates in both countries ($dt_i > 0$, $dt_j < 0$). The latter policy corresponds to a move towards a common average of initial tax rates. This harmonization scheme was initially suggested for EU commodity tax harmonization, and it is also used frequently in theoretical work (e.g., Keen, 1987, 1989).

5.1 Differences in production costs

We first consider the case where the firms have different costs of production and tax rates differ across countries, but market size is identical. Again, we adopt the convention that $c_1 < c_2$ and cost differences exceed tax differences so that firm 1's critical value of $\bar{\theta}$ is binding under both tax principles. Moreover, we focus on the case where the country hosting the low-cost firm (country 1) levies the lower tax in the absence of tax coordination. Hence we evaluate

$$d\bar{\theta}_1^m = \frac{\partial \bar{\theta}_1^m}{\partial t_1} dt_1 + \frac{\partial \bar{\theta}_1^m}{\partial t_2} dt_2 \quad \text{for } t_1 < t_2; dt_1 \geq 0, dt_2 \leq 0. \quad (20)$$

Under the destination principle, differentiating the critical values of $\bar{\theta}_1$ in (15) with respect to t_1 and t_2 yields

$$\begin{aligned} \frac{\partial \bar{\theta}_1^{DP}}{\partial t_1} &= \frac{\alpha_2[\alpha_2 + 2(1+t_2)(c_2 - c_1)] \{\varepsilon_1 + (1+t_1)[2\alpha_1 c_1 + 2(c_2 - c_1)\gamma]\}}{(1+t_2)\varepsilon_1^2} > 0, \\ \frac{\partial \bar{\theta}_1^{DP}}{\partial t_2} &= \frac{-(1+t_1)\{(1+t_2\varepsilon_1[2\alpha_2 c_1 + c_2\delta] + \alpha_2\delta[\varepsilon_1 + (1+t_1)c_2\delta])\}}{(1+t_2)^2\varepsilon_1^2} < 0, \end{aligned} \quad (21)$$

where $\varepsilon_1 \equiv \alpha_1^2 - 2(1+t_1)(c_2 - c_1)[2\alpha_2 - (t_1 - t_2)c_2] > 0$ from (15), $\gamma \equiv 2\alpha_2 - (t_1 - t_2)c_2 - (1+t_1)c_2 > 0$ from condition (7) and $\delta \equiv 2(1+t_2)(c_2 - c_1) > 0$.

Under the origin principle, differentiating (16) with respect to t_1 and t_2 gives

$$\frac{\partial \bar{\theta}_1^{OP}}{\partial t_1} = \frac{-\alpha_2[2c_1\varepsilon_2 + 2(\alpha_2 + 2\phi)(\alpha_2 - \phi)]}{\varepsilon_2^2} < 0,$$

$$\frac{\partial \bar{\theta}_1^{OP}}{\partial t_2} = \frac{4c_2[\alpha_2 - (1+t_2)c_2](\alpha_2^2 + 2\alpha_2\phi) - 2c_2\phi(\alpha_1^2 - 4\alpha_2\phi)}{\varepsilon_2^2} > 0, \quad (22)$$

where $\varepsilon_2 \equiv \alpha_1^2 - 4\alpha_2[(1+t_2)c_2 - (1+t_1)c_1] > 0$ from (16) and $\phi \equiv (1+t_2)c_2 - (1+t_1)c_1 > 0$. In the numerator of $\partial \bar{\theta}_1^{OP}/\partial t_2$, the positive first term exceeds the second because $2c_2[2\alpha_2 - 2(1+t_2)c_2 - \phi] > 0$ from condition (7). From the same condition it follows that $(\alpha_2^2 + 2\alpha_2\phi) - (\alpha_1^2 - 4\alpha_2\phi) = [(1+t_2)^2c_2^2 - (1+t_1)^2c_1^2] + \phi(6\alpha_2 - 2a) > 0$.

Substituting (21) and (22) in (20) shows that the reform dh increases the critical value of $\bar{\theta}_1^{DP}$ and reduces the critical value of $\bar{\theta}_1^{OP}$. This result is summarized in

Proposition 4: *If the low-cost firm faces the lower tax rate, then any alignment of tax rates makes a collusive agreement less likely under the destination principle, but more likely under the origin principle.*

This result is easily understood. Under the destination principle, the incentives for the low-cost firm to defect from the secret cartel are partly offset if the firm's home country has a lower tax rate than its neighbour. Tax harmonization weakens this offsetting effect arising from international tax differentials and thus tends to raise the critical value of $\bar{\theta}_1^{DP}$. Under the origin principle, in contrast, a low domestic tax rate strengthens the incentive for the low-cost firm to defect from the collusive agreement. A narrowing of the tax differential mitigates this effect and accordingly lowers $\bar{\theta}_1^{OP}$. Therefore, any narrowing of the tax differential destabilizes the secret cartel under the destination principle, but stabilizes it under the origin principle.¹⁹

Our above analysis has incorporated the result from the literature on non-cooperative international commodity taxation that countries hosting a low-cost firm tend to levy lower taxes (or higher subsidies). In this setting Proposition 4 implies that tax rate harmonization is desirable under the destination principle, in the sense that it increases the likelihood that a socially unwanted secret cartel will break up. Under the origin principle, however, the opposite is true and tax rate harmonization will have undesirable, 'stabilizing' effects on the collusive agreement. Interestingly, these results correspond precisely to the contrasting effects that tax rate harmonization has in duopoly models of imperfect competition when production (cost)

¹⁹Again, it is straightforward to analyze the effects of tax rate harmonization if differences in market size, rather than production costs, are the underlying asymmetry. In this case we find that if the firm with the smaller home market faces the lower tax rate, then any narrowing of the tax differential makes a collusive agreement less likely under the destination principle, but more likely under the origin principle (details are available from the authors).

characteristics differ in the two markets. As shown by Keen and Lahiri (1993) and Lockwood (2001, sec. 5), tax rate harmonization under the destination principle will be welfare-enhancing in these circumstances, because it has no effects on production but aligns relative consumer prices across countries. In contrast, Keen, Lahiri and Raimondos-Møller (2002) have shown that tax rate harmonization under the origin principle will be welfare-reducing in the presence of cost differentials, because it increases the market share of the less efficient firm and thus reduces international production efficiency. The driving force behind this last result, as in our Proposition 4, is that tax differentials under the origin principle reinforce the incentive for the low-cost firm to enter the foreign market.

5.2 Isolated differences in tax rates

Lastly, we consider the case where exogenous differences in tax rates are the only asymmetry between countries. Assuming again, without loss of generality, that $t_1 < t_2$, the binding constraints for the stability of the collusive agreement are given in (17). Differentiation with respect to t_1 and t_2 yields under the destination principle

$$\frac{\partial \bar{\theta}_2^{DP}}{\partial t_1} = \frac{-(1+t_2)\alpha_1[2c(1+t_1) + \alpha_1]}{(1+t_1)^2\alpha_2^2} < 0, \quad \frac{\partial \bar{\theta}_2^{DP}}{\partial t_2} = \frac{\alpha_1^2[\alpha_2 + 2c(1+t_2)]}{(1+t_1)\alpha_2^3} > 0. \quad (23)$$

Similarly, we get under the origin principle

$$\frac{\partial \bar{\theta}_1^{OP}}{\partial t_1} = \frac{-2\alpha_2c(\alpha_1 + \alpha_2)}{[\alpha_2 - c(t_2 - t_1)]^3} < 0,$$

$$\frac{\partial \bar{\theta}_1^{OP}}{\partial t_2} = \frac{2c[2\alpha_2 - c(t_2 - t_1)][\alpha_2 - c(t_2 - t_1)] + 4\alpha_2c^2(t_2 - t_1)}{[\alpha_2 - c(t_2 - t_1)]^2} > 0. \quad (24)$$

Substituting (23) and (24), respectively, into (20), we get the following result:

Proposition 5: *If only tax rates differ between countries, then tax rate harmonization stabilizes a collusive agreement under both the destination and the origin principle.*

This last result follows directly from the model property that, absent other asymmetries, tax differentials are critical in destabilizing the collusive arrangement between firms. Under the destination principle, an increase in t_1 and a decrease in

t_2 both reduce the incentive for the high-tax firm 2 to defect from the collusive agreement, either by reducing the exporting profits in market 1 or by increasing the monopoly profits that can be earned in its home market 2. Under the origin principle, an alignment of taxes reduces the competitive advantage of the low-tax firm 1; this reduces firm 1's gains from exporting and also increases its losses in the punishment phase.

Hence, if differences in tax rates are exogenous to the model (implying that they are derived from asymmetries that are unrelated to the profitability of firms), then the argument against tax rate harmonization becomes a general one in our tacit collusion setting, and applies equally under the destination and origin principles. This provides an interesting contrast to the argument – made in the previous literature and confirmed in Proposition 4 above – that the effects of tax rate harmonization depend crucially on the tax principle in operation. Instead, Proposition 5 parallels the general case against tax rate harmonization developed in the political economy literature (Brennan and Buchanan, 1980; see also Edwards and Keen, 1996). In this strand of literature it is usually argued that when governments are not sufficiently disciplined by the political process, then tax competition between governments can play a corrective role that shouldn't be precluded by tax rate agreements. In a similar way, firms behave non-competitively in the present setting of tacit collusion. Tax differentials can correct this market failure by inducing firms to engage in 'exporting wars', and this incentive should not be weakened by an alignment of commodity tax rates between countries.

6 Conclusions

In this paper we have analyzed the effects of international commodity tax policies on the stability of collusive agreements between firms. Such non-competitive behaviour, aimed at maintaining national monopolies, is still present in various segments of the European industry and the question we have raised here is whether tax policy can help to promote the incentives for firms to leave the collusive arrangement and enter foreign markets. We have asked two distinct questions for tax policy. First, is the destination or the origin principle to be preferred as a means of inducing competition between firms? Second, how is the incentive to leave a secret cartel affected by tax rate harmonization, as currently discussed in the European Union?

We have pursued these questions in two different settings. In the first, production costs differ between firms and an international commodity tax differential reflects non-cooperative responses of national governments to the cost asymmetry (as derived in previous literature on the subject). In the second scenario, an exogenous difference in tax rates is the only asymmetry, implying that the determinants of national commodity tax rates are unrelated to the profitability of firms.

Turning first to the choice of an international commodity tax principle, our analysis generally favours the origin over the destination principle when a positive correlation between costs of production and tax rates is incorporated into our tacit collusion framework. The basic effect at work is that tax differentials under the origin principle reinforce the asymmetries in the competitive positions of the two firms and thus weaken the common interest of the two firms in maintaining a socially harmful secret cartel. When tax rates are the only asymmetry, there is no unambiguous answer to the question of whether the destination or the origin principle is more likely to induce duopoly competition. However, if the model is extended to allow for more than two countries and firms, then the destabilizing effect of this extension is stronger under the origin principle. In sum, therefore, our results indicate that the policy case in favour of the origin principle extends to settings of imperfect competition that are quite different from the ones that have been discussed in the previous literature.

With respect to the issue of tax rate harmonization, our conclusions in the case where tax differentials interact with other asymmetries are strikingly similar to those obtained in a setting of duopoly competition between firms (Keen, Lahiri and Raimondos-Møller, 2002). Tax rate harmonization is undesirable under the origin principle, whereas it is beneficial under the destination principle. The alternative scenario with isolated tax differences leads instead to the unambiguous result that tax harmonization stabilizes socially undesirable secret cartels under both the destination and origin principles. This result reinforces earlier arguments against tax rate harmonization derived from a political economy perspective and indicates that tax coordination may encourage cartelization not only among governments, but also among firms. If non-competitive behaviour by both governments and firms are seen as relevant features of European economies, then this indeed raises serious doubts about the medium-term plans of the European Commission to fully harmonize VAT rates in the European Union.

Appendix

Proof of Proposition 1:

We denote the numerators in (15) and (16) by n^{DP} and n^{OP} , respectively, while the denominators are indicated by d^{DP} and d^{OP} . This yields

$$n^{DP} - n^{OP} = \alpha_2 \left[\alpha_2 \frac{(t_1 - t_2)}{(1 + t_2)} + 2c_1(t_1 - t_2) \right], \quad (\text{A.1})$$

from which follows $\text{sign}(n^{DP} - n^{OP}) = \text{sign}(t_1 - t_2)$.

For the denominators the comparison is

$$d^{DP} - d^{OP} = c_2(t_2 - t_1)[4\alpha_2 - 2(1 + t_1)(c_2 - c_1)]. \quad (\text{A.2})$$

Using condition (7), this implies $\text{sign}(d^{DP} - d^{OP}) = -\text{sign}(t_1 - t_2)$. From (A.1) and (A.2) together we thus get $\text{sign}(\bar{\theta}_1^{DP} - \bar{\theta}_1^{OP}) = \text{sign}(t_1 - t_2)$. \square

Proof of Proposition 2:

To prove Proposition 2 we show that the *difference* in the critical values under the destination and origin principles is increasing in the market size parameter a and decreasing in unit costs c . Hence, we have to prove that

$$\frac{\partial \bar{\theta}_2^{DP}}{\partial a} - \frac{\bar{\theta}_1^{OP}}{\partial a} > 0, \quad \frac{\partial \bar{\theta}_2^{DP}}{\partial c} - \frac{\bar{\theta}_1^{OP}}{\partial c} < 0. \quad (\text{A.3})$$

Differentiating $\partial \bar{\theta}_2^{DP}$ and $\partial \bar{\theta}_1^{OP}$ with respect to a and using $\alpha_2 + c(t_2 - t_1) = \alpha_1$ from (5) yields

$$\frac{\partial \bar{\theta}_2^{DP}}{\partial a} = \frac{-2(1 + t_2)\alpha_1 c(t_2 - t_1)}{(1 + t_1)\alpha_2^3}, \quad \frac{\partial \bar{\theta}_1^{OP}}{\partial a} = \frac{-2c(t_2 - t_1)(\alpha_1 + \alpha_2)}{[\alpha_2 - c(t_2 - t_1)]^3}. \quad (\text{A.4})$$

Partial differentiation with respect to c proceeds analogously. This gives, using $(1 + t_2)\alpha_1 - (1 + t_1)\alpha_2 = a(t_2 - t_1)$

$$\frac{\partial \bar{\theta}_2^{DP}}{\partial c} = \frac{2\alpha_1(1 + t_2)a(t_2 - t_1)}{(1 + t_1)\alpha_2^3}, \quad \frac{\partial \bar{\theta}_1^{OP}}{\partial c} = \frac{2(\alpha_1 + \alpha_2)a(t_2 - t_1)}{[\alpha_2 - c(t_2 - t_1)]^3}. \quad (\text{A.5})$$

Combining the two terms in (A.4) yields

$$\frac{\partial \bar{\theta}_2^{DP}}{\partial a} - \frac{\partial \bar{\theta}_1^{OP}}{\partial a} = \frac{2c(t_2 - t_1)\Gamma}{(1 + t_1)\alpha_2^3[\alpha_2 - c(t_2 - t_1)]^3}, \quad (\text{A.6})$$

and similarly for the terms in (A.5)

$$\frac{\partial \bar{\theta}_2^{DP}}{\partial c} - \frac{\partial \bar{\theta}_1^{OP}}{\partial c} = \frac{-2a(t_2 - t_1)\Gamma}{(1+t_1)\alpha_2^3[\alpha_2 - c(t_2 - t_1)]^3}, \quad (\text{A.7})$$

where

$$\Gamma = \alpha_2^3(\alpha_1 + \alpha_2)(1+t_1) - (1+t_2)\alpha_1[\alpha_2 - c(t_2 - t_1)]^3.$$

The denominators of (A.6) and (A.7) are positive from (7). Hence, Γ must be positive for (A.3) to hold. Partly multiplying out the terms in Γ gives

$$\begin{aligned} \Gamma &= \alpha_2^4(1+t_1) - \alpha_2^3\alpha_1(t_2 - t_1) + 3(1+t_2)\alpha_2\alpha_1c(t_2 - t_1)[\alpha_2 - c(t_2 - t_1)] \\ &\quad + (1+t_2)\alpha_1c^3(t_2 - t_1)^3. \end{aligned}$$

Using $\alpha_1 = \alpha_2 + c(t_2 - t_1)$, this can be rearranged to

$$\begin{aligned} \Gamma &= \alpha_2^4(1+2t_1 - t_2) - \alpha_2^3c(t_2 - t_1)^2 + 2(1+t_2)\alpha_2\alpha_1c(t_2 - t_1)[\alpha_2 - c(t_2 - t_1)] \\ &\quad + (1+t_2)\alpha_2c(t_2 - t_1)[\alpha_2^2 - c^2(t_2 - t_1)^2] + (1+t_2)\alpha_1c^3(t_2 - t_1)^3 \\ &= \alpha_2^4(1+2t_1 - t_2) + 2(1+t_2)\alpha_2\alpha_1c(t_2 - t_1)[\alpha_2 - c(t_2 - t_1)] \\ &\quad + (1+t_1)\alpha_2^3c(t_2 - t_1) + (1+t_2)c^4(t_2 - t_1)^4 > 0, \end{aligned}$$

which can be signed from $1 \geq t_2 \geq t_1 \geq 0$ and equation (7). \square

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