Tax competition and strategic complementarity

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A common property of tax competition models is that players' reaction functions slope upwards, i.e. that there is strategic complementarity. A central consequence of this property, namely that moving sequentially instead of simultaneously would benefit both players in a two-player game, fails to receive appropriate attention. For this would seem to imply a tendency away from the simulataneous move Nash equilibrium that established theory bases its recommendations on.

The purpose of the present paper is to expose, and to discuss, some inner workings of the received public economic theory on tax competition. We expressly recognize that rules arise endogenously and explain (a) when the folk wisdom that tax competition games exhibit strategic complementarity is justified and when it is not as well as (b) why in most interesting strategic situations involving the possibility of precommitment simultaneous moves in the tax competition game do not arise in (pure strategy) equilibrium.

(JEL: H25, H24, H30)

1 *Introduction*

Like other disciplines, economics has its folk wisdom: a class of propositions that are widely known, and shared, but which have received insufficient independent attention. This paper starts by acknowledging that one common property of tax competition models, namely that tax rates are, in a large number of cases, strategic complements, fully deserves being included in this interesting group.

Certainly, most scholars are aware that countries' reaction functions slope upwards in standard models of horizontal tax competition.[1] There is also some respectable emipirical evidence confirming this positive slope (Devereux, Lockwood and Redoano 2002). Furthermore, most economists are certainly aware that if agents' choices are strategic complements throughout, choosing sequentially is better for every agent than the simultaneous move Nash equilibrium. However, precious little has been made of this general knowledge.

For it would seem to imply that *not only is there an incentive for countries to seize the initiative, but doing so would work to the other governments' advantage*, too. One might still rationalize simultaneous moves by recourse to the argument that players do not fully internalise all the benefits of seizing the initiative, but this not done; instead most of the literature seems to settle on simultaneous moves by default.

There are a few papers that consider Stackelberg-type equilibria. For instance, in Baldwin and Krugman (2000), capital tax competition stops short of the bottom of the race because policy makers move sequentially (see also Gordon 1992). Konrad and Schjelderup (1999) demonstrate that leadership by some countries in a tax harmonization agenda may benefit all countries (i.e., both within and outside the harmonising coalition) if tax rates are strategic complements. However, in all papers the order of moves is treated as exogenous.

The purpose of the present paper is to provide a critique of the standard public economic theory on tax competition that takes our folk wisdom seriously: if a player can make herself better of by unilateral precommitment, and if this does not hurt any other player,[2] what is there to keep her? We expressly recognize that rules arise endogenously and explain (a) when the folk wisdom that tax competition games exhibit strategic complementarity is justified and when it is not as well as (b) why in most interesting strategic situations involving the possibility of precommitment simultaneous moves in the tax competition game do not arise in (pure strategy) equilibrium.

[1] In fact, the author owes the original impetus for writing this paper to Marcel Gerard, who alluded to these upward slopes as a common knowledge of sorts at the 2005 annual meeting of the *Scottish Economic Society*.

[2] Precommitment might, of course, hurt taxpayer-citizens, both at home (with Leviathan preferences) and abroad.

I begin by a brief recap of the game-theory framework of tax competition theory, paying particular attention to the nexus between strategic complementarity and precommitment (section 2). In order to develop the argument that this detracts from the plausibilty of the standard approach to modelling tax competition, we need to continue in two steps: First, it needs to be shown that tax competition does in fact exhibit strategic complementarity in a large number of cases, and second, we need to posit a model in which the order of moves is endogenous, and in which simultaneous moves do not emerge as a feature of equilibrium. Sections 3 and 4, respectively, are devoted to these tasks. Section 5 concludes.

2 Strategic complementarity and pre-commitment re-visited

Let us begin our discussion by re-visiting the game theory framework of tax competition theory, and the links between this framework and the reasons for rules – in particular, the reason for *precommitment*. As this is standard fare out of textbooks on advanced microeconomics,[3] our discussion can be brief.

Figure 1 shows the determination of the simultaneous move Nash equilibrium in a standard two-country tax competition model. A country's reaction function is the locus of all best responses to the other country's choice of tax rate; we obtain it by fixing tax rates for the second country (the dashed vertical and horizontal lines, respectively, in figure 1) and finding the point where the uppermost (rightmost) attainable iso-revenue curve just touches, finally combining all those points to get the reaction function. In models with locally benevolent dictators, a representative citizen's indifference contour replaces the iso-revenue contour.

In a (simultaneous move) Nash equilibrium, both countries play best responses, such that the equilibrium occurs where the two reaction functions intersect. Note that this implies some inefficiency, as the slopes of the indifference curves in this point are by construction perpendicular to each other.

All of this is standard price theory, except for two things: first, in the typical oligopoly models, iso-profit curves will slope towards the axes (and higher levels of utility will be associated with a move towards the origin); and reaction curves are upward-sloping (see section 3 for a formal analysis of whether this is justified).

[3] See, for example, Wolfstetter (1999: 65–105).

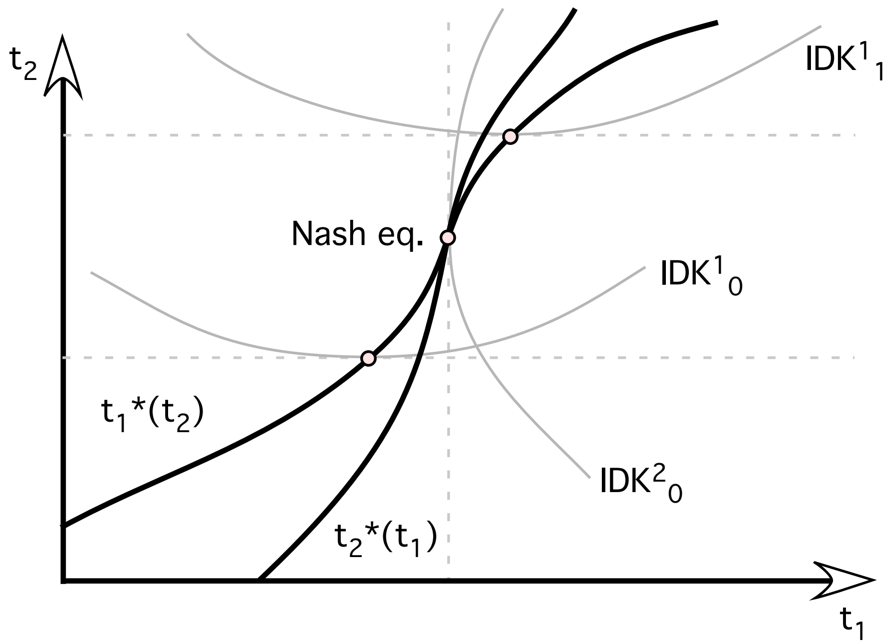

Figure 1: Indifference curves, reaction functions, and Nash equilibrium

It is the latter difference that turns out to be crucial. To illustrate it, figure 2 depicts the Stackelberg or sequential move solution in a tax competition model with upward-sloping reaction functions. The country moving first (the "Stackelberg leader") can anticipate the foreign reaction to its policy, effectively picking its most preferred solution on the other country's reaction function. As shown in the illustration, this will be the point where one of the leader's indifference curves just touches the follower's reaction funtion, and it will – except in the case of perfectly inelastic responses – diverge from the simultaneous move equilibrium.

It is well known[4] that if both reaction functions slope upwards, the Stackelberg solution is better for *both* parties than the simultaneous move solution ("strategic complementarity" of instruments, illustrated by the fact that the Stackelberg point is inside the Pareto lens relative to the Nash point in figure

[4]An abstract treatment of strategic complementarity is Gal-Or (1985).

2). While there is always an incentive to move first, viz. to commit to a rule of action in such a game, with strategic complementarity this *precommitment* benefits both players.[5] This feature of tax competition models is at the very centre of our argument. Before looking at the meta-level, however, we first need to address the question of whether the situation depictzed in figure 2 is in fact representative of standard tax competition theory.

[5]It is often helpful to characterise strategic situations by way of simple ordinal 2×2 games, of which there are altogether 74 distinct variants (Rapoport and Guyer 1966). The following two normal forms reflect the so-called precommitment situation, in which it is advantageous for at least one of the players to commit unilaterally to a specific action. The action committed to would not be chosen in the simultaneous move Nash equilibrium. For this reason, there is an intrinsic temptation to renege on the commitment, should the committed player be allowed to choose again (the essence of the time consistency problem). Well-known examples for this kind of strategic situation include the taxation of wealth and wealth transfers as well as monetary policy (see Beckmann 1998).

		Column player	
		left	right
Row player	top	(2,3)	(3,4)
	down	(1,1)	**(4,2)**

		Column player	
		left	right
Row player	top	(4,3)	(1,4)
	down	(2,1)	**(3,2)**

The main difference between the two normal forms is that in the second one, we have strategic complementarity, and precommitment by the column player (to "left") benefits both agents. Note, however, that it may still be to the detriment of a third, inactive party – such as consumers or taxpayers – that is not modelled in the game. Not all dilemma situations are undesirable from a welfare point of view (Pies 2000).

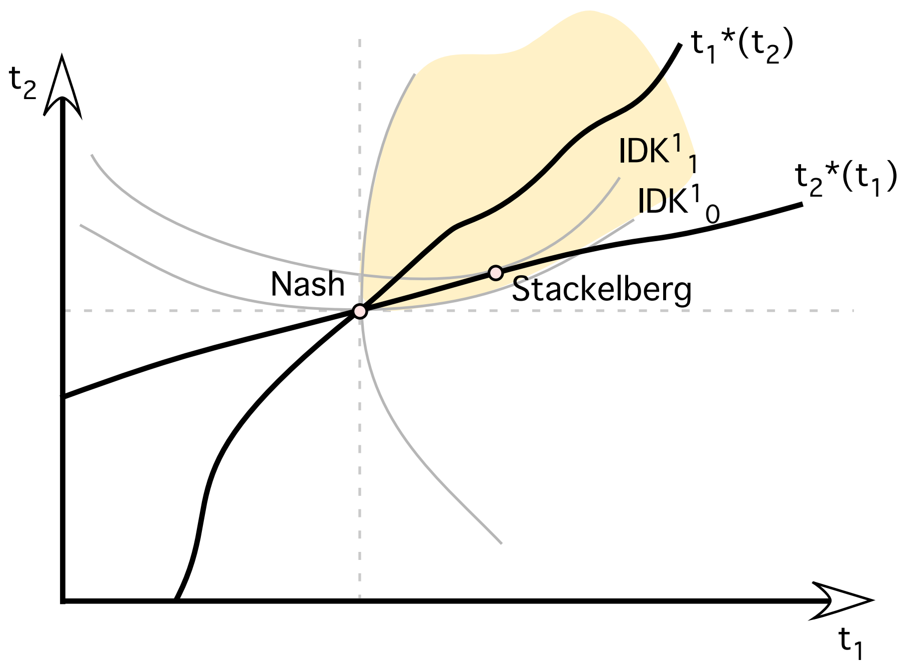

Figure 2: Strategic complementarity and Stackelberg

3 The slope of reaction functions in general TC models

3.1 The basics of tax competition theory

The centrepiece of tax competition models is an interjurisdictional mobility of the tax base, which generates an externality of tax policy.[6] Although the standard models refer to capital mobility and capital (or corporate) income tax rates as policy instruments, the basic approach can be employed when analysing governments' incentives to combat tax evasion (Beckmann 2001) as well as in the field of regulatory competition (Sinn 2003), amongst other things. In the final analysis, the framework relies on a straightforward application of standard price theory, and it cannot come as a surprise that a fair number of insights carry over from there.

[6]In the case of *vertical* tax competition alone, it is not the mobility of the base, but rather the impact on the *share* of revenues that the other echelons of government receive that creates the externality.

One such insight concerns the comparison between the effects of vertical and horizontal competition. If one country raises taxes, part of its tax base flees the country for the rest of the world, which will increase tax revenues of other countries – a positive externality. As with all good things that the perpetrator does not fully internalise, too little is done, and the effective tax rate remains inefficiently low. In vertical tax competition, on the other hand, a tax increase has both a tax share and a tax base externality. The former is always negative: A country raising its tax rate obtains a larger piece of the overall pie and reduces the share of the other echelons of government. The latter externality, however, will be positive if the federation is on the efficient part of the Laffer curve, and negative if it is not. While we cannot determine the net effect *a priori*, there is some reason to believe that there is a tendency for *pure* vertical tax competition amongst *Leviathan* governments to end up on the inefficient part of the Laffer curve, as figure 3 illustrates.

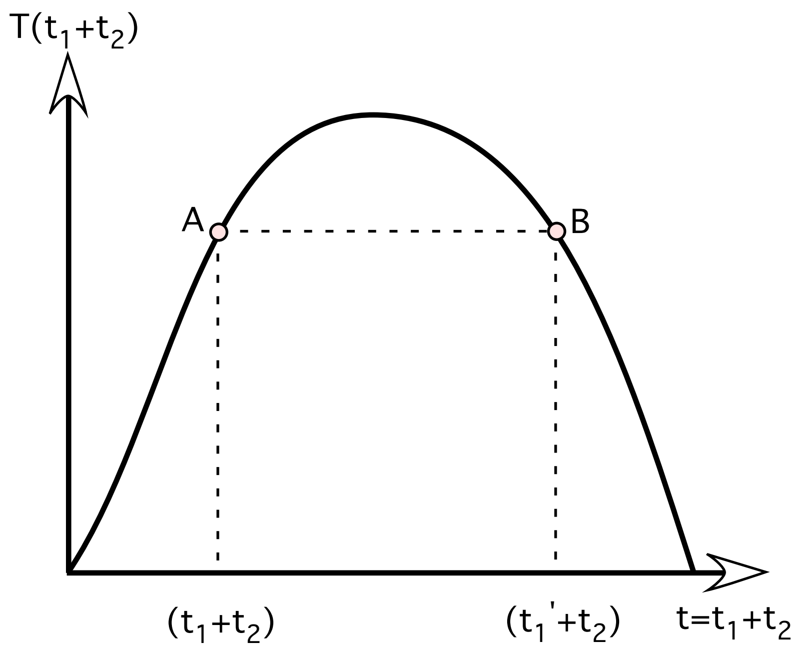

Figure 3: Simple vertical tax competition among Leviathans

Suppose that overall tax revenues are a function of the sum of federal and state (or European and national) tax rates $T = T(t_1 + t_2)$, and that each government's share of the booty is equal to $\frac{t_i}{t_i+t_j}$. In that case, it is clear that no point on the efficient part of the Laffer curve – except the revenue maximum itself – can be a simultaneous move Nash equilibrium. For starting at such a solution (say, point A in figure 3), each of the players can make itself better of by unilaterally increasing its tax rate from t_1 to such that a point on the inefficient part is reached (point B in figure 3) where the overall revenue is the same as before. As a consequence of this move, however, the government in question will have a higher share of those revenues, and so the original solution could not have been a Nash equilibrium. In the literature, it is also either the addition of horizontal competition – with its downward effect on tax rates – or another technicality that ensures a solution on the efficient part of the frontier (Wrede 1997).

Returning to horizontal tax competition for the moment, let us note that the international allocation of capital depends on a *tax arbitrage condition*: In the basic model due to Zodrow and Mieszkowski (1986) all countries are small open economies, such that the arbitrage condition reads

$$f'(k_i) - t_i = \rho$$

where ρ is the given world net tax rate, t_i country i's per unit tax and $f(\bullet)$ the intensive production function, assuming linear homogeneity. This equation can be inverted to yield the private sector reaction as $k = k(t_i + \rho)$ where $\frac{\partial k}{\partial t_i} = \frac{1}{f''} < 0$.

If there are just a few countries, this assumption does not fit. Even with Nash expectations, countries would still recognise that the exodus of capital will drive down gross rates of return elsewhere, making foreign investment less attractive. The general arbitrage condition, of course, is that the net return on identical investment be the same everywhere, or

$$f_i'(k_i) - t_i = f_j'(k_j) - t_j \qquad \forall i, j \tag{1}$$

If we continue to call the net rate of interest ρ and confine our attention to the two-country case, (1) can be used to derive the following useful property:

$$\frac{\partial \rho}{\partial t_1} = f_1'' \frac{\partial k_1}{\partial t_1} - 1 = f_2'' \frac{\partial k_2}{\partial t_1}$$

3.2 Horizontal tax competition between Leviathan governments

We now proceed to derive reaction functions for the two-country model formally, beginning with the simple Leviathan case, in which both countries maximise their rax revenue R. Country i's problem, therefore, reads

$$\max_{t_i} \quad R_i = t_i\, k_i(t_i, t_j)$$

with the obvious[7] first-order condition

$$k_i + t_i \frac{\partial k_i}{\partial t_i} = 0$$

Totally differentiating this condition and rearranging, we obtain the reaction function as

$$\frac{dt_i^*}{dt_j} = -\frac{\frac{\partial k_i}{\partial t_j} + t_i^* \frac{\partial^2 k_i}{\partial t_i \partial t_j}}{2\frac{\partial k_i}{\partial t_i} + t_i^* \frac{\partial^2 k_i}{\partial t_i^2}} \qquad (2)$$

As $\frac{\partial k_i}{\partial t_j} > 0$ and $\frac{\partial k_i}{\partial t_i} < 0$, standard assumptions on second order partials – $\frac{\partial^2 k_i}{\partial t_i \partial t_j} > 0$ [8] and $\frac{\partial^2 k_i}{\partial t_i^2} < 0$ – are sufficient to ensure that the reaction function given by (2) slopes upwards. It follows that a sequential move Nash equilibrium would be better for both governments than the simultaneous move solution. We also see from figure 2 that the Stackelberg solution entails higher tax rates, at least partially counteracting the downward pressure on tax rates due to tax competition.

However, it is also obvious from the illustration that the Stackelberg solution fails to be efficient:[9] While the follower's *reaction function* has positive slope – as we have just demonstrated – and the Stackelberg leader's indifference curve just touches in the Stackelberg solution, the follower's *indifference*

[7]After all, this case is analogous to the profit maximisation problem of a monopolist without marginal cost.

[8]The intution for this particular sign would be that there exists a negative effect of an own tax increase on capital invested at home, but that this effect is weakened as taxes abroad are raised.

[9]Neglecting the welfare of taxpayers, of course. For a discussion of how tax competition may serve a useful function in curbing Leviathan, the obvious reference is still Edwards and Keen (1996).

contour must by construction have zero slope in this point. The two indifference curves, therefore, cut instead of touching, and the Stackelberg solution cannot be efficient (cannot entail a full internalisation of the intergovernmental externality).

3.3 Horizontal tax competition between locally benevolent dictators

The formal argument from the preceding subsection will, of course, apply to the more interesting case where governments maximise residents' welfare[10] As in the seminal piece by Zodrow and Mieszkowski (1986), utlity is defined over private consumption c and a public good g (i.e., $u = u(c, g)$), and we also employ a normalised constant returns to scale technology in such a way that the marginal rate of transformation between g and c stays fixed at unity. Noting that private consumption is equal to the sum of labour income $f_i - f_i' k_i + \rho \overline{k}_i$ – where $\overline{k}_i$ denotes the resident's exogenous capital endowment – while public consumption just equals tax receipts $t_i k_i$, we find the first-oder condition

$$\frac{u_g}{u_c} = \frac{k_i + \frac{\partial \rho}{\partial t_i}(k_i - \overline{k}_i)}{k_i + t_i \frac{\partial k_i}{\partial t_i}} \tag{3}$$

Equation (3) differs from the standard condition in that it has a second term in the numerator, which obviously depends on country i's net tax export position. In a symmetric solution, this term would vanish, leading back to the well-known solution. This is even though in using (1), we have allowed for governments to take an effect on the world net interest rate into account.

Tedious but straightforward manipulation of the total differential of condition (3) leads to equation (4) for the slope of governments' reaction functions in the benevolent dictator case:

$$\frac{dt_i^*}{dt_j} = \frac{\frac{\partial \rho}{\partial t_j}\frac{\partial k_i}{\partial t_j} + \frac{\partial^2 \rho}{\partial t_i \partial t_j}(k_i - \overline{k}_i) - t_i \frac{\partial^2 k_i}{\partial t_i \partial t_j}}{(1 - \frac{\partial \rho}{\partial t_j})\frac{\partial k_i}{\partial t_i} - (k_i - \overline{k}_i)\frac{\partial^2 \rho}{\partial t_i^2} + t_i \frac{\partial^2 k_i}{\partial t_i^2}} \tag{4}$$

Standard arguments employed above would have us attribute a positive overall sign to (4) for the symmetric Nash equilibrium (where $k_i - \overline{k}_i$ vanishes

[10] We will do away with intra-jurisdiction conflicts in the usual manner by assuming that each region is populated by a single representative individual.

for all countries). In the more general case, on the other hand, the bets seems to be off: we cannot claim that reaction functions will *always* slope upwards in tax competition models, and this uncertainty is chiefly due to asymmetries in the model.

This analysis opens up a new possible scenario in which the reaction functions of some countries – net exporters or importers of capital – slope upwards, while those of countries with the reverse position slope downwards. The following illustration 4 captures the essence of that situation. We see that while precommitment by the player with the decreasing reaction function (player 2) still benefits both parties, precommitment by the other agent (player 1, whose reaction function slopes upwards) does not. This is just another case of the general principle that whether precommitment will benefit all players depends on the reaction *of the followers* (Beckmann 1998: chapter 4).

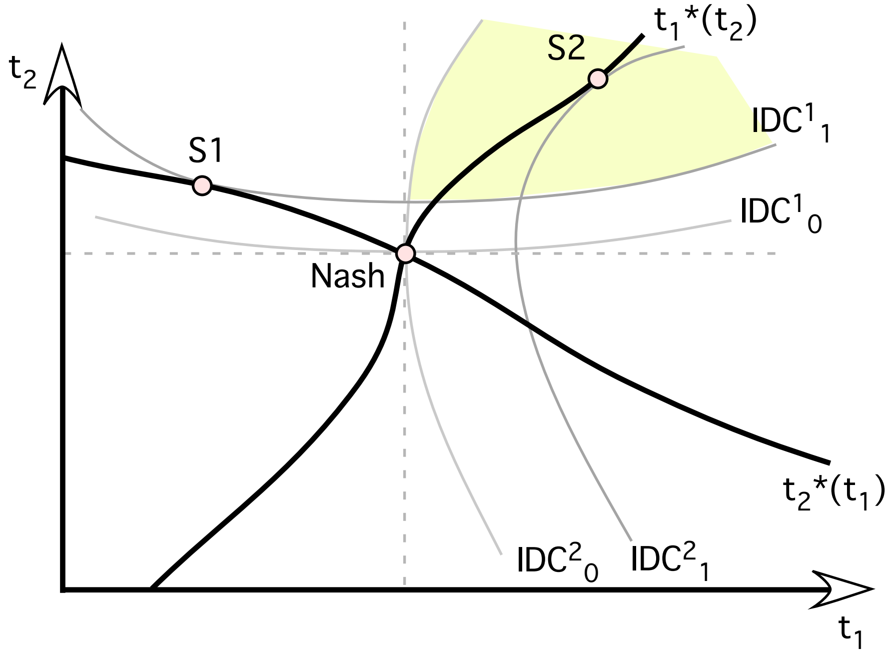

Figure 4: Asymmetric tax competition

The next question that comes naturally, given the above discussion, is of course whether net capital importers are, *ceteris paribus*, more likely to exhibit downward sloping reaction functions than are net capital exporters. A preliminary answer to that question can be drawn from equation (4): if (a) the negative influence of the own tax rate t_i on local FDI is the smaller, the higher foreign taxes t_j, and if (b) increasing taxation will lead, keeping taxation abroad constant, to an accelerating efflux of capital, then it will be capital exporters who are more likely to exhibit downward sloping reaction functions.

3.4 Vertical tax competition with Leviathan objectives

In the final part of this section, let us turn to pure vertical tax competition, where a higher-level jurisdiction taxes the same tax base as a lower-level jurisdiction, such as the member states.[11] Supposing that the overall tax revenue depends on the sum of the various tax rates – which rules out vertical competition in the definition of the tax base (depreciation) –, and that a jurisdiction's share depends on the ratio of its regional tax rate to the overall tax rate, level i's tax revenues will be:

$$R_i = \frac{t_i}{t_i + t_j} k(t_i + t_j)$$

Assuming Leviathan preferences and thus maximising R_i with respect to t_i, we obtain the first-order condition:

$$\frac{t_j}{t_i^* + t_j} k(t_i^* + t_j) = -t_i^* k'(t_i^* + t_j) \tag{5}$$

Totally differentiating and re-arranging yields the reaction function

$$\frac{dt_i^*}{dt_j} = -\frac{t_i k + k'(t_i + t_j)(t_i^2 + t_i t_j + t_2)}{(t_i + t_j)^2 (k' + k'') + t_j (t_i + t_j) k' - t_j k} \tag{6}$$

The denominator is negative under the standard assumptions $k', k'' < 0$; however, the sign of the numerator remains ambiguous. Even with the most

[11] Obviously, there is at present no such element of vertical fiscal competition in the European Union. Vertical tax competition may be found in Switzerland, however, and the United States exhibit vertical tax competition in the sense that the various echelons of government have an influence on the effective tax rate levied.

simple asumptions regardingb government preferences, we are thus unable to tell conclusively whether jurisdiction i's reaction function slopes upwards or not.

4 Vying for precommitment: meta-games

As we have seen, precommitment works to the advantage of at least one player. There exists, therefore, at least one country in most tax competition games that could make itself better off by working to change the rules of the game and committing to its tax rate in advance. This detracts from the plausibility of the simultaneous move Nash equilibrium that is normally employed in the tax competition literature.

We now proceed to analyse this situation a bit more formally, with the aim of providing a *distinctio completa* of the possible strategic situations in the two-country case. Consider a two-stage game, the second stage of which consists of the two-country interaction modelled in section 3. At the first stage, however, both countries simultaneously decide whether to commit to a tax rate (strategy label C) or not (strategy label D). Choosing C, country i incurs a fixed cost ω^i of precommitment. If a single country chooses C, it becomes the Stackelberg leader; otherwise, the simultaneous move Nash solution will obtain at at the second stage. Let us denote the payoff of country j with precommitment by country i ($i, j \in \{1, 2\}$) as $\pi^j(S^i)$. Table 1 gives the general normal form for this meta-game.[12]

Table 1: General normal form for the precommitment game

		Country 2	
		C	D
Country 1	C	$\pi^1(N) - \omega^1, \pi^2(N) - \omega^2$	$\pi^1(S^1) - \omega^1, \pi^2(S^1)$
	D	$\pi^1(S^2), \pi^2(S^2) - \omega^2$	$\pi^1(N), \pi^2(N)$

As general constraints on the payoffs in normal form 1, we can impose the following for the case with two upward-sloping reaction functions,

[12]But see sub-subsections 4.1.1 and 4.1.3 for some qualifications and an alternative.

(7) $$\pi^i(S^i) \lesseqgtr \pi^i(S^j) > \pi^i(N) > \pi^i(N) - \omega^i$$

whereas, if only country i's reaction function slope upwards, the following will hold for country j:

(8) $$\pi^j(S^j) > \pi^j(N) > \pi^j(S^i) \lesseqgtr \pi^j(N) - \omega^j$$

Inequalities (7) and (8) still leave a plethora of possible combinations. The remainder of this section will provide an exhaustive listing and discussion of these possibilities, depending on the payoff values and on the cost ω of precommitment.

4.1 Both reaction functions slope upwards

Not surprisingly, the central question in this case turns out to be whether unilateral commitment is still better for the Stackelberg leader if we take its cost ω into account.

4.1.1 Precommitment does not pay: $\pi^i(S^i) - \omega^i \leq \pi^i(N) \quad \forall \quad i \in \{1, 2\}$

In this case, we can characterise the relevant strategic situation at the meta-level with the help of a single ordinal 2×2 game, the normal form of which is given below.

		Country 2	
		C	D
Country 1	C	(1 , 1)	(2 , 4)
	D	(4 , 2)	**(3 , 3)**

(D,D) is a dominant strategy equilibrium in this case, but note that it is no "dilemma" in any way: the solution turns out to be efficient because excessive investment in precommitment technology is avoided.

For readers well versed in the economics of rent seeking, this result may appear a bit odd. The reason is our modelling of the top left strategy combination: if both countries precommit, we just revert to the simultaneous move Nash equilibrium (with reduced payoffs due to the ωs). Alternatively, one might treat precommitment as random, the probability of success for country i depending on the ratio $\frac{\omega^i}{\sum \omega}$.[13]

Assuming this version of the model as well as risk neutrality, the payoff in the top left corner of normal form 1 would read

$$\text{(9)} \qquad \frac{\omega^i}{\omega^i + \omega^j}\,\pi^i(S^i) + \left(1 - \frac{\omega^i}{\omega^i + \omega^j}\right)\pi^i(S^j) - \omega^i$$

which clearly exceeds $\pi^i(N) - \omega^i$ if we take (7) into account. However, as long as we are willing to assume that $\pi^i(S^i) > \pi^i(S^j)$, i.e. that the gross advantage of being a first mover exceeds the gross advantage of having the other guy move first, we still end up with the same normal form at the meta level.[14]

Any material change would need to pre-suppose $\pi^i(S^i) \leq \pi^i(S^j)$, such that the attraction of being a follower makes joint precommitment (the top left solution) sufficiently more attractive than in the model embodied by normal form 1.[15] In this case, we might in fact find a prisoners' dilemma at

[13] The basics of rent seeking can be found in any decent textbook on public choice, an obvious reference being Mueller (2003: 333–358). Some normative ramifications are discussed in Rowley (1988).

[14] By assumption, we have $\pi^i(S^i) - \omega^i \leq \pi^i(N)$, and as both reaction curves slope upwards, $\pi^i(S^j) > \pi^i(N)$ as well. As long as $\pi^i(S^i) > \pi^i(S^j)$, it follows that expression (9) is less than $\pi^i(N)$ and will also be exceeded by $\pi^i(S^i) - \omega^i$. Therefore, the ordinal normal form given in the text for the present case will not change.

[15] To be precise, if we have $\pi^i(S^i) > \pi^i(S^j)$, it follows that $\pi^i(S^i) - \omega^i$ will certainly be smaller than expression (9), and that we have at least the following change of normal form (assuming symmetry throughout)

		Country 2	
		C	D
Country 1	C	(2 , 2)	(1 , 4)
	D	(4 , 1)	**(3 , 3)**

While this change certainly appears innocuous (we still have a dominant strategy equilibrium with simultaneous moves at the second stage), our initial assumption that $\pi^i(S^i) - \omega^i \leq \pi^i(N)$ no longer guarantees that the payoff in the bottom right cell is greater than the payoff (9) in the top left cell. As $\pi^i(S^j)$ grows, it may, therefore, be the case that a PD situation emerges.

the meta level, because we would in effect have allowed the *expected private cost of precommitment to become negative.* We will return to the alternative formulation in later sub-sections of the present paper, where I shall also defend the model chosen for this paper.

4.1.2 Precommitment pays for just one country

Reverting to our original model as depicted in normal form 1, we now consider the asymmetric case where the net payoff as a Stackelberg leader exceeds the gross payoff with simultaneous moves for just one of the two countries; without loss of generality, let us label this particular country as 1 (the row player). We now have $\pi^1(S^1) - \omega^1 > \pi^1(N)$ as well as $\pi^2(S^2) - \omega^2 \leq \pi^2(N)$, and can distinguish the two sub-cases given below.

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(3 , 4)**
	D	(4 , 2)	(2 , 3)

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(4 , 4)**
	D	(3 , 2)	(2 , 3)

In both cases, precommitment by the row player – the country for which "precommitment pays" – is the unique equilibrium, and is also efficient.

		Country 2	
		C	D
Country 1	C	(3 , 3)	(1 , 4)
	D	(4 , 1)	**(2 , 2)**

4.1.3 $\pi^i(S^i) - \omega^i > \pi^i(N) \quad \forall \quad i \in \{1, 2\}$

If precommitment pays for both countries, an additional distinction needs to be made according to whether the net payoff as a leader exceeds the payoff as a follower for both, just one, or none of the countries. In the symmetric cases, we find two variants of the "Chicken" game, both of which sport multiple equilibria. *In neither case, however, can a simultaneous move situation at the second stage arise as the result of a first-stage Nash equilibrium in pure strategies.* It might only come about as a first-stage equilibrium in mixed strategies happens to be played out this way.

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(3 , 4)**
	D	**(4 , 3)**	(2 , 2)

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(4 , 3)**
	D	**(3 , 4)**	(2 , 2)

If we have additional asymmetry, the first-stage strategic situation will be a coordination game with a unique pareto-efficient equilibrium, as shown below.

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(3 , 3)**
	D	**(4 , 4)**	(2 , 2)

This strategic situation appears clearly innocuous, with very few reasons to doubt that players will be able to co-ordinate on the "good" equilibrium in this case.

As a result, the standard assumption of simultaneous moves in a tax competition game appears to be in need of re-thinking. If we introduce a meta-game where the sequence of moves itself is determined endogenously, equilibria will entail Stackelberg leadership in most interesting cases. To put it mildly, we cannot take simultaneity for granted.

However, we still need to discuss the "rent-seeking" alternative outlined above to see whether adopting it would (a) yield materially different results and (b) be justified with respect to the type of problem we are analysing.

Addressing the first question first and assuming as before that $\pi^i(S^i) - \omega^i > \pi^i(N)$ for both countries, we first note that this assumption together with inequality (7) implies

$$\frac{\omega^i}{\omega^i + \omega^j}\,\pi^i(S^i) + \left(1 - \frac{\omega^i}{\omega^i + \omega^j}\right)\pi^i(S^j) - \omega^i > \pi^i(N)$$

It is, however, still not necessarily true that the payoff given by (9) – the left-hand side in the above inequality – exceeds the gross payoff when following, $\pi^i(S^j)$. We may therefore find any of two strategic situations, both of which are variants of the "chicken" type.[16]

Finally, let us assume that the net payoff of being a Stackelberg leader falls short of the gross payoff of being a follower for both countries. It is then obvious that no commitment is the worst situation for both parties, and that

$$\pi^i(S^i) > \frac{\omega^i}{\omega^i + \omega^j}\,\pi^i(S^i) + \left(1 - \frac{\omega^i}{\omega^i + \omega^j}\right)\pi^i(S^j) - \omega^i > \pi^i(S^i) - \omega^i$$

This leaves us with the unique normal form

[16]One of these is:

		Country 2	
		C	D
Country 1	C	(2 , 2)	**(3 , 4)**
	D	**(4 , 3)**	(1 , 1)

The other possible game form for this case is given in the text below.

		Country 2	
		C	D
Country 1	C	(3 , 3)	**(2 , 4)**
	D	**(4 , 2)**	(1 , 1)

which again represents a game of chicken with two pure strategy equilibria, none of which involves simultaneous moves at the second stage of play.

While I have argued that adopting a standard assumption of rent-seeking theory will not affect the main conclusion of this paper materially, the additional point could be raised that the model chosen for this paper is in fact the adequate one (answering the second question raised above). To see why, consider that the *absence of a supranational authority* in the tax competition literature means that there is no collective decision-making process from which to seek rents. The strategic setup more closely resembles the situation of two opposing military leaders who attempt to achieve pre-emption,[17] facing a binary choice of approaches.

4.2 Just one reaction function slopes upwards

We might expect the asymmetric configuration depicted in figure 3.3 to yield more interesting strategic situations at the meta-level. Our analysis shows this expectation to be justified. Without loss of generality, we can label the country having an upwards-sloping reaction function as country 1 (or i), the other(s) as country 2 (or j). We can see from figure 3.3 that inequalities (7) and (8) will continue to hold. Proceeding as before, we now discuss the four main cases in which precommitment pays for no country, for both countries, or just for one of them (which, in turn, can be either of type i or of type j).

4.2.1 $\pi^i(S^i) - \omega^i \leq \pi^i(N) \qquad \forall \quad i \in \{1, 2\}$

This case is quite straightforward. All relevant sub-cases have a single equilibrium in dominant strategies, which is efficient, entails no precommitment and consequently leads to a simultaneous move Nash equilibrium at the second stage of play. There is no essential difference between the corresponding case with two upward-sloping reaction functions, discussed in 4.1.1, and it appears sufficient for purposes of illustration to give a single sub-case here:

[17] On the concept of pre-emption, see ???.

		Country 2	
		C	D
Country 1	C	(1 , 1)	(2 , 2)
	D	(4 , 3)	**(3 , 4)**

4.2.2 $\pi^i(S^i) - \omega^i > \pi^i(N) \quad \forall \quad i \in \{1, 2\}$

In 4.1.3, we previously found either a strategic situation of the chicken type or a coordination game, depending on whether the net payoff as a Stackelberg leader exceeds the utility of being a follower. A similar distinction between two main patterns can be made here, although the crucial question is now whether the j-type country (with a downward-sloping reaction function) prefers being a follower to moving simultaneously after having expended the precommitment cost ω^j. If this is the case, either of the following two normal forms obtains, and we have multiple equilibria:

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(3 , 2)**
	D	**(4 , 4)**	(2 , 3)

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(4 , 2)**
	D	**(3 , 4)**	(2 , 3)

Note that the first strategic situation depicted above allows for the equilibria to be ranked according to the Pareto criterion. Therefore, co-ordination on the bottom left solution, where the j-type country precommits while the i-type country follows in the common interest, appears plausible.

Precommitment by the j-type is also the prominent feature when the role of Stackelberg follower is the least attractive position for this type. If *everything* beats having the other country precommit, C becomes a dominant strategy in our model, and we find a single first-stage equilibrium (by iterated elimination of strictly dominated strategies), in which the i-type refrains from precommitment.

		Country 2	
		C	D
Country 1	C	(1 , 2)	(3 , 1)
	D	**(4 , 4)**	(2 , 3)

		Country 2	
		C	D
Country 1	C	(1 , 2)	(4 , 1)
	D	**(3 , 4)**	(2 , 3)

In both sub-cases, the solution is obviously efficient.

4.2.3 Precommitment pays only for the i-type: $\pi^1(S^1) - \omega^1 > \pi^1(N)$ while $\pi^2(S^2) - \omega^2 \leq \pi^2(N)$

In the final two cases, we turn to the asymmetric configurations. We still find the same question to be crucial: is the Stackelberg follower position better for the j-type than a simultaneous move equilibrium in which the investment in precommitment is wasted? However, the consequences are starkly different: in the present case, there will be no Nash equilibrium in pure strategies at all if the worst solution for the j-type country is to be a Stackelberg follower. The two possible strategic situations are given below:

		Country 2	
		C	D
Country 1	C	(1 , 2)	(3 , 1)
	D	(4 , 3)	(2 , 4)

		Country 2	
		C	D
Country 1	C	(1 , 2)	(4 , 1)
	D	(3 , 3)	(2 , 4)

In the other group of cases, we do obtain a unique Nash equilibrium which involves precommitment, *albeit by the type i player*. This equilibrium may even be inefficient, as the first normal form given below illustrates. If effect, there exists a recurring precommitment problem in this variant of our model, which one might be tempted to relegate, Buchanan-fashion, to a yet higher level of rule-making. The obvious problem with this approach lies in the question of whether this call on "level $k+1$" will lead to an infinite regress. In normative matters it clearly will – the so-called "Münchhausen trilemma"[18] – , whereas the answer depends on the assumptions regarding precommitment technologies that one is prepared to make in a positive analysis. For the purposes of the present paper, however, we need not go any further.

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(3 , 2)**
	D	(4 , 3)	(2 , 4)

		Country 2	
		C	D
Country 1	C	(1 , 1)	**(4 , 2)**
	D	(3 , 3)	(2 , 4)

4.2.4 Precommitment pays only for the j-type: $\pi^1(S^1) - \omega^1 \leq \pi^1(N) \quad \text{while} \quad \pi^2(S^2) - \omega^2 > \pi^2(N)$

Concluding on what might be termed a conciliatory note, we now consider the final group of sub-cases, described by the normal forms below:

[18]See Beckmann (2005) on this and related problems in constitutional economics.

		Country 2	
		C	D
Country 1	C	(1 , 1)	(2 , 2)
	D	**(4 , 4)**	(3 , 3)

		Country 2	
		C	D
Country 1	C	(1 , 2)	(2 , 1)
	D	**(4 , 4)**	(3 , 3)

Evidently, if isolated precommitment pays only for the j-type country with a downward sloping reaction function, the situation scarcely involves an element of conflict at all. The single equilibrium in both first-stage games represents the best outcome for both players, and in one case there is even a complete Paretian ordering over all four possible outcomes. At any rate, in neither strategic situation do we find simultaneous moves at the second stage.

5 Conclusion

The chief purpose of the present paper was to expose, and to discuss, some inner workings of the received public economic theory on tax competition. Additionally, we expressly recognized that rules arise endogenously, and that the advantages of the Stackelberg leadership position provide incentives for governments to expend resources on precommitment in a meta-game. We explained

- why the folk wisdom that tax competition games exhibit strategic complementarity is in fact generally justified,
- why it is sometimes not (and when),
- why in most interesting strategic situations involving the possibility of precommitment simultaneous moves in the tax competition game do not arise in (pure strategy) equilibrium.

These results shed a different light on the unreflected use of the simultaneous move Nash equilibrium concept in tax competition theory. Our argument ought, however, not to be misconstrued as providing a specific alternative model. Here, we owe some caution to the critique of game theory (Gurrien 2004, Hargreaves-Heap and Varoufakis 1995).

We provide just an argument against the unreflected use of simultaneous move solutions, which might also be contrued as an argument against the unreflected use of game theory itself. For while game theory has a great value in describing a strategic situtión and in working out the structure of interaction among rational agents (or equilibrium and dynamics among programmed agents), it must be treated with caution when provided as a positive model of a given interaction between concrete individuals.

An additional – and final – point of caution concerns the scope of tax competition theory itself. It is quite obvious, and has been illustrated by the preceding discussion, that the neoclassical theory of tax competition basically involves a fairly straightforward application of price theory to the area of international taxation. This type of analysis appears well suited to all cases where government policies may be viewed as setting *effective tax rates*. Besides tax rate competition, this includes changing definitions of the tax base, lenience towards tax evasion (Beckmann 2001), regulation (Sinn 2003), outright subsidies or the procurement of public goods. It may be less suited where there is *systems competition* in the narrow sense of the term, i.e. where governments compete by innovating in the area of procedures or rules for economic policy.

It is perhaps unfortunate that constitutional economics does not – at least in its present state – lend itself to facile formalisation using the equilibrium-oriented toolbox of neoclassical economics. For this arguably causes a lopsided division of efforts, for which the present paper happens to provide another example.

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