Tax Rate Harmonization and Asymmetric Tax Competition for Profits with Repeated Interaction

Wolfgang Eggert* Jun-ichi Itaya†

February 27, 2009

Abstract

This paper analyzes a model of corporate tax competition with repeated interaction and with the strategic use of profit shifting within multinationals. We show that international tax coordination is more likely to prevail if the degree of asymmetry in terms of productivity differences between countries is smaller, or if concealment cost of profit shifting are larger when the tax authorities adopt grim trigger strategies. Allowing for renegotiation in the tax harmonization process generally requires more patient tax authorities to support tax harmonization as a subgame perfect equilibrium. We find somewhat paradoxical situations where higher costs of profit shifting make international tax arrangements less sustainable under weakly-renegotiation-proof strategies.

Keywords: corporate taxation, tax coordination, multinational firms

JEL classifications: H 25, H 87, F 23

*University of Paderborn, CESifo and ifo Institute for Economic Research at the University of Munich, Warburgerstr. 100, 33098 Paderborn, Germany. Tel +49-5251-60-5002; E-mail: Wolfgang.Eggert@uni-paderborn.de

†Graduate School of Economics and Business Administration and CESifo, Hokkaido University, Sapporo, 060-0809, Japan. Tel:+81-11-706-2858; Fax:+81-11-706-4947; E-mail: itaya@econ.hokudai.ac.jp

1 Introduction

The taxation of income of multinational firms and the proper assignment of the 'fiscal common'(Konrad, 2008) to individual countries has been a long-standing issue in both policy and academic debates.[1] Concerns about the definition of a 'fair' share of the corporate tax base (corporate income or profits) are particularly strong in the European Union where many of the obstacles to capital market integration have been eliminated as part of the internal market program. Corporate income continues to be taxed at different rates across countries. This means that multinational firms have a motive to manipulate transfer prices for intra firm trade. Regulations for judging the appropriateness for transfer prices may moderate the incentives to shift profits across borders from low to high-tax countries. However, auditing and enforcement of tax rules relies on the voluntary cooperation between players in the tax game. Recent empirical evidence suggests that the resulting amount of profit shifting is substantial (Egger, Eggert and Winner, 2006, Huizinga and Laeven, 2007) with adverse effects on tax revenue in high-tax countries.

There is a growing literature that has mainly addressed corporate tax competition in the presence of multinational firms and transfer pricing. Elitzur and Mintz (1996) discuss corporate tax competition between governments when the transfer price affects both the amounts of profits shifted and the incentives for the subsidiary's managing partner, and show that tax harmonizations to reduce the impact of negative fiscal externalities is likely to lower corporate tax rates. Haufler and Schjelderup (2000) extends a model of corporate tax competition to allow for the tax authorities to use a tax rate and a tax base (depreciation allowances) simultaneously. They find that recent corporate tax reforms in the OECD where corporate tax rates have been decreased in conjunction with a broadening of the tax base, are optimal responses to the increased presence of multinationals and transfer pricing. On the other hand, Mansori and Weichenrieder (2001) and Rainmodos-Moller and Scharf (2002) model competition

[1] Wilson (1999), Fuest, Huber and Mintz (2005), and Sørensen (2007), among them, provide excellent surveys.

in transfer pricing regulations by two governments, and identify that strategic transfer pricing rules leads to a "race-of-the-top" in transfer pricing with decreased output and interafirm trade of multinationals. These two papers also find that harmonization of transfer pricing rules among countries could potentially bring about a Pareto improvement.[2]

Nevertheless, neither of these papers has considered the sustainablity of tax harmonization or transfer pricing rules to eliminate or mitigate the inefficiency generated by such wasteful profit shifting activities. Because of the limitation of a static analysis, the analytical focus of those models lies mainly on whether or not there is a welfare-enhancing tax harmonization or tax coordination as compared to a noncooperative Nash equilibrium. As a result, it does not suffice to guarantee the sustainability of such coordination. This is because in the context of static (or one-shot) tax competition, the structure of payoffs accruing to countries displays characteristics of "Prisoner's dilemma", which is mainly caused by a positive fiscal externality associated with corporate taxation [see, e.g.,Wildasin (1989)]. In this case, the coordinating countries are unable to reach a Pareto-improving (or efficient) outcome even if it exists and to sustain it as a self-enforced equilibrium outcome, because there is a strong incentive for countries to deviate from a Pareto improving coordinated tax rate in order to reap gains.

Recently, Cardarelli, Taugourdeau and Vidal (2002), Catenaro and Vidal (2006) and Itaya, Okamura and Yamaguchi (2008) have built repeated interaction models with tax competition for mobile capital. Apart from the reality of a repeated interactions setting, it is well known that repeated interactions facilitate cooperation, and, moreover, that the use of a repeated interactions model makes it possible that tax harmonization among governments is sustainable, based on simple 'folk theorem' arguments.

[2]Recently, many authors, among many others, Eggert and Schjelderup (2003), and Riedel and Runkel (2007), Nielsen, Raimondos-Møller and Schjelderup (2008) have compared the *Separate Accounting* and *Formula Apportionment* principles of corporate taxation in the framework of corporate tax competition with multinationals and profit shifting.

Our paper explicitly investigates how the presence of multinationals and profit shifting affect the likelihood of cooperation which aims at establishing harmonization of corporate taxation. In particular, we are interested in how the presence of profit shifting affects the likelihood of such cooperation. To see this we carry out comparatives statics analysis with respect to changes in the concealment cost of profit shifting. Second, in the presence of profit shifting, we also ask whether an increasing asymmetry in terms of productivity differences of the affiliates promotes tax harmonization or not. Asymmetry is needed to induce the tax authorities to set different tax rates, which in turn gives them an incentive to make profit shifting. Thirdly, we incorporate the world capital market which endogenously determines the interest rate, unlike the standard corporate profits tax competition model with the fixed world interest rate [see, e.g., Haufler and Schjelderup (2000), Riedel and Runkel (2007]. In this sense, our model is a general equilibrium model like a capital tax competition model such as Zodrow and Mieszkowski (1986), and Willson (1986). Such an approach makes it possible to deduce more realistic and richer implications compared to the standard corporate profit competition model with the fixed world interest rate because changes in corporate income taxes create both a profit shifting externality and a fiscal externality (i.e., the tax-base effect through variations in capital demand).

Furthermore, the analysis permits a characterization of the way that equilibria under the infinitely repeated grim trigger and finitely repeated weakly renegotiation (WRP) strategies depend on country-specific asymmetries and on the concealment costs of cross-border profit-shifting. We find that the possibility of renegotiation under the WRP strategy generally requests that tax authorities should be more patient compared to those under grim trigger strategies; in this sense, harmonization of tax rates are less likely to be implemented as a subgame perfect equilibrium. Interestingly, our comparative static analysis reveals that tax harmonization becomes more likely in economic scenarios where the multinational firm perceives higher costs of cross-border profit-shifting with grim trigger strategies, whereas an increase in such costs reduces the likelihood to obtain harmonization as the outcome with decentralized decision-making in economic environments where renegotiation is possible.

The reminder of the paper is organizes as follows. Section 2 presents a simple model of asymmetric tax competition for the profits of a multinational firm and characterizes the cooperative solution as a target tax rate at which governments are coordinated. Grim trigger strategies in tax policy are analyzed in Section 3 and the outcome with weakly renegotiation-proof strategies is central in Section 4.

2 The model

We consider two countries $i = 1, 2$ which are inhabited by a large number of investors endowed with $\overline{k}$ units of capital. In each period these investors allocate their capital internationally to finance investment of a multinational firm operating in the two countries. The multinational firm maximizes profits net of the corporation tax through the choice of factor employment and strategic manipulation of declared costs. The government in each country tries to combat profit shifting through cost manipulation, but is restricted to a source tax on book profits.

Technologies

Production technologies. The multinational firm seeks k_i units of per capita capital and an essential service to produce output. For analytical convenience, we treat the size of the essential service, such as labor inputs, fixed at unity (Riedel and Runkel, 2007). The affiliate of the multinational firm in country i has a technology described by the strictly concave, constant-returns-to-scale production function (Bucovetsky, 1991, Haufler, 1997):

$$f_i(k_i) := (A_i - k_i)\, k_i,$$

where the marginal productivity (of the first unit) of capital, A_i, may differ among (asymmetric) countries. We assume throughout that the marginal productivity of capital is positive, i.e., $A_i > 2k_i$.

Profit–shifting technology. Self selection of firms into profit-shifting and the externalities caused thereby do play a central role in this analysis. Potential for profit shifting is arising because the multinational firm has better information as to the actual costs than the tax authority. The choice of the declared cost structure between affiliated entities creates possibilities to transfer of profits between taxing jurisdictions. We shall argue that the true costs of the essential service are unity, $s = 1$. Thus, a choice of $s > 1$ implies overinvoicement and $s < 1$ underinvoicement of the service. To limit strategic transfer pricing it seems natural to model the costs of misdeclaration by a convex function. In the analysis of repeated interaction below it will become necessary to compare directly the *levels* of profits in the cooperative and non-cooperative phases of the repeated game defined later. To this end we specify that the costs of profit shifting are quadratic in the level of misdeclaration (see, e.g., Haufler and Schjelderup (2000))

$$q(s) = \beta(s-1)^2 \quad \text{with} \quad \beta \geq 0.$$

The lower bound $\beta = 0$ corresponds to complete or unhindered profit shifting and thus to complete or perfect spillovers of the activities of the multinational firm on the tax bases of countries.

Institutions

Aggregate economic profits of the multinational firm are $\sum_{i=1}^{2}[f_i(k_i) - r_i k_i]$, where r is the world-market rental rate per unit of capital. Book profits of the multinational firm after the corporation tax amount to[3]

$$\Pi := \sum_{i=1}^{2} \pi_i = \sum_{i=1}^{2} \left\{ (1-\tau_i) \left[f_i(k_i) - r_i k_i + (-1)^i (s-1) \right] \right\} - q(s), \tag{1}$$

where τ_i denotes the tax rate levied on corporate profits in country i (i.e., π_i).

In the stationary environment of repeated games the multinational firm chooses k_i and s repeatedly to maximize (1). Choices are characterized by the first-order conditions (recall $A_i > 2k_i$):

$$\frac{\partial f_i(k_i)}{\partial k_i} = A_i - 2k_i = r_i \qquad i = 1, 2, \tag{2}$$

$$\frac{\partial q(s)}{\partial s} = (1-s)\beta = \tau_1 - \tau_2. \tag{3}$$

Denote in the following by $\theta := A_1 - A_2$ the difference in productivities between the affiliates of the multinational firm. Let $\theta \geq 0$ in what follows without loss of generality.

Many existing analyses on tax competition (e.g., Kanbur and Keen, 1993) assume the fiscal authorities to maximize tax revenues. Janeba and Peters (1999) point out that tax revenue maximization is not analogous to assuming a Leviathan type government.[4] Corporate taxes are levied in OECD countries to ensure an effective level of taxation of entrepreneurial income. We thus think that tax revenue generation is a good proxy of actual behavior. In the repeated

[3] Alternatively, one could assume that the costs of misdeclaration are deductible from the tax base in one of the two countries or at some convex combination. Since all these are noteworthy alternatives Nielsen, Raimondos and Schjelderup (2008) check robustness and show that alternative modeling assumptions have an insignificant effect on outcome.

[4] In the literature on corporate tax competition with multinational firms and profit shifting, moreover, several authors such as Elitzur and Mintz (1996), Mansori and Weichenrieder (2001), it is popular to assume tax revenue maximizing governments.

game tax revenue maximization implies maximizing the discounted sum of tax revenues over an infinite time horizon:

$$V_i = \sum\nolimits_{t=0}^{\infty} \delta^t R_i \qquad i = 1, 2,$$

where $\delta_i \in (0, 1)$ is the common (actual) discount factors possessed by the tax authorities of the respective countries. We have assumed a separating accounting system under which corporate income is taxed in the country where the multinational firm declares, the one-shot tax revenue in country i is

$$R_i (r, \tau_1, \tau_2) := \tau_i \ \left[f_i (k_i) - rk_i + (-1)^i (s - 1)\big)\right] \qquad i = 1, 2. \tag{4}$$

Capital market equilibrium

We look at a stage game of the above repeated game. A market equilibrium in this stationary economic environment is a world rental rate r such that for all tax rates τ_i, in each period the multinational firm maximizes profits (1), while equity holders choose their place of investment to maximize income and the capital market clears:

$$k_1(r) + k_2(r) = 2\bar{k}. \tag{5}$$

Substituting out for k_i in (5) using (2) gives the world market rental rate for capital:

$$r = \frac{1}{2} \left(A_1 + A_2 - 4\bar{k}\right). \tag{6}$$

Substituting (6) back into r in (2) gives the capital demand functions of the multinational firm:

$$k_i = \frac{1}{4} \left[4\bar{k} - (-1)^i \theta\right] \qquad i = 1, 2, \tag{7}$$

where we assume $\theta \in [0, 4\bar{k})$ throughout in order to ensure strictly positive investment in both countries. Then use the capital demand functions (7) and the market rental rate (6) in the profit definition (1) to get the one-shot (global) profit of the multinational firm:

$$\Pi = \frac{(\tau_1 - \tau_2)^{\,2}}{2\beta} + \sum_{i=1}^{2} \frac{(1-\tau_i)\,(r + A_i)^{\,2}}{4}. \tag{8}$$

Substituting out for k_i using (7), for r using (6) and for s using (3) in (4), the one-shot tax revenue function (4) becomes

$$R_i = \tau_i \pi_i = \tau_i \left[\frac{(\theta - (-1)^i 4\bar{k})^2}{16} + (-1)^i \frac{\tau_1 - \tau_2}{\beta} \right] \qquad i = 1, 2, \tag{9}$$

where π_i represents the tax base faced by the tax authority of country i.

The one-shot non-cooperative game

We first consider the tax authorities to act independently and non-cooperatively in making their policy decisions. The solution of the problem is a (one-shot) Nash equilibrium in tax rates:

$$\tau_i^N := \arg\max \ \left\{ R_i \left(\tau_i, \tau_j^N \right) \quad \text{s.t.} \quad (2), (3), (5) \right\} \qquad i = 1, 2, \ i \neq j.$$

Note that independent decision-making does not imply that individual authorities ignore the effects of their choices of taxes on the international allocation of profits. When country i changes its tax rate on profits it anticipates a change in taxable profits as a consequence of profit shifting activities of the multinational firm because the profits relocate to the other country. Solving the first-order conditions for the tax rate gives

$$\tau_i(\tau_j) = \frac{1}{32} \left[\beta \left(4\bar{k} - (-1)^i \theta \right)^2 + 16\tau_j \right] \qquad i = 1, 2, \ i \neq j. \tag{10}$$

Inspection of (10) shows that best responses satisfy $\partial\tau_i(\tau_j)/\partial\tau_j < 1$, $i, j = 1, 2$ but $i \neq j$, implying the existence of a unique Nash equilibrium. The solution of (10) is

$$\tau_i^N = \frac{1}{48}\beta\left[48\bar{k}^2 - (-1)^i 8\bar{k}\theta + 3\theta^2\right] \qquad i = 1, 2. \tag{11}$$

These tax rates reveal that – given that concealment costs are positive (i.e., $\beta > 0$) – the more productive country (country 1) chooses to levy the tax at a higher rate than the less productive country (country 2). The difference in taxes vanishes in the absence of a difference in productivities ($\theta = 0$); in other words, the presence of the difference in productivities induces decentralized governments to set different tax rates, which in turn motivates multinational firms to engage in profit shifting. Substituting (11) into (9) gives the one-shot Nash tax revenue:

$$R_i^N = \frac{1}{2304}\beta\left[48\bar{k}^2 - (-1)^i 8\bar{k}\theta + 3\theta^2\right]^2 \qquad i = 1, 2. \tag{12}$$

It is clearly straightforward that $R_1^N - R_2^N = (1/24)\,\beta\theta\bar{k}\left(\theta^2 + 16\bar{k}^2\right) > 0$, implying that tax revenues are higher in country 1 where the multinational's local affiliate has the more advanced technology (i.e., country 1), whereas the absence of such a difference leads to equal (zero) tax revenues. We may then characterize the market rental rate and the allocation of capital as $r^N = r$ in (2) and $k_i^N = k_i$, $i = 1, 2$, in (7). The one-shot global profits of the multinational firm are

$$\Pi^N = \frac{\theta^2}{8} - \frac{\beta\theta^4}{128} - 2\beta\bar{k}^4 + \left(2 - \frac{13\beta\theta^2}{36}\right)\bar{k}^2. \tag{13}$$

That $\partial\Pi^N/\partial\beta < 0$ is intuitive; higher compliance (concealment) costs decrease profits in a noncooperative situation. It is also seen from (13) that profits are increasing in θ for low values of the compliance cost parameter β and inverse U shaped in θ for higher values of β. Thus profits are decreasing in θ in situations with high compliance costs. The economic argument here is that a high marginal compliance cost combined with a difference in productivities among affiliates imply that tax rates differ between countries, giving rise to profit shifting activities at the firm level to lower the tax burden in the high-tax country. High marginal compliance costs reduce the profitability of profit shifting, allowing the high-tax country to cut into the profits of the multinational firm.

Cooperative solution

Although an infinite repetition of the Nash tax rates that prevail in the one-shot tax competition game constitutes a subgame perfect Nash equilibrium in repeated games, there is a possibility that governments may achieve a higher discounted sum of tax revenue by setting corporate tax rates in a cooperative manner. In the present model with a stationary economic environment the problem of finding the maximum of the discounted sum of joint tax revenues over an infinite horizon simply amounts to infinite repetition of maximizing the one-shot joint tax revenue in all periods. The first-order conditions for maximizing the one-shot joint tax revenue $R_1^C + R_2^C$ are given by

$$r^C = A_i - 2k_i \qquad i = 1, 2. \tag{14}$$

$$0 = \tau_1 - \tau_2. \tag{15}$$

Condition (14) is the condition for the optimal use of capital. Condition (15) characterizes the tax rates needed to minimize the costs of profit shifting, i.e., minimum concealment costs, although the absolute level of τ^C is indeterminate. This means that the cooperation to maximize joint tax revenue requires equal tax rates, i.e., $\tau^C := \tau_i$, $i = 1, 2$, though all periods, to eliminate a pure waste of resources associated with compliance costs.

Using (6) and (7) that $r^C = r$ in (2) and $k^C = k_i$, $i = 1, 2$, in (7) gives the one-shot profits of the multinational firm:

$$\Pi^C = (1 - \tau^C)\frac{\theta^2 + 16\bar{k}^2}{8}. \tag{16}$$

Profits are independent of concealment costs since there does not exist any motive for profit shifting in the absence of tax rate differentials. In contrast, profits are increasing in θ, at least for non-confiscatory rates of the corporate tax. Making use of the common tax rate $\tau^C := \tau_i, i = 1, 2$, in (9) yields tax revenue under tax harmonization as

$$R_i^C = \frac{\tau^C}{16}\left[\theta - (-1)^i 4\bar{k}\right]^2 \qquad i = 1, 2. \tag{17}$$

It is seen that $R_1^C - R_2^C = \tau^C \theta \bar{k} > 0$. This implies larger tax revenues in the country where the more productive affiliate is located.

3 Repeated interaction

Cooperation in tax policy requires that countries levy taxes at equal rates (i.e., tax harmonization) in all periods in order to avoid the resource costs of (wasteful) profit shifting activities. However, signing an agreement (or implicit collusion) that implements cooperation in tax setting is an economic activity which potentially is costly for the individual country. This means that a prerequisite (a necessary condition) to implement an agreement is the willingness of the national tax authorities to participate in the agreement.

Participation constraints. The participation constraints imply that cooperation should give a higher tax revenue compared to the outcome with non-cooperative behavior for each country in any period of time, i.e., $R_i^C \geq R_i^N$, $i = 1, 2$. Using (17) to substitute out for R_i^C and (12) to substitute out for R_i^N, and solving for the equality gives the lower bounds $\underline{\tau}_i^C$ at which a country is indifferent between tax coordination and tax competition as

$$\underline{\tau}_i^C = \frac{\beta}{144}\frac{\left[3\theta^2 - (-1)^i 8\bar{k}\theta + 48\bar{k}^2\right]^2}{\left[\theta - (-1)^i 4\bar{k}\right]^2} \qquad i = 1, 2. \tag{18}$$

It is straightforward to check that the lower bounds of both countries are U-shaped in $\theta \in [0, 4\bar{k})$, where $\underline{\tau}_i^C = \beta\bar{k}^2$ at $\theta = 0$. It is also easy to confirm that

$\underline{\tau}_1^C < \underline{\tau}_2^C$ for $\theta \in (0, 4\bar{k})$ and $\underline{\tau}_1^C = \underline{\tau}_2^C$ at $\theta = 0$. Set the coordinated tax rate τ^C to be strictly greater than this lower bound associated with each θ:

$$\tau^C > \underline{\tau}_2^C = \max\left\{\underline{\tau}_1^C, \underline{\tau}_2^C\right\}. \tag{19}$$

As θ approaches the upper bound (i.e., $4\bar{k}$), the lower bound $\underline{\tau}_2^C$ goes to plus infinity. This implies that none of countries will participate in the tax harmonization when the affiliates located in different countries are highly asymmetric in technologies.

Best-deviation tax rate. The best-deviation tax rate τ_i^D maximizes tax revenue in country i, given that the other country sets τ^C. Substituting out τ_j for τ^C in the best reply function of country i, $i \neq j$, in (10) gives

$$\tau_i^D := \frac{1}{32}[16\tau^C + \beta\left(\theta - (-1)^i 4\bar{k}\right)^2] \qquad i = 1, 2. \tag{20}$$

Then use (20) to substitute out for τ_i in the expression for R_i in (9), given $\tau_j = \tau^C$, $i, j = 1, 2$ but $i \neq j$, to get the best deviation tax revenue:

$$R_i^D := \frac{[16\tau^C + \beta\left(\theta - (-1)^i 4\bar{k}\right)^2]^2}{1024\beta} \qquad i = 1, 2. \tag{21}$$

It is straightforward to see that $R_1^D - R_2^D > 0$, so the more productive country (i.e., country 1) gets a higher level of tax revenue when deviating from cooperation. Moreover, it is easy to show that $R_i^D > R_i^C$, $i = 1, 2$. Yet, the implication is not that countries always tend to deviate from coordination, since deviating countries will potentially be punished by reverting to the Nash equilibrium (i.e., the punishment phase) which is accompanied by further lower tax revenues. Hence, it is important to use a relative measure for profitability of deviation, and we will introduce the minimum discount factor in the following which reflects such a relative measure.

Minimum discount factors. Let us assume that the tax authorities in both countries adopt the grim trigger strategy in setting their tax rates; that is, country i sets its capital tax at some predetermined level denoted by $\tau^C > \tau_i^N$

at the beginning of the game onwards as long as country j $(j \neq i)$ maintains τ^C, in the previous period. If the tax authority of some country deviates from τ^C in, say, period t, then cooperation collapses and triggers punishment which results in a Nash equilibrium from period $t+1$ to forever thereafter. Accordingly, the conditions to sustain cooperation are given by

$$\frac{1}{1-\delta}R_i^C \geq R_i^D + \frac{\delta}{1-\delta}R_i^N \qquad i = 1,2, \tag{22}$$

which is equivalent to

$$\delta_i \geq \frac{R_i^D - R_i^C}{R_i^D - R_i^N} \qquad i = 1,2. \tag{23}$$

The *minimum* values of both countries' discount factors which sustain cooperation are obtained as follows. For country 1 we use (17) to substitute out for R_1^C, (21) to substitute out for R_1^D and (12) for R_1^N on the right-hand side of (23). For country 2 we use (17) for R_2^C, (21) for R_2^D and (12) for R_2^N on the right hand side of (23) to get

$$\begin{aligned}\hat{\delta}_i &:= \frac{R_i^D - R_i^C}{R_i^D - R_i^N} && (24)\\ &= \frac{9[\beta\left(\theta-(-1)^i 4\bar{k}\right)^2 - 16\tau^C]^2}{9[16\tau^C + \beta\left(\theta-(-1)^i 4\bar{k}\right)^2]^2 - 4\beta^2\left[3\theta^2-(-1)^i 8\bar{k}\theta + 48\bar{k}^2\right]^2} && i = 1,2.\end{aligned}$$

Minimum discount factor. The cooperative tax rate τ^C is sustainable as a subgame perfect Nash equilibrium of the repeated game only in situations where the *actual* (common) discount factor of both countries, δ, is larger than the *threshold* discount factor defined by $\delta^* = \hat{\delta}_2 = \max\{\hat{\delta}_1, \hat{\delta}_2\}$. This is confirmed by inspection of (24). The minimum discount factor of country 2 to sustain cooperation is always greater than that of country 1, except at $\theta = 0$ or $\beta = 0$ where $\hat{\delta}_1 = \hat{\delta}_2$.

Comparative statics. We are now ready to analyze the effect of a change in some principle parameters on outcome. First, we differentiate δ^* with respect to θ to get (see Appendix A)

$$\frac{\partial \delta^*}{\partial \theta} = \frac{\partial \hat{\delta}_2}{\partial \theta} > 0. \tag{25}$$

To understand the economic mechanisms underlying (25), we need to know how an increase in the degree of productivity difference affects the tax bases of the respective countries at all phases of the repeated game. To this end, we first differentiate R_2^C in (17) with respect to θ. This gives[5]

$$\frac{\partial R_2^C}{\partial \theta} = \tau^C \frac{\partial \pi_2^C}{\partial \theta} = \frac{\tau^C}{8}\left(\theta - 4\bar{k}\right) < 0, \tag{26}$$

for $\theta \in [0, 4\bar{k})$. To explain this result notice that an increase in the difference of productivities has opposite effects on the tax revenues of the two countries given by (17). A higher θ induces the multinational firm to expand (shrink) its production by making more (less) investments in the high- (low-) productivity country. As a result, the high-productivity country 1 enjoys larger profits, while the low-productivity country 2 does lower profits. There is no incentive for the multinational firm to shift profits across countries due to the common tax rate. Hence, an increasing asymmetry in productivities between countries has a negative effect on the tax base in country 2 in the cooperative phase without any tax-rate effect and this explains the observation that country 2 ends up collecting less tax revenue compared to that of country 1. This means that cooperation becomes less attractive for the low-productivity country 2.

The effect of an increase in θ on the tax revenue of country 2 in the deviation phase can be decomposed into tax-rate and tax-base effects as follows:[6]

$$\frac{\partial R_2^D}{\partial \theta} = \pi_2^D \frac{\partial \tau_2^D}{\partial \theta} + \tau_2^D \frac{\partial \pi_2^D}{\partial \theta} = \frac{[16\tau^C + \beta\left(\theta - 4\bar{k}\right)^2]\left(\theta - 4\bar{k}\right)}{256} < 0. \tag{27}$$

[5]Note that $\partial R_1^C / \partial \theta = (\tau^C/8)\left(\theta + 4\bar{k}\right) > 0$ for the high-productivity country 1.

[6]Note that $\partial R_1^D / \partial \theta = (1/256)[16\tau^C + \beta\left(\theta + 4\bar{k}\right)^2]\left(\theta + 4\bar{k}\right) > 0$ for the high-productivity country 1.

where $\partial\tau_2^D/\partial\theta = (\beta/16)(\theta - 4\overline{k}) < 0$ and $\partial\pi_2^D/\partial\theta = (1/16)(\theta - 4\overline{k}) < 0$. An increase in θ causes both tax-rate and tax-base effects in the deviation phase. The tax-rate effect is negative since a higher θ leads to a decrease in τ_2^D from (20). The tax-base effect works through two channels; that is, changes in capital demand and the amount of profit shifting. The tax-base effect arising from variations in capital demand is negative since (7) implies that a higher degree of country-specific asymmetries measured by θ causes a reduction of the tax base in country 2 (i.e., π_2^D) as a result of the lower capital demand associated with country 2's lower marginal productivity, whereas the amount of profit shifting to country 2 is increased due to a larger tax differential $\tau_2^D - \tau^C$. It follows from $\partial\pi_2^D/\partial\theta < 0$ that the first tax-base effect dominates the second one and so their sum is negative. Taken together, an increase in the asymmetries between countries makes deviation less profitable for the country in which the local affiliate has the lower productivity, which is consistent with the negative sign of (27).

The effect of an increase in θ on country 2's tax revenue in the Nash equilibrium phase can also be decomposed into tax-rate and tax-base effects:[7]

$$\frac{\partial R_2^N}{\partial\theta} = \pi_2^N \frac{\partial\tau_2^N}{\partial\theta} + \tau_2^N \frac{\partial\pi_2^N}{\partial\theta} = \frac{\beta\left[3\theta^2 - 8\bar{k}\theta + 48\bar{k}^2\right]\left(3\theta - 4\bar{k}\right)}{576} \gtreqless 0, \tag{28}$$

where $\partial\tau_2^N/\partial\theta = (\beta/24)(3\theta - 4\overline{k}) \gtreqless 0$ and $\partial\pi_2^N/\partial\theta = (1/24)(3\theta - 4\overline{k}) \gtreqless 0$. Tax revenue in the Nash equilibrium phase is increasing in θ for $3\theta > 4\overline{k}$ and decreasing in θ for $3\theta < 4\overline{k}$ provided $\beta \neq 0$. The intuition for the result is as follows. A higher level of θ always decreases the capital demand of country 2, whereas the larger tax differential $\tau_1^N - \tau_2^N$ makes the amount of profit shifting to country 2 larger, thus leading to an ambiguous effect on the tax base π_2^N. In addition, it follows from (11) that an increase in θ has an ambiguous effect on τ_2^N. These results together indicate that the whole effect on the tax revenue depends on the size of θ.

The above results reveal the change of incentives caused by an increase in asymmetries between countries in different phases of the repeated game. This

[7] Note that $\partial R_1^N/\partial\theta = (\beta/576)\left[3\theta^2 + 8\bar{k}\theta + 48\bar{k}^2\right]\left(3\theta + 4\bar{k}\right) > 0$ for the high-productivity country 1.

serves as a basis of the following discussion which attempts to shed more light on the economic mechanisms which establish cooperation as the outcome of a repeated game. The problem of the tax authority is to choose whether or not to maintain tax harmonization; it compares the immediate gain from its unilateral deviation with the opportunity cost when reverting to the Nash equilibrium in all the subsequent periods. To simplify the exposition, suppose that the actual discount factor of country 2 happens to coincide with the minimum discount factor δ^* in (24). Subtracting R_2^C from the resulting equality gives

$$\frac{\delta^*}{1-\delta^*}\left(R_2^C - R_2^N\right) = R_2^D - R_2^C. \tag{29}$$

The left-hand-side of (29) represents the discounted future (opportunity) costs from country 2's unilateral deviation, while its right-hand side is the immediate gain from deviating. For ease of exposition, we further decompose the discounted future costs on the left-hand-side of (29) into two components: the discount factor component $\delta^*/(1-\delta^*)$ and the opportunity cost incurred by country 2, $R_2^C - R_2^N$. Comparing (26) with (27), and with (28) reveals that the effect on the immediate gain from deviation, $\partial(R_2^D - R_2^C)/\partial\theta$, is positive, while that on the future loss, $\partial(R_2^C - R_2^N)/\partial\theta$, is negative. Put together, the gain is larger than the loss, so that country 2 has a stronger incentive to deviate. This is because the *negative* effect of increasing θ on R_2^C should be much larger than that on R_2^N or R_2^D in absolute value, which stems from the fact that there is no tax-rate effect in the case of $\partial R_2^C/\partial\theta$ which may counter-act the tax-base effect. Hence, the minimum discount factor δ^* should be higher so as to resort to the equality in (29) and exactly this economic intuition is confirmed by (25).

We use the same structure of arguments to discuss the economic consequences of an increase in the marginal compliance costs β on the incentives of tax authorities to implement tax harmonization. By differentiating δ^* with respect to β we obtain (see Appendix A)

$$\frac{\partial\delta^*}{\partial\beta} = \frac{\partial\hat{\delta}_2}{\partial\beta} < 0. \tag{30}$$

Similarly, differentiating the corresponding tax revenues with respect to β yields

$$\frac{\partial R_2^C}{\partial \beta} = 0, \tag{31}$$

$$\frac{\partial R_2^D}{\partial \beta} = \frac{\partial \tau^D}{\partial \beta}\pi_2^D + \tau^D \frac{\partial \pi_2^D}{\partial \beta} = \tau_2^D \frac{-16\tau^C + \beta(\theta - 4\bar{k})^2}{32\beta^2} < 0, \tag{32}$$

$$\frac{\partial R_2^N}{\partial \beta} = \pi_2^N \frac{\partial \tau_2^N}{\partial \beta} = \frac{1}{2304}\left[48\bar{k}^2 - (-1)^i 8\bar{k}\theta + 3\theta^2\right]^2 > 0. \tag{33}$$

An increase in β has no effect on the productivities in the two countries so that the change has a second order effect on capital input decisions, i.e., there is no tax-base effect through variations in capital demand. Consequently, there remains the tax-base effect through changes in the amount of profit shifting since the multinational firm only adjusts the level of profit shifting activities in response to the tax differentials.

Interestingly, higher levels of compliance costs reduce both the gains and the losses from deviation. To see this compare (31) with (32) and with (33). This comparison reveals that the immediate gain from deviation is decreasing in β (i.e., $\partial(R_2^D - R_2^C)/\partial\beta < 0$), so does the future loss, (i.e., $\partial(R_2^C - R_2^N)/\partial\beta < 0$). Nevertheless, the reduction in R_2^D is *in absolute value* larger than the increase in R_2^N. This explains the result from (30) in that the incentive for deviation is weakened.

The result is quite intuitive. An increase in the barriers for profit shifting means that it becomes relatively unattractive for the multinational firm to shift profits across borders. A lower mobility of profits reduces the potential of tax authorities to cut into the profits created by firms for any given choice of the tax rate in the neighboring country. Stated differently, two asymmetric countries perceive a lower degree of tax base mobility, implying that countries find it easier to cooperate.

Proposition 1 *In a repeated tax competition game with grim trigger strategies*

(i) there is a subgame perfect equilibrium in which the cooperative equal tax rates (i.e., the Pareto-efficient tax harmonization) are sustained if both countries are sufficiently patient;

(ii) the less productive country has a stronger incentive to deviate from the Pareto-efficient tax harmonization;

(iii) an increase in the difference in productivities among countries makes the Pareto-efficient tax harmonization more difficult; and

(iv) an increase in the concealment cost of profit shifting makes the Pareto-efficient tax harmonization easier.

4 Renegotiation

The trigger strategy postulates that countries can be deterred from short-run opportunism by threats of continued future retaliation. It seems counter-intuitive that once punishment is activated, it continues forever.

We can briefly describe the concept of WRP strategies which support the cooperative tax rate as a subgame perfect equilibrium as follows. In each period, each country chooses τ^C, provided the other country chooses τ^C in the previous period. If country i alone deviates from the coordinated tax rate τ^C by choosing its best-deviation tax rate τ_i^D, in some period, then country j starts to punish i by choosing τ_j^N in the next period (or over the following several periods). Defector i has two options to react. She can either accept the punishment and choose τ^C for a finite sequence of m periods (repentance phase), or not to give in and continue with defection, whereby choosing the best-reply tax rate τ_i^N to the tax rate τ_i^D chosen by punisher i (retaliation phase). In the first case defector i resumes cooperation after the punishment has been implemented for finite periods, while in the second case the punishment (non-cooperative choice of taxes) is prolonged forever.

The sequence of the coordinated tax rate τ^C thus constitutes a WRP strategy in an infinitely repeated game between the two governments if the following four conditions are satisfied (see Farrel and Maskin, 1989, page 335)

$$R_i^D + \frac{\delta}{1-\delta} R_i^N \leq \frac{1}{1-\delta} R_i^C, \tag{34}$$

$$R_i^D + \delta \frac{1-\delta^m}{1-\delta} R_i(\tau^C, \tau_j^D) \leq \frac{1-\delta^{m+1}}{1-\delta} R_i^C, \tag{35}$$

$$\frac{\delta^m}{1-\delta} R_i^C + \frac{1-\delta^m}{1-\delta} R_i(\tau^C, \tau_j^D) \geq \frac{1}{1-\delta} R_i^N, \tag{36}$$

$$\frac{1-\delta^m}{1-\delta} R_j^D + \frac{\delta^m}{1-\delta} R_j^C \geq \frac{1}{1-\delta} R_j^C \qquad i = 1, 2,\ i \neq j. \tag{37}$$

Condition (34) means that the payoff from deviation, R_i^D, and anticipated realization of Nash revenues, R_i^N, in the retaliation phase must not exceed payoff under cooperation. Condition (35) requires that defection in one period and cooperation resumed over m periods gives a lower payoff compared to cooperation over $m+1$ periods. Condition (36) requires that tax revenues from being punished over m periods and cooperation resumed after m punishment periods must not fall short of that from playing non-cooperatively. Condition (37) ensures that punishment is credible in the sense that the punisher has no incentive to renegotiate on the preassigned punishment. For this the discounted tax revenues from deviating m periods and cooperation resumed after m punishment periods must not fall short of that from playing cooperatively. Since $R_j^D \geq R_j^C$ implies (37), this condition is trivially satisfied and thus imposes no additional restriction. Furthermore, since it can easily be verified that conditions (36) and (37) together imply (34), we can drop (34) also.

Minimum discount factors under WRP strategies. For analytical convenience, assume that the punishment length is restricted to one period (i.e. $m = 1$) so that conditions (35) and (36) further simplify to

$$(1+\delta) R_i^C \geq R_i^D + \delta R_i(\tau^C, \tau_j^D), \tag{38}$$

$$(1-\delta) R_i(\tau^C, \tau_j^D) + \delta R_i^C \geq R_i^N, \qquad i = 1, 2,\ i \neq j. \tag{39}$$

To get the *minimum* values of the discount factors of both countries in the retaliation phase and repentance phases we rewrite (38) and (39), respectively, as

$$\hat{\delta}_i^{NR} \geq \frac{R_i^D - R_i^C}{R_i^C - R_i(\tau^C, \tau_j^D)}, \tag{40}$$

$$\hat{\delta}_i^{PN} \geq \frac{R_i^N - R_i(\tau^C, \tau_j^D)}{R_i^C - R_i(\tau^C, \tau_j^D)}, \qquad i = 1, 2,\ i \neq j, \tag{41}$$

where R_i^D is given by (21) and R_i^C is given by (17).

The tax revenue when being punished $R_i(\tau^C, \tau_j^D)$ in the repentance phase is obtained as follows; setting τ_i equal to τ^C and using (20) to substitute out τ_j for τ_j^D in the expression for $R_i(\tau^C, \tau_j^D)$ in (9) gives

$$R_i^P := R_i(\tau^C, \tau_j^D) = \frac{\tau^C \left[\beta\left(3\theta^2 - (-1)^i 8\bar{k}\theta + 48\bar{k}^2\right) - 16\tau^C\right]}{32\beta}. \tag{42}$$

It is straightforward that $R_i^N - R_i^P \geq 0$, since $R_i^N < R_i^P$ would economically mean that repentance becomes meaningless. Solving for the equality of $R_i^N - R_i^P \geq 0$ gives the lower bound of the harmonized tax rate, $\underline{\underline{\tau}}_i^C$, under WRP strategies:

$$\underline{\underline{\tau}}_i^C = \frac{1}{24}\beta\left[3\theta^2 - (-1)^i 8\bar{k}\theta + 48\bar{k}^2\right] \geq 0 \qquad i = 1, 2, \tag{43}$$

implying, from (18), that $\underline{\underline{\tau}}_i^C > \underline{\tau}_i^C$. Thus, the minimum cooperative tax rate is always higher than that under grim trigger strategies. Clearly, this confirms the expectation that renegotiation weakens the potential to achieve tax harmonization since it takes the edge off the thread.

Lemma 1 *In the repeated game supported by weakly renegotiation-proof strategies the minimum tax rate that is necessary to implement tax cooperation is larger than that under grim trigger strategies.*

To yield a characterization of the minimum discount factors in the retaliation and repentance phases for the two countries, rewrite (40) and (41) using R_i^D from (21), R_i^C from (17) and R_i^P from (42):

$$\hat{\delta}_i^{NR} = \frac{[\beta\left(\theta-(-1)^i 4\bar{k}\right)^2 - 16\tau^C]^2}{32\tau^C[16\tau^C - \beta\left(\theta+(-1)^i 4\bar{k}\right)^2]} \qquad i=1,2, \tag{44}$$

$$\hat{\delta}_i^{PN} = \frac{\left[24\tau^C - \beta\left(3\theta^2 - 8(-1)^i\bar{k}\theta + 48\bar{k}^2\right)\right]\left[48\tau^C - \beta\left(3\theta^2 - 8(-1)^i\bar{k}\theta + 48\bar{k}^2\right)\right]}{72\tau^C\left[16\tau^C - \beta\left(\theta+4(-1)^i\bar{k}\right)^2\right]}. \tag{45}$$

Minimum discount factor. If the actual discount factors for both countries exceed all of those minimum values, the two countries find it in their interests to cooperate. Let $\delta^{**} := \max\{\hat{\delta}_1^{NR}, \hat{\delta}_2^{NR}, \hat{\delta}_1^{PN}, \hat{\delta}_2^{PN}\}$. Inspection of (45) shows that $\hat{\delta}_2^{PN} > \hat{\delta}_1^{PN}$, and (44) implies that $\hat{\delta}_2^{NR} > \hat{\delta}_1^{NR}$, except at $\beta = 0$ or $\theta = 0$ where $\hat{\delta}_2^{PN} = \hat{\delta}_1^{PN}$ and $\hat{\delta}_2^{NR} = \hat{\delta}_1^{NR}$.

Furthermore, it is seen from (44) and (45) that $\lim_{\tau^C\to\infty}\hat{\delta}_2^{NR} = 1/2$ and $\lim_{\tau^C\to\infty}\hat{\delta}_2^{PN} = 1$; clearly also $\underline{\underline{\tau}}^C > 1/16\beta\left(4\bar{k}+\theta\right)^2$ for all $\beta > 0$. This means that the discontinuity in (44) and (45) at $\tau^C = 1/16\beta\left(4\bar{k}+\theta\right)^2$ does not occur in the relevant domain of τ^C.[8] At $\tau^C = \underline{\underline{\tau}}^C$ we further find

$$\hat{\delta}_2^{NR}(\underline{\underline{\tau}}^C) = \frac{\left(3\theta+4\bar{k}\right)^2\left(\theta+12\bar{k}\right)^2}{36\theta^4 + 896\bar{k}^2\theta^2 + 9216\bar{k}^4},$$

$$\hat{\delta}_2^{PN}(\underline{\underline{\tau}}^C) = \frac{48\theta\bar{k}\left(\theta+4\bar{k}\right)^2}{9\theta^4 + 224\bar{k}^2\theta^2 + 2304\bar{k}^4},$$

[8] Note that $\lim_{\tau^C\to(\beta/16)\left(4\bar{k}+\theta\right)^2}\hat{\delta}_2^{NR} = \infty$ and $\lim_{\tau^C\to(\beta/16)\left(4\bar{k}+\theta\right)^2}\hat{\delta}_2^{PN} = \infty$ for $3\theta - 4\bar{k} > 0$ and $= -\infty$ for $3\theta - 4\bar{k} < 0$. Hence, depending on the value of θ, the discount factors (44) and (45) may have a local minimum for values of τ^C in the interval $(\beta/16)\left(4\bar{k}+\theta\right)^2, \underline{\underline{\tau}}^C]$ which, in any case, lies outside the domain $(\underline{\underline{\tau}}^C, 1]$.

so that $\hat{\delta}_2^{NR}(\underline{\tau}^C) > \hat{\delta}_2^{PN}(\underline{\tau}^C)$. To complete the identification of δ^{**}, we solve $\hat{\delta}_2^{NR} = \hat{\delta}_2^{PN}$ to get the relevant solution $\widetilde{\tau}^C$ as[9]

$$\begin{aligned}\widetilde{\tau}^C &= \frac{1}{48}\left(6\beta\theta^2 + 96\beta\bar{k}^2\right)\\ &+ \frac{1}{48}\sqrt{\beta^2\left[9\theta^4 + 16\bar{k}\left(3\theta^3 + 2\bar{k}\left(19\theta^2 + 24\bar{k}\left(\theta + 3\bar{k}\right)\right)\right)\right]} > 0. \end{aligned} \tag{46}$$

Then

$$\delta^{**}(\tau^C)\begin{cases} = \hat{\delta}_2^{NR}(\tau^C) & \text{if } \tau^C \in (\underline{\tau}^C, \widetilde{\tau}^C),\\ = \hat{\delta}_2^{PN}(\tau^C) & \text{if } \tau^C \in (\widetilde{\tau}^C, 1],\end{cases}$$

whose graphs are depicted in Figure 1.

As before, we investigate the effects of a change in the principle model parameters θ and β on the likelihood to implement tax coordination. To interpret results in a way outlined in the previous section, we rewrite conditions (40) and (41), respectively as

$$R_2^D - R_2^C = \delta^{**}\left(R_2^C - R_2^P\right), \tag{47}$$

$$R_2^N - R_2^P = \delta^{**}\left(R_2^C - R_2^P\right), \tag{48}$$

whose left-hand sides represent the immediate gains to deviate from the preassigned scenarios, and whose right-hand sides represent the discounted (one-period) opportunity costs from deviation.

Let us first discuss the economic consequences of an increase in the asymmetry measured by θ. As in the previous section, $\partial(R_2^D - R_2^C)/\partial\theta > 0$, while it turns out from (28) and inspection of

$$\frac{\partial R_2^P}{\partial\theta} = \frac{\tau^C\left(6\theta - 8\bar{k}\right)}{16} \gtreqless 0, \tag{49}$$

that $\partial(R_2^N - R_2^P)/\partial\theta \gtreqless 0$. It is also seen that it becomes less attractive for a low-productivity country to trigger cooperation through repentance since $\partial(R_2^C -$

[9] The second solution (not reported here for brevity) violates the participation constraint as it has a value smaller than $(\underline{\tau}^C, 1]$.

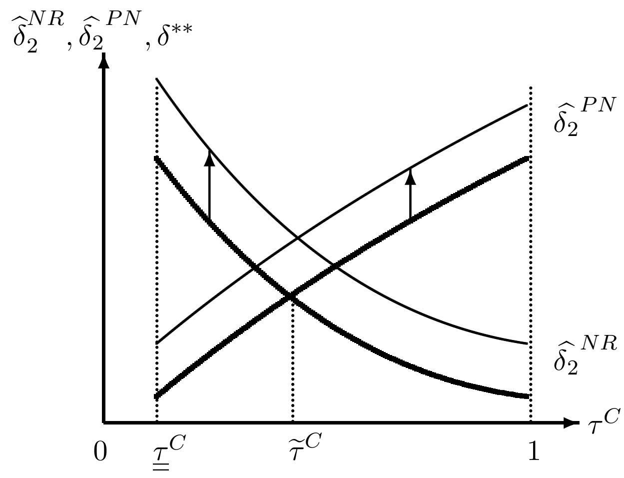

Figure 1: An increase in θ shifts the $\widehat{\delta}_2^{NR}$ and the $\widehat{\delta}_2^{PN}$-curve up; note that $\partial\widetilde{\tau}^C/\partial\theta > 0$ from (46).

$R_2^P)/\partial\theta < 0$, whose sign follows from (28) and (49). This discussion reveals that an increase in asymmetry of productivities between countries reduces the likelihood to obtain cooperation as an equilibrium outcome. This intuition is confirmed by differentiating (44) and (45) with respect to θ. This gives (see Appendix B)

$$\frac{\partial\hat{\delta}_2^{NR}}{\partial\theta} > 0 \text{ and } \frac{\partial\hat{\delta}_2^{PN}}{\partial\theta} > 0. \tag{50}$$

Figure 1 illustrates that the range of the coordinated tax rate τ^C, which is less than one and consistent with (43), becomes more narrow in response to the increase in θ, implying that it is harder to sustain tax coordination.

In the previous section we obtained the result that an increase in the concealment costs parameter β unambiguously increases the likelihood to sustain cooperation as an equilibrium outcome. This is not the case here. Straightforward differentiation yields $\partial(R_2^D - R_2^C)/\partial\beta < 0$, which confirms the intuition that higher concealment costs reduce the profitability of deviating behavior as before. It is also intuitive that a higher β reduces the costs of being punished in the repentance phase; that is, $\partial(R_2^N - R_2^P)/\partial\beta < 0$.

Interestingly, however, the increase in β not only reduces the costs of noncooperation but also the benefit from cooperation as $\partial(R_2^C - R_2^P)/\partial\beta < 0$. To

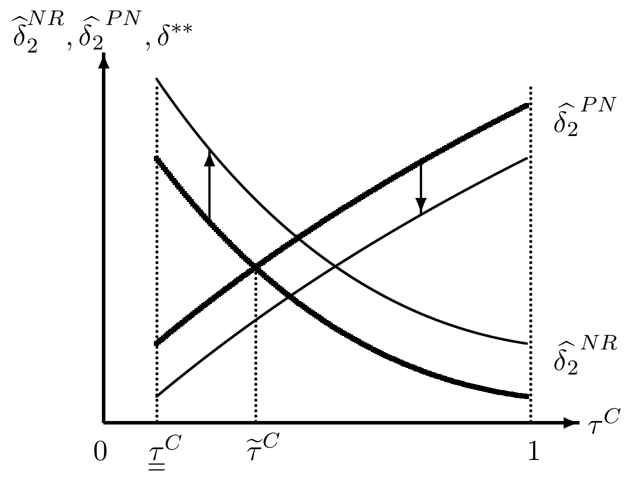

Figure 2: An increase in β shifts the $\widehat{\delta}_2^{NR}$-curve up and the $\widehat{\delta}_2^{PN}$-curve down; note that $\partial\widetilde{\tau}^C/\partial\beta > 0$ from (46).

evaluate the overall effect thus requires to quantitatively weigh counteracting effects in (44) and (45). It follows that (see Appendix C)

$$\frac{\partial\hat{\delta}_2^{NR}}{\partial\beta} > 0 \text{ and } \frac{\partial\hat{\delta}_2^{PN}}{\partial\beta} < 0. \tag{51}$$

We use a figure to summarize results. Figure 2 illustrates that the relevant range of the coordinated tax rate τ^C becomes more narrow in response to higher β for lower values of τ^C, whereas it becomes wider for higher values of τ^C.

Proposition 2 *In a repeated tax competition game with weakly renegotiation-proof strategies*

(i) there is a subgame perfect equilibrium in which the cooperative equal tax rates (i.e., the Pareto-efficient tax harmonization) are sustained if both countries have sufficiently high discount factors;

(ii) an increase in the difference of productivities among countries makes the Pareto-efficient tax harmonization more difficult; and

(iii) an increase in the concealment cost of profit shifting makes the Pareto-efficient tax harmonization easier if the coordinated tax rate is higher than $\tilde{\tau}^C$, vice versa if the coordinated tax rate is lower than $\tilde{\tau}^C$.

5 Conclusion

This analysis has shown not only that countries *can* cooperate with repeated interaction to achieve a Pareto-efficient tax harmonization; and identified economic environments where countries *are willing* to cooperate in the presence of profit shifting within multinationals. When tax authorities interact only once, they often have an incentive to deviate from cooperation, since a cooperation outcome is not a Nash equilibrium. The crucial condition is a high discount factor (i.e., close to one). Although the discount factor may not be directly observable, it should be larger when the frequency of interaction is high (i.e., the period between interaction is short). An empirically testable implication of our analysis thus is that measures of tax harmonization are more likely to happen between economically well integrated countries. However, the possibility to establish tax harmonization as a subgame perfect equilibrium will be reduced either if countries become asymmetric or if the concealment cost of multinationals for profit shifting is lower.

Another important insight of the paper is that the political will to implement tax harmonization depends on the precise institutional setup of the international negotiations. In practice, what constitutes cooperation in tax setting is often fuzzy or complicated. This constitutes an argument to rely on *temporary* punishment, i.e., to accept renegotiation. After all, tax authorities may well get together after a deviation and agree to 'let bygones be bygones'. This makes tax harmonization self-defeating. Hence, renegotiation surely reduces the possibility to establish measures of international tax harmonization.

Renegotiation also causes a remarkable difference in the effects of a variation in the costs of profit shifting, e.g. though an international standardization of rules for arms length pricing on the firm level. An increase in such costs might reduce profit-shifting and, at the same time, distorts the incentives of tax authorities to establish tax harmonization. This result sheds new light on the fact that political restrictions are crucial determinants for successful cooperation (e.g., whether renegotiation is allowed). We have demonstrated that increasing firms costs (through the introduction of standardization) may reduce profit-shifting activities and, at the same time, reduce the chances to achieve cooperation in tax policy; the present analysis suggests that the outcome depends on the precise level of the envisaged harmonized tax rate. This insight may explain the historical failure of proposals to introduce measures of tax harmonization in the European Union and elsewhere. Nevertheless, much more econometric and theoretical work are needed to gain more knowledge about the dynamics in international treaty (re)negotiations.

The model used in this paper certainly is highly stylized and rests on some strongly simplifying assumptions. A central assumption is that the fiscal authorities are limited in their capacity to calculate the profits of the multinational. The model has ignored any possibility that governments share information about tax bases across borders. Moreover, countries not only compete in tax rates, but also in other parameters of the tax system (e.g., depreciation allowances). Another rather obvious model extension would be to introduce utility maximizing governments although tractability then would certainly dictate the use of numerical methods to solve for outcomes with asymmetric countries; and one could relax the demand for strict tax rate equalization by considering that tax treaties often set a floor (bandwidth) of tax rates (i.e., a common minimum tax rate). Finally, although in the present model corporate income taxation is based on the separate accounting (SA) principle, it is clearly interesting to investigate how the results of this paper are affected by a formula apportionment (FA) regime. While all of them are interesting routes for future research, the existence of an economic motive in tax harmonization processes should be robust to these modifications of the model.

A Appendix

Differentiating (24) with respect to θ yields

$$\frac{\partial\delta^*}{\partial\theta} = -\frac{9\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]^2\left[-8\beta^2(-8\bar{k}+6\theta)\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)^2\right.}{\left[-4\beta^2\left(48\bar{k}^2-8\theta+3\theta^2\right)^2+9\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)^2\right]^2}$$
$$+\frac{36\beta\left(-4\bar{k}+\theta\right)\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]}{-4\beta^2\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)^2+9\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)^2}. \tag{A.1}$$

Taking a common denominator and then ignoring the denominator yields

$$-9\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]^2\left[-8\beta^2(-8\bar{k}+6\theta)\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)\right.$$
$$\left.+36\beta\left(-4K\bar{k}+\theta\right)\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)\right]+36\beta\left(-4\bar{k}+\theta\right)\left[-16\tau^C+\beta\left(-4K+\theta\right)^2\right], \tag{A.2}$$

Ignoring the common factor $36\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]$ in (A.2) yields

$$-\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]\left[-4\beta^2(-4\bar{k}+3\theta)\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)+\right.$$
$$\left.9\beta\left(-4\bar{k}+\theta\right)\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)\right]+\beta\left(-4\bar{k}+\theta\right)S,$$

where $S := -4\beta^2\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)^2+9\left[16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]^2$. Rearranging the above expression gives:

$$=\frac{16\tau^C-\beta\left(-4\bar{k}+\theta\right)^2}{-4\bar{k}+\theta}\left[-4\beta^2\left(16\bar{k}^2-16\theta\bar{k}+3\theta^2\right)\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)+\right.$$
$$\left.9\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)-144\tau^C\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)\right]$$
$$+\beta\left(-4\bar{k}+\theta\right)S,$$

Collecting terms, we have

$$
\begin{aligned}
=&\frac{16\tau^C}{-4\bar{k}+\theta}S - \left[16\tau^C - \beta\left(-4\bar{k}+\theta\right)^2\right]\left[32\beta^2\bar{k}\left(48\bar{k}^2 - 8\bar{k}\theta + 3\theta^2\right)\right] \\
&- \frac{144\tau^C}{-4\bar{k}+\theta}\left[16\tau^C - \beta\left(-4\bar{k}+\theta\right)^2\right]\left[16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right].
\end{aligned}
$$

Finally, we have

$$
\begin{aligned}
=&\left[S - 9\left(16\tau^C - \beta\left(-4\bar{k}+\theta\right)^2\right)\left(16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right)\right]\frac{16\tau^C}{-4\bar{k}+\theta} \\
&- \left[16\tau^C - \beta\left(-4\bar{k}+\theta\right)^2\right]\left[32\beta^2\bar{k}\left(48\bar{k}^2 - 8\bar{k}\theta + 3\theta^2\right)\right]. \qquad \text{(A.3)}
\end{aligned}
$$

By definition $\hat{\delta} < 1$ in (24), implying that the first component of the first term in (A.3) is negative, and, moreover, its second term of (A.3) is clearly negative. Taking into account $-16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2 < 0$, we have (25).

On the other hand, differentiating (24) with respect to θ yields

$$
\begin{aligned}
\frac{\partial\delta^*}{\partial\beta} =& -\frac{9\left[-16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right]^2\left[-8\beta\left(48\bar{k}^2 - 8\bar{k}\theta + 3\theta^2\right)^2\right.}{\left[-4\beta^2\left(48\bar{k}^2 - 8\bar{k}\theta + 3\theta^2\right)^2 + 9\left(16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right)^2\right]^2} \\
&+ \frac{18\left(-4\bar{k}+\theta\right)^2\left[-16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right]}{-4\beta^2\left(48\bar{k}^2 - 8\bar{k}\theta + 3\theta^2\right)^2 + 9\left(16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right)^2}.
\end{aligned}
$$

Taking a common denominator and then ignoring the denominator yields

$$
\begin{aligned}
&-9\left[-16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right]^2 \times \\
&\left[-8\beta\left(48\bar{k} - 8\bar{k}\theta + 3\theta^2\right)^2 + 18\left(-4K+\theta\right)^2\left(16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right)\right] \\
&+ 18\left(-4\bar{k}+\theta\right)^2\left[-16\tau^C + \beta\left(-4\bar{k}+\theta\right)^2\right]S.
\end{aligned}
$$

Ignoring the common factor $18\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]$ and rearranging yields

$$
\begin{aligned}
&=\left[16\tau^C-\beta\left(-4\bar{k}+\theta\right)^2\right]\frac{1}{\beta}\left[-4\beta^2\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)^2+9\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)\right.\\
&\quad\left.\times\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)-144\tau^C\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)\right]+\left(-4\bar{k}+\theta\right)^2 S.
\end{aligned}
$$

Combining terms yields

$$
\begin{aligned}
=&\frac{1}{\beta}\left[16\tau^C-\beta\left(-4\bar{k}+\theta\right)^2+\beta\left(-4\bar{k}+\theta\right)^2\right]S\\
&-\frac{144\tau^C}{\beta}\left[16\tau^C-\beta\left(-4\bar{k}+\theta\right)^2\right]\left[16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right].
\end{aligned}
$$

Ignoring the common factor $16\tau^C/\beta$ and further rearranging leads to

$$
\begin{aligned}
&\left[-4\beta^2\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)^2+9\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)^2\right]\\
&-9\left[16\tau^C-\beta\left(-4\bar{k}+\theta\right)^2\right]\left[16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right],\\
&\geq\left[-4\beta^2\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)^2+9\left(16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right)^2\right]\\
&-9\left[16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]^2>0.
\end{aligned}
$$

The last inequality follows from the fact that $1>\hat{\delta}$ in (24), which proves (30).

B Appendix

The effect of a change in θ in the NR phase of a weakly renegotiating-proof equilibrium, we differentiate (44) with respect to θ to get

$$\begin{aligned}\frac{\partial\hat{\delta}_2^{NR}}{\partial\theta} =& \frac{\beta\left(4\bar{k}+\theta\right)\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]^2}{16\tau^C\left[16\tau^C-\beta\left(4\bar{k}+\theta\right)^2\right]^2}+\\ & \frac{\beta\left(-4\bar{k}+\theta\right)\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]}{8\tau^C\left[16\tau^C-\beta\left(4\bar{k}+\theta\right)^2\right]}>0,\end{aligned}$$

whose positive sign immediately follows from $-4\bar{k}+\theta<0$ and the participation constrain $\tau^C>\underline{\underline{\tau}}^C>1/16\beta(4\bar{k}+\theta)^2$.

In order to identify the effect of a change in θ in the PN phase, we differentiate (45) with respect to θ to get

$$\begin{aligned}\frac{\partial\hat{\delta}_2^{PN}}{\partial\theta} =& -\frac{\beta\left(8\bar{k}-6\theta\right)\left[24\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]}{72\tau^C\left[-16\tau^C+\beta\left(4\bar{k}+\theta\right)^2\right]}+\\ & -\frac{\beta\left(8\bar{k}-6\theta\right)\left[48\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]}{72\tau^C\left[-16\tau^C+\beta\left(4\bar{k}+\theta\right)^2\right]}\\ & +\frac{2\beta\left(4\bar{k}+\theta\right)\left[24\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]\left[48\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]}{72\tau^C\left[-16\tau^C+\beta\left(4\bar{k}+\theta\right)^2\right]^2}.\end{aligned} \tag{B.1}$$

Ignoring the denominator of (B.1) and then collecting the first and second terms yields

$$\begin{aligned}&\beta\left(8\bar{k}-6\theta\right)\left[16\tau^C-\beta\left(4\bar{k}+\theta\right)^2\right]\left[72\tau^C+2\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]\\ &+2\beta\left(4\bar{k}+\theta\right)\left[24\tau^C+\beta\left(-48\bar{k}^2+8K\bar{k}\theta-3\theta^2\right)\right]\left[48\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right].\end{aligned} \tag{(B.2)}$$

Dividing the above expression by 2β and then dividing the first term into two terms:

$$\begin{aligned}
=& -4\theta\left[16\tau^C-\beta\left(4\bar{k}+\theta\right)^2\right]\left[36\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)\right]\\
&+\left(8\bar{k}-\theta\right)\left[16\tau^C-\beta\left(16\bar{k}^2-8\bar{k}\theta+\theta^2\right)\right]\left[36\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)\right]\\
&+\left(4\bar{k}+\theta\right)\left[24\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)\right]\left[48\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)\right].
\end{aligned} \tag{B.2}$$

Since $48\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)<0$, which implies that $36\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)<0$ and $24\tau^C-\beta\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)<0$. Note further that $16\tau^C-\beta\left(4\bar{k}+\theta\right)^2>0$ from the definition of $\hat{\delta}_2^{PN}$ in (45). Taken together, the first, second and third terms in (B.2) are all positive, so does (B.2), which proves (51).

C Appendix

In order to get the effect of a change in β on the minimum discount factor $\hat{\delta}_2^{NR}$ in the NR phase, we differentiate (44) with respect to β to get

$$\begin{aligned}
\frac{\partial\hat{\delta}_2^{NR}}{\partial\beta}=&\frac{\left(4\bar{k}+\theta\right)^2\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]^2}{32\tau^C\left[16\tau^C-\beta\left(4\bar{k}+\theta\right)^2\right]^2}+\\
&\frac{\beta\left(-4\bar{k}+\theta\right)^2\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]}{16\tau^C\left[16\tau^C-\beta\left(4\bar{k}+\theta\right)^2\right]}>0,
\end{aligned}$$

whose positive sign immediately follows from $-4\bar{k}+\theta<0$ and the participation constrain $\tau^C>\underline{\underline{\tau}}^C>1/16\beta(4\bar{k}+\theta)^2$.

In order to get the effect of a change in the PN phase we differentiate (45) with respect to β to get

$$\begin{aligned}\frac{\partial\hat{\delta}_2^{PN}}{\partial\beta} =& -\frac{\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\left[24\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]}{72\tau^C\left[-16\tau^C+\beta\left(4\bar{k}+\theta\right)^2\right]}+ \\ & -\frac{\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\left[48\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]}{72\tau^C\left[-16\tau^C+\beta\left(4\bar{k}+\theta\right)^2\right]} \\ & +\frac{\left(4\bar{k}+\theta\right)^2\left[24\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]\left[48\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]}{72\tau^C\left[-16\tau^C+\beta\left(4\bar{k}+\theta\right)^2\right]^2}.\end{aligned} \tag{C.1}$$

Taking a common denominator and ignoring the denominator yields

$$\begin{aligned}&\left(48\bar{k}^2-8\bar{k}\theta+3\theta^2\right)\left[-16\tau^C+\beta\left(-4\bar{k}+\theta\right)^2\right]\left[72\tau^C+2\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right] \\ &+\left(4\bar{k}+\theta\right)\left[24\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]\left[48\tau^C+\beta\left(-48\bar{k}^2+8\bar{k}\theta-3\theta^2\right)\right]>0.\end{aligned} \tag{C.2}$$

Since (C.2) is positive, (C.1) is negative.

References

Bucovetsky, S. (1991). Asymmetric tax competition. *Journal of Urban Economics* 30, 167—181.

Cardarelli, R., Taugourdeau, E. and J.-P. Vidal (2002). A Repeated Interactions Model of Tax Competition. *Journal of Public Economic Theory* 4, 19-38.

Catenaro, M. and J.-P. Vidal (2006). Implicit Tax Co-ordination Under Repeated Policy Interactions. *Recherches Economiques de Louvain* 72, 1-17.

Egger, P., M. Larch, M. Pfaffermayr and H. Winner (2006). The impact of endogenous tax treaties on foreign direct investment: theory and evidence. *Canadian Journal of Economics* 39, 901—931.

Eggert, W. and G. Schjerderup (2003). Symmetric Tax Competition under Formula Appointment, *Journal of Public Economics Theory* 5, 430-446.

Elitzur, R. and J. Mintz (1996). Transfer pricing rules and corporate tax competition, *Journal of Public Economics* 60, 401-422.

Farrell, J. and E. Maskin (1989). Renegotiation in Repeated Games, *Games and Economic Behavior* 1, 327-360.

Fuest, C., B. Huber and J. Mintz (2005). Capital mobility and tax competition, *Foundations and Trends in Microeconomics* 1, 1—62.

Haufler, A. (1997). Factor taxation, income distribution, and capital market integration. *Scandinavian Journal of Economics* 99, 425—446.

Haufler, A. and G. Schjelderup (2000). Corporate tax systems and cross country profit shifting, *Oxford Economic Papers* 52, 306-325.

Huizinga, H.P. and S.B., Nielsen (1997). Capital income and profit taxation with foreign ownership of firms. *Journal of International Economics* 42, 149—165.

Itaya, J., M. Okamura, and C.Yamaguchi. (2008) Are Regional Asymmetries Detrimental to Tax Coordination in a Repeated Game Setting? forthcoming in *Journal of Public Economics.*

Janeba, E. and W. Peters (1999). Tax Evasion, Tax Competition and the Gains From Nondiscrimination: The Case of Interest Taxation in Europe, *The Economic Journal* 109, 93-101.

Kanbur, R. and M. Keen (1993). Jeux Sans Frontières: Tax Competition and Tax Coordination when Countries Differ in Size. *American Economic Review* 83, 877-892.

Konrad, K. (2008). Mobile tax base as a global common, *International Tax and Public Finance* 15, 395-414.

Manori, K.S., and A.J., Weichenrieder (2001), Tax Competition and transfer pricing disputes, *FinanzArchiv* 58, 1-11.

Nielsen, S.B., P. Raimondos-Møller and G. Schjelderup (2008). *Company taxation and tax spillovers: separate accounting versus formula apportionment*, Paper presented at a conference on 'Multinational Taxation and Tax Competition', Amsterdam.

Riedel, N., and M. Runkel (2007). Company tax reform with a water's edge, *Journal of Public Economics*, 91, 1533-1554.

Wildasin, D. E. (1989). Interjurisdictional capital mobility: Fiscal externality and a corrective subsidy, *Journal of Urban Economics*, 25**,** 193-212 .

Wilson, J. D. (1986). A theory of interregional tax competition, *Journal of Urban Economics* 19(3), 296-315.

Wilson, J. D. (1999). Theories of tax competition, *National Tax Journal*, 52, 269—304.

Zodrow, G. R. and P. Mieszkowski (1986). Pigou, Tiebout, property taxation, and the underprovision of local public goods. *Journal of Urban Economics* 19(3), 356—370.