Intra-regional Competition for FDI amongst Heterogeneous Nations

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Abstract
We set up a model of generalised oligopoly where countries of different size compete for an exogenous, but variable, number of identical firms. We initially establish the equilibrium rates of corporate taxation and the allocation of the industry between the countries, each nation independently seeking to maximize its benefits from industrial activities. We then examine the implications of changing the composition of the region with respect to the relative sizes and number of its constituent countries.

Keywords: tax/subsidy competition, oligopolistic markets, devolution

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1. Introduction

The rise in foreign direct investment (FDI) and the increasing role played by large, multinational firms have been amongst the most important dimensions of the continuing globalization of the world economy over the past three decades. These developments have had profound effects on the attitude taken by governments towards the location of mobile firms in their jurisdictions. This is reflected in the policies governments have adopted in order to encourage investment by these firms.

We are assuming that local production of the good yields higher social benefits than imports. This reflects what seems to be a widely-held government view. There are many possible reasons why, independently of capital income and tax/subsidy payments, host countries may favour local production. In our analysis in this paper, we use the framework introduced by Haufler and Wooton (1999) where trade between any two countries is costly. As a result, the market price is lower (and consumer surplus higher) under local production compared to importation of the product. Benevolent governments will recognise this and seek to attract FDI. Beyond this motivation, there may be labour market benefits from inward FDI. MNEs may offer wage premia above workers' outside options, a polar case of which occurs when inward FDI relieves involuntary unemployment (Haaparanta, 1996 and Bjorvatn and Eckel, 2006). Alternatively, inward FDI may be associated with localised technological spillovers to indigenous firms (Fumagalli, 2003 and Olsen and Osmundsen, 2003). In our concluding section, we shall discuss how our results may have to be modified were we to change the incentives for the governments.

Our starting point is the two-country model of Haufler and Wooton (2010) in which the nations compete to attract firms from an oligopolistic industry. The major modification that we make to their model, is having *m* countries competing to attract the firms. It will be useful to identify two benchmark cases. The first of these is *full symmetry*, whereby all *m* countries are identical to one another. The second benchmark case will be *limited heterogeneity*, in which the region will be split into two sets of countries, each group being composed of identical countries, but where the national populations differ across the groups.

Our analysis develops as follows. In section 2 we present the basic model. Section 3 analyses the non-cooperative tax equilibrium and the allocation of firms where countries differ in size. Section 4 derives the welfare effects of economic devolution, examining the industrial geography of the region is affected as the number and size of the member countries changes. Section 5 concludes.

2. A multi-country model

We consider a region in which the countries compete to attract a fixed number of firms. These firms produce an homogeneous good, labelled x, in an oligopolistic industry. A second, private good, the numeraire commodity z, is produced under conditions of perfect competition. Every household in the region supplies a single unit of labour. The numeraire industry, which uses labour as the only input, is freely traded resulting in the international equalisation of the wage in that industry as w.

The region starts initially with m countries, each represented by a government that uses taxation policy to improve the economic wellbeing of its residents. The residents of the countries earn only wage income, while profit income accrues to capital owners that reside in a third (outside) country. The countries may differ in size where there are n_i consumers in country i . The population of the region is normalised to unity and so

$$\sum_{M} n_i = 1, \text{ where } M = \{1, 2 \ldots m\}. \tag{1}$$

2.1 Consumers

Consumers in all countries are assumed to have identical preferences for the goods, given by

$$u_i = \alpha x_i - \frac{\beta}{2} x_i^2 + z_i, \qquad i \in M. \tag{2}$$

Moreover, total income from the business tax (as detailed below), denoted by T_i, is redistributed equally and in a lump-sum fashion to the consumers in each country. The budget constraint for a representative consumer in country i is then

$$w + \frac{T_i}{n_i} = z_i + p_i x_i, \tag{3}$$

where p_i is the price of good x in country i. Utility maximisation leads to inverse-demand curves $\alpha - \beta x_i$, $\forall\ i$. Aggregating the demand for good x over all consumers yields market demand curves for each country, denoted X_i:

$$X_i = \frac{n_i(\alpha - p_i)}{\beta}. \tag{4}$$

If we compare any two countries i and j, where $n_i > n_j$, the market demand curve of the larger country i is flatter than that of country j. In this sense market i is the more profitable one for firms, as we shall see below.

2.2 The oligopolistic industry

There are k firms in total, based outside of the region. Each of these firms possesses one unit of "knowledge capital" (such as a license or patent) that can be profitably employed in the imperfectly competitive industry i. This factor is indispensable for the production of good x but limited in availability such that, at most, k firms can engage in production. In addition, each firm faces fixed and identical costs of setting up a production facility in any of the countries. These costs are assumed to be sufficiently large to ensure that each firm will set up, at most, one production plant in the region. Thus each firm will serve the regional market from one of the countries in the region.[1] Firms are assumed to be identical except with

[1] If trade costs were sufficiently high relative to these fixed costs, the firm might choose to "jump" the trade barrier and produce in more than one market. We assume that this is not the case. We further assume that the trade costs between the region and the rest of the world are sufficiently high that no firm would choose to

respect to the location of their production facilities. Location matters because, while all firms can sell their products in all countries, there are trade costs associated with exports to a firm's foreign market. Thus each country's market may be served by both "local" firms that produce domestically and "foreign" firms that are based in the other country.

Labour is the only variable input in good x production. Each unit of good x requires the efforts of γ workers, where γ is chosen so that production of x does not exhaust each country's labour supply. Given this, the marginal cost of production can be defined as $\omega \equiv \gamma w$.[2] The cost of exporting each unit of output is τ, which effectively raises the marginal cost of serving the foreign market to $(\omega + \tau)$. We are assuming that all of the trade costs are "real", taking the form of, say, transport costs or administrative barriers to the free movement of goods between countries. There are no (endogenously determined) tariffs between the countries as we assume that the region is a free-trade-area.

Firms are assumed to behave as Cournot competitors and are able to segment their markets, choosing the quantities to sell on their domestic and export markets independently.[3] The total operating profit of each firm, which equals the return to the required unit of knowledge capital, is thus defined as

$$\pi_i = \left(p_i - \omega\right) x_{ii} + \sum_{j \neq i} \left(p_j - \omega - \tau\right) x_{ji}, \tag{5}$$

where π_i is the pre-tax profit of a firm based in country i and x_{ji} represents sales in country j by a firm based in country i, $i, j \in M$. A firm is at a cost disadvantage in its export market as the marginal cost of exports is higher than that for domestic sales. Consequently an exporter will sell less in a market than an indigenous rival.

service the region's national markets from a third country outside the region. For notational simplicity the fixed costs are suppressed in the equations below.

[2] Since the wage w is equalised across the region, it does not enter the location decision of firms in our model. Thus the firms' choice of location is not driven by labour costs.

[3] In equilibrium, firms will receive a lower producer price for their exports than for goods destined for the domestic market. The trade structure is simply a generalisation of the "reciprocal dumping" model of Brander and Krugman (1983).

Suppose that of the k firms selling in country i, k_i firms are "local" in that they have their production facility in the country, while the remaining $(k - k_i)$ firms service the market from other countries within the region. Maximising (5) taking into account demand (4), yields output levels per firm:

$$x_{ii} = \frac{n_i\left[\alpha - \omega + (k - k_i)\tau\right]}{\beta(k+1)}; \quad x_{ji} = \frac{n_j[\alpha - \omega - (1 + k_j)\tau]}{\beta(k+1)}; \tag{6}$$

We focus on the cases where the trade cost is sufficiently low to ensure that $x_{ji} > 0$ for all $i \neq j$ and that each firm exports into the market of every foreign country. Solving the right-hand expression of (6) for minimum trade cost that results in no exports from country i to country j yields:

$$\tau_i^P = \frac{\alpha - \omega}{k_i + 1}. \tag{7}$$

This prohibitive trade cost depends upon k_i, the number of firms located in the importing country. Clearly, the more firms that produce domestically, the more intense the competition in the local market and, consequently, the lower the threshold in the trade cost to cut off imports from other countries. If countries with larger populations attract a greater number of firms, then they will have lower prohibitive trade costs than smaller countries.

We further assume that the resource constraints $\gamma k_i(x_{ii} + \sum_{j \neq i} x_{ji}) < n_i$ for all $i, j \in M$ are met and that the numeraire good is produced in each country. Observe that $x_{ji}/x_{ii} < 1$, confirming our assertion that a foreign firm's share of a market is always less than that of a local firm whenever there are trade costs ($\tau > 0$).

Total sales in the market of country i are found from aggregating the outputs in (6):

$$X_i = k_i x_{ii} + (k - k_i)x_{ij} = \frac{n_i\left[k(\alpha - \omega - \tau) + k_i\tau\right]}{\beta(k+1)} \tag{8}$$

The equilibrium price in market i is found by substituting (8) into the demand curve (4):

$$p_i = \frac{\alpha + k\omega + (k - k_i)\tau}{k+1}. \tag{9}$$

Notice that consumer prices in every country fall when the total number of firms k increases and competition in the oligopolistic industry is thereby intensified. Moreover, in each country the consumer price is a rising function of the number of active firms in the *other* country. In other words, whatever the size of the industry, having more firms producing locally intensifies domestic competition and drives down consumer prices.

Substituting (6) and (9) into (5) yields the pre-tax profits of a firm that is based in country i:

$$\pi_i = \frac{n_i\left[\alpha - \omega + (k - k_i)\tau\right]^2}{\beta\left(k+1\right)^2} + \frac{\sum_{j \neq i} n_j\left[\alpha - \omega - \left(1 + k_j\right)\tau\right]^2}{\beta\left(k+1\right)^2}. \tag{10}$$

We define the differential between profits for two firms location in countries i and j, respectively, as $\Pi_{ij} \equiv \pi_i - \pi_j$.

We assume that profits are taxed at source by the host countries of the firms. Let t_i be the lump-sum tax imposed on each firm by country i. Then total tax revenues are

$$T_i = t_i k_i \qquad \forall\, i \in M. \tag{11}$$

The tax differential between countries i and j is defined to be $\Delta_{ij} \equiv t_i - t_j$. In deciding upon where to invest, firms will compare profits net of taxes and locate in the most profitable country. The locational equilibrium for the industry is characterised by

$$\Pi_{ij} - \Delta_{ij} = 0 \tag{12}$$

for every pairwise combination of countries, $i, j \in M$. Using (10), we can rewrite this condition in terms of the numbers of local firms operating in each country as a function of the size of each country and the tax differential between the two nations:

$$k_i n_i - k_j n_j = (n_i - n_j)D - \frac{\beta\left(k+1\right)}{2\tau^2}\Delta_{ij}, \tag{13}$$

where $D \equiv [(\alpha - \omega)/\tau + (k - 1)/2]$. Clearly, from equation (13), the number of firms located in each of two countries depends upon relative country size and on the difference in their taxes on firms.[4]

2.3 Benchmark cases

In order to investigate the properties of the equilibrium characterised by(13), it is useful to limit the amount of heterogeneity across the region. We shall consider our two benchmark scenarios in turn.

2.3.1 Full symmetry

Suppose that we have full symmetry in the region, in that countries are identical to each other, having population shares of $n_i = 1/m$. Then it is clear from (13) that, when any two countries choose the same taxes, then they will each be host to the same number of firms.

2.3.2 Limited heterogeneity

Suppose, for example, that the region can be divided into two groups of countries, types a and b, where the only difference between the two groups is the population size of the member countries. If m_i is the number of countries in the region of type i, then the population constraint becomes $m_a n_a = m_b n_b = 1$. Suppose there are μ times as many countries of type a as there are of type b (that is, $m_a = \mu m_b$) and that each country of type a has a population that is v the size of that of a representative country of type b (that is, $n_a = v n_b$).[5]

If the countries, apart from their size, are identical, we can anticipate that they adopt the same behaviour in their attempts to attract firms. If the outcome of the tax competition game is unique, all countries of a particular type will impose the same corporate tax and therefore $\Delta_{aa} = \Delta_{bb} = 0$, while there will be a unique values for Δ_{ab}, k_a and k_b with

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4 In the context of only two countries, this expression is identical to the locational equilibrium in equation (11) of Haufler and Wooton (2010).

5 Our analysis treats k_a and k_b as continuous variables. Hence we only approximate the "true" model when the number of firms is small (relative to the number of countries) and the relocation of a single firm has discrete implications for the equilibrium allocation.

$m_a k_a = m_b k_b = m$. Substituting these constraints into (13) yields an explicit value for the number of firms in each type of country:

$$k_a = \frac{1}{\mu+\nu}\left\{\frac{(\mu+1)k}{m} + \left[(\nu-1)D - \frac{m(\mu\nu+1)}{(\mu+1)}\frac{\beta(k+1)}{2\tau^2}\Delta_{ab}\right]\right\}, \tag{14}$$

$$k_b = \frac{1}{\mu+\nu}\left\{\nu\frac{(\mu+1)k}{m} + \mu\left[(\nu-1)D - \frac{m(\mu\nu+1)}{(\mu+1)}\frac{\beta(k+1)}{2\tau^2}\Delta_{ab}\right]\right\}. \tag{15}$$

The first terms in (14) and (15) are very similar and are determined exclusively by the relative size of each country and of the relative numbers of each type of country. If all countries are the same size ($v = 1$), the first term in each expression is the same. As the relative size of type-*a* countries increases, the first term would indicate that they would attract fewer domestic firms than those that choose to locate in relatively smaller, type-*b* countries. However, the role of the second term in each of (14) and (15) must also be taken into account.

Suppose, initially, that each country charges the same tax, that is $\Delta_{ab} = 0$. In these circumstances when all countries the same size ($v = 1$), the second term in each expression is zero and there is a symmetric equilibrium with $k_i = k/m$, the firms being evenly spread across the region.

Now consider the case where each type-*a* country is larger than a type-*b* country, that is, $v > 1$. In the absence of trade costs ($\tau = 0$), a firm's location is irrelevant to its capacity to earn profits and therefore k_i is undefined. When $\tau > 0$, the relative size of the local market has a positive influence on the number of firms located in a country. It is straightforward to show that the influence of the second term on relative country size outweighs that of the first in both (14) and (15) such that k_a rises and k_b falls as v increases.

The question then arises whether there is a tendency for agglomeration in the region as one type of country becomes larger than the other type. The number of firms per capita in a type-*a* country relative to that in a type-*b* country is *R* where

$$R = \frac{(\mu+1)k + m(\nu-1)D}{\nu\left[\nu(\mu+1)k - \mu m(\nu-1)D\right]}. \tag{16}$$

Differentiating (16) with respect to v yields a complicated expression that is difficult to sign. We therefore resort to using numerical simulations in order to illustrate the outcomes. Our initial results are shown in Figures 1 and 2.

INSERT FIGURE 1 NEAR HERE

Consider, first of all, the role of country size. It is clear from Figure 1 that, when the two types of country are the same size (that is, $v = 1$), then each attracts the same number of firms (twelve apiece in an industry of 120 firms and ten potential host nations—five of each type).[6] As the relative size of the two types of nations diverges, more firms locate in the relatively more populous type-*a* nations than in the smaller type-*b* countries. It is further clear from the figure that *R* is increasing in v. Consequently, the attraction of the relatively larger market is such that agglomerative forces strengthen as the size differential between the two types of country increases and the relatively larger country captures a disproportionate share of the industry.

INSERT FIGURE 2 NEAR HERE

Now consider the role of the trade cost in determining the concentration of firms in larger countries. Haufler and Wooton (2010) discuss the agglomeration of firms that occurs in the larger country of their two countries as trade barriers fall. A similar result can be found in our multi-country regional model as trade becomes better integrated (τ falls). Figure 2 plots

[6] In Figures 1 and 2, we have set $\alpha - \omega = 5$, while the trade cost used in Figure 1 is 12.5%.

the numbers of firms in each of the two types of country for different levels of trade cost.[7] As expected, larger countries always attract more firms than smaller countries capture, but this agglomeration is more pronounced as the trade cost diminishes. R, the per-capita share of firms in larger countries rises as trade cost τ falls, such that the relatively smaller countries eventually become de-industrialised.

3. Equilibrium taxes and location

Differences in taxes will further affect the location of firms such that, if country a taxes firms more heavily than country b (that is, $\Delta_{ab} > 0$), country a's share of the firms will be relatively smaller than it would otherwise be. We now consider countries' optimal choices of corporate taxes and determine the resulting geographical distribution of firms and the welfare outcomes in equilibrium.

3.1 Governments

The government of each country imposes lump-sum taxes on the imperfectly competitive firms operating within its borders, with the intention of influencing the location decisions of firms in that industry, as determined in equation (13). A positive tax on foreign firms will raise revenues that are (assumed to be) redistributed lump-sum to all of the households in country in which they are collected. Crucially, these taxes may be negative, acting as a subsidy to attract more investment to the country in question. If the firms are attracted in this manner, the funds necessary to pay for the inducement are raised through lump-sum taxation of consumers. Despite being lump-sum in character, these taxes/subsidies will still distort the location decision of internationally mobile firms.[8]

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[7] In the numerical simulation, $v = 1.1$, meaning that type-a countries have 10 per cent larger populations than type-b countries.

[8] Introducing an *ad valorem* profit tax, instead of a lump-sum tax on firms, would complicate the algebra, but would not change our qualitative results.

Governments maximise the welfare of their representative consumers. To derive aggregate welfare in each country, we use the budget constraint (3) to substitute out for the consumption of the numeraire good z_i in the individuals' utility function (2) and employ the inverse demands to eliminate p_i. Further employing $x_i = X_i/n$, using the equilibrium prices from (9) in the market demand functions (4) and aggregating over consumers yields:

$$W_i \equiv n_i u_i \equiv S_i + T_i + n_i w, \tag{17}$$

where S_i is country i's total consumer surplus in the market for the imperfectly competitive good

$$S_i = \frac{n_i \left[k(\alpha - \omega - \tau) + k_i \tau \right]^2}{2\beta (k+1)^2} \tag{18}$$

and T_i is defined in (11).

Hence, given our specification of individual utilities, national welfare can be expressed as the sum of aggregate consumer surplus in the imperfectly competitive market and the money income of all consumers (the sum of wage income and tax revenue).[9] Consumer surplus in each country is rising in the total number of firms in the industry, k, as this intensifies competition and reduces producer prices in both countries. Moreover, a rise in the share of firms located in country i raises the nation's consumer surplus in that country (but lowers it in other countries) because consumer prices are lower when more firms produce locally. This gives each nation an incentive to attract firms to its home jurisdiction.

3.2 Tax competition for FDI

We consider a 3-stage game between governments.

1. Governments simultaneously and irreversibly set their corporate tax levels.
2. Firms choose where to locate within region.
3. Firms produce output and sell to consumers in both domestic and foreign markets.

[9] Note that the wage income terms in (17) are constants and will thus not affect any of our results.

We solve using backwards induction for the subgame-perfect Nash equilibrium.

3.3 Welfare maximisation

National welfare as a function of the corporate tax rate and the number of firms located in the country can be found by substituting (11), (13) and (18) into (17). We can then differentiate each country's welfare expression with respect to its own corporate tax. The crucial interaction in this model is the response of firms located in other countries to an individual nation's reduction in its corporate tax. Differentiating the locational equilibrium expression (13) with respect to t_i yields:

$$\frac{dk_j}{dt_i} = \frac{n_i}{n_j}\frac{dk_i}{dt_i} + \frac{m\beta\left(k+1\right)}{2\tau^2 n_j}, \tag{19}$$

where the total number of firms in the region is unchanged, that is,

$$\sum_j^M \frac{dk_j}{dt_i} = 0. \tag{20}$$

To simplify the analysis, we turn to our two benchmark cases of full symmetry (identical countries) and limited heterogeneity (two sizes of country in the region).

3.3.1 Full symmetry

We evaluate the first-order condition for the optimal tax rates when all countries are the same size, $n_i = 1/m$. Substituting this into (19) and solving using (20), we can determine that

$$\frac{dk_i}{dt_i} = -\frac{\left(m-1\right)\beta\left(k+1\right)}{2\tau^2}. \tag{21}$$

We see immediately from (21) that the more countries there are in the region, the greater the responsiveness of firm entry to cuts in a nation's tax on firms.

We use (21) when we differentiate (17) and solve for the first-order condition, finding a closed-form solution for the symmetric Nash equilibrium tax rate:

$$t^S = \frac{k\tau}{(k+1)\beta}\left[\frac{2\tau}{m(m-1)} - \frac{m(\alpha-\omega)-(m-1)\tau}{m^2(k+1)}\right], \tag{22}$$

where the superscript S stands for the symmetric case.[10]

INSERT FIGURE 3 NEAR HERE

The relationship between the number of countries in the region and the level of corporate taxes in equilibrium is illustrated in Figure 3.[11] As m increases, each of the identical countries will have fewer local firms in equilibrium. This has a non-monotonic impact on t^S, the equilibrium corporate tax. When there are few countries, the competition between nations is strong and the firms are offered subsidies in equilibrium. This competition becomes less intense as the number of countries increases and the subsidies that were previously offered become taxes. However, as the number of nations in the region continues to rise, the tax charged declines.

3.3.2 Limited heterogeneity

We now consider the implications of having differently sized countries in the region. In order to promote simplicity, we continue to assume that each type-a country has v times the population of a type-b country and that there are μ as many of the former type than of the latter. We must now consider the difference in the optimal taxes of the two types of country.

The change in the number of firms in a country in response to the change in another national corporate tax now depends upon the relative size of the two countries. As one country's tax is changed, firms reallocate around the region in pursuit of the highest after-tax profits, but again there is no increase in the number of firms.

[10] Expression (20) is the multi-country equivalent of equation (14) in Haufler and Wooton (2010). They provide an intuitive justification for the components that determine the Nash tax level under full symmetry.

[11] In the simulation in Figure 3, there continue to be 120 firms, but $(\alpha - \omega)$ is set to 5 in order to illustrate more clearly the non-monotonic relationship between m and the equilibrium tax.

Suppose a country of type *a* were to change its tax. This will induce firm movements from ($m_a - 1$) other type-*a* countries and from m_b type-*b* countries. Adding together the movements of firms we have

$$0 = \frac{dk_i}{dt_i} + (m_a - 1)\frac{dk_a}{dt_i} + m_b \frac{dk_b}{dt_i}.$$

Substituting (19) and manipulating this expression to yield the change in the number of firms operating in a type-*a* country in response to a change in its tax:

$$\frac{dk_a}{dt_a} = \frac{(\mu\nu+1)\left[(\mu+1)-(\mu+\nu)m\right]}{\nu(\mu+1)(\mu+\nu)}\frac{\beta(k+1)}{2\tau^2}. \tag{23}$$

Now consider welfare maximisation of a type-*a* country by choosing its optimal tax. Differentiating (17) with respect to the tax, substituting (23), and setting the expression to zero to find an optimum yields:

$$t_a = \frac{\tau\nu(\mu+1)}{\beta(k+1)^2 m(\mu\nu+1)}\left\{\frac{\tau\left[(2k+1)m(\mu+\nu)+(\mu+1)\right]}{m(\mu+\nu)-\nu(\mu+1)}k_a - C\right\}, \tag{24}$$

where $C \equiv k(\alpha - \omega - \tau)$.

Similarly, we can derive the response by firms to a change in the tax of a type-*b* country:

$$\frac{dk_b}{dt_b} = \frac{(\mu\nu+1)\left[\nu(\mu+1)-(\mu+\nu)m\right]}{(\mu+1)(\mu+\nu)}\frac{\beta(k+1)}{2\tau^2}. \tag{25}$$

This allows us to determine the optimal tax for a type-*b* country by differentiating (17) and substituting (25) to find

$$t_b = \frac{\tau(\mu+1)}{\beta(k+1)^2 m(\mu\nu+1)}\left\{\frac{\tau\left[(2k+1)m(\mu+\nu)+\nu(\mu+1)\right]}{m(\mu+\nu)-\nu(\mu+1)}k_a - C\right\}. \tag{26}$$

We now have four equations ((14), (15), (24) and (26)) in four unknowns (k_a, k_b, t_a, and t_b) to characterise the Nash equilibrium in corporate taxes.

Substituting (14) into (24) and substituting (15) into (26), yields the reaction functions for type-a and type-b countries, respectively.

$$t_a = \frac{A}{A-B}t_b + \frac{Z}{(A-B)}\left\{\left[\frac{2(\nu-1)A}{k} + \frac{\nu B}{k+1}\right]C + \tau\left[(k+1)(\nu-1) + \frac{2k(\mu+1)}{m}\right]A\right\}, \tag{27}$$

$$t_b = \frac{X}{X-Y}t_a - \frac{Z}{(X-Y)}\left\{\left[\frac{2(\nu-1)X}{k} + \frac{kY}{k+1}\right]C + \tau\left[(k+1)(\nu-1) + \frac{2k\nu(\mu+1)}{m}\right]X\right\}, \tag{28}$$

where

$$\begin{aligned}
&A \equiv \nu\left[(\mu+1) + (2k+1)m(\mu+\nu)\right],\\
&B \equiv (2k+1)(\mu+\nu)\left[(\mu+1) - m(\mu+\nu)\right],\\
&X \equiv \mu\left[\nu(\mu+1) + (2k+1)m(\mu+\nu)\right],\\
&Y \equiv (2k+1)(\mu+\nu)\left[\nu(\mu+1) - m(\mu+\nu)\right], \text{ and}\\
&Z \equiv \tau(\mu+1)/\beta(k+1)m(\mu\nu+1)(AY+BX-BY).
\end{aligned}$$

Expressions (27) and (28) can be solved to find the tax rates and numbers of firms attracted by each type of country in the Nash equilibrium.

$$t_a^N = Z\left\{\begin{array}{l}\tau\left[(k+1)(\nu-1)Y - \dfrac{2k(\mu+1)}{m}\left[(X-Y) + \dfrac{\nu}{\mu}X\right]\right]A\\ + \dfrac{\left[(3k+2) - 2(k+1)\nu\right]AY + k\nu(X-Y)B}{k(k+1)}C\end{array}\right\}, \tag{27}$$

$$t_b^N = Z\left\{\begin{array}{l}\tau\left[(k+1)(\nu-1)B - \dfrac{2k(\mu+1)}{m}\left[\dfrac{\nu}{\mu}(A-B) + A\right]\right]X\\ - \dfrac{\left[(3k+2)\nu - 2(k+1)\nu\right]BX + k(A-B)Y}{k(k+1)}C\end{array}\right\}, \tag{28}$$

$$k_a^N = \frac{B}{2(\mu+\nu)(AY+BX-BY)}\left\{\begin{array}{l}\dfrac{2k(\mu+1)\left[\mu(X-Y) + \nu X\right] - (k+1)m\mu(\nu-1)Y}{\mu\nu}\\ - \dfrac{(3k+2)(\nu-1)Y}{\tau k(k+1)}C\end{array}\right\}, \tag{29}$$

$$k_b^N = \frac{\mu Y}{2(\mu+\nu)(AY+BX-BY)}\left\{\begin{array}{l}\dfrac{2k(\mu+1)\left[\nu(A-B) + \mu A\right] + (k+1)m\mu(\nu-1)B}{\mu\nu}\\ + \dfrac{(3k+2)(\nu-1)B}{\tau k(k+1)}C\end{array}\right\}. \tag{30}$$

INSERT FIGURE 4 NEAR HERE

The relationship between relative country size, v, relative number of type of country, μ, and the Nash taxes in equilibrium are illustrated in Figure 4. The left-hand panel of the diagram shows the taxes imposed by type-*a* countries while the taxes set by type-*b* countries are shown in the right-hand panel. The vertical scales of the two panels differ but the same tax is set by both groups of nations when all countries are the same size ($v = 1$). Thus, both types of country offer the same subsidy to firms along the μ axes of the two figures.

When type-*a* countries become larger than those of type-*b*, the tax imposed by bigger countries rises and this increase is greater when there are relatively few type-*a* countries (that is, μ is small). Thus, the greater the size advantage of type-*a* countries and the fewer their number, the higher the tax that they will impose on firms in the Nash equilibrium.

The results for type-*b* countries are not quite so straightforward. As a disparity in size arises, then initially the smaller countries will increase the subsidy that they offer to firms. However, continuing increases in the relative size of type-*a* countries will lead type-*b* countries to reduce their subsidy offers in equilibrium. The reasons for this behaviour will be the subject of future investigation.

4. Summary and conclusions

In this paper we have set up a simple regional model of trade and investment where countries can differ in size from each other. We use this structure to examine the location choices of firms in an oligopolistic industry where the countries offer tax incentives to persuade firms to locate their production within the nations' frontiers.

In order to keep the model tractable and in an effort to promote the intuition of our results, we focussed on two benchmark cases: full symmetry, where all countries are the same size as each other; and limited heterogeneity, where the region is split into groups of large and small countries. We have characterised this Nash equilibrium in corporate taxes, determining the taxes set by large and small countries and the resulting distribution of industry across the region.

The immediate task ahead of us is to investigate how the geography of the region affects the distribution of industry. In particular, we shall be interested in determining how agglomeration of industry is affected by the numbers and sizes of the different types of country. It would also be useful to establish how fragmentation of a country affects its ability to attract firms. This would give us an analytical tool to investigate the consequences of devolving corporate taxation powers to sub-national governments and offer some insight into the geographical implications for industrial activity of the division of existing nations into smaller states.

References

Bjorvatn, Kjetil, and Carsten Eckel (2006), "Policy Competition for Foreign Direct Investment between Asymmetric Countries." *European Economic Review* 50, 1891-1907.

Brander, James A., and Paul Krugman (1983), "A 'Reciprocal Dumping' Model of International Trade." *Journal of International Economics* 15, 313-323.

Fumagalli, Chiara (2003), "On the Welfare Effects of Competition for Foreign Direct Investments." *European Economic Review* 47, 963-983.

Haaparanta, Pertti (1996). "Competition for Foreign Direct Investments." *Journal of Public Economics* 63, 141-153.

Haufler, Andreas, and Ian Wooton (1999), "Country Size and Tax Competition for Foreign Direct Investment." *Journal of Public Economics* 71, 121-139.

Haufler, Andreas, and Ian Wooton (2010), "Competition for Firms in an Oligopolistic Industry: The Impact of Economic Integration." *Journal of International Economics* 80, 239-248.

Olsen, Trond E., and Petter Osmundsen (2003). "Spillovers and International Competition for Investments." *Journal of International Economics* 59, 211-238.

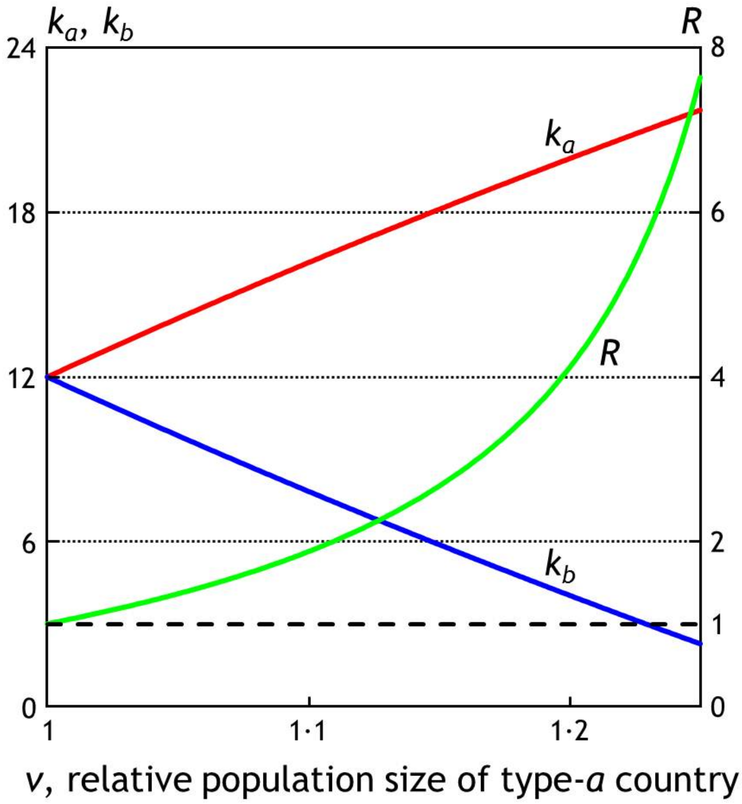

Figure 1

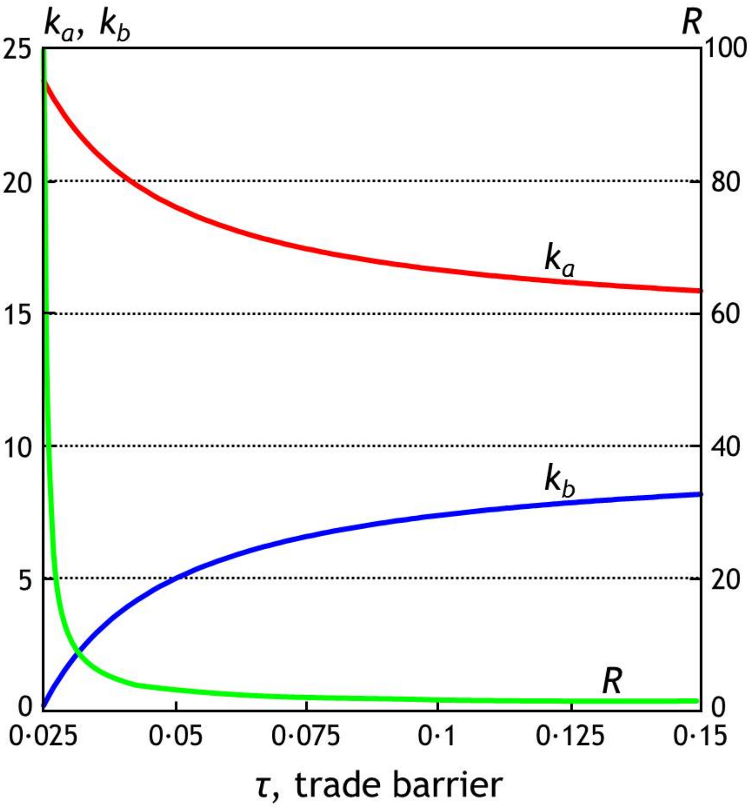

Figure 2

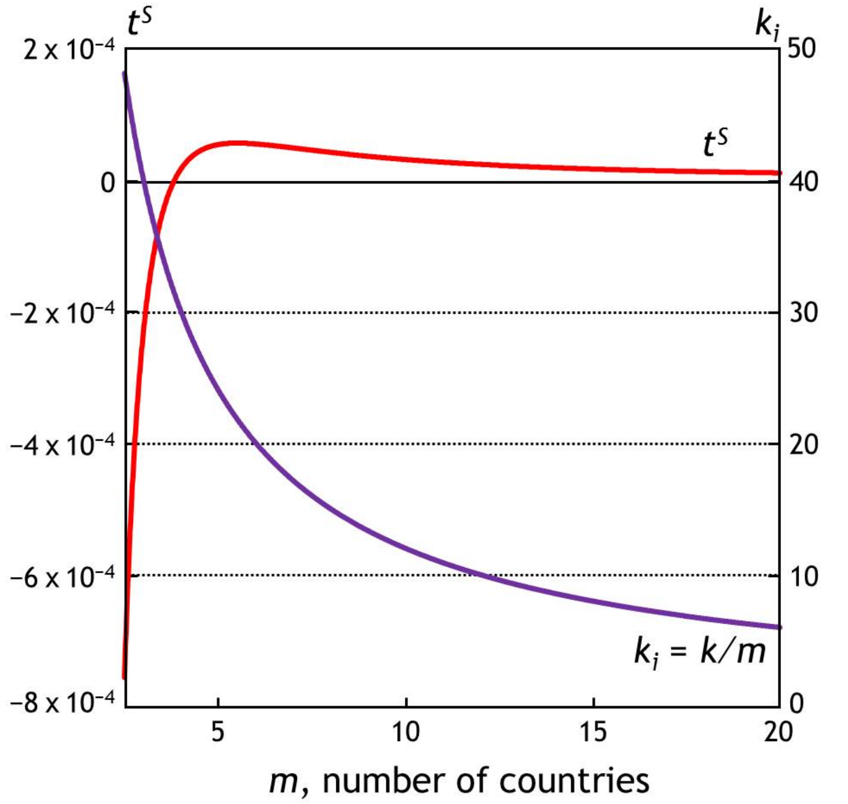

Figure 3

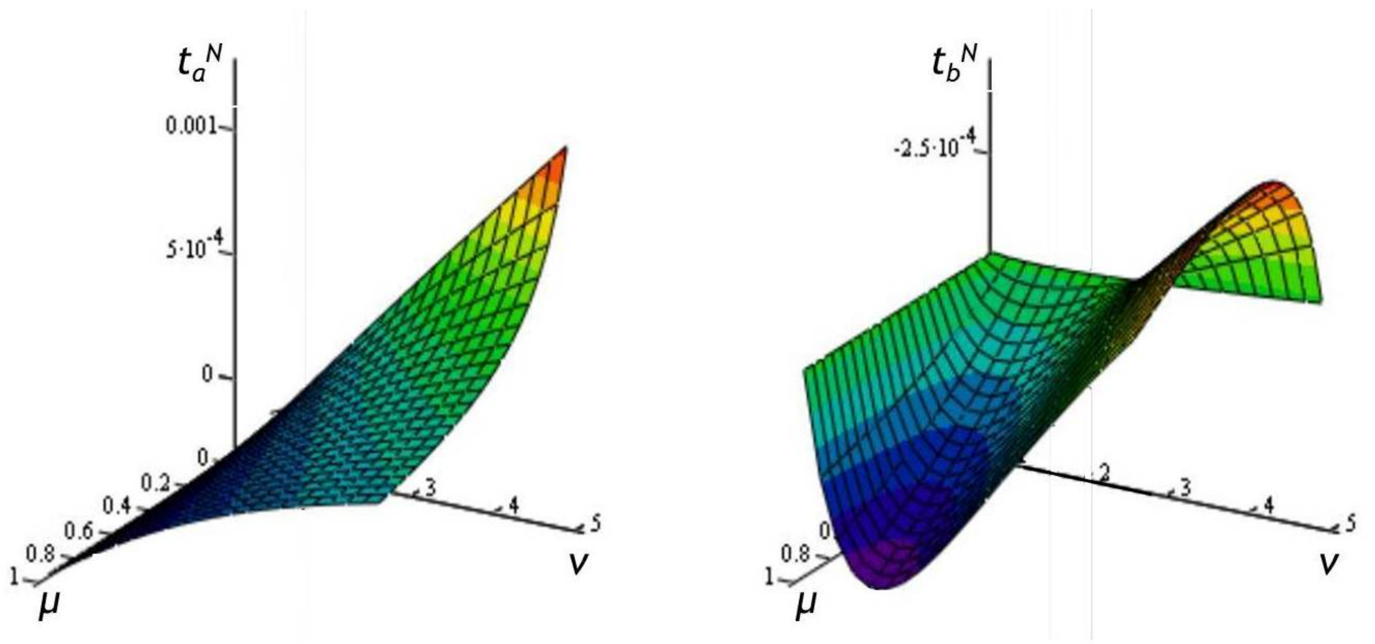

Figure 4