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Competing for a Duopoly:

International Trade and Tax Competition

Abstract

We analyse the tax/subsidy competition between two potential host governments to attract the plants of firms in a duopolistic industry. Competition between identical countries for a monopoly firm's plant is known to result in subsidy inflation which leaves the winning country indifferent towards hosting the firm. In sharp contrast, we show that, with two firms, both are taxed in equilibrium and the host countries appropriate the entire social surplus generated within the industry–despite the explicit non-cooperation between governments. We extend our baseline model to allow for differences in country size. We investigate when this size asymmetry becomes sufficiently large to change the nature of the equilibrium, inducing concentration of production in the larger country.

Keywords: tax competition; foreign direct investment; oligopoly; market size asymmetries.

JEL classifications: F12; F23; H25; H73.

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1 Introduction

The idea that competition for foreign direct investment (FDI) results in a "race to the bottom" in taxes is a recurrent theme of public opinion in developed countries. Bidding contests between national governments for the footloose plants of multinational enterprises (MNEs) tend, according to this view, to depress corporate tax revenues and inflate subsidy payments.[1] The end result is that MNEs are perceived as capturing a disproportionate share of the benefits of FDI. During the late 1990s, these public concerns were reflected at the policy level in the launching of initiatives by both the European Union and the OECD to combat "harmful" tax competition (see European Commission, 1997; OECD, 1998).

Empirical support for this race-to-the-bottom hypothesis is provided by a small number of studies of particularly striking cases. For example, in 1994 the US state of Alabama offered Mercedes an incentive package worth approximately $230 millions for a new plant to employ 1,500 workers (Head, 1998). Similarly, in the UK, Siemens was offered £50 millions in 1996 to locate a 1000-worker semiconductor plant in Tyneside, northeast England. That factory closed 18 months later, and the company had to repay £18 millions in grants.[2] However, the representativeness of such case studies of tax/subsidy competition for FDI is certainly open to question.[3]

Some possible causes of a downward pressure on equilibrium corporate tax rates (or an upward pressure on subsidy payments) are suggested by existing formal analyses of tax/subsidy competition for FDI. These have focused on the polar cases of industry structure–perfect

[1] For example, according to the eminent British political philosopher, John Gray, "(t)ax competition among advanced states works to drain public finances and make a welfare state unaffordable" (Gray, 1998, p. 88). Some argue that the race to the bottom will manifest itself more broadly–such as in a scramble to dismantle environmental protections (for an analysis of which, see Markusen *et al.*, 1996). However, our focus is tax/subsidy competition.

[2] See also Kozul-Wright and Rowthorn (1998, p. 86).

[3] For example, Devereux *et al.* (2002) find no evidence of a race to the bottom over time in the "effective" marginal and average corporate tax rates of 18 countries (the EU and G7) during the 1980s and '90s.

competition and monopoly. Zodrow and Mieszkowski (1986), for example, examine the determination of capital taxes and public good provision in a world of perfect competition and small, open economies. In that situation, a rise in one country's capital tax creates a positive externality as capital is driven abroad, benefiting other countries as the capital inflows result in higher tax revenues and wages. In a non-cooperative environment, national governments fail to account for these external benefits and, consequently, set tax rates and public good provision at inefficiently low levels. In contrast, Haufler and Wooton (1999) focus on the case of monoply. They examine the tax/subsidy competition game between two potential host countries for a single firm's production plant. If the countries place the same value on local production and neither country offers an inherently more profitable location for the firm, then subsidy payments "race to the top" in equilibrium, such that the winning location gains no benefit from hosting the FDI.[4]

However, in contrast to these theoretical perspectives, much empirical evidence suggests neither perfect competition nor monopoly is the appropriate setting to analyze tax competition for FDI. In the data, FDI intensity is generally found to be positively correlated with measures of source- and host-country product market concentration. Davies and Lyons (1996, chapter 7), for example, report a correlation coefficient of +0.5 between indices of the "transnationalization" within the EU of large European manufacturers and production concentration across firms at the EU level.[5] This suggests using an imperfectly competitive environment to analyze the competition by national governments for FDI. Consequently, we use formal game-theoretic analysis to develop intuition on how tax/subsidy competition works in international oligopolies and to determine how the social surplus is divided between

[4] In the Haufler and Wooton model, the competition between identical countries for the monopolist is a standard first-price auction. Other analyses of bidding for a monopolist that produce positive subsidies in equilibrium are Black and Hoyt (1989), King *et al.* (1993), Haaparanta (1996), and Menezes (2003).

[5] For additional evidence, see Caves (1996, section 4.1) and UNCTAD (1997, chapter 4).

host countries and MNEs. In our model, two potential host countries compete to attract the FDI of two firms,.which are entirely owned outside of the host countries. By locating a plant in either country, a firm can serve both host countries' product markets. The two host-country governments set their taxes/subsidies independently to maximize national social welfare.

We assume that, *ceteris paribus*, nations prefer local production to imports and this creates the incentive for national governments to compete to attract the FDI. This arises in our model through the existence of trade costs which make servicing a national market cheaper with local production than through imports. These cost differences are passed on to consumers as price savings, so consumers prefer local production to imports. But this is not the only potential benefit that might arise from local production. For example, an MNE may offer a wage premium over workers' outside options, an extreme case of which occurs when inward FDI relieves involuntary unemployment (Haaparanta, 1996; Bjorvatn and Eckel, 2006). Alternatively, the inward FDI may be associated with localized technological spillovers to indigenous firms (Fumagalli, 2003; Olsen and Osmundsen, 2003).

There are two reasons why we have chosen to focus on trade costs. The first is parsimony. We want to build the minimal model that contains both interesting geography and government preferences over firms' locations. Trade costs accomplish both while we would need to place more structure on our model in order to include the alternative sources of welfare gain from inward FDI. Secondly, all these various sources of welfare gain from inward FDI are qualitatively identical in the respect that they all expand with increases in the country's market size. Thus with a larger local market, inward FDI will result in a bigger increase in consumer surplus, more workers being employed by the firm, and (reasonably) a larger number of indigenous firms in other sectors benefitting from (non-rivalrous) spillovers.

Our modelling choices can be motivated by an event such as market integration within Europe. During the debate on the Single Market Initiative (SMI) in the European Union, there were two commonly suggested outcomes of the removal of trade barriers between European member states. The first involved a rationalisation of production, where manufacturers with plants in several European countries would choose to concentrate all their production for the European market in a single plant and, thereby, exploit economies of scale. The second effect concerned the new FDI that might be attracted from outside the EU as a result of the SMI. Given unchanging trade costs of serving EU markets from outside Europe, the lowering of barriers on intra-EU trade might induce non-European firms to establish a plant in Europe to serve the entire market (where, previously, they either served European markets by exports or not at all). Therefore, an interpretation of our model is that it considers the competition to be the single host for FDI within a region following a policy event such as the SMI.

Our central result is presented in the context of a baseline model with identical countries. We show that, subject to the fulfilment of an intuitive condition on the fixed cost of plants, a perfect equilibrium exists where one firm locates in each country and the countries fully capture the firms' profits in taxes.[6] Therefore, the host countries appropriate the entire social surplus generated in the industry in equilibrium. This result for duopoly differs strikingly from that where two identical countries compete in taxes/subsidies for a single firm. In the monopoly case, the equilibrium subsidy equals the countries' (common) valuation of local production over imports, and the winning country is left indifferent towards hosting the plant.

[6] The plant fixed cost acts like the "price" of firms because it limits the extent to which the countries can raise corporate taxes while retaining FDI. Therefore, the condition on plant costs underlying the equilibrium requires that attracting two firms rather than just one is "too expensive" in terms of foregone tax revenue, while one firm is "cheap enough" to be preferred to none.

In our baseline equilibrium, it is clear that the firms will locate in different countries as the existence of trade costs means that co-location would drive down the firms' variable profits down and result in post-tax losses. We then investigate the conditions under which the qualitative features of the equilibrium of our baseline model survive the introduction of differences in the sizes of the countries. We derive a condition on the market-size asymmetry between the two host countries under which production remains internationally dispersed and the countries continue to set corporate taxes to fully extract the firms' profits. If the market-size aymmetry becomes too great, this equilibrium breaks down. When the size difference between the host countries is sufficiently large, the bigger country is able to attract both firms in equilibrium *and* impose a corporate tax, despite the offer of a subsidy by the smaller country. This new equilibrium has similar features to that derived by Haufler and Wooton (1999) for monopoly and a large asymmetry in country size.[7] Due to its superior location advantage (a result of trade costs and a large national market), the larger country is able to tax the firms while retaining their plants. In this equilibrium, the smaller country offers a subsidy equal to its valuation of a single firm, while the tax imposed by the larger country leaves the firms close to indifferent towards relocating.

To the best of our knowledge, Janeba (1998) is the only existing formal analysis of tax/subsidy competition under oligopoly. However, both Janeba's modelling set-up and the resulting incentives are very different from ours. Like us, he considers a two-country, two-firm world. In his model, each country owns one of the firms, and the government policy instrument is an output tax/subsidy, which can be interpreted as a profit tax/subsidy. The firms compete à la Cournot on a third market through costless exports. When firms are constrained to produce in their home countries (as in Brander and Spencer, 1985), both

[7] Ottaviano and van Ypersele (2005) also present a qualitatively identical equilibrium in a model of tax competition between countries of different sizes under large-group monopolistic competition.

governments use output subsidies in equilibrium to make their national firms more aggressive on the product market (profit-shifting). However, when the firms' plants are mobile, tax competition drives the countries' output subsidies down to zero. Key to this result is the assumption of nondiscrimination between domestic and foreign firms. Therefore, starting at the Brander/Spencer-type equilibrium, each government has an incentive to cut its output subsidy under plant mobility, thereby driving its own firm abroad where it will be subsidized by foreign taxpayers. In contrast to our model, the incentives created by Janeba's set-up mean that (in the presence of output subsidies) governments do not wish to attract inward FDI, a characteristic which seems difficult to reconcile with experience. Another important difference is that Janeba's "third market" assumption means that the impact of national market-size asymmetries cannot be assessed.

We set out our model of tax competition to attract a duopoly industry in section 2. The baseline version of the model is solved in section 3, where two identical host countries compete in taxes/subsidies for the plants of two firms. This benchmark analysis yields a symmetric equilibrium where the countries set corporate taxes at the same level, and each country attracts a single firm. In section 4, we address the question of whether this symmetry depends on the assumption of identical host countries by allowing one of the host countries to have a larger national market. We conclude in section 5 by discussing some potential extensions to our analysis and by considering the restrictiveness of some of the specific assumptions we have imposed.

2 Model

We model the tax/subsidy competition between two host countries, A and B, for the plants of two identical firms. The two firms produce a homogeneous good, and county A is $n \geq 1$

times larger than B. The national demand curves are:

$$Q_A = n(\alpha - p_A) \text{ and } Q_B = \alpha - p_B, \tag{1}$$

where p_i is the market price in country i. Parameter α measures the common reservation price, and n is an index of the size advantage of country A.

Our game has three stages and complete but imperfect information:

Stage 1: Governments A and B simultaneously and irreversibly announce their bids, B_A and B_B.

Stage 2: The two firms simultaneously and irreversibly pick locations, choosing between $\{\varnothing, A, B\}$, where $\varnothing$ is the no-entry option.

Stage 3: Firms compete à la Cournot to serve both countries' markets.

We solve the game backwards to isolate its subgame perfect Nash equilibria in pure strategies. In order to limit taxonomy, we shall occasionally invoke the assumption that the firms' pre-tax profits are nonnegative. Our central result on equilibrium existence (Proposition 1) does not require this. To establish equilibrium uniqueness in the case of identical host countries (Proposition 2), we assume that pre-tax profits are nonnegative in equilibrium. In the extension to the case of a large size differential between the countries in section 4.2, we assume that both firms' pre-tax profits are nonnegative for all pairs of location choices.

From the viewpoint of firms, the governments' bids are location-specific fixed costs (corporate taxes are levied on a source basis). For $i \in \{A, B\}$, $B_i > 0$ represents a lump-sum subsidy and $B_i < 0$ a lump-sum tax ($B_i = 0$ is laissez-faire). We assume that the governments cannot discriminate between firms when setting bids.

2.1 Profits of the Firm

In addition to taxes/subsidies, firms face three types of cost, all of which are independent of the location of production. The fixed cost of a plant is F, and we assume that firms establish at most one plant. The marginal production cost is w, and a specific transport cost of τ applies to goods shipped between the two host countries. We further assume that if a firm chooses $\varnothing$, it cannot serve markets A and B from a third country due to prohibitive trade barriers.

If only one of the firms establishes a plant, then the market equilibrium is the monopoly solution. Variable profits per head are:

$$\pi_{L\varnothing} \equiv \frac{1}{4}(\alpha - w)^2, \quad \text{on local sales at marginal cost } w;$$
$$\pi_{F\varnothing} \equiv \frac{1}{4}(\alpha - w - \tau)^2, \quad \text{on export sales at marginal cost } w + \tau.$$

In the presence of trade costs, $\tau > 0$, $\pi_{L\varnothing} > \pi_{F\varnothing}$, meaning that local production is more profitable than serving a market though exports.

If both firms establish plants, then the market equilibrium is given by Cournot duopoly. Variable profits per head depend on both firms' locations:

$$\left.\begin{aligned} \pi_{LF} &\equiv \frac{1}{9}(\alpha - w + \tau)^2, && \text{if firm produces locally and rival produces abroad;} \\ \pi_{LL} &\equiv \frac{1}{9}(\alpha - w)^2, && \text{if both firms produce locally;} \\ \pi_{FF} &\equiv \frac{1}{9}(\alpha - w - \tau)^2, && \text{if both firms produce abroad;} \\ \pi_{FL} &\equiv \frac{1}{9}(\alpha - w - 2\tau)^2, && \text{if firm produces abroad and its rival produces locally.} \end{aligned}\right\} \quad (2)$$

If the firms establish plants in different countries, we assume that trade cross-hauling occurs– that is, the simultaneous export and import of the homogeneous good. This requires that the trade cost be non-prohibitive:

$$0 \leq \tau < \overline{\tau} \equiv \frac{1}{2}(\alpha - w), \quad (3)$$

where $\overline{\tau}$ is the prohibitive transport cost. Condition (3) ensures that every possible Cournot equilibrium is interior. If there are trade costs, then we know from (2) that:

$$\left.\begin{aligned} &\pi_{LF} > \pi_{LL} > \pi_{FF} > \pi_{FL}, \\ &\pi_{LF} + \pi_{FL} > \pi_{LL} + \pi_{FF}. \end{aligned}\right\} \tag{4}$$

A firm's total operating profits, Π_{ij}, are defined as the sum of profits from serving both markets when the firm is located in country i and its competitor is in country j. For a monopolist, $j = \varnothing$ and total profits for the firm are:

$$\begin{aligned} \Pi_{A\varnothing} &\equiv n\pi_{L\varnothing} + \pi_{F\varnothing} - F, \\ \Pi_{B\varnothing} &\equiv \pi_{L\varnothing} + n\pi_{F\varnothing} - F, \end{aligned}$$

where $i = \{A, B\}$ denotes the location of the firm's own plant. If there are trade costs and $n > 1$ then $\Pi_{A\varnothing} > \Pi_{B\varnothing}$. That is, A is the more profitable plant location when it has a larger market and there are trade barriers between the countries. However, if $\tau = 0$, then profits are independent of the location of production.

Under duopoly, the total operating profits of the firm are:

$$\left.\begin{aligned} &\Pi_{AA} \equiv n\pi_{LL} + \pi_{FF} - F, \quad \Pi_{AB} \equiv n\pi_{LF} + \pi_{FL} - F, \\ &\Pi_{BA} \equiv \pi_{LF} + n\pi_{FL} - F, \quad \Pi_{BB} \equiv \pi_{LL} + n\pi_{FF} - F. \end{aligned}\right\} \tag{5}$$

From (4) we can determine that, in the presence of trade costs:

$$\left.\begin{aligned} \Pi_{AB} = \Pi_{BA} > \Pi_{AA} = \Pi_{BB}, &\qquad \text{for } n = 1; \\ \Pi_{AB} > \Pi_{BA}, \quad \Pi_{AA} > \Pi_{BB}, &\qquad \text{for } n > 1; \\ \text{and } \Pi_{AB} > \Pi_{AA}, &\qquad \text{for } n \geq 1. \end{aligned}\right\} \tag{6}$$

There are three elements to (6). Firstly, with equally sized countries, profits are higher when production is geographically dispersed. Second, when A has a larger market than B, regardless of whether production is to be geographically dispersed or concentrated in one country, locating in A is more profitable than setting up in B. Third, a firm located in A benefits if its rival moves production abroad to B whatever the relative sizes of the two countries. However, the same cannot be said of a firm based in B as the ranking of Π_{BA} and Π_{BB} is crucially sensitive to n, a property that will be important for the analysis of section 4.

Firms are assumed to choose their locations independently to maximize profits. Let

$$\Delta_j \equiv \Pi_{Aj} - \Pi_{Bj} \tag{7}$$

be the profit differential arising from locating a plant in A rather than B, when the rival firm locates in country j. We call this country A's "geographic advantage" though, as Δ_j may be negative, being in A may not always be the more advantageous location.

We can determine a firm's best response to the location choice of the other firm. In response to its rival's choice of $j \in \{A, B, \varnothing\}$, a firm has the following locational preferences:

$$\left.\begin{array}{lll} A \succ \varnothing & \text{if and only if} & B_A > -\Pi_{Aj}; \\ B \succ \varnothing & \text{if and only if} & B_B > -\Pi_{Bj}; \\ A \succ B & \text{if and only if} & B_A > B_B - \Delta_j. \end{array}\right\} \tag{8}$$

If country B adopts a *laissez-faire* stance (that is, $B_B = 0$) then, for a given location choice of j by firm 1, Δ_j is the largest tax that country A can levy if it is to attract firm 2. From (4) and (5), we know that $\Delta_B > \Delta_A$. That is, the largest tax that A can levy while retaining firm 2 is higher if firm 1 is located in B rather than in A. This occurs because firm 2 makes higher profits in A if production is internationally dispersed. For all j, Δ_j is increasing in n because locating in A becomes more attractive as its market grows.

2.2 Welfare and Governments

The benefits of local production to a country's citizens are realised in the lower prices set for domestically produced goods compared to those for imports, the latter being subject to trade costs. With free trade, consumers are indifferent as to the location of production.

We now determine the levels of consumer surplus that arise depending on the locations of the firm or firms. When there is a single firm in the market, the consumer surplus per head is

$$S_{L\varnothing} \equiv \frac{1}{8}(\alpha - w)^2, \quad \text{if the monopolist produces locally; while}$$
$$S_{F\varnothing} \equiv \frac{1}{8}(\alpha - w - \tau)^2, \quad \text{if the monopolist produces abroad.}$$

Clearly, with trade costs, local production is better as $S_{L\varnothing} > S_{F\varnothing}$, creating an incentive to attempt to attract the FDI.

When there are two firms, the locational configurations of production become more complex. Consumer surplus per head under Cournot duopoly is:

$$S_{LL} \equiv \frac{2}{9}(\alpha - w)^2, \quad \text{if both firms produce locally;}$$
$$S_{LF} \equiv S_{FL} \equiv \frac{1}{18}(2\alpha - 2w - \tau)^2, \quad \text{if one firm is local, other produces abroad;}$$
$$S_{FF} \equiv \frac{2}{9}(\alpha - w - \tau)^2, \quad \text{if both firms produce abroad.}$$

Clearly,

$$S_{LL} > S_{LF} \equiv S_{FL} > S_{FF},$$

the more firms in local production, the better.

We assume that goverments A and B are benevolent, both being motivated by national social welfare, and that they set their taxes/subsidies, B_A and B_B, independently. National social welfare is defined as total consumer surplus minus total subsidy payments (or plus tax revenues).[8] The governments must balance their budgets, only being able to redistribute income in a lump-sum manner between their citizens and the foreign MNEs. The MNEs are assumed to be wholly owned outside of countries A and B, so their post-tax profits do not contribute to social welfare in the host countries.[9]

[8] This definition and the national demand functions in (1) are consistent with quasi-linear preferences.

[9] Ferrett and Wooton (2006) examine how changing the international distribution of a monopoly firm's ownership affects the outcome of the tax/subsidy competition for its FDI.

3 Baseline Case: Identical Host Countries

In this section we analyze equilibrium bids and firm locations in the case where countries A and B are of equal size, $n = 1$. This symmetrical case is used to demonstrate our central result.

[FIGURE 1 HERE]

Figure 1 uses (8) to plot the firms' equilibrium locations as functions of the countries' bids, B_A and B_B, when the countries are of equal size.[10] Inter-regional boundaries are drawn in the bid space, and the firms' equilibrium response to an offer of (B_B, B_A) is indicated by $[i, j]$ where $i, j \in \{A, B, \varnothing\}$. As the countries are the same size, these inter-regional boundaries are symmetric around the $B_A = B_B$ line. Qualitatively, these boundaries are robust to changes in the transport and plant costs, τ and F, respectively. Reducing τ cuts $\Delta_B = -\Delta_A$, the profit advantage to locating abroad from the rival firm, because the firms' profits vary less with their plant locations. With free trade ($\tau = 0$), the $[A, B]$ region collapses into the line $B_A = B_B$. Changing F alters all of the Π_{ij} terms and shifts the inter-regional boundaries. However, their relative positions do not move.

Point E in Figure 1 is just above and to the right of $(-\Pi_{BA}, -\Pi_{AB})$ such that the taxes being levied on the firms are an amount ε less than these values. At E, the firms locate in different countries and (almost) all of their profits are captured in tax by the host countries. We shall call E the point of "full profit extraction" and it is our candidate for the bidding equilibrium. Suppose that firm 1 locates in A. Given that $B_A = B_B = -\Pi_{AB} + \varepsilon$ at E, it is clear that firm 2's optimal location is B. As $\varepsilon > 0$, the firm is (just) profitable in B, so it will enter. Were it to choose A, competition with its co-located rival would drive down its

[10] Details of the derivation of the plots of location equilibria in Figures 1-3 are given in Ferrett and Wooton (2005). Note that all three figures are drawn for the case of nonnegative pre-tax profits in all location pairs.

earnings, making production unprofitable after taxes.

We now derive conditions for the full–profit-extraction point E to be a bidding equilibrium. As the countries are assumed to be the same size, the model is symmetric. Therefore we focus on country A's choice of B_A given that $B_B = -\Pi_{BA}$. By varying B_A, there are three distinct location equilibria that A can induce: $[A, A]$, $[A, B]$, and $[B, \varnothing]$. For any given location equilibrium where it attracts at least one firm, A's optimal B_A will be as low as possible. Consumer surplus is determined solely by the location of the firms and is unaffected by B_A and therefore the government will want to set the lowest subsidy (or highest tax), conditional on B_A inducing the desired location outcome. Therefore, A will never deviate from E to another point in $[A, B]$, and if it deviates to $[A, A]$, it will optimally set $B_A = -\Pi_{AA} + \varepsilon$.

In order to rule out tax-cutting from point E, we need A's social welfare at E to be at least as great as that just inside $[A, A]$, which means that:

$$S_{LF} + \Pi_{AB} \geq S_{LL} + 2\Pi_{AA}. \tag{9}$$

Expanding the profit terms, and rearranging, yields a lower limit on a firm's fixed costs such that $F \geq \underline{F}$, where

$$\underline{F} \equiv S_{LL} - S_{LF} + 2\left(\pi_{LL} + \pi_{FF}\right) - \left(\pi_{LF} + \pi_{FL}\right). \tag{10}$$

The easiest way to think of country A's bidding incentives, when B_A is set to fully extract profits, is that A reimburses the fixed plant costs F of the firms it attracts and then completely taxes away their variable profits. Therefore, F acts like the "price" of a firm. (10) requires that F exceed the marginal benefit to A of a second firm, which is the gain in consumer surplus plus the rise in taxable variable profts resulting from having both firms.

We must also rule out tax-raising by government A. This requires that A's social welfare at E be at least as great as that in $[B, \varnothing]$:

$$S_{LF} + \Pi_{AB} \geq S_{F\varnothing}. \tag{11}$$

This corresponds to determining an upper limit on fixed costs such that $F \leq \overline{F}$, where

$$\overline{F} \equiv S_{LF} - S_{F\varnothing} + (\pi_{LF} + \pi_{FL}). \tag{12}$$

By raising its tax from point E, country A induces a location equilibrium of $[B, \varnothing]$, that is, it drives the local firm out of the industry altogether. To preclude this, we require that the firm "price" F lie below the marginal benefit of the first firm, given in (12). Lemma 1 compares $\underline{F}$ and $\overline{F}$.

Lemma 1: For all nonprohibitive τ, $\overline{F} > \underline{F}$.

Proof: Straightforward algebraic comparison of $\underline{F}$ and $\overline{F}$, expanded in terms of (α, w, τ).

This establishes our main result in this section:

Proposition 1 (Full Profit Extraction): With equally-sized host countries, all non-prohibitive transport costs are consistent with the existence of a perfect equilibrium in our tax competition game that is characterized by internationally dispersed production and corporate taxes that fully extract profits.

We have shown that for any $\tau \in [0, \overline{\tau}]$ it is possible to set F so that point E in Figure 1 is a perfect equilibrium. The fact that the equilibrium at E involves full profit extraction is particularly striking. By way of contrast, consider the tax/subsidy competition between two equally-sized countries for a monopoly firm's plant (Haufler and Wooton, 1999). Because the host countries are identical, the monopolist will locate its plant in the country that offers the higher bid. Therefore, in equilibrium, the countries' bids will be driven up to their common valuation of local production over imports, $S_{L\varnothing} - S_{F\varnothing}$.[11] This monopoly case is probably the simplest possible example of the "race to the bottom": tax competition causes subsidy inflation that leaves the winning country indifferent between hosting the monopolist's plant and not. Compared to monopoly, equilibrium corporate taxes could not be more different under duopoly. In equilibrium at point E, the firms are indifferent between entering the industry and staying out, and corporate taxes "race to the top" to capture all the firms' profits.

For the remainder of this section, we invoke the assumption $\Pi_{AB} = \Pi_{BA} \geq 0$. That is, we assume that the plant cost F is sufficiently small to make pre-tax profits at E non-negative, so the equilibrium B_A and B_B represent corporate *taxes*. In addition to being a useful limit on taxonomy, this assumption allows us to focus on arguably the most empirically relevant cases because, in practice, net corporate taxes are generally positive (Devereux *et al.*, 2002). The assumption of non-negative pre-tax profits at E has two consequences. Note that $\Pi_{AB} \geq 0$ is equivalent to $F \leq \pi_{LF} + \pi_{FL}$. This is a tighter restriction than $F \leq \overline{F}$ in (12), and consequently Proposition 1 must be qualified. An interval of F-values exists that satisfies and therefore supports an equilibrium at E with nonnegative pre-tax profits if and only if $\tau \in \left[\frac{4}{17}(\alpha - w), \frac{1}{2}(\alpha - w)\right]$. Second, and more importantly, the assumption $\Pi_{AB} \geq 0$ permits a simple proof of equilibrium uniqueness.

Proposition 2: If pre-tax profits under internationally dispersed production with equally-sized host countries are nonnegative, then the full-profit-extraction perfect equilibrium described in Proposition 1 is unique.

Proof: We split Figure 1 into two parts.

[11] This is a standard first-price auction.

(i) $B_A, B_B \leq -\Pi_{AA}$. Here, there are four location equilibria: $[\varnothing, \varnothing]$, $[A, \varnothing]$, $[B, \varnothing]$ and $[A, B]$. Country A could profitably deviate from any candidate equilibrium point in $[\varnothing, \varnothing]$ or $[B, \varnothing]$ by setting $B_A = -\Pi_{AB} + \varepsilon$ and this would increase both A's consumer surplus and A's tax revenue. Similarly, country B could profitably deviate from any point in $[\varnothing, \varnothing]$ or $[A, \varnothing]$ by setting $B_B = -\Pi_{BA} + \varepsilon$. Finally, note that point E is the only possible bidding equilibrium in $[A, B]$ because, at all other points, at least one country can profitably deviate by increasing its tax without affecting the firms' locations.

(ii) $B_A > -\Pi_{AA}$ or $B_B > -\Pi_{BB}$. Here, the problem of isolating bidding equilibria is identical to that tackled in section 4.2 below, where we show that no bidding equilibrium exists in this part of the bid space for $n = 1$.

4 Market Size Asymmetries

The perfect equilibrium derived in the previous section for the case of identical host countries was both qualitatively and quantitatively symmetric. Not only did both countries attract a single firm and levy taxes to fully extract profits, but the equilibrium corporate taxes were quantatively the same in both countries. In this section, we let country A be $n > 1$ times larger than B. While we would expect this asymmetry from differences in country size to result in international differences in equilibrium tax levels, we wish to investigate whether full profit extraction can remain a characteristic of the equilibrium despite the size differential between countries.[12]

[12] We conjecture that the alternative generalization that allows country A to offer a lower marginal production cost than B will produce qualitatively identical results to the case of the market-size asymmetry that we examine. Under asymmetries in both market size and marginal cost, country A will value local production, as opposed to imports, more highly than B, and firms will also tend, independently of taxes/subsidies, to be drawn towards country A.

4.1 Small Country-Size Difference

We begin with the following definition, which will be useful in grouping together qualitatively identical cases:

Definition: We say that the country-size asymmetry n is "small" if and only if $\Pi_{BA} \geq \Pi_{BB}$; otherwise, n is "large."

Formally, the cut-off between small and large n occurs at

$$n = \overline{n} \equiv \frac{\pi_{LF} - \pi_{LL}}{\pi_{FF} - \pi_{FL}} \equiv \frac{2(\alpha - w) + \tau}{2(\alpha - w) - 3\tau} \tag{13}$$

At $\tau = 0$, $\overline{n} = 1$. $\overline{n}$ is increasing in τ and realises a maximum value of 5 when $\tau = \overline{\tau}$ in (3), in which case the trade barrier is prohibitive. The distinction between small and large n has an important consequence for the firms' equilibrium locations in the case where, in anticipation of internationally dispersed production, the host countries set their taxes to fully extract profits:

Lemma 2: If $(B_A, B_B) = (-\Pi_{AB}, -\Pi_{BA})$, then the firms' equilibrium locations are $[A, B]$ for small n but $[B, B]$ for large n.

Proof: Use BR_j to denote a firm's optimal location ("best response") if its rival chooses j. With $(B_A, B_B) = (-\Pi_{AB}, -\Pi_{BA})$, it is straightforward to verify using (8) that: for small n, $\{BR_A = B, BR_B = A, BR_\varnothing = B\}$, which gives a location equilibrium of $[A, B]$; and for large n, $\{BR_A = BR_B = BR_\varnothing = B\}$, which gives a location equilibrium in dominant strategies of $[B, B]$.

It is immediately clear from Lemma 2 that the perfect equilibrium derived in the previous section for $n = 1$ can only generalize to small n. Before we proceed to catalogue the perfect equilibria in our tax-competition game when $n > 1$, it is instructive to consider why full profit extraction can only occur when the size difference between the countries is not large.

Assume that, in anticipation of internationally dispersed production, the host countries set taxes to fully extract profits, as in the previous section. If the firms do indeed locate in different countries, they will earn zero post-tax profits. Now consider the effect on the pre-tax profits of a firm in B (the "B-incumbent") of its rival relocating from A to B. The B-incumbent's profits in its local market will fall as competition intensifies, but its profits on exports to the larger A market will rise. If the size difference between A and B is sufficiently large, the latter effect will outweigh the former. Consequently, the B-incumbent's total pre-tax profits would rise when its rival jumps from A to B, resulting in *both* firms earning strictly positive post-tax profits (given that the countries' corporate taxes are fixed). This explains why, given $(B_A, B_B) = (-\Pi_{AB}, -\Pi_{BA})$, $[A, B]$ ceases to be a location equilibrium when n is large. Its viability is destroyed by the strong incentive for relocation that is offered by a low corporate tax in B.

The preceding discussion makes it clear that we can only hope to generalize the perfect equilibrium under identical host countries to the case of small n. We now search explicitly for equilibria in that case. Figure 2 plots the firms' equilibrium locations in bid space for small n.[13] Figure 2 is qualitatively identical to Figure 1, although when $n > 1$ the plot of equilibrium locations is no longer symmetric around the line $B_A = B_B$. Specifically, $n > 1$ makes country A a more attractive plant location and therefore, as n rises, the inter-regional boundaries from Figure 1 shift south-east, which enlarges the $[A, A]$ area but shrinks $[B, B]$.

[13] The mechanics of constructing Figure 2 are described at length in Ferrett and Wooton (2005). One point to note is that in the shaded triangle immediately to the left of E there exists no location equilibrium in pure strategies if the firms locate simultaneously. However, if the firms moved sequentially in stage 2, the location equilibrium in the triangle would be $[A, \varnothing]$, with the leader choosing A. Moreover, all of the location equilibria under simultaneous moves would be preserved under sequential moves (with the leader choosing the more profitable location).

[FIGURE 2 HERE]

We begin by investigating the conditions for the existence of a perfect equilibrium at point E in Figure 2. Because the countries are no longer identical, we now have two conditions to rule out tax cutting, both of which are analogous to (10). Country A prefers point E to $(-\Pi_{BA}, -\Pi_{AA}+\varepsilon)$ just inside $[A, A]$ if and only if

$$nS_{LF} + \Pi_{AB} \geq nS_{LL} + 2\Pi_{AA}. \tag{14}$$

Expanding the profit terms, and rearranging, yields a lower limit on a firm's fixed costs such that $F \geq \underline{F_A}$, where

$$\underline{F_A} \equiv n(S_{LL} - S_{LF}) + 2\left(n\pi_{LL} + \pi_{FF}\right) - (n\pi_{LF} + \pi_{FL}). \tag{15}$$

Similarly, country B prefers point E to $(-\Pi_{BB}+\varepsilon, -\Pi_{AB})$ if and only if

$$S_{LF} + \Pi_{BA} \geq S_{LL} + 2\Pi_{BB}. \tag{16}$$

Expanding the profit terms, and rearranging, yields a lower limit on a firm's fixed costs such that $F \geq \underline{F_B}$, where

$$\underline{F_B} \equiv S_{LL} - S_{LF} + 2\left(\pi_{LL} + n\pi_{FF}\right) - (\pi_{LF} + n\pi_{FL}). \tag{17}$$

By analogy with (12), there are also two conditions to rule out tax-increasing deviations from point E in Figure 2:

$$F \leq \overline{F_A} \equiv n\left(S_{LF} - S_{F\varnothing}\right) + \left(n\pi_{LF} + \pi_{FL}\right), \tag{18}$$

for country A; and

$$F \leq \overline{F_B} \equiv S_{LF} - S_{F\varnothing} + \left(\pi_{LF} + n\pi_{FL}\right). \tag{19}$$

for country B. Lemma 3 compares the four critical levels of F derived above.

Lemma 3: For all $n \in (1, \overline{n}]$: (i) both $\underline{F_A} > \underline{F_B}$ and $\overline{F_A} > \overline{F_B}$; and (ii) $\overline{F_B} > \underline{F_A}$.

Proof: Straightforward algebraic comparison of the $\underline{F}$ and $\overline{F}$ terms, expanded in terms of (α, w, τ).

It follows immediately from Lemma 3 that Proposition 1, on the existence of perfect equilibrium, generalizes to all small n. For the remainder of this section, we again invoke the assumption that $\Pi_{AB} > \Pi_{BA} \geq 0$, in other words, pre-tax profits at the equilibrium point E are not negative. Clearly, the requirement that $\Pi_{BA} \geq 0$ is more demanding than $F \leq \overline{F_B}$, so we need to establish when $\pi_{LF} + n\pi_{FL} \geq \underline{F_A}$. That is, we need to determine whether there are values of F that support a full-profit-extraction equilibrium at E with nonnegative pre-tax profits. This occurs if and only if

$$n \leq n^* \equiv \frac{4(\alpha - w) + 6\tau}{8(\alpha - w) - 11\tau} \tag{20}$$

where $n^* > 1$ if and only if $\tau > \frac{4}{17}(\alpha - w)$. Therefore, for trade costs $\tau \in \left[\frac{4}{17}(\alpha - w), \frac{1}{2}(\alpha - w)\right]$ and fixed costs $F \in \left[\underline{F_A}, \pi_{LF} + n\pi_{FL}\right]$, a perfect equilibrium with nonnegative pre-tax profits exists at the full-profit-extraction point E for all $n \in [1, n^*]$.

It is instructive to compare the critical value n^* above with $\overline{n}$, our smallness criterion (13). For all parameter values, $n^* < \overline{n}$. Therefore, there is always a range of values of n where the country size differential is still small yet is big enough that the full-profit-extraction point E cannot be an equilibrium if pre-tax profits are non-negative. Of course, with non-negative pre-tax profits, $n^* < \overline{n}$ is not surprising. When n is very close to $\overline{n}$ (that is, Π_{BB} and Π_{BA} are almost the same), country B can attract both firms with only a very small cut in its tax from its level at E, thereby approximately doubling its tax revenue.

Finally, we note that it is straightforward, under the assumption of non-negative pre-tax profits at the equilibrium, to extend Proposition 2 to all small n. Proposition 3 sums up the results of this section.

Proposition 3: The existence and uniqueness results given in Propositions 1 and 2 for the case of identical host countries generalize to cases where there is a small difference in the sizes of the host countries.

4.2 Large Country-size Difference

We turn now to the examination of bidding equilibria when the country-size asymmetry is "large," $n > \overline{n}$ in (13). The discussion following Lemma 2 above showed why a perfect equilibrium with internationally dispersed production and full profit extraction cannot exist if n is large. If n is large then locating in the larger market becomes more of an imperative for both firms despite the more intense competition that would result. We would expect country A to be host to at least one of the firms. The question is whether the size differential is now sufficiently great to result in both firms being persuaded to invest in the larger country.

In this section, we shall assume that the firms' pre-tax profits are non-negative for all location pairs. While this assumption is not needed to prove the existence of the perfect equilibrium described in Proposition 4 below, it does simplify the argument for its uniqueness (which is developed from Lemma 4). Moreover, the assumption of non-negative pre-tax profits becomes, *ceteris paribus*, less restrictive as n rises because the firms' variable profits are increasing in n.

[FIGURE 3 HERE]

The firms' equilibrium locations for large n are plotted in Figure 3. We concentrate our search for bidding equilibria outside the region where the best response to a location of A is $\varnothing$. Thus we exclude bid pairs with $B_A \leq -\Pi_{AA}$ and $B_B \leq -\Pi_{BA}$, because no bidding equilibria exist there. If $B_A \leq -\Pi_{AA}$ and $B_B \leq -\Pi_{BA}$, then there are four possible location equilibria: $[\varnothing, \varnothing]$, $[A, \varnothing]$, $[B, \varnothing]$, and $[B, B]$.[14] Lemma 4 rules out perfect equilibria in this

[14] The precise plot of location equilibria in this area of bid space depends on the level of τ relative to

area:

Lemma 4: If $\Pi_{AA}, \Pi_{BA} \geq 0$ and n is large, then no perfect equilibrium exists in our tax competition game with $B_A \leq -\Pi_{AA}$ and $B_B \leq -\Pi_{BA}$.

Proof: With $B_A \leq -\Pi_{AA}$ and $B_B \leq -\Pi_{BA}$ and large n, the four potential location equilibria are $[\varnothing, \varnothing]$, $[A, \varnothing]$, $[B, \varnothing]$ and $[B, B]$. Because $\Pi_{AA} \geq 0$, no bidding equilibria are possible with locations $[\varnothing, \varnothing]$, $[B, \varnothing]$ or $[B, B]$ because country A could profitably deviate to just inside the $[A, A]$ region with $B_A = -\Pi_{AA} + \varepsilon$ and thereby increase both tax revenue and consumer surplus. Similarly, no bidding equilibrium is possible with locations $[A, \varnothing]$ because country B could profitably deviate to just inside the $[A, B]$ or $[B, B]$ regions with $B_B = -\Pi_{BA} + \varepsilon$.

Lemma 4 usefully narrows down the scope of our search for perfect equilibria with large n by confirming our initial intuition that, in any perfect equilibrium, both firms will enter the industry. In Figure 3, the only remaining location equilibria are $[A, A]$, $[A, B]$ and $[B, B]$.

We now determine country A's best bidding responses for large n. For a bid from country B of $B_B \geq -\Pi_{BA}$, country A will be choosing between three location pairs, $[A, A]$, $[A, B]$ and $[B, B]$. Consider the lowest bids that country A would have to offer to achieve the investment that it wants. Of all the offers that would induce the firms to choose $[A, A]$, country A strictly prefers setting $B_A = B_B - \Delta_A + \varepsilon$. This maximizes the revenue from its two-firm tax base. Likewise, amongst the offers that would result in the firms choosing $[A, B]$, country A strictly prefers setting $B_A = B_B - \Delta_B + \varepsilon$. This maximizes the tax revenue from the one firm that A attracts. Because it collects no tax revenue under $[B, B]$, country A is indifferent between all B_A that attract no firms.

$(\alpha - w)$. We do not give the plots here for reasons of space, but they are available from the authors on request. Note, however, that the proof of Lemma 4 places no restrictions on these plots.

The value to country A of attracting a single firm, given that the second firm chooses B, is

$$V_A^1 \equiv n\,(S_{LF} - S_{FF}) \tag{21}$$

which measures the increase in country A's consumer surplus if either of the two firms jumps from B to A. In other words, this is A's valuation of $[A, B]$ over $[B, B]$. The smallest "price" A would have to pay in order to tempt one of the firms away from B is $B_A = B_B - \Delta_B + \varepsilon$. This is strictly less than B_B because of the geographic advantages that A's market offers: arising both from having a larger local market than B and from the relaxation of the intense competition that occurs when the firms co-locate. Country A will optimally bid one firm away from B if and only if its valuation exceeds the price. We can express this in terms of $\overline{B_B}$, the maximum bid that country B could make that still makes it just worthwhile for A to attempt to grab one firm:

$$B_B \leq \overline{B_B} \equiv V_A^1 + \Delta_B.$$

The value to country A of attracting both firms away from B, rather than a single firm, is A's valuation of $[A, A]$ over $[A, B]$:

$$V_A^2 \equiv n\,(S_{LL} - S_{LF}) - (\Delta_B - \Delta_A)\,. \tag{22}$$

The first term of (22) is the increase in A's consumer surplus. The second term $(\Delta_B - \Delta_A) > 0$ is the extra bid payment A must make (or taxes that it must forego) in order to retain the firm under $[A, B]$.[15] The price A must pay to attract the second firm away from B is $B_A = B_B - \Delta_A + \varepsilon$. Country A will optimally bid the second firm away from B if and only if its valuation exceeds the price. Writing this in terms of $\underline{B_B}$, the maximum bid that B could

[15] The presence of the term in $(\Delta_B - \Delta_A)$ in V_A^2 follows from our assumption that the countries cannot, in setting their bids, discriminate between the firms. If A bids more to attract an additional firm, its bid payment to the firm already hosted must rise by the same amount (the countries are "oligopsonists" in the market for firms).

make that still makes A attempt to get the second firm, yields:

$$B_B \leq \underline{B_B} \equiv V_A^2 + \Delta_A.$$

The critical values V_A^1, V_A^2 and associated bids $\overline{B_B}$, $\underline{B_B}$ are shown in Figure 3, where R_A is country A's best response function. It is straightforward to show that $V_A^1 > V_A^2$ (that is, the marginal benefit of having the first local firm is greater than that arising from capturing the second) and $\overline{B_B} > \underline{B_B} > 0$. Therefore, for $B_B \in \left[-\Pi_{BA}, \underline{B_B}\right]$, A's best response is to induce $[A, A]$. In response to $B_B \in \left[\underline{B_B}, \overline{B_B}\right]$, A should induce $[A, B]$. Finally for $B_B \geq \overline{B_B}$, A optimally bids V_A^1, inducing $[B, B]$.[16]

Repeating the preceding analysis for country B results in R_B, B's best response function, which is qualitatively identical to R_A. By analogy with the four critical values derived above, we get

$$\begin{aligned} V_B^1 &\equiv (S_{LF} - S_{FF}), \\ \overline{B_A} &\equiv V_B^1 - \Delta_A, \\ V_B^2 &\equiv (S_{LL} - S_{LF}) - (\Delta_B - \Delta_A), \text{ and} \\ \underline{B_A} &\equiv V_B^2 - \Delta_B. \end{aligned}$$

In particular, note that $V_A^1 > V_B^1$ and $V_A^2 > V_B^2$; that is, the larger country has a higher valuation of both a first and a second firm. The *sole* reason for this is that (for a given number of firms already hosted) A gains more in aggregate consumer surplus by attracting an additional firm than does B. For a given bid posted by the other country, the prices to B of one or two firms are both higher than those faced by A, because country A has the advantage of being able to offer the firms a larger local market. However, the premium that

[16] Although country A's social welfare is the same for all B_A that induce $[B, B]$, an assumption that countries never post weakly dominated bids rules out all $B_A > V_A^1$ in response to $B_B > \overline{B_B}$.

must be paid to attract both firms rather than just one is the same for both countries and equal to $(\Delta_B - \Delta_A)$.

A bidding equilibrium exists at point E in Figure 3 if and only if $V_A^2 \geq \overline{B_A}$ (or, equivalently, $\underline{B_B} \geq V_B^1$). In this equilibrium, country A attracts both firms, country B offers a subsidy equal to V_B^1, and country A trumps this with a tax just less than $-\overline{B_A}$. Note that $\overline{B_A} > -\Pi_{AA}$, so not all of the firms' profits are captured in tax in this equilibrium. The existence condition $V_A^2 \geq \overline{B_A}$ holds if and only if

$$n \geq n^{**} \equiv \frac{12\,(\alpha - w) + 5\tau}{12\,(\alpha - w) - 17\tau}. \tag{23}$$

This existence condition holds for all large n as, if we compare the definition of $\overline{n}$ in (13) with that of n^{**} in (23), it is clear that $\overline{n} > n^{**}$. Moreover, the equilibrium at point E is unique. From Lemma 4, no bidding equilibrium can exist in Figure 3 where $B_A \leq -\Pi_{AA}$ and $B_B \leq -\Pi_{BA}$. Thus the equilibrium at E is unique if and only if $V_A^1 > \underline{B_A}$ (or, equivalently, $\overline{B_B} > V_B^2$), which holds for all $\tau > 0$ and $n \geq 1$. Finally, we note that for all non-prohibitive τ, we can show that $n^{**} > n^*$ and so in the interval $n \in (n^*, n^{**})$ no pure-strategy bidding equilibrium exists.

Proposition 4 sums up the results of this section.

Proposition 4: If the size asymmetry between the host countries is large and both firms' pre-tax profits are non-negative in all location configurations then, in the unique perfect equilibrium of our tax competition game: (*i*) the firms co-locate in the larger country; and (*ii*) equilibrium post-tax profits are strictly positive.

In summary, when n is large enough, the equilibrium of the international competition is characterized by both firms being attracted to the larger country, where their investments are taxed despite the offer of a subsidy from the smaller country.

5 Conclusion

Our central result concerns the outcome of the competition between two identical countries to attract the investment of two identical firms. We show that a perfect equilibrium exists where production is internationally dispersed and all the firms' profits are captured in tax by the host countries. This "race to the top" in corporate taxes contrasts strikingly with the "race to the bottom" that would be observed in the competition between two identical countries for a monopoly firm's plant. Thus the outcome of tax competition for FDI under oligopoly is qualitatively different to that in the polar cases of perfect competition and monopoly.

We then investigated the robustness of this central result to changes in the relative sizes of the competing countries. Under the assumption of non-negative pre-tax profits at equilibrium, we showed that, for a sufficiently small degree of size asymmetry between the countries, the unique perfect equilibrium is qualitatively identical to that in our central result with production dispersed and profits being fully extracted by taxes. For a larger degree of size asymmetry, however, there is a unique equilibrium where both firms locate in the larger country and earn strictly positive post-tax profits.

Our interest lies in the outcomes of tax/subsidy competition in situations where both firms and host countries care about production locations. Transport costs are an especially simple way of creating such an environment, as consumers would rather have (cheaper) locally produced goods than imports, while these trade costs also mean that a firm cares about its own location and that of its rival. However, our results are not limited to the particular specification of the model that we have used. For example, government concerns about the location of MNEs' plants often appear primarily driven by the relief of involuntary unemployment and the promotion of technology spillovers to indigenous firms. We argue that these wider governmental motivations are qualitatively identical to those of our driving force of increasing consumer surplus. However, in order to introduce explicitly these additional host-country incentives, we would need to impose additional structural assumptions. These would unnecessarily complicate the analysis without altering the qualitative results. Essentially, the simple expedient of trade costs allows us to build the minimal model of tax/subsidy competition where location matters to both firms and host countries.

We have imposed linearity assumptions on the cost and demand functions, and this makes it straightforward for us to derive closed-form solutions. However, we believe that our qualitative results would survive with more general (but well-behaved) functional forms given that linearity is not a necessary part of our intuitive explanation. For example, it is the geographic structure of our model, specifically the existence of transport costs, that underlies our central result on the existence of equilibrium with internationally dispersed production and full profit extraction. It is because firm co-location intensifies competition and competes profits down (in the case of sufficiently similar country sizes) that the firms optimally locate in different countries in our baseline equilibrium. Furthermore, for any cost/demand functions, the two critical levels of the plant fixed cost F between which our baseline equilibrium exists will continue to be given by conditions (10) and (12). Different functional forms would merely alter specific the expressions for conumer surplus and per-capita profits.

A further set of possible extensions centres around altering the policy instruments available to the host countries. The assumptions we make of lump-sum taxes/subsidies, balanced government budgets, and non-discrimination between the two firms are very simple and facilitate a clear analysis. In practice, of course, governments have a much richer menu of policy instruments and options available, and therefore more degrees of freedom than the governments in our model. However, an interpretation of our central result that we favour is that it demonstrates that governments do not need a large policy space in order to appropriate the entire social surplus generated in a mobile industry. Moreover, we conjecture (following Haufler and Wooton, 1999) that our result would survive if proportional profits taxes were substituted for the lump-sum taxes we have used.[17]

Our central result takes the market-power inefficiency caused by Cournot duopoly for granted. We could allow the governments to partially address this inefficiency by using a production or consumption subsidy to eliminate some of the deadweight loss of oligopoly. However, we anticipate that our central result would remain intact under such an extension because the key requirement, that firm co-location cuts profits relative to dispersed production, would survive.

We have restricted the firms in our model to building at most one plant, ruling out the possibility of a firm establishing a plant in each country. This is in line with much of the existing literature, and it usefully simplifies the firms' strategy spaces. In the perfect equilibrium described in our central result, it is clear that neither firm would find it profitable to establish a second plant in its rival's location, as doing so would compete profits down to below the tax level. Of course, this does not preclude the possibility that, in response to corporate taxes at the full-profit-extraction levels described in Proposition 1, one firm might enter the region with two plants and thereby pre-empt entry by the second firm. However, from the perspective of the host countries, it is clearly better that two competing single-plant firms locate in the region than a single monopolist with plants in each country. Even if corporate taxes fully capture firm profits, the social surplus is clearly higher when the two plants are run independently (duopoly) than under a monopoly MNE. Given this, it is reasonable to expect governments to encourage rivalry by making entry relatively easier for a potential competitor than for an existing firm. Such a presumption implicitly underlies

[17] For example, a perfect equilibrium with internationally dispersed production and a corporate tax rate of 100 per cent on positive profits clearly exists if the plant cost F is such that pre-tax profits are strictly positive with dispersed production but strictly negative under co-location.

our assumptions on the location options available to firms. Furthermore, the one-plant assumption relates well to our motivation in terms of European integration, which was set out in the Introduction.

A final set of extensions might allow for more host countries and/or firms. It seems clear that the logic of our arguments and, by extension, our qualitative results should readily generalize to many other specifications with oligopoly in the product markets. With g countries of "similar" sizes and h firms ($h \geq g$ and h/g an integer), we anticipate the possibility of constructing a full-profit-extraction bidding equilibrium where each country hosts h/g firms. In this case, the tradeoffs facing each country would be the same as those in our baseline model with identical countries. Under full profit extraction, the government effectively reimburses firms' plant investment costs and then taxes away of all their variable profits. Therefore, a bidding equilibrium with full profit extraction requires that the plant cost be neither so low that attracting additional inward FDI is affordable nor so large that increasing corporate taxes and driving firms away is worthwhile. We also conjecture that the analysis of the large size-asymmetry case is generalizable to more than two firms (but sticking with two host countries). It should always be possible to find a sufficiently large size difference such that the larger country attracts all the firms, the smaller country bids its valuation for one firm, and the larger country's bid just trumps its rival's bid. We would expect the minimum size asymmetry necessary for the existence of such a bidding equilibrium to be increasing in the number of firms. Formalizing some of these extensions is a task for the future.

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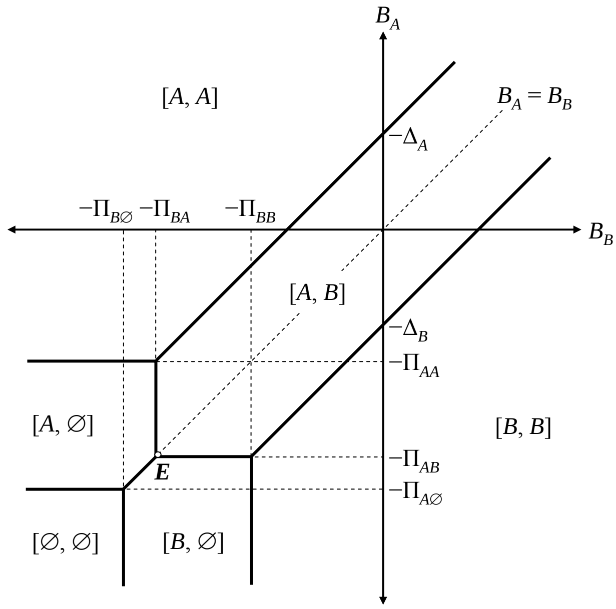

Figure 1. Equilibrium locations with equally sized countries

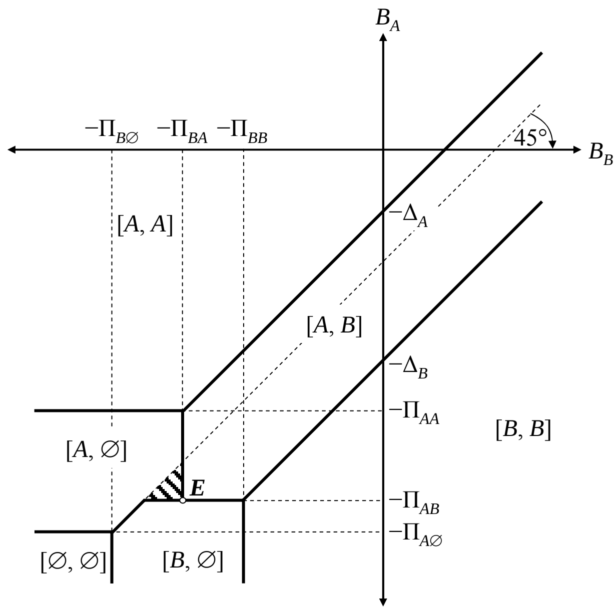

Figure 2. Equilibrium locations with a small country-size asymmetry

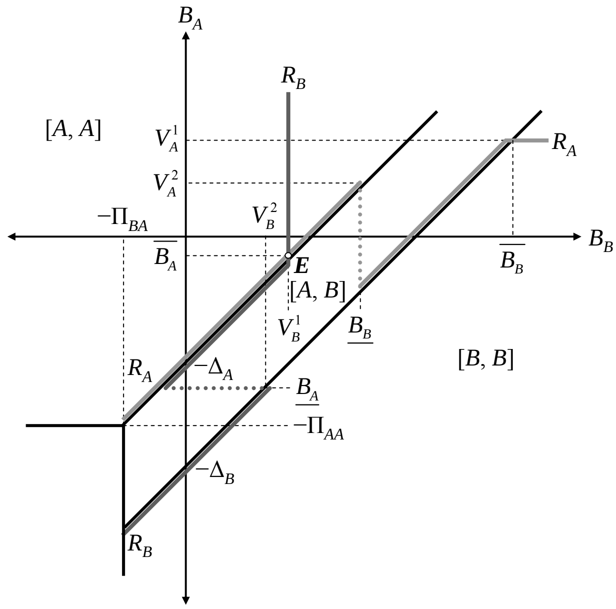

Figure 3. Equilibrium locations with a large country-size asymmetry