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ABSTRACT

Competition for FDI with Vintage Investment and Agglomeration Advantages

Countries compete for new FDI investment, whereas stocks of FDI generate agglomeration benefits and are potentially subject to extortionary taxation. We study the interaction between these aspects in a simple vintage capital framework with discrete time and an infinite horizon, focussing on Markov perfect equilibrium. We show that the equilibrium taxation destabilizes agglomeration advantages. The agglomeration advantage is valuable, but is exploited in the short run. The tax revenue in the equilibrium is substantial, and higher on "old" FDI than on "new" FDI, even though countries are not allowed to use discriminatory taxation. If countries can provide fiscal incentives for attracting new firms, this stabilizes existing agglomeration advantages, but may erode the fiscal revenue in the equilibrium.

JEL Classification: F21 and H71
Keywords: agglomeration, bidding for firms, dynamic tax competition, foreign direct investment and vintage capital

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1 Introduction

Foreign direct investment (FDI) depreciates slowly once the investment has been made in some country. During this phase, the foreign investor is potentially subject to the opportunistic behavior of the host country. In particular, as the burden of a tax on this investment or its returns overwhelmingly falls on expatriates whose utility is typically not part of national welfare, host countries may like to resort to extortionary taxation. This possibility makes foreign investors reluctant to invest and may cause underinvestment, which is known as the hold-up problem of FDI.[1] Simultaneously with the slow depreciation of old FDI from previous investment periods, however, new investors show up and make the location choices for their new investments. Host countries face a trade-off. They compete in attempting to attract new FDI, and at the same time they would like to extract revenue from their acquired stock of FDI. If countries are not able to discriminate between old and new FDI for tax purposes, or have agreed collectively not to do so, a country would like to "extort" revenues from the old stock of FDI but, at the same time, this may cause the country to lose the competition for new FDI.

We consider FDI in a framework with an infinite sequence of periods to study the relationship between countries' incentives to tax old FDI and to attract new FDI, where new investment in each period is determined as the outcome of fiscal competition between two countries, A and B. In each period one new investor shows up and invests either in A or B. His investment becomes fixed and immobile in the next period. Given this structure, there is always one country that has a positive stock of old FDI and one country with no old FDI when it comes to the fiscal competition for new FDI. The fiscal parameters (taxes) that are chosen by the countries at the beginning of each period apply both to the new FDI and to the old FDI in this period. For this reason the stock of old FDI exerts a strategic effect on competition. It makes the country with substantial old FDI reluctant to choose a low tax. The country without a stock of old FDI is more "lean and hungry". It does not sacrifice tax revenue on immobile old FDI when choosing a low tax. In a dynamic framework with an infinite horizon the situation is more complex and reveals other effects. In particular, the competition for winning the new FDI in a given period is not only driven by the asymmetry in the stocks of old FDI. Considerations about how winning the new FDI in a given period will alter the incentives for competition in future periods also play a role. We

[1] A recent empirical study of outright expropriation or nationalization of FDI and a brief literature overview is provided by Duncan (2006). Our focus is more on "cold" expropriation that occurs via extortionary taxation. Schnitzer (1999) highlights some of the theoretical differences between the two concepts.

solve this problem for the tax competition equilibrium, using the concept of Markov perfect equilibrium.

Our main results are as follows. First, we show that the Markov perfect equilibrium is in mixed strategies. The country with the high stock of old FDI chooses a higher expected tax rate than its competitor, but in the equilibrium both countries win the new FDI in a given period with positive probability. Second, even though countries cannot choose discriminatory taxes and must choose the same tax rate to apply to old and new FDI, the expected tax burden on old FDI tends to be higher than the expected tax burden on new FDI. Note also that the expected overall tax burden for FDI in each period is constant over time and the tax rates are strictly positive in all periods. Hence, although the countries may be perfectly symmetric from an ex-ante point of view, the vintage property of FDI shelters tax competition between the countries from becoming a race to the bottom. Fourth, these results contribute a novel reason for why the hold-up problem of FDI need not be severe. Positive taxes and positive FDI occur in a Markov perfect tax competition equilibrium.

Our analysis also allows an examination of agglomeration advantages: new FDI may have a cost advantage if the investment occurs in a country which has a high stock of old FDI already. We ask whether this cost advantage will generally stabilize the role of being the country with the higher stock of FDI or whether an agglomeration advantage is likely to be only temporary. We show that the country with a high stock of old FDI is likely to lose the agglomeration advantage over time, but may re-gain it in the future. The agglomeration advantage oscillates randomly over time between the two countries, and this is an equilibrium outcome. A country could perfectly prevent a shift of the agglomeration advantage to the competing country and could perpetuate the agglomeration advantage by way of its tax policy. However, such behavior does not emerge in the equilibrium. Instead, a country is tempted to extract revenue from the existing stock of FDI if it has the agglomeration advantage. In the mixed strategy equilibrium that emerges the country that accumulated an agglomeration advantage is more likely to lose it in the next period than it is to keep it.

One surprising result of our analysis is that the greater the agglomeration advantage enjoyed by the country with the high stock of old FDI, the lower the tax rates of both countries in equilibrium and the lower the expected discounted value of tax revenues accruing to the two countries. Even without an agglomeration advantage, a country with a high level of old FDI acts more passively in the competition for new FDI, setting higher taxes on average than its rival in order to reap the increased revenues from old FDI. The agglomeration advantage helps counteract this disadvantage, leveling the

playing field in the competition and therefore making both countries more aggressive in stochastically lowering taxes in order to attract new FDI. For the country without old FDI, this effect is clear. Due to the agglomeration effect, the degree to which it must discount its tax rate below its rival's in order to attract new investment increases, leading it to reduce its rate on average. For the country with old FDI, the effect is more subtle. Since it sets higher taxes on average in order to milk revenues from its old FDI, it is more likely to lose new FDI to its rival. A greater agglomeration advantage therefore reduces its payoff from competing for new FDI in the future, when it is more likely to have to cut taxes to overcome the advantage. Therefore, it is willing to cut its tax rate more in the current period in order to avoid losing its advantage.

Although agglomeration advantages increase the competition between the two countries and lower the discounted value of tax revenues, at the same time the difference between the present discounted value of the tax revenues of the country possessing an agglomeration advantage and the country which does not increases in the agglomeration advantage itself. Consequently, such advantages are valuable assets that yield a long term flow of benefits to the country possessing them.

Political arguments are often advanced that such an advantage needs to be nurtured to be sustained. Although, in our framework, an agglomeration advantage is beneficial for country that has it, in the equilibrium the country is willing to risk losing this advantage for benefits in the short run. A closer look at the history of agglomeration advantages and technology leadership shows that they need not last forever. Instead, they may shift from one location to another over time. A famous example is the shift of technology leadership in the context of Dyestuffs Industries and the emergence of leadership in Germany in the late 19th century. Historians describe the success of the Dyestuffs industry in Germany as being brought about by several factors, including lenient patent laws, the interaction between research and industry and considerable public investment in chemical laboratories (see Murmann and Homburg 2001 and Harhoff 2007). Whether the German administration was more lean and hungry than the British administration must be left an open question here. A second piece of evidence can be gained from consideration of corporate taxation in the European Union. The new member states of the European Union choose taxes on corporate income that are far below the average rates that apply to the European Union as a whole. Also, these new accession countries do not have a large stock of old FDI. Hence, they do not pay a high price in terms of reducing the tax rates on the previously attracted FDI or their capital base more generally if they reduce their tax rates. They are "lean and hungry", and they may shift investment agglom-

eration away from the "old" agglomeration in the capital rich member states towards the new member states.

The hold-up problem in FDI has been carefully studied. Several analyses focus on the long-term relationship between the investor and the host country, in the absence of inter-country competition. Eaton and Gersowitz (1983) showed that equilibria with tacit collusion can solve the hold-up problem between investors and the government if the government is sufficiently patient. Thomas and Worrall (1994) consider a dynamic game in which investment may build up slowly over time. They also focus on equilibrium with tacit collusion and punishment strategies. Konrad and Lommerud (2001) show that incomplete information may partially solve the hold-up problem. If the profitability of foreign direct investment is not perfectly observed by the host country government, some expected share of the foreign direct investor's rents is shielded from expropriation even if the government can rely on an optimal incentive contract: the investor earns an information rent in expectation, and this information rent makes positive investment feasible. Schnitzer (1999) considers the role of control rights of the investor. The potential profitability loss that results from a transfer of control rights in connection with expropriation may deter such expropriation, but is less effective in limiting "cold expropriation" by extortionary taxation. The aspect of inter-country competition comes into play in Janeba (2000) who shows that building up excess capacity in different countries may allow a multinational enterprise to react elastically to extortionary taxation by shifting its production and profits to the locations with low taxes. Janeba's truly intriguing mechanism is related in spirit to Kehoe (1989) who argues that tax competition between regions may resolve the hold-up problems in the context of time consistent capital taxation. In our framework the FDI and the profits it generates become perfectly immobile once the investment is in place, but a country that attracted the FDI in the past must decide how much tax to extract from this immobile base, knowing that a choice of a high tax makes it less likely that it will win the ongoing competition for new FDI.

Three other lines of literature are closely related to our analysis. First, Kind et al. (2000) and Baldwin and Krugman (2004) study tax competition if capital is initially agglomerated in one of the countries. In their frameworks the country with the agglomeration advantage may preserve this advantage by applying 'limit taxes'. We show that, in a dynamic context with new FDI in each period, the vintage nature of investment may cause the agglomeration advantage of a country to be transitory. Our analysis therefore leads to a different prediction about the intertemporal sustainability of agglomeration advantages and may provide an explanation for why regions or countries may lose their agglomeration advantages over time. The vintage structure

of investment in our framwork is similar to the 'overlapping generations' structure in the multi-period finite horizon model of Holmes (1999). He shows that agglomeration at a geographic location that has a natural disadvantage compared to another location may exhibit a drift and move to the geographic location that has the natural advantage, if this advantage is high enough. However, he does not address tax policy or the strategic dynamic interaction and competition between governments.

Second, more recently, a small literature on tax competition with stocks of capital and flows of investment has emerged. Wildasin (2003) and Hatfield (2006) consider dynamic capital taxation as an optimal control problem. Countries try to extract tax revenue from an imperfectly mobile capital stock that is partially owned by foreigners. These approaches are in continuous time. This literature does not consider a time structure of invested capital that results in the strictly positive tax revenues of our Markov perfect equilibrium, and does not allow for the vintage dynamics, temporary asymmetries and random oscillation of capital agglomeration.

Third, our analysis is related to problems that have been studied in Bertrand markets with subsets of loyal or informed and uninformed customers, building on the fundamental insights in Varian (1980). The nature of the pricing equilibrium in mixed strategies that emerges from such problems is similar to the mixed strategies that result in our problem of FDI competition (e.g., Narasimhan 1988).[2] Chen and Rosenthal (1996) consider a problem of dynamic duopoly with some customers losing their loyalty in every period and solve for the Markov perfect equilibrium in this context. Their framework is more general regarding the number of states that can emerge in the Markov process, but there is no equivalent to the cost asymmetry that results from agglomeration advantages.

Our analysis proceeds as follows. In Section 2 we describe the framework of our formal analysis. Section 3 solves for a Markov perfect equilibrium and its comparative static results. Section 4 considers investment subsidies as an additional instrument of competition. Section 5 concludes.

2 The formal framework

We consider a dynamic framework with an infinite number of periods $t = 1, 2, ...$ There are two countries, A and B, each with an infinite life span. In each period one foreign investor i_t arrives and decides whether to locate

[2] Wang (2004), Andersson and Konrad (2001) and Marceau, Mongrain and Wilson (2007) consider tax competition in finite horizon games with mobile and immobile tax base, leading to equilibria similar to those in Narasimhan (1988).

a unit of FDI in country A or in country B. We denote this decision as $i_t \in \{A, B\}$. The investment exists for two periods and cannot relocate. If $i_t = B$ in period t, this investment is also located in B in period $t+1$. The investment depreciates and disappears at the end of period $t+1$. Accordingly, in each period there is one old unit of FDI that is located either in A or in B, and one newly arriving unit of FDI that is perfectly mobile between A and B. A unit of FDI generates profit in each of the two periods and completely depreciates after that. The profits in each period are exogenously given for each investment. Moreover, there is a cost of investment in the first period of FDI. This cost may depend on the choice of location. We assume that the cost is lower if the FDI locates in the country in which there is already one active unit of FDI, and the cost saving that occurs in this case, compared to investing in the other country, is equal to $\Delta \geq 0$. This cost saving is called the agglomeration advantage. If $\Delta = 0$, then there is no agglomeration advantage. The FDI's profit is then fully independent of the location choice. If $\Delta > 0$, then the country which attracted the investment i_{t-1} in period $t-1$ has an agglomeration advantage in period t: everything else equal, the firm making the investment decision prefers to invest in the country which attracted the investment in the previous period, due to the cost savings. This cost saving can refer to a number of factors that are typically associated with agglomeration advantages, including technological spillovers from the investment in place to the newly arriving investment.[3] Given these assumptions, in the absence of governmental policy, FDI is attracted by the region which attracted investment in the past. However, the governments in both regions are active players and we turn to their action space next.

Countries simultaneously choose taxes $T_A(t)$ and $T_B(t)$, respectively, at the beginning of each period t, prior to the location choice of newly arriving FDI. These taxes are constrained from above by $T_j \in [0, r]$ with r sufficiently small compared to the profits from FDI to make FDI always attractive and the investor's participation constraint non-binding. These taxes are non-discriminatory in the sense that the tax $T_j(t)$ that is chosen by country j for period t applies to all FDI which resides in j in this period, both old FDI that located in j already in period $t-1$, and new FDI that locates in j in period t.

Investors' payoffs are determined by their exogenous profits in the two periods of their activity, by the set-up costs for FDI in the first period of

[3]Several microfoundations for Δ could be given, based on trade cost, knowledge spillovers, labor market externalities and others. For a short survey and further references see Devereux, Griffith and Simpson (2007). Strange, Hejazi and Tang (2006) emphasize coping with uncertainty as a common denominator of several agglomeration advantages that have been identified.

activity, by the taxes they have to pay, and by their discount rate that makes first and second period payments comparable. We assume that all investors and governments have the same common discount rate, expressed by a common discount factor equal to $\delta \in (0,1)$, which is taken as time invariant and exogenous. Accordingly, if i_t locates in A, then investor i_t's payoff is

$$\pi_{i_t}(A) = \begin{cases} G - T_A(t) + \Delta - \delta T_A(t+1) & \text{if} \quad i_{t-1} \text{ located in } A \\ G - T_A(t) - \delta T_A(t+1) & \text{if} \quad i_{t-1} \text{ located in } B, \end{cases} \tag{1}$$

with G exogenously given. Investor i_t's payoff of locating in B is obtained analogously.

The determination of the objectives of governments in tax competition frameworks is a more delicate matter. Within our restricted framework, we assume that a government's payoff is equal to the present value of its revenues from taxing FDI. The normative basis for this assumption is that even a government that aims at maximizing the social welfare in the respective country would like to extract tax revenue from FDI, because foreigners bear the burden of these taxes, and their utility should not enter the objective function of a government that aims to maximize the welfare of its citizens. Accordingly, country j's objective function at a given period t is

$$\theta_{t-1}(T_j(t)) + \sum_{k=t}^{\infty} \theta_k (T_j(k) + \delta T_j(k+1)) \delta^{k-t} \tag{2}$$

with $\theta_k = 1$ if $i_k = j$ and $\theta_k = 0$ otherwise.

Before characterizing and restricting the players' sets of strategies, we characterize the set of histories of the game in different periods. Assuming that, in period $t = 1$, one investor had already chosen its location i_0, the sequence of actions that is described in section 2 establishes possible histories at any point in time. When countries make their tax choices at the beginning of period t, a history is a sequence of actions $h_t = \{i_0, (T_A(1), T_B(1), i_1), ..., (T_A(t-1), T_B(t-1), i_{t-1})\}$, and all feasible histories at period t constitute the elements of the set H_t. Accordingly, a pure local strategy of country j at period t is a mapping $T_j(h_t, t)$ from H_t into $[0, r]$. Similarly, when the investor who arrives at the beginning of period t chooses its investment location, the mapping i_t is a mapping from $H_t \times [0,r] \times [0,r]$ into $\{A, B\}$ that assigns a location choice to each feasible $(h_t, T_A(t), T_B(t))$. In this framework the set of possible equilibrium outcomes is typically very large. However, it is natural to restrict the strategy space and to look at Markov perfect equilibria. For this purpose we restrict the set of behavioral strategies of countries and investors to those which employ local strategies in each period t as follows. Countries

choose $T_j(i_{t-1}) \in [0, r]$, solely as a function of the location decision of investor i_{t-1} in period $t-1$, who either invested in country A or in country B. We allow countries to employ local randomization, described by their cumulative distribution functions $F_j(i_{t-1}), j = A, B$, with support $[0, r]$. Note that, by construction, these mappings are not dependent on the historical time period and these restrictions require that all histories that lead to the same investment decision i_{t-1} are mapped into the same tax choices by countries (with possible mixing) in period t. Similarly, we restrict the set of behavioral strategies of investors as follows. The investor who chooses the location of FDI at the beginning of period t makes its location choice as a function of $(i_{t-1}, T_A(t), T_B(t))$. These restrictions require that all histories that lead to the same investment decision i_{t-1} and tax rate choices $T_A(t)$ and $T_B(t)$ are mapped into the same investment choices by the investor i_t that chooses the location of FDI in the respective period t. By construction, these mappings are also not dependent on the time period.

3 Markov perfect equilibrium

We now consider the equilibrium tax choices of the governments. We determine the net fiscal burden that is imposed on FDI, and whether the tax choices stabilize or destabilize a given agglomeration advantage. In order to make this comparison, we note that the agglomeration advantage is sustained in a laissez-faire equilibrium forever: If $\Delta > 0$ and $T_i(t) \equiv 0$, the new FDI would always invest in the country which has the stock of old FDI. This is the benchmark for evaluating whether equilibrium tax policy destabilizes or strengthens an existing agglomeration of capital.

We now turn to the equilibrium with endogenous tax policy and state our main result:

Proposition 1 *Let $r > 2\Delta(1+\delta)$. (i) A Markov perfect equilibrium in stationary strategies with positive taxes $T_A(i_{-1})$ and $T_B(i_{-1})$ exists in which*

$$F_j(T) = \left\{ \frac{(\delta+2)T + \delta\Delta - r}{(\delta+2)T + (\delta-2)\Delta + r\delta} \text{ for } T \in (\frac{r - 2\Delta(1+\delta)}{\delta+2} + \Delta, r) \right. \quad (3)$$

and $F_j(T) = 0$ for $T < \frac{r-2\Delta(1+\delta)}{\delta+2} + \Delta$ and $F_j(T) = 1$ for $T \geq r$, if $i_{-1} = j$,

$$F_j(T) = \left\{ 2\frac{(\delta+2)T + 2\Delta(1+\delta) - r}{(\delta+2)T + \Delta(3\delta+2) + r\delta} \text{ for } T \in [\frac{r - 2\Delta(1+\delta)}{\delta+2}, r - \Delta) \right. \quad (4)$$

and $F_j(T) = 0$ for $T < \frac{r-2\Delta(1+\delta)}{\delta+2}$ and $F_j(T) = 1$ for $T \geq r - \Delta$, if $i_{-1} \neq j$. (ii) If $i_0 = B$, then the payoffs for A and B in period $t = 1$ are $v_A^* = \frac{r(1+\delta)-2\Delta}{(2+\delta)(1-\delta)}$

and $v_B^* = 2\frac{r-\delta\Delta}{(\delta+2)(1-\delta)}$ *in this equilibrium. For* $i_0 = A$ *the same property holds with* A *replacing* B *and vice versa.*

Proof. For (i), consider first the choice of an investor who locates his FDI in period t. He anticipates that the actual FDI location in t will lead to the same expected tax burden in $t+1$ on this investment, because the respective host country will will choose the same local tax strategy in period $t+1$, irrespective whether this host country is A or B. The location decision can, hence, be made on the basis of returns in period t only. In period t the agglomeration benefit matters: investing in the country in period t that hosts the FDI made in $t-1$ has a cost advantage of size Δ. Therefore, if $i_{t-1} = B$, then $i_t = B$ if

$$T_B(t) < T_A(t) + \Delta. \tag{5}$$

The FDI is made in A if the reverse inequality holds, and FDI may be located in either country with equal probability if equality holds in (5). It is important for this result that each investor appear and decides only once. An investor whose FDI has expired its two periods of activity disappears and will not re-appear with new FDI in the future.

Turn now to the tax choices by countries. Note that the one-stage deviation principle applies. To see this note that the lowest aggregate payoff for a country is bounded from below by zero. Also, the highest payoff (2) of a country is bounded from above by

$$\frac{2r}{1-\delta}. \tag{6}$$

Payoff differences between arbitrary action profiles are therefore bounded from above by (6) for each single country.

Suppose now that all future investors and countries A and B follow the candidate equilibrium choices in all periods $t+1, ...$ This allows us to calculate continuation value v_1 at $t+1$ that applies for the country j for which $i_t = j$ and the continuation value v_0 that applies for the country j for which $i_t \neq j$ as follows: if $T_j(t+1) = r$, the investor i_{t+1} locates FDI not in j, but in the other country with probability 1. As this tax choice has a positive probability mass in the candidate equilibrium strategy for j with $i_{t-1} = j$, it must hold that

$$r + \delta v_0 = v_1. \tag{7}$$

Second, given the equilibrium candidate strategies, country j with $i_t = j$ is indifferent in period $t+1$ between choosing $T_j = r$ and $T_j = q + \Delta$ with

$$q = \frac{r - 2\Delta(1+\delta)}{\delta + 2} \tag{8}$$

being the lower bound of the equilibrium support for the country without old FDI. As $T_j(t) = q + \Delta$ will attract FDI in period t with probability 1, it must hold that

$$(\frac{r - 2\Delta(1+\delta)}{\delta + 2} + \Delta)2 + \delta v_1 = v_1. \tag{9}$$

These two equations can be used to calculate the continuation values as

$$v_1 = 2\frac{r - \delta\Delta}{(\delta + 2)(1 - \delta)} \tag{10}$$

and

$$v_0 = \frac{r(1+\delta) - 2\Delta}{(2+\delta)(1-\delta)}. \tag{11}$$

Consider now period t. It remains to show that the local strategies F_A and F_B are mutually optimal replies. Consider first country B. Given the candidate equilibrium choices of A, country B's payoff as a function of $T_B(t)$ can be written as

$$F_A(T_B - \Delta)(T_B + \delta v_0) + (1 - F_A(T_B - \Delta))(2T_B + \delta v_1) \tag{12}$$

Inserting (4), (10) and (11) shows that the value of (12) is equal to v_1 in (10) for all $T_B \in [q + \Delta, r]$. Moreover, all $T_B \notin [q + \Delta, r]$ yield a lower payoff. This makes any mixed strategy F_B that has $[q+\Delta, r]$ as its support an optimal reply to F_A. Turn now to the tax choices of country A, anticipating that country B chooses F_B as in (3), and the continuation values v_1 and v_0 as in (10) and (11). Country A's payoff as a function of $T_A \in [q, r - \Delta]$ is

$$F_B(T_A + \Delta)\delta v_0 + (1 - F_B(T_A + \Delta))(T_A + \delta v_1). \tag{13}$$

Inserting (3), (10) and (11) shows that the value of (13) is equal to v_0 in (11) for all $T_A \in [q, r-\Delta)$ and smaller than v_0 for any feasible $T_A \notin [q, r-\Delta]$.

Note for completeness that (4) and (3) are cumulative distribution functions, and the lower bound of taxes, q, is positive if $r > 2\Delta(1 + \delta)$ holds.

For (ii), the equilibrium payoffs v_A^* and v_B^* for A and B given $i_0 = B$ are equal to the continuation values v_0 and v_1 as in (11) and (10), respectively. ■

The equilibrium in Proposition 1 involves mixed strategies and cannot be in pure strategies for reasons that are analogous to Bertrand pricing games with loyal and non-loyal customers as, for instance, in Narasimhan (1988). The discontinuity regarding countries' tax base at $T_A = T_B - \Delta$ causes the non-existence of an equilibrium in pure strategies[4] and yields equilibria in

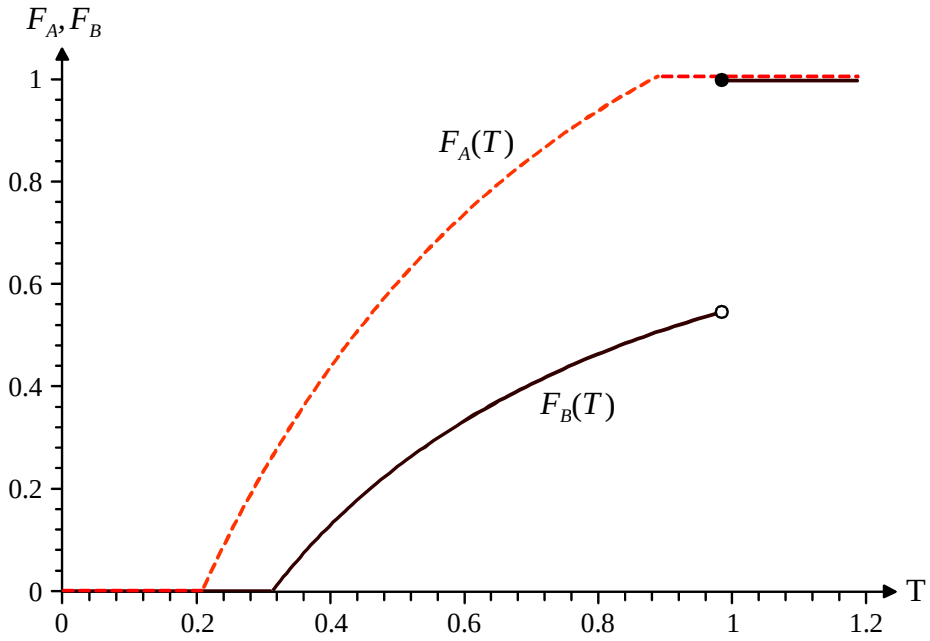

Figure 1: CDF's T_A and T_B for a period t with $i_{t-1} = B$, for $\delta = 0.9$, $\Delta = 0.1$ and $r = 1$.

mixed strategies. The equilibrium cdf's in Proposition 1 are depicted in Figure 1 for a situation with $i_{-1} = B$.

To make the outcome intuitively plausible, consider first F_A. Country A which does not have a stock of old FDI in this period will not charge a tax higher than $r - \Delta$; the maximum tax charged by country B is $T_B = r$ (which is the exogenously given maximum) and given the agglomeration advantage of country B in the respective period, with a tax that exceeds $r - \Delta$ country A will never be able to attract any new FDI. This determines the upper limit of the support for country A. The lower limit of A's support is determined similarly: country B always has the option to charge a high tax $T_B = r$ on its immobile tax base (the FDI that located in country B in the previous period), and this yields positive tax revenue in this period, even if the investment in period t will then take place in A. For this reason, B is not willing to reduce

[4]Consider, for instance, $i_{t-1} = B$, and $\Delta = 0$. Country A would like to attract the investment in period t, and is willing to undercut any positive tax rates chosen by country B. However, for resulting high tax rates p_A, country B would like to undercut A likewise, making making p_A suboptimal for A. For tax rates sufficiently lower than r, country B prefers to choose $p_B = r$. But given $p_B = r$, a p_A that is discretely smaller than p_B is, again, not an optimal reply for A.

its tax to a level arbitrarily close to zero. Instead, there is a smallest positive tax such that B is indifferent between charging $T_B = r$ on the old FDI and not attracting the FDI in this period on the one side, and charging this minimum tax if this yields B the FDI in that period with probability 1. This lower limit is determined as $q + \Delta$. But given that B will never adopt a tax that is lower than $q + \Delta$ and A will never undercut this smallest tax by more than Δ, the lower bound of A's support is $T_A = q$. Within the interval $[q, r - \Delta]$, country A randomizes in a way that makes B just indifferent for all possible choices in its support. Similarly, B randomizes on the interval $[q+\Delta, r)$ in a way that makes A just indifferent between taxes in its support. In addition this requires that B places a mass point at $T_B = r$.

Note that the country which has the agglomeration advantage in period t loses this advantage in the next period with a probability that is strictly higher than $1/2$ in the equilibrium that is characterized in Proposition 1. In the laissez-faire equlibrium the agglomeration advantage was sustained over time with a probability of 1. Accordingly, endogenous tax policy destabilizes existing agglomerations and makes it more likely that a country will lose a historically given agglomeration advantage.

Some further qualitative properties of the equilibrium are characterized in the next proposition.

Proposition 2 *The following properties hold for the Markov perfect equilibrium with cdfs (3) and (4): (i) The period tax burden on "old" FDI is higher in expectation than the period tax burden on "new" FDI. (ii) The expected tax revenue on total FDI per period is higher than r.*

Proof. The proof of property (i) uses a revealed preference argument. Let, without loss of generality, $i_{t-1} = B$. This "old" FDI is taxed by $T_B(t)$ in period t. The "new" FDI in period t is taxed by $T_B(t)$ if $i_t = B$, and by $T_A(t)$ if $i_t = A$. Moreover, $i_t = A$ if $T_B(t) - \Delta > T_A(t)$. Hence, the tax burden is the same on "old" and "new" FDI if $i_t = i_{t-1}$, and is lower (or at most the same, which happens only if $T_A(t) = T_B(t)$ and $\Delta = 0$) if $i_t \neq i_{t-1}$. Because both countries randomize their tax rates independently according to (3) and (4), outcomes with $T_A(t) < T_B(t) - \Delta$ happen with positive probability.

Consider (ii). The expected tax revenue could be calculated from the cdfs. As this is cumbersome, consider an alternative measure. The sum $v_0 + v_1$ is the present value of the sum of both countries' tax revenue at any given t. Now, after inserting and rearranging, this sum can be written as

$$v_0 + v_1 = \frac{r}{(1-\delta)} + \frac{r - 2(1+\delta)\Delta}{(2+\delta)(1-\delta)}. \tag{14}$$

This sum exceeds $\frac{r}{(1-\delta)}$ if $r > 2\Delta(1+\delta)$. However, $\frac{r}{(1-\delta)}$ is the present value of tax revenue that emerges if, on average, the total tax revenue is equal to r in each period, and $r > 2\Delta(1+\delta)$ is the condition stated in the proposition that is required to make the country that has no agglomeration advantage choose a positive minimum tax in the equilibrium. ■

Proposition 2 shows that the equilibrium exhibits the property that FDI is taxed more heavily when it matures. Tax policies under which investors receive a preferential tax treatment in early periods of investment are known as "tax holidays" and are widely studied in the tax competition literature. The usual assumption in this context is that countries may be able to commit to a lower tax for some time, but their commitment power does not stretch into the indefinite future. In our framework "tax holidays" result endogenously from the equilibrium outcome in which countries with a stock of old FDI have a tendency to choose higher taxes than countries with no such stock when competing for new FDI. It is based here on a reversion-to-the-mean effect: new FDI can choose the country which exhibits the superior fiscal conditions in the period of investment. Old FDI has to accept the conditions chosen in the respective country in which it is located.

The putty-clay nature of FDI causes two different effects regarding the location choice of future FDI: an incumbency effect and an agglomeration benefit effect. To study the incumbency effect, we set $\Delta = 0$. In this case the country which attracted FDI in the previous period has an immobile tax base in the current period. Let this country be B. If B chooses a high tax, it is likely that the tax chosen by A is lower and the FDI goes to A. A high tax rate therefore is likely to make country B lose the mobile tax base in this period, and this is a twofold loss: the country loses the tax revenue on this tax base in the current period and it loses the advantage of having an immobile tax base in the next period. The competing country A has a twofold gain from attracting FDI in the current period, and this is a reason why country A has a strong incentive to undercut the tax rate chosen by B: first, A does not have an immobile tax base from previous FDI; hence, it does not lose tax revenue on this tax base by reducing its own tax rate in a given period. Second, a lower tax rate makes it more likely that the tax rate is sufficiently low to attract the new investment in that period, which can then be taxed in the current period, and is an immobile tax base that can be taxed by A also in the next period. The nature of this competition makes it likely that a country which attracted FDI in the previous period will not attract it in the current period. Hence, investment alternates stochastically over time. For $\Delta = 0$, it is more likely that the investment takes place in the country without immobile tax base in a given period. More formally:

Proposition 3 *For the Markov perfect equilibrium with cdfs (3) and (4), when* $\Delta = 0$ *the probability that* $i_t = i_{t-1}$ *is* $1/4$.

Proof. Suppose $i_{t-1} = B$. Then

$$F_A(T) = \begin{cases} 2\dfrac{T(\delta+2)-r}{T(\delta+2)+r\delta} \text{ for } T \in [\dfrac{r}{\delta+2}, r) \end{cases}$$

and

$$F_B(T) = \begin{cases} \dfrac{T(\delta+2)-r}{T(\delta+2)+r\delta} \text{ for } T \in (\dfrac{r}{\delta+2}, r) \end{cases},$$

with $F_j(T) = 0$ for $T < \frac{r}{\delta+2}$, and $F_j(T) = 1$ for $T \geq r$, $j = A, B$. Accordingly, A "wins" the tax competition for the new investment in period t with a probability

$$P_{A \text{ wins}} = \int_q^r F_A'(x)(1 - F_B(x))dx = 3/4$$

■

A country that attracted the investment in the previous period has an incentive to exploit this immobile investment, and this makes the country disadvantaged vis-a-vis the competitor without such a stock of tax base that can be exploited. Following Fudenberg and Tirole (1984), one may say that the country which currently has a stock of investment is a "fat cat", whereas its competitor has the "lean and hungry look". This analysis reveals that the country that attracted much past investment has a strategic disadvantage. Capture of previous investment, hence, is not only a benefit, but equilibrium forces drive future investment away from saturated countries and towards lean and hungry countries.

An agglomeration effect comes into play if investments exhibit positive spillovers towards each other (or towards new investment in our case), i.e., if there are technological benefits from agglomeration, which are measured in our framework by Δ. The higher the agglomeration advantage Δ enjoyed by the country with old FDI, the lower the tax rates of both countries in equilibrium and the lower the expected discounted value of tax revenues accruing to the two countries. However, the difference between the present discounted value of the tax revenues of the country possessing an agglomeration advantage and the country competing with it for new investment, increases in the agglomeration advantage Δ. Consequently, when such advantages exist, they are valuable assets that yield benefits to the country possessing them.

Proposition 4 *Suppose* $r > 2\Delta(1+\delta)$. *(i) The higher the agglomeration advantage* Δ *the lower the equilibrium tax rate of each country in the sense of first order stochastic dominance. (ii)* $v_1 - v_0$ *is increasing in* Δ.

Proof. (i) Let $i_{t-1} = j$ and write the equilibrium distribution of country j given in 3 as a function of Δ,

$$F_j(\Delta) = \frac{(\delta+2)T + \delta\Delta - r}{(\delta+2)T + (\delta-2)\Delta + r\delta} \equiv \frac{N}{D}$$

where N stands for numerator and D for denominator. Note that

$$dF_j(\Delta)/d\Delta = \frac{\delta}{D} - \frac{(\delta-2)N}{D^2} = \frac{\delta}{D} - \frac{(\delta-2)}{D}F_j(\Delta)$$

It is easily verified that D is positive over the relevant range, so that $sgn\ (dF_j(\Delta)/d\Delta) = sgn\ \ [\delta - (\delta-2)F_j(\Delta)] > 0$. Hence, the effect of an increase in the agglomeration parameter Δ is to raise the probability that the country with old FDI sets its tax rate below any given level T in the support of its distribution. A similar result holds for the country with no vintage FDI. If $i_{t-1} \neq j$, then from (4)

$$F_j(\Delta) = 2\frac{(\delta+2)T + 2\Delta(1+\delta) - r}{(\delta+2)T + \Delta(3\delta+2) + r\delta} \equiv 2\frac{N}{D}$$

where again N stands for numerator and D for denominator. Since

$$dF_j(\Delta)/d\Delta = \frac{4(1+\delta)}{D} - \frac{2(3\delta+2)N}{D^2} = \frac{4(1+\delta)}{D} - \frac{(3\delta+2)}{D}F_j(\Delta)$$

and D is positive, $sgn\ (dF_j(\Delta)/d\Delta) = sgn\ [4(1+\delta) - (3\delta+2)F_j(\Delta)] > 0$.

(ii) From (11) and (10) it is easily verified that $v_1 - v_0 = \frac{r+2\Delta}{(\delta+2)}$, which is increasing in Δ. ■

This calculation therefore shows that as Δ increases both countries set lower taxes on average but that the advantage of being the beneficiary of the agglomeration effect grows.

4 Bidding for firms

We assumed so far that countries have to tax old and new FDI according to the same rules. A country which attracted FDI in the past, hence, sacrifices the opportunity to levy a high tax on this immobile investment if it chooses to compete seriously for the new investment, and this caused considerable fiscal revenues in the equilibrium in Proposition 1. When competing for FDI, countries are often not allowed to use discriminatory taxation with respect to old and new investment. However, they may use an additional instrument in the competition for new investment. As has been highlighted in the literature

(e.g., Black and Hoyt 1989, Besley and Seabright 1999, and Kessing, Konrad and Kotsogiannis 2008), countries may make upfront transfers to new FDI, and may bid for FDI much like in a standard auction. This second instrument will generally change the nature of the equilibrium and may erode the fiscal net revenue that remains to countries.

To analyse this more formally, we enlarge set of actions of countries in each period. Each country chooses the tax $T_j(t) \in [0, r]$ that applies to any old and new FDI that is located in country j in the given period, and also it makes a bid $S_j(t) \in [0, k]$ to the new investor in the respective period t. Here, k is an exogenous constant, sufficiently large to be non-binding, but finite. For instance, any $k \geq 2r + \Delta$ is a suitable limit. This changes period payoffs of countries. Let, e.g., $i_{t-1} = B$. Then the payoff of country B in period t is $T_B(t)$ if $i_t = A$, and $2T_B(t) - S_B(t)$ if $i_t = B$, and the period payoff of A is $T_A(t) - S_A(t)$ if $i_t = A$ and zero otherwise.

Moreover, given $i_{t-1} = B$, a foreign direct investor's total payoff is equal to $G + \Delta + S_B(t) - T_B(t) - \delta T_B(t+1)$ if $i_t = B$, and it is equal to $G + S_A(t) - T_A(t) - \delta T_A(t+1)$ if $i_t = A$. Accordingly, anticipating the future tax burden in the country of location, the investor will locate the FDI in the country with higher payoff. For equal payoffs we apply here a more specific tie-breaking rule and assume that, if the payoffs are equal, the investor locates in the country which has the agglomeration advantage.

Strategy sets, histories, and a restriction to Markov perfect strategies follow straightforwardly from these assumptions, and we can state the following proposition

Proposition 5 *Suppose $r > 2\Delta(1 + \delta)$ and let $i_0 = B$. Then a Markov perfect equilibrium exists in which $T_A^*(t) = T_B^*(t) = r$, and $S_j^*(t) = \delta(r + \Delta) + r - \Delta$ if $i_{t-1} = j$, and $S_j^*(t) = \delta(r + \Delta) + r$ if $i_{t-1} \neq j$, for all $t = 1, 2, ...$ The payoffs in this equilibrium are $v_A^* = 0$ and $v_B^* = r + \Delta$.*

Proof. Note first that the one-stage deviation principle applies also for the augmented framework for analogous reasons. Consider now the decision of an investor at t. As both countries charge the same tax in period $t + 1$, regardless of i_t, the investor can base the location decision on a comparison of period t payoffs. There are savings in investment of Δ from investing in i_{t-1}. Let $i_{t-1} = B$. Then $i_t = B$ if and only if $S_B(t) - T_B(t) + \Delta \geq S_A^*(t) - T_A^*(t)$. Continuation play in periods $t + s$ for $s = 1, 2, ...$ as in the candidate equilibrium in Proposition 5 yields continuation values for the countries as $v_A = 0$ and $v_B = r + \Delta$ if $i_t = B$, and $v_A = r + \Delta$ and $v_B = 0$ if $i_t = A$. Let $i_{t-1} = B$. Suppose that B anticipates $T_A^*(t) = r$ and $S_A^*(t) = \delta(r + \Delta) + r$. Then the payoff of B becomes equal to $T_B(t)$ if

$S_B(t) - T_B(t) + \Delta < S_A^*(t) - T_A^*(t)$, and equal to $2T_B(t) - S_B(t) + \delta v_1$, if $S_B(t) - T_B(t) + \Delta \geq S_A^*(t) - T_A^*(t)$. Among the latter choices, the payoff maximizing choice is $S_B(t) - T_B(t) = \delta(r+\Delta) - \Delta = \delta(r+\Delta) + r - r - \Delta = S_B^*(t) - T_B^*(t)$. We now turn to country A. The payoff of A is equal to zero for all $S_A(t) - T_A(t) \leq S_B^*(t) - T_B^*(t) + \Delta$. Moreover, the payoff for A is negative for all $S_A(t) - T_A(t) > \delta v_1 = \delta(r+\Delta) = \delta(r+\Delta) + r - \Delta - r + \Delta = S_B^*(t) - T_B^*(t) + \Delta$. This completes the proof. ■

Proposition 5 shows that the high tax revenue outcome in the tax competition equilibrium of Proposition 1 is a consequence of a lack of a sufficient number of fiscal instruments. If the countries have as many instruments as there are types of tax bases, then the competition between countries again becomes cut-throat in nature. This result is not unexpected and confirms the intuition that differential taxation of tax bases with different elasticities tends to strengthen tax competition, as, for instance, in Janeba and Peters (1999) and Haupt and Peters (2005).

Proposition 5 also highlights the interaction between the number of available fiscal instruments and the agglomeration effect. In the absence of subsidization, from Proposition 4 we know that an increase in the agglomeration effect Δ lowers the present discounted value of tax revenues for both countries. Proposition 5 shows the reverse; an increase in the agglomeration effect Δ raises the discounted value of net revenues of the country with old FDI and has no effect on the value of net revenues for the competing country, which are zero. This arises because, in the presence of two instruments, competition for new FDI is decoupled from revenues extracted from old FDI. Due to the immobility of old FDI, the host country can reap the complete hold-up benefit, r. At the same time, perfect Bertrand-like tax competition for new FDI drives the return from that FDI to Δ for the host country with agglomeration advantages and zero for its rival.

The result in Proposition 5 is interesting for two further reasons. First, it shows that the restrictions on subsidies paid to new FDI that apply in the European Union may moderate tax competition for FDI within Europe and may prevent a 'race to the bottom'. Second, the result shows that tax competition that is complemented by countries' bidding for FDI may lead to higher average tax revenues but lower fiscal net revenues than if such bids are not feasible. Note that the aggregate tax revenues in the equilibrium in Proposition 5 are equal to $2r$ in each period, and are smaller than $2r$ in the equilibrium that is characterized in Proposition 1. However, the present value of all aggregate fiscal net revenues of all future periods is equal to $r + \Delta$ in the equilibrium with bidding for FDI, and the expression in (14) in the equilibrium in Proposition 1. An immediate implication of the comparison of the present value of aggregate fiscal net revenues under the two regimes is

the following proposition:

Proposition 6 *Suppose* $r > 2\Delta(1+\delta)$. *The present discounted value of aggregate fiscal net revenues is higher with a single instrument* $(T_j(t))$ *(in the equilibrium characterized in Proposition 1), than with two instruments* $(T_j(t)$ *and* $S_j(t))$ *(in the equilibrium characterized in Proposition 5), if and only if* $r > \frac{\Delta(4+\delta(1-\delta))}{(1+\delta)^2}$.

This observation is interesting from an empirical point of view. Empirically the relationship between capital mobility, effective marginal tax rates, and fiscal net revenues is not straightforward. For instance, sustained or even increasing tax revenue has been observed jointly with a reduction in marginal tax rates.[5] If the increased competition for FDI has been complemented with a change in the number or composition of instruments, sustained or even increasing tax revenue does not preclude a drop in fiscal net revenue. As shown in Proposition 6, for δ sufficiently large, two instruments generate less fiscal revenue than one. At the same time, the average statutory tax rates are higher than in the case with only one tax instrument.

5 Discussion

Countries that compete for FDI face a trade-off. They would like to attract further FDI, which is easier if the country can offer attractive fiscal conditions. Countries would also like to extract tax revenue from FDI, once the investment is in place and cannot easily be relocated. This trade-off is studied here, allowing for fiscal competition for FDI. We take account of the fact that FDI is mobile ex-ante and can react to the fiscal conditions that apply in different countries, that FDI becomes immobile and potentially subject to extortionary taxation once it is in place while it depreciates over time, and that the competition for the flow of fresh FDI and the extraction of revenue from old FDI occurs simultaneously. We analyse a Markov perfect equilibrium of this dynamic problem assuming that countries have very limited means for treating fresh FDI fundamentally differently from old, immobile FDI. In addition, we allow for potentially positive agglomeration effects, defined as a cost advantage for FDI from locating in a country which has a high stock of FDI.

Our main findings are: A country's acquired stock of immobile FDI is a mixed blessing. On the one hand, the country can extort this immobile tax

[5] Devereux, Griffith and Klemm (2002), for instance, address the puzzle that corporate tax revenue did not decrease, despite decreases in tax rates.

base. On the other hand, such extortionary taxes will affect newly acquired FDI. The temptation to extort the immobile tax base is a strategic disadvantage in the tax competition for new FDI. As a result, the country which has accumulated a stock of immobile FDI at the beginning of a period will, on average, charge a higher tax, and is likely to lose the agglomeration advantage to a country without a stock of immobile FDI. A frequent change in the agglomeration advantage between countries will be observed along the equilibrium path in a Markov perfect equilibrium with stationary strategies. Our theoretical results appear to be consistent with empirical results by Dumais, Ellison and Glaeser (2002). They recognize (p. 193) that "...concentration is the outcome of a life cycle process in which new plants are constantly being born, existing plants are expanding and contracting at different rates, and a substantial number of businesses are failing" and consider empirically what drives agglomeration and deagglomeration. They find that (p. 200) "...new firm births and expansions of existing plants have a deagglomerating effect...". We provide a fiscal competition argument that can explain this effect. Moreover, we find that the agglomeration advantage intensifies both countries' incentives to charge lower taxes.

In the analysis we first assumed that countries cannot rely on discriminatory taxation that allows taxation of old and new FDI with differential rates. The empirical counterpart of this assumption is the convention according to which differential treatment of different types of capital investment is considered as harmful tax competition (by the OECD). Of course, countries are innovative in finding arrangements to circumvent any rule against discriminatory taxation. For instance, when it comes to FDI, countries often promise tax holidays where this is legally feasible, provide investing firms with public infrastructure without charging an adequate user fee, or sell them property or other production inputs at below market value.[6] If discriminatory taxation is feasible, it changes the nature of the equilibrium. A Markov perfect equilibrium emerges in which each country taxes the stock of investment that has previously been invested in this country at its maximum. Independently of this time consistent treatment of old FDI, the countries compete in attracting new FDI. This was analysed in section 4. As a result, agglomeration may perpetuate itself, but the economic advantage of agglomeration may be very small.

We considered only two countries and assumed new FDI depreciates in two periods. If there are more than two countries, only the countries with the smallest stocks of old FDI are likely to enter seriously into the competition.

[6] This motivates the study of the acquisition process of FDI as an auction, as in Black and Hoyt (1989), Besley and Seabright (1999) and Oman (2000).

However, it would be appropriate to allow for more than one FDI project per period in an analysis that allows for more than two countries as well. Finally, if FDI lasts for more than two periods, this will also generate interesting new questions, but at a considerable cost of complexity. For instance, for three periods, two countries and one FDI project arriving in each period, the set of states in a given period t has four elements: the two states in which i_{t-2} and i_{t-1} occurred in the same country (A or B), and the two states in which i_{t-2} occurred in one country and i_{t-1} occurred in the other country. The study of two countries, one project at a time, and a time horizon of two periods for each FDI project is the minimal framework in which vintage effects of such investment can be studied in a tax competition framework, but we expect that many of the insights carry over qualitatively to a more complex setup.

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