Implicit tax co-ordination under repeated policy interactions

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1 Introduction

It is often argued that, in an environment in which capital is able to move freely, governments' ability to rely on capital taxation becomes increasingly constrained. Fiscal authorities would then be made better off by more actively co-ordinating their tax policies or, alternatively, by relinquishing their tax authority in favour of a supra-national authority. While the common wisdom that capital mobility exerts a "race-to-the-bottom" on capital tax rates is widely accepted in the theoretical literature on tax competition, the empirical literature so far has found little support for this outcome. ce

The theoretical literature on tax competition[1] is largely based on conventional static frameworks, in which the tax game lasts only one period, thereby disregarding the possibility of repeated interactions between policy-makers. Concerning capital income taxation, in particular, it traditionally relies on the assumption that capital owners are sensitive to net returns to capital (i.e. to tax differentials) when making portfolio choices or investment decisions. Settings of these tax competition models are essentially twofold.

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1 See Wilson (1999) for a comprehensive survey.

On the one hand, small open economies compete for a fixed amount of internationally mobile capital (e.g. Zodrow and Mieszkowski, 1986), but fail to internalise the impact of their respective tax policies on the world after-tax return to capital. On the other hand, governments are assumed to engage in tax games *à la* Nash, in the context of which they are, however, aware that their tax policy affects the after-tax return to capital (see for instance Wildasin, 1988). Under both settings, capital mobility drives down capital tax rates, albeit to a lower extent in the latter class of models. When tax revenues finance public goods, this results in an under-provision of local public goods that negatively affects the citizens' welfare. Nevertheless, tax competition is welcome if governments are revenue-maximisers and subordinate their competitive behaviour to, for example, the aim of increasing their size. Clearly, a normative assessment of tax competition ultimately depends on the views one has on the preferences of governments (Edwards and Keen, 1996).

Even though the above static tax competition models generally conclude that tax competition leads to a "race-to-the-bottom", empirical research has so far found mixed evidence at best about a significant downward effect of capital mobility on tax rates. In this regard, a recent review of empirical studies on the sensitivity of capital flows to tax rates by Krogstrup (2003) has also concluded that capital tax competition would appear to have put a downward pressure on capital tax rates while shifting the burden from capital to labour in EU member states during the 1980s and 1990s. This pressure seems to have been counteracted by agglomeration economies. Regarding the location choice of foreign direct investment, it is stressed that, on the one hand, empirical evidence supports the view that the tax policy of a country does not affect the choice of its resident investors between home and foreign investment. On the other hand, a country's tax policy affects the investment decisions of prospective foreign investors.

This paper attempts to reconcile theory and evidence by extending the basic tax competition model to account for repeated policy interactions between governments. We argue that, when such interactions are associated to a systematic "punishment" of the deviating policymaker, the Nash equilibrium outcome of static tax competition models may not necessarily coincide with the outcome of the tax game in a repeated interaction framework. On the contrary, governments may secure a co-operative outcome by threatening to retaliate if one of them deviates from the co-ordinated tax rates. In such a case, explicit policy co-ordination via a supra-national tax authority would not be necessary. However, one could argue that some explicit tax co-ordination might be desirable in order to avoid the pitfalls of competition from smaller economies, when there are incentives to free ride. This policy asymmetry relates to the fact that large regions face a weaker response of the capital stock to tax rates, which means that they are less inclined to engage in tax competition. By contrast, as competition generally benefits smaller economies, the latter are more likely to be the source of negative externalities to large countries in the absence of supra-national regulation.

To our best knowledge, there are only few papers in the literature addressing the topic of fiscal competition in a repeated interaction framework. In his model of property tax competition, Coates (1993) assumes that governments do not take into account the externalities associated to the use of their domestic tax rate, showing that there may be incentives to subsidise capital. Cardarelli, Taugourdeau and Vidal (2002) extend upon the framework developed by Coates, setting up a repeated interactions model of tax competition and establishing the conditions under which tax policy harmonisation can result from repeated interactions between the policymakers. They show that tax harmonisation will not prevail in the case of strong regional asymmetries[2], in which case the establishment of a centralised fiscal authority is suggested as a solution to the tax competition problem. In a related game theoretical approach inspired by Barro and Gordon (1983), Fourçans and Warin (2002) also find that the lack of explicit tax harmonisation may not lead to a "race-to-the-bottom" of tax rates, as a co-operative outcome can result from repeated interactions between governments.

This paper aims to build upon the model by Cardarelli *et al.* by looking at capital tax competition in a repeated interaction framework characterised by the absence of capital mobility sunk costs. While such costs were postulated in their paper to avoid a zero tax rate on capital under the assumption of linear technologies, the underlying assumption in our paper is that production occurs according to Cobb-Douglas technologies. Furthermore, we analyse the role of cross-country asymmetries on the outcome of the tax competition repeated game. We adopt the view that governments compete for a fixed world supply of capital and abstract from welfare considerations, assuming that governments only aim to maximise tax revenues. Moreover, governments are either short-sighted, maximising only current revenue, or far-sighted, seeking to maximise a discounted sum of current and future tax revenues. Only under the second scenario is the co-ordinated tax outcome ultimately sustainable, provided cross-country asymmetries remain limited and governments are sufficiently patient.

The paper proceeds as follows. Section 2 develops a streamlined one-shot model of tax competition. Section 3 extends this model to account for repeated interactions, while section 4 concludes.

2 The "one-shot" tax game

Let us consider a world economy consisting of two countries (indexed with subscripts i and j), whose governments compete to tax the income of a fixed

[2] Taugourdeau (2002) extends the analysis of Cardarelli *et al.* (2002) by considering a bargaining equilibrium between governments.

and exogenously given world supply of capital. The allocation of capital between country i and j satisfies :

$$2k = k_i + k_j \tag{1}$$

where $2k$ stands for the world total supply of capital. Labour is perfectly immobile and in fixed supply, whereas capital is perfectly mobile. The production technologies are assumed to be of the Cobb-Douglas type. The gross marginal return to capital invested in country i is given by :

$$r_i = \alpha A_i k_i^{\alpha-1} \tag{2}$$

where A_i is a country-specific parameter, capturing cross-country differences in their endowments of immobile factors such as, for example, labour, land, or even differences in total factor productivity. For the sake of simplicity[3], in the remainder of this paper we shall refer to A_i as the size of country i. Perfect capital mobility implies that net marginal returns to capital are equal in all locations. The equilibrium capital allocation is therefore determined by the arbitrage condition :

$$(1 - t_i)\,\alpha A_i k_i^{\alpha-1} = (1 - t_j)\,\alpha A_j k_j^{\alpha-1} \tag{3}$$

Governments levy taxes on capital according to the source principle of taxation[4]. The capital tax revenue in country i is :

$$T_i = t_i \alpha A_i k_i^{\alpha} \tag{4}$$

where t_i is country i's capital income tax rate.

Governments act strategically with a view to maximising capital income tax revenue. We assume that governments are intrinsically revenue-maximisers, hence departing from the view of governments as benevolent social planners. In this context, it should be noted that our model abstracts not only from labour income taxation but also from spending, so that we are focusing on a precise aspect of tax policy, namely the taxation of internationally mobile capital.

Governments choose their capital income tax rate under the constraint that capital is perfectly mobile, taking other governments' tax policies as

[3] Assuming that production in each country occurs according to a neoclassical technology using three inputs, capital (k_i), labour (l_i) and land (x_i), output is given by : $y_i = B_i k_i^{\alpha} l_i^{\beta} x_i^{1-\alpha-\chi}$. When labour and land endowments are exogenous, we can write : $y_i = A_i k_i^{\alpha}$, where $A_i B_i l_i^{\beta} x_i^{1-\alpha-\chi}$ reflects differences in endowments of immobile factors, labour or land, or in productivity.

[4] There are two polar principles of international taxation : the residence (of the taxpayer) principle and the source (of income) principle. Under the residence principle, residents are taxed on their whole income regardless of its origin. Under the source principle, all incomes originating in a country are taxed in this country regardless of the country of residence of the taxpayer. The source principle is usually assumed in models of tax competition; see Razin and Sadka (1994) for a survey on tax competition.

given. This is a Nash tax game, where government i maximises its capital income tax revenue (4) from an internationally mobile tax base under the arbitrage condition for capital (3), taking government j's capital tax rate as given. Government i's reaction function is therefore the solution to the following maximisation problem:

$$\max_{t_i} t_i \alpha A_i \left[k_i\left(t_i, t_j\right)\right]^{\alpha} \tag{5}$$

where

$$k_i\left(t_i, t_j\right) = \frac{2k\left(\frac{A_i(1-t_i)}{A_j(1-t_j)}\right)^{\frac{1}{1-\alpha}}}{1+\left(\frac{A_i(1-t_i)}{A_j(1-t_j)}\right)^{\frac{1}{1-\alpha}}} \tag{6}$$

is the equilibrium stock of capital as a function of tax rates resulting from the arbitrage condition (4).

After some computations, the reaction function of government i, $t_i = R_i\left(t_j\right)$, is defined by the following equation, which results from the first-order condition of problem (5):

$$1-t_j = \frac{A_i}{A_j}\left(1-t_i\right)^{2-\alpha}\left(\frac{1-\alpha}{\alpha-\left(1-t_i\right)}\right)^{1-\alpha} \tag{7}$$

Note that although one does not obtain an analytical solution for government i's reaction function R_i, the properties of the above expression, which implicitly defines this function, can be easily analysed. Equation (7) is of the form:

$$y = f(x) = \Gamma x^{2-\alpha}\left(\frac{1-\alpha}{\alpha-x}\right)^{1-\alpha}$$

where x, y and Γ denote $1-t_i$, $1-t_j$ and $\frac{A_i}{A_j}$, respectively. The domain of f is $[0,\alpha[$ and its range $[0,+\infty[$. One can easily check that f is strictly increasing and convex on $]0,\alpha]$ (implying strict concavity of government i's reaction function) and that $f(0)=0$, $\lim_{x\to\alpha} f(x) = +\infty$ and $f(0)=0$.

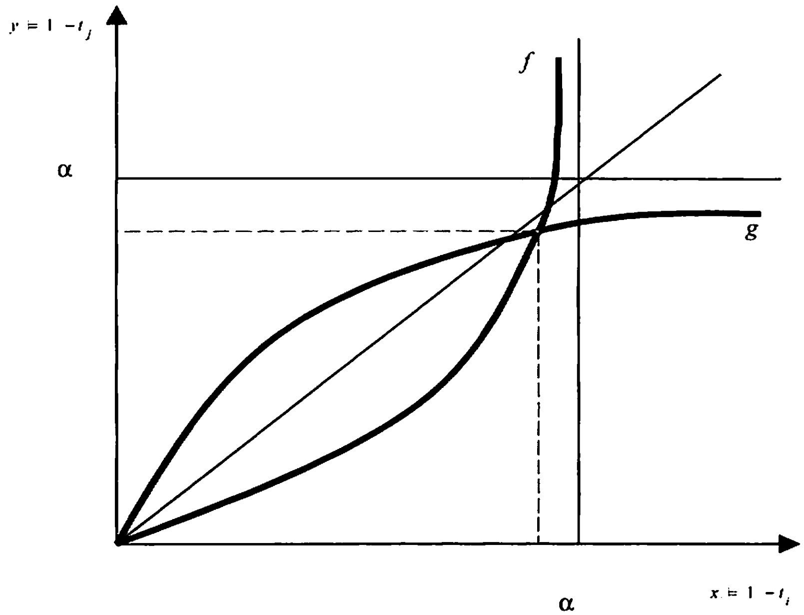
The reaction function of government j is derived analogously:

$$1-t_i = \left(\frac{A_i}{A_j}\right)^{-1}\left(1-t_j\right)^{2-\alpha}\left(\frac{1-\alpha}{\alpha-\left(1-t_j\right)}\right)^{1-\alpha} \tag{8}$$

This expression, which can be easily obtained from (7) by substituting i with j, is of the form:

$$x = h(y) = \Gamma^{-1} y^{2-\alpha}\left(\frac{1-\alpha}{\alpha-y}\right)^{1-\alpha}$$

Figure 1 *Nash Reaction Functions* $(A_i < A_j)$



The qualitative properties of this function are identical to those of the function f we studied above. In particular, we can define the inverse function $g = h^{-1} : [0, +\infty[\to [0, \alpha[$, which is strictly increasing and concave on $]0, +\infty]$. One can easily check that $\lim_{x \to 0} g(x) = +\infty$. The intersection of the curves representing the functions f and g characterises the Nash tax rates. The qualitative properties of these functions ensure the existence and uniqueness of the Nash equilibrium of this tax game, as illustrated by figure 1. The Nash tax rates belong to the interval $]1 - \alpha, 1]$.

Multiplying (7) by (8), one obtains a simple relation between $x^N = 1 - t_i^N$ and $y^N = 1 - t_j^N$:

$$\left(\alpha - x^N\right)\left(\alpha - y^N\right) = (1 - \alpha)^2 x^N y^N \tag{9}$$

Solving equation (9) for y^N and substituting y^N with its expression in (7) yields a new expression, the solution of which characterises the Nash tax rate of government i, $t_i^N = 1 - x^N$:

$$\Gamma^{\frac{1}{1-\alpha}}(1 - \alpha)\left(\frac{x^N}{\alpha - x^N}\right)^{\frac{2-\alpha}{1-\alpha}}\left(1 - (2 - \alpha)x^N\right)^{\frac{1}{1-\alpha}} = 1 \tag{10}$$

When countries are symmetric ($A_i = A_j$ or $\Gamma = 1$), the Nash tax rate is easily calculated from equation (10) :

$$t^N = \frac{2\,(1 - \alpha)}{2 - \alpha} \tag{11}$$

The equilibrium allocation of capital can be also computed by plugging the Nash tax rates into equation (6):

$$k_i^N = \frac{2k\Gamma^{\frac{1}{1-\alpha}}\left(\frac{x^N}{y^N}\right)^{\frac{1}{1-\alpha}}}{1+\Gamma^{\frac{1}{1-\alpha}}\left(\frac{x^N}{y^N}\right)^{\frac{1}{1-\alpha}}} \tag{12}$$

$$k_j^N = 2k - k_i^N \tag{13}$$

Finally, the Nash tax revenues are defined as:

$$T_i^N = \alpha t_i^N A_i \left(k_i^N\right)^\alpha \tag{14}$$

$$T_j^N = \alpha t_j^N A_j \left(2k - k_i^N\right)^\alpha \tag{15}$$

The following proposition characterises the relationship between cross-country asymmetries in size and the equilibrium tax rates.

Proposition 1 *An increase in the relative size of country i implies an increase in the Nash tax rate of government i and a decrease in the Nash tax rate of government j.*

Proof. We take the logarithmic derivative of equation (10):

$$\frac{1}{1-\alpha}\frac{d\Gamma}{\Gamma} + \frac{2-\alpha}{1-\alpha}\frac{dx^N}{x^N} + \frac{2-\alpha}{1-\alpha}\frac{dx^N}{\alpha - x^N} - \frac{2-\alpha}{1-\alpha}\frac{dx^N}{1-(2-\alpha)x^N} = 0$$

$\frac{dx}{d\Gamma}$ is of the same sign as:

$$-\frac{1}{x^N} - \frac{1}{\alpha - x^N} + \frac{1}{1-(2-\alpha)x^N} = -\frac{\left(x^N\right)^2 - \alpha(3-\alpha)x^N + \alpha}{x^N\left(\alpha - x^N\right)\left(1-(2-\alpha)x^N\right)}$$

Let us study the sign of the polynomial:

$$P(x) = x^2 - \alpha(3-\alpha)x + \alpha$$

Since we have $P(0) = -\alpha(3-\alpha) < 0$, $P(\alpha) = \alpha(\alpha - 1) < 0$ and $P(\alpha) = \alpha(\alpha-1)^2 > 0$, we conclude that $P(x) > 0$ for all $x \in [0, \alpha]$.

Hence: $\frac{dx}{d\Gamma} < 0$. From equation (9) it also follows that $\frac{dy^N}{dx^N} > 0$. □

This proposition states that, in a two-country model, the tax rate differential is exacerbated by asymmetries in country sizes. Intuitively, this is explained by the fact that large countries face a weaker response of their capital stock to tax rates, allowing them to maintain higher tax rates than small countries. This result is in line with initial insights into issues involving tax competition and regional size, according to which small jurisdictions levy lower tax rates in equilibrium (see Bucovetsky (1991) and Wilson (1991))

3 Game under repeated interactions

In this section we examine how repeated interactions between governments can affect their behaviour regarding taxation of internationally mobile capital. Extending this simple tax competition model to a dynamic environment, we assume that governments maximise the discounted sum of their tax revenues. The objective of government i can therefore be written as:

$$V_i = \sum_{t=0}^{+\infty} \delta_i^t T_{i,t} \tag{16}$$

where $T_{i,t}$ stands for government i's capital income tax revenue in period t and δ_i is government i's discount factor. In each period t governments play a stage game similar to the one-shot tax game described in the previous section. Clearly, an infinite repetition of the Nash strategies is a solution to the repeated tax game, which gives governments the following payoffs:

$$V_i^N = \sum_{t=0}^{+\infty} \delta_i^t T_i^N \tag{17}$$

$$V_j^N = \sum_{t=0}^{+\infty} \delta_j^t T_j^N \tag{18}$$

However, governments can achieve higher levels of capital income tax revenues by setting capital income tax rates in a co-operative manner. For instance, they could meet and decide on co-ordinated tax rates, not necessarily equal across countries but still higher than the Nash tax rates. Let us denote with t_i^C ($> t_i^N$) and t_j^C ($> t_j^N$) the pair of co-ordinated tax rates. More specifically, we consider the possibility for governments to co-ordinate on a common capital income tax rate[5] ($t_i^C = t_j^C = t^C < 1$).

In a framework of repeated interactions between governments, tax co-ordination can be underpinned by trigger-type strategies[6]. Each government co-operates and levies the co-ordinated tax rate as long as the other

[5] Please note that at the efficient level ($t = 1$), the arbitrage condition determining the equilibrium allocation of capital cannot be used. We would then have to discuss the allocation of capital when tax rates are both equal to the efficient level. We have chosen a co-ordinated tax rate strictly smaller than 1 for the sake of expositional simplicity.

[6] This is obviously a restriction on the set of governments' strategies. Analysing other types of strategies goes beyond the scope of this paper.

government co-operates and reverts to the Nash tax rate otherwise. In the repeated tax game, the tax strategy of government j can be expressed as follows :

$$t_{j,t+1} = \begin{cases} t^C & \text{if } t_{i,t} = t^C \\ t_j^N & \text{otherwise} \end{cases}$$

If governments implement their tax policies in a co-ordinated manner, the government $s(=i,j)$ can achieve the following payoffs :

$$V_s^C = \sum_{t=0}^{+\infty} \delta_s^t T_s^C = \sum_{t=0}^{+\infty} \delta_s^t \alpha t_s^C A_s \left(k_s^C\right)^\alpha \tag{19}$$

where the international allocation of capital is :

$$k_i^C = \frac{2k\Gamma^{\frac{1}{1-\alpha}}}{1+\Gamma^{\frac{1}{1-\alpha}}} \tag{20}$$

$$k_j^C = \frac{2k}{1+\Gamma^{\frac{1}{1-\alpha}}} \tag{21}$$

Tax co-ordination prevails if governments have no incentive to deviate from the co-ordinated tax rate. The deviating government reaps short-run benefits but incurs long-run losses compared to tax co-ordination.

Without loss of generality, we shall consider the incentives to deviate of government j in the remainder of this paper. If it chooses to deviate, government j sets its tax rate according to its reaction function. This government's tax rate is its best reply against government i playing t^C. Hence, t_j^D is the solution to the following equation, which implicitly defines t_j^D as a function of t^C :

$$\frac{\left(1-t_j^D\right)^{2-\alpha}}{\left(t_j^D-(1-\alpha)\right)^{1-\alpha}} = \frac{\Gamma\left(1-t^C\right)}{(1-\alpha)^{1-\alpha}} \tag{22}$$

By definition of the reaction function, note that $t_j^D = t_j^N$ if $t^C = t_i^N$. One can easily check from (22) that there exists a unique $t_j^D \in \left]1-\alpha, t^C\right]$ for all $t^C \in \left]t_i^N, 1\right]$ and that the deviating tax rate varies positively with the co-ordinated tax rate ($\frac{dt_j^D}{dt^C} > 0$). It should also be noted that, not surprisingly, international capital flies from the country that implements the co-ordinated strategy to the deviating country, increasing its short-run tax revenue ($k_j^D > k_j^C$). Government j can enjoy only once the benefits of its treachery, as government i will thereafter revert to the Nash tax strategy. However, government j's value of the continuation game is the Nash payoff, V_j^N. The payoff the deviating government can achieve is given by :

$$V_j^D = T_j^D + \delta_j V_j^N = \alpha t_j^D A_j \left(2k - k_i^D\right)^\alpha + \delta_j V_j^N \tag{23}$$

Our next proposition emphasises how tax co-ordination can emerge endogenously from repeated interactions.

Proposition 2 *In the absence of cross-country asymmetries, a co-ordinated capital income tax rate is sustainable if governments are sufficiently patient.*

The proof is simple and intuitive, as the result is a straightforward application of one well known version of the folk theorem (Friedman, 1971) in game theory[7]. Tax co-ordination is sustainable if the loss incurred by the deviating country in terms of future losses stemming from the setback from the co-ordinated to the Nash tax strategies exceeds the short-run gain generated by undercutting the co-ordinated tax rate. Hence, co-ordination of tax policies is sustainable if:

$$V_j^D = T_j^D + \delta_j V_j^N < V_j^C \tag{24}$$

Multiplying (24) by $(1 - \delta_j)$ we obtain:

$$(1 - \delta_j)\, T_j^D + \delta_j T_j^N < T_j^C \tag{25}$$

It can be easily checked that, when δ_j tends to 1, this expression can be simplified as:

$$t_j^N < t^C \tag{26}$$

since in the symmetric case, we have $k_i^N = k$ and $k_i^C = k$.

Condition (26) holds owing to the definition of the co-ordinated tax rates. Hence, if governments' discount factors are sufficiently close to 1, tax co-ordination can be an outcome of the tax game with repeated interactions. It follows that in the case of symmetric countries, the endogenous outcome of the repeated tax game suggests that there is no intrinsic need for greater centralisation. Nevertheless, centralised tax co-ordination or harmonisation may be desirable in the presence of strong regional asymmetries, when there are incentives to free ride.

Our final proposition deals with the sustainability of decentralised or endogenous tax co-ordination in the presence of strong cross-country asymmetries.

Proposition 3 *If cross-country differences in size are sufficiently large, decentralised co-ordination on a common capital income tax rate is not sustainable.*

Intuitively, the unattainability of decentralised co-ordination on a common tax rate in the presence of large cross-country differences in size relates to the fact that the smaller country benefits from higher tax revenues under Nash than under harmonisation. To prove this formally, we

[7] See Pearce (1992) for a more comprehensive elaboration on co-operation and rationality under repeated games.

shall proceed as follows. First, we consider the feasibility condition in the limit case where governments' discount factors tend to 1. Second, we prove that this condition cannot hold whenever asymmetries are sufficiently large. Condition (25) can be written as follows:

$$\left(\frac{t_j^N}{t^C}\right)^{\frac{1}{\alpha}} < \frac{1}{1+\Gamma^{\frac{1}{1-\alpha}}} \frac{1}{1-\frac{k_i^N}{2k}} \tag{27}$$

Using expression (12) we obtain:

$$\left(\frac{t_j^N}{t^C}\right)^{\frac{1}{\alpha}} < \frac{1+\Gamma^{\frac{1}{1-\alpha}}\left(\frac{1-t_i^N}{1-t_j^N}\right)^{\frac{1}{1-\alpha}}}{1+\Gamma^{\frac{1}{1-\alpha}}} \tag{28}$$

When the indicator for cross-country asymmetries, Γ, tends to infinity, one can easily check from equations (9) and (10) that t_i^N and t_j^N tend to 1 and $1-\alpha$, respectively. When Γ tends to infinity, condition (28) becomes: $\left(\frac{1-\alpha}{t^C}\right)^{\frac{1}{\alpha}} < 0$. Since the LHS of this expression is strictly positive, we have shown by contradiction that decentralised tax co-ordination is not sustainable if asymmetries are sufficiently large. Intuitively, tax co-ordination is sustainable whenever the short-run gain of deviating from the co-ordinated tax policy exceeds the future loss of reverting to tax competition. The smaller a country in relative terms, the more it can gain from undercutting the larger country's tax rate, as it can benefit from the wider tax base of the larger country, at least in the short term. Gains from tax harmonisation are increasing in a government's discount factor, but if cross-country asymmetries are sufficiently large, even the most patient government in a small country, i.e., a government characterised by a discount factor equal to unity, would find it beneficial to reap the short-run gains from tax competition.

4 Conclusion

Tax harmonisation in Europe is a recurrent debate. While static theoretical models of tax competition traditionally point to the dangers of harmful tax competition, empirical evidence supporting the extreme view of a "race-to-the-bottom" of tax rates remains weak. This suggests that implicit co-ordination mechanisms may in fact be at work. In this paper, using a simple model with Cobb-Douglas production functions, we argued that repeated interactions between policy-makers may be key to reconciling theory with evidence. Repeated interactions and the threat to revert to the unpleasant Nash equilibrium forever may lead to co-ordination of tax strategies also in the absence of a supra-national tax authority.

This result hinges upon the structure of the tax game under repeated interactions and would generalise to more sophisticated settings. The sustainability of implicit tax co-ordination under repeated interactions in the symmetric case (proposition 2) would hold in any setting where tax revenues under tax harmonisation exceed tax revenues under tax competition (see equation (25)). The impossibility of decentralised co-ordination on a common tax rate in the presence of large cross-country asymmetries (proposition 3) generalises to any setting where a country has higher tax revenues at the Nash equilibrium than under harmonisation. A more precise characterisation of asymmetries leading to such a result, however, obviously requires a specification of the revenue function.

References

Barro R. and D. Gordon (1983), "Rules, Discretion and Reputation in a Model of Monetary Policy", *Journal of Monetary Economics*, 12, pp. 101-122.

Bucovetsky S. (1991), "Asymmetric Tax Competition", *Journal of Urban Economics*, 30, pp. 167-181.

Coates D. (1993), "Property Tax Competition in a repeated game", *Regional Science and Urban Economics*, 30, pp. 167-181.

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

Edwards J. and M. Keen (1996), "Tax Competition and Leviathan", *European Economic Review*, 40, pp. 113-13.

Fourçans A. and T. Warin (2002), "Tax Harmonization in Europe : Do the Member States Give the Right Signal", *mimeo.*

Friedman J. (1971), "A Noncooperative Equilibrium for Supergames", *Review of Economic Studies*, 38, pp. 1-12.

Krogstrup S. (2003), "Are Capital Taxes Racing to the Bottom in the European Union", HEI Working Paper No. 01/2003.

Pearce D.G. (1992) "Repeated Games : cooperation and rationality", in *Advances in Economic Theory Sixth World Congress*, Vol. 1. Cambridge University Press.

Razin A. and E. Sadka (1994), "International fiscal policy coordination and competition", in *Handbook of International Macroeconomics*, F. van der Ploeg (Ed.), Basil Blackwell.

Taugourdeau E. (2002), "Is fiscal cooperation always sustainable when regions differ in size ? Lessons for the EMU", *Cahiers de la MSE*, no. 2002.27, University of Paris I.

Wildasin D.E. (1988), "Nash Equilibria in Models of Fiscal Competition", *Journal of Public Economics*, 35(2), pp. 229-240.

Wilson J. (1991), "Tax competition with interregional differences in factor endowments", *Regional Science and Urban Economics*, 21, pp. 423-451.

Wilson J. (1999), "Theories of Tax Competition", *National Tax Journal*, 52(2), pp. 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, pp. 356-370.