Master PEI : Game Theory in Banking, Finance, and the International Arena

Final Exam, Sciences Po, November 2021

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Duration : 105 mn. No document, no calculator allowed.

The OECD's solution to tax multinational enterprises' income

Part A (11 pts). Tax competition between two countries : implementing a minimum corporate tax

A.1) (2 pts) The corresponding payoff matrix writes as

$A \backslash B$	L	H
L	$LY^A; LY^B$	$L(Y^A + \alpha^B Y^B); H(1-\alpha^B)Y^B$
H	$HY^A(1-\alpha^A); L(Y^B + \alpha^A Y^A)$	$HY^A; HY^B$

A.2) (2 pts) From our initial assumption, we have :

— $\alpha^A < H - L = (H-L)\frac{Y^A}{Y^A}$, so $LY^A < HY^A(1-\alpha^A)$ and $BR^A(L) = \{H\}$;

— $\alpha^B < \frac{H-L}{L}\frac{Y^A}{Y^B}$, so $L(Y^A + \alpha^B Y^B) < HY^A$ and $BR^A(H) = \{H\}$;

— $\alpha^B < H - L = (H-L)\frac{Y^B}{Y^B}$, so $LY^B < H(1-\alpha^B)Y^B$ and $BR^B(L) = \{H\}$;

— $\alpha^A > \frac{H-L}{L}\frac{Y^B}{Y^A}$, so $L(Y^B + \alpha^A Y^A) > HY^B$ and $BR^B(H) = \{L\}$.

So, country A has a strictly dominant strategy of imposing the tax rate H (i.e., $H \succ_A L$) and country B has no dominant strategy.

A.3) (2 pts) From **A.2)**, at equilibrium A plays its strictly dominant strategy H and B best responds by playing L. So, there is a unique Nash equilibrium, which consists in for country A (resp. B) to tax at rate H (resp. L). Formally, the set of Nash equilibrium writes as $\{(H, L)\}$.

From the previous analysis, the outcome (H, H) (resp. (H, L)) maximizes country A's (resp. B's) payoff. The outcomes (L, L) and (L, H) are Pareto-dominated by (H, H). So, the set of Pareto optima is $\{(H, H),(H, L)\}$.

Suppose country A applies a new law according to which domestic companies which are taxed at a lower rate abroad have to pay the difference in tax to country A. We assume that companies have not yet had time to change tax location.

A.4) (2 pts) The corresponding payoff matrix writes as

$A\backslash B$	L	H
L	$LY^A; LY^B$	$L(Y^A + \alpha^B Y^B); H(1-\alpha^B)Y^B$
H	$HY^A(1-\alpha^A) + (H-L)Y^A\alpha^A; L(Y^B + \alpha^A Y^A)$	$HY^A; HY^B$

Country A still has a strictly dominant strategy of imposing the tax rate H, and B still best responds by playing L. So, the set of Nash equilibrium is the same as in the previous answer : $\{(H, L)\}$.

A.5) (1 pt) Although the unique Nash equilibrium is the same as in the previous answer, the payoffs associated to the equilibrium Pareto dominates the previous payoffs since country A has increased his tax revenue by $(H-L)Y^A\alpha^A$ while country B has the same payoff.

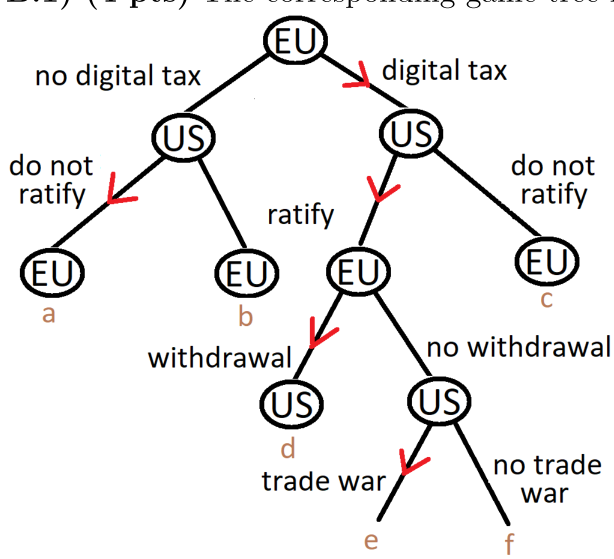
A.6) (2 pts) The corresponding payoff matrix writes as

$A\backslash B$	L	H
L	$LY^A; LY^B$	$L(Y^A + \alpha^B Y^B); H(1-\alpha^B)Y^B$
H	$HY^A; LY^B$	$HY^A; HY^B$

In which case, country B also has a strictly dominant strategy of imposing the tax rate H (i.e., $H \succ_B L$). So, there is a unique Nash equilibrium, which consists in for each country to tax at the high rate : $\{(H, H)\}$.

Part B (4 pts). Using threat to achieve tax cooperation between the EU and the US

B.1) (4 pts) The corresponding game tree is :



From 1) $d \succ_{EU} a$, and from 2) $d \succ_{EU} f$. From 3) $a \succ_{US} b$, from 4) $d \succ_{US} c$, and from 5) $e \succ_{US} f$. By backward induction, there is a unique subgame perfect Nash equilibrium which sequentially consists in : for the EU to implement the digital tax ; for the US to ratify the tax suggested by the OECD only in case of a EU digital tax ; for the EU to withdraw its

digital tax after the US ratification ; and for the US to start a trade war in case of absence of EU withdrawal.

Part C (5 pts). Minimum tax in repeated interaction

C.1) (2 pts) For any country $i \in \{1, 2\}$, $BR^i(\tau^*) = \frac{\tau^*}{2} + \frac{1}{20} = \frac{1}{8} + \frac{1}{20} = \frac{28}{160} = \frac{7}{40} = 17.5\% \neq \tau^*$, so the rate τ^* is not sustainable. The one-shot Nash equilibrium satisfies

$$BR^i(BR^j(\tau_i)) = \tau_i \iff \frac{1}{2}(\frac{\tau_i}{2} + \frac{1}{20}) + \frac{1}{20} = \tau_i \iff \tau_i^N = \frac{1}{10} = 10\%.$$

So, there is a unique Nash equilibrium, which is given by $(\tau_1^N, \tau_2^N) = (\frac{1}{10}, \frac{1}{10})$. This equilibrium is symmetric and we denote $\tau^N = \frac{1}{10}$.

C.2) (2 pts) Grim-trigger strategies prescribe the countries to set the rate τ^* as long as no deviation is observed, and set the static Nash-equilibrium tax rate τ^N forever after a deviation is observed. The optimal deviation of country i from cooperation is given by $BR^i(\tau_j^*) = 17.5\%$. Country i finds it optimal not to deviate at period $\bar{k} \geq 1$ if the following incentive condition holds :

$$\sum_{k=0}^{+\infty} \delta^k g_i(\tau^*, \tau^*) \geq \sum_{k=0}^{\bar{k}-1} \delta^k g_i(\tau^*, \tau^*) + \delta^{\bar{k}} g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) + \sum_{k=\bar{k}+1}^{+\infty} \delta^k g_i(\tau^N, \tau^N)$$

which is equivalent to the incentive condition for deviation at period 0 :

$$\sum_{k=0}^{+\infty} \delta^k g_i(\tau^*, \tau^*) \geq g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) + \sum_{k=1}^{+\infty} \delta^k g_i(\tau^N, \tau^N)$$

This condition is equivalent to

$$\frac{g_i(\tau^*, \tau^*)}{1-\delta} \geq g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) + \frac{\delta g_i(\tau^N, \tau^N)}{1-\delta}$$

$$\iff g_i(\tau^*, \tau^*) \geq g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*)(1-\delta) + \delta g_i(\tau^N, \tau^N)$$

$$\iff \delta(g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) - g_i(\tau^N, \tau^N)) \geq g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) - g_i(\tau^*, \tau^*)$$

$$\iff \delta \geq \frac{g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) - g_i(\tau^*, \tau^*)}{g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) - g_i(\tau^N, \tau^N)} \equiv \bar{\delta}$$

where the last equivalence uses the fact that the denominator is positive. Indeed, since $g_i(\tau_i, \tau_j)$ increases in τ_j, from $\tau_j^* = 25\% > 10\% = \tau_j^N$, we have $g_i(\tau^N, \tau^N) \leq g_i(\tau_i^N, \tau_j^*)$ and, by definition of $BR^i(.)$, the RHS is lower than $g_i(\tau_i = BR^i(\tau_j^*), \tau_j^*)$.

C.3) (1 pt) If a minimum corporate tax rate is set internationally at level $\underline{\tau} \in (\tau^N, \tau^*)$ the static Nash-equilibrium tax rate τ^N can no longer be used as a punishment after a deviation is observed. In particular, at discount factor $\bar{\delta}$, from $g_i(\underline{\tau}, \underline{\tau}) > g_i(\tau^N, \tau^N)$ we have

$$\sum_{k=0}^{+\infty} \bar{\delta}^k g_i(\tau^*, \tau^*) < g_i(\tau_i = BR^i(\tau_j^*), \tau_j = \tau^*) + \sum_{k=1}^{+\infty} \bar{\delta}^k g_i(\underline{\tau}, \underline{\tau})$$

so the incentive condition does not hold and the minimum discount factor $\bar{\delta}$ is not valid anymore. The countries have to be more patient for their tax cooperation to be sustainable.

We can conclude that although the static theory of tax competition implies that a minimum tax cannot be harmful (except, perhaps, at an extremely high level), this is no longer true in dynamic tax competition. Indeed, a lower bound on tax rates restricts the ability of countries to punish deviators, which makes cooperation harder to sustain. For more discussion on this result, see Kiss, Á. (2012). Minimum taxes and repeated tax competition. *International Tax and Public Finance*, 19(5), 641-649.

Part D (2 Bonus pts). Solution concept

D) (2 pts) The set of outcomes satisfying this solution concept in the prisoner's dilemma is empty. Indeed, the prisoner's dilemma has a unique Nash equilibrium. This outcome is then the only candidate for the suggested solution concept. However, it is Pareto dominated so it is not immune against bilateral deviation that is profitable for at least one player.