Tax reform, delocation and heterogeneous firms: Base widening and rate lowering rule

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ABSTRACT

We model international tax competition allowing for agglomeration forces and heterogeneous firms. This provides a new perspective since a tax schedules have different effects on the international relocation decision of small and large firms (large firms are endogenously more sensitive to tax competition) and these decisions affect industry productivity in addition to the usual effects. The model allows us to study rate-lowering base-widening reforms. We show it is generally possible to design such a reforms that raises revenue without losing firms.
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1. INTRODUCTION

International tax competition has been an important concern for decades, but the heightened mobility of firms and technology – spurred in part by the rapid improvements in the quality and price of international communication – has drawn renewed interest.

From the 1980s onward, one common response has been to cut corporate tax rates but widen the base to which it is applied. The United States, Austria, France, Finland, Germany, Canada and the United Kingdom have sharply cut the rates and widened the base of their respective corporate tax regimes between 1980 and 2003.[2] Some small European countries such as Belgium, the Netherlands and Greece have reduced tax rates with an unchanged tax base.[3]

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[2] The statutory tax rates have substantially reduced in many countries: the United States from 50 % in 1980 to 39 % in 2003, Australia from 50% to 30%, Austria from 61%(in 1982) to 34% (in 2003), Canada from 45% to36%, France from 50% to 35%, UK from 52% to 30%, Germany from 62% to 40%, Ireland from 45% to 13%, and Japan from 53% to 41%. The present discounted value of depreciation allowances has widened in some countries: UK from 100% (1980) to 73% (2003), Canada from 94% to 73%, France from 81% to 77%, Germany

It has been argued that this sort of reform mitigates distortions and spreads the tax burden more evenly (UK HM Treasury, 2003). Such reforms may also increase tax revenue. As Devereux, Griffith and Klemm (2002) show, in many OECD countries the effective corporate tax rates have fallen and tax bases (measured by the present discounted value of allowances available in plant and machinery) have substantially widened, while at the same time tax revenue collected has risen.

It is also commonly asserted that such reforms are necessary to prevent the largest firms from leaving, a point that is easy to see. A broader base and lower rate has a larger impact on the effective rate of large firms, so the reforms' impact on international relocation decisions varies according to corporate size, boosting the reforming nation's attractiveness for large firms more than for small firms.

The purpose of our paper is to formally study international tax competition in the presence of significant agglomeration economies and firm heterogeneity. The former allows us to consider a situation where big economies maintain higher taxes in equilibrium (Ludema and Wooton 1998, Kind, Midelfart-Knarvik and Schjelderup 2000, Andersson and Forslid 2003, and Baldwin and Krugman 2004). The later allows us to consider the differential impact of tax reforms by firm size and to examine the firm-level impact of tax reform – an issue that has recently been highlighted by empirical studies on the firm-size distribution of tax payments, which typical finds that tax is paid by quite a small number of firms and the payers are typically large firms (Baer, 2002; Shome, 2004; Auriol and Warlters, 2005).[4]

At the theoretically level, our framework opens the door to extensions of the international tax competition literature. In particular, it allows us to consider the implications of tax reforms (such as the rate-lowering-base-widening) that alter the effective tax rate paid be firms of different size/profitability. Obviously, such reforms cannot be fully explored theoretically in the classic international tax competition model which assumes homogenous firms. In particular, we show that allowing for heterogeneity permits a given tax scheme to have a different effect on the relocation decision of small and big firms, with the biggest firms being endogenously more likely to relocate in reaction to high-taxes.

The inclusion of firm heterogeneity permits three extensions of the theoretical analysis of international tax competition. First, it allows the model to capture the very real-world concern that large/profitable firms find it easier to escape taxation. Second, it allows us to consider the revenue implications of reforms that tilt the size-tax-burden profile in a setting where firms can relocate to avoid taxation and some do so in equilibrium. This creates the smooth trade-off between higher tax rates and keeping firms at home. Third, since firm-size is associated with firm-level productivity in our model (following that by-now standard approach in Melitz 2003), tax reform has an impact on the average productivity of firms in each nation. In

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from 76% to 71% and Australia from 71% to 66%. On the other hand, some small nations have kept the same rates over the twenty year period: 75% in Belgium, 78% in Switzerland and 73% in the Netherlands. Note that the present discounted value is calculated for an investment in machinery and plant. See the data resource for detail: http://www.ifs.org.uk/corptax/internationaltax.zip.

[3] Ireland has widened its tax base by reducing deductions while leaving rates unchanged, leading to increased tax revenue over the decade.

[4] For instance, as shown in Baer (2002) 0.4% of taxpayers account for 61% of total domestic tax collection in Kenya and 57% in Colombia. According to Shome (2004), large taxpayers account for 80-90 percent of the tax revenue in Asian and Latin American countries. To reflect this phenomenon, an attempt to widen the profit tax base is one of the most possible ways of raising tax revenue in developing countries. A narrow tax base comes from higher opportunity costs and entry costs for small firms. Auriol and Warlters (2005) found that a 1% increase of the entry sunk cost increases the informal sector by 14% and suggested that reducing market entry fees in developing countries could enlarge their tax base.

particular, a rate-lowering-base-widening reform tends to bring the most productive firms 'back home' and thus can raise average industry productivity as well as raise tax revenue.

The inclusion of heterogeneous firms is not entirely new to the tax literature, since it has been already analysed by the important papers of Burbidge, Cuff and Leach (2004, 2006). Their model, however, is quite different from ours in that the former can be thought of as an extension of the basic tax competition model (perfect competition, immobile labour and mobile capital) which assumes that firm productivity differences are both firm-specific and location specific. In our model, the source of firm heterogeneity is the exogenous distribution of firm-level productivity – due, for example, to firm-specific assets such as organisational capital, intellectual property, or tacit technological knowledge. In Burbidge et al., some firms have a comparative advantage in one country, while the other firms have it in the other. As a result, tax rates could be higher in one nation without driving out all firms – even with perfect competition. In their model, the firm-level-region-specific productivity differences create a quasi-rent that can be taxed up to a point without firms relocating away from the higher tax. This leads to spatial sorting whereby firms locate to exploit their own locational comparative advantage.

The focus of Burbidge, Cuff and Leach (2006) is the study of tax regimes and the provision of public goods, rather than tax reforms and firm location with trade costs as in our model. A related paper is Haufler and Schjelderup (2000) which is a theoretical study concerning optimal tax systems in the presence of profit shifting in foreign direct investment (FDI) via transfer pricing. They suggest that the optimal tax reform is to reduce tax rates so as to prevent firms from shifting their profits to foreign nations when FDI is introduced.

Our paper is organised in six sections. The next introduces the application of the basic model. Section 3 studies the impact of taxation on firm relocation. Section 4 explores implications of tax reform, and Section 5 considers the impact of globalisation (i.e. free trade). The last section provides our concluding remarks.

2. THE HETEROGENEOUS MOBILE FIRMS MODEL

This section introduces the basic economic model with internationally mobile heterogeneous firms. It is best thought of as a marriage of the Meltiz (2003) model and the 'footloose capital' model of Martin and Rogers (1995).

2.1. *The footloose capital model with heterogeneous firms*

We work with a world consisting of two nations (North and South) and two sectors (manufacturing and the numeraire sector). Before turning to the equations, we discuss the basic intuition behind the forces that affect the location of industry in the absence of taxes.

Most of the basic forces in the model are not directly related to the heterogeneity of firms. The manufacturing section is marked by Dixit-Stiglitz competition, increasing returns at the firm-level and trade costs. As is well-known from the international trade and economic geography literature, this combination of assumptions generates both agglomeration and dispersion forces. The agglomeration force stems from the fact that firms want to locate in the big market (other things equal) to reduce their trade costs. This agglomeration effect is countered by a dispersion force known as the 'local competition' effect. That is, while locating in the big market allows firms to save on trade costs, the presence of many firms also implies tougher competition. Since firm want to be far from their competitor (other things equal), this is a dispersion force.[5] The location equilibrium is marked by an international division of firms that just balances the agglomeration and dispersion forces.

Firm heterogeneity introduces new effects since the balance of agglomeration and dispersion forces varies according to firm size. The ultimate source of firm-level heterogeneity in our model is firm-level differences in marginal cost (productivity), which implies that firms with low marginal costs charge a lower price and thus sell more and earn higher operating profits. Since different firms sell different amounts, the balance of agglomeration and dispersion forces varies by firm size. In particular, the trade cost saving aspect of big-market location is especially attractive to big firms that sell a lot. Likewise, the competition-protection aspect of location in the small market is especially attractive to firms that sell little. The thrust of this is that large firms tend to agglomerate preferentially in the large region. In other words, the equilibrium tends towards a spatial separation of firms by size with the big market tending to have a disproportionate share of large, highly productive firms.

This feature of the model is the key to our novel tax analysis, since it means that changes in the tax gap between the big and small markets will lead to changes in the spatial segmentation by firm size. We now turn to introducing the model more formally.

2.1.1 Basic assumptions

The manufacturing sector ('industry') consists of firms that each produce a differentiated variety and compete in a monopolistic competition setting. The tastes of the representative consumer in each region are quasi-linear:

$$\textbf{(1)} \qquad U = \mu \ln C_M + C_A, \quad C_M \equiv \left(\int_{i \in \Theta} c_i^{1-1/\sigma} di \right)^{1/(1-1/\sigma)}, \qquad \sigma > 1 > \mu > 0$$

where C_M and C_A are, respectively, consumption of the composite of M-sector varieties and consumption of the numeraire-sector (good A). Here, $\sigma > 1$ denotes the constant elasticity of substitution between any two M-sector varieties, μ is the expenditure share of manufacturing goods, and Θ is the set of all varieties consumed.

Heterogeneity in our model stems only from differences on the supply side. Each manufacturing firm requires a unit of capital as its fixed cost and uses only labour in the variable costs. However, firms have heterogeneous unit labour requirements. The marginal production cost for firm *i* is given by the wage rate 'w' times its firm-specific unit labour coefficient, denoted as 'a_i'. It may help to think of 'capital' as knowledge capital, i.e. each firm's blueprint for producing its unique variety. The 'a_i' is associated with the firm's blueprint, so it is unaffected by the firm's location choice (i.e. the unit labour input coefficient is firm-specific, not market-specific). Since all Dixit-Stiglitz varieties enter **(1)** symmetrically, we see that heterogeneity enters only on the supply side.

Each nation's endowment of labour and capital is fixed, as are all of the firm-level a_i's. To be concrete and to keep the analysis tractable, we assume each nation's distribution of a_i's is described by the Pareto distribution:

$$\textbf{(2)} \qquad G[a] = \left(\frac{a}{a_0} \right)^{\rho}; \qquad \rho \geq 1 \equiv a_0 \geq a \geq 0$$

[5] That is, firms can use international trade costs as a partial shield from competitors located in the big market by locating in the small market.

Here ρ is shape parameter and a_0 is the scale parameter, i.e. the highest possible a; we normalise a_0 to unity by choice of units.

Capital is internationally mobile while labour is not. Since each firm is associated with a particular unit of capital (a blueprint), capital mobility is synonymous with firm mobility.

Trade in manufactures is subject to 'iceberg' trade costs in the sense that firms must ship $\tau > 1$ units of their good in order to sell one unit in the other nation.

Since the main focus of the analysis is on the interaction between taxes and the location of industry, we make the numeraire sector as simple as possible. Specifically, we assume it is marked by constant returns, perfect competition, costless trade and that it uses only labour.

The thrust of our analysis concerns the impact of taxes on firm migration. Since we do not want to conflate technology-driven effects on location with those of taxes, we assume the $G[a]$ is identical for the two regions. Moreover, to avoid capital movement that is driven by unequal capital-labour ratios, we assume that the nations have identical capital-labour ratios even though North is bigger, i.e. North has proportionally more of both L and K, so nations differ only in size.

Figure 1 shows the distribution of a's in North and South. The distribution in the North is $G[a]\,K$; in the South it is $G[a]\,K^*$, where K and K^* are the North's and South's endowment of capital (i.e. mass of blueprints/varieties). This means that the total mass of firms in the North and South are K and K*, respectively.[6]

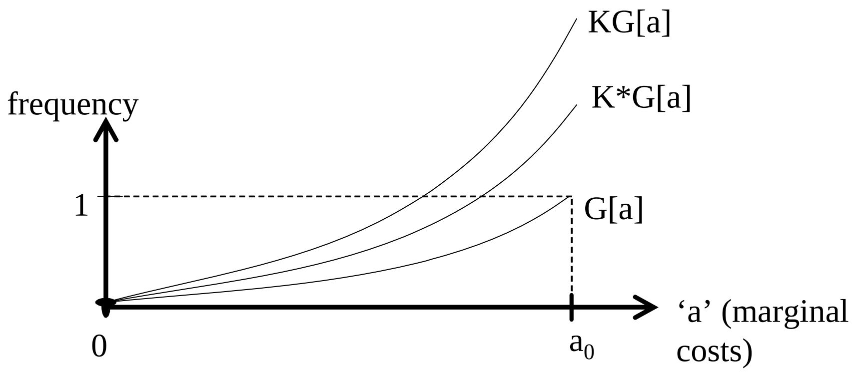

Figure 1: Endowed distribution of capital and marginal costs in North and South.

The wage rate in each nation is set in a competitive labour market, but the reward to each firm's unit of capital is determined by the firm's Ricardian rent, i.e. its operating profit. As a consequence, different firms will earn different rewards on their capital in equilibrium. As in Melitz (2003), the most efficient firms will earn the highest reward on their capital. Melitz (2003) shows that the aggregate level of capital can be endogenised such that the average reward to capital equals the discount rate, but allowing for this would unduly complicate our model. Instead, we take the nations' capital stocks and $G[a]$ as part of the nations' endowments.

2.1.2 Intermediate results

The presence of the simplified numeraire sector facilitates the general equilibrium analysis substantially. Constant returns, perfect competition and zero trade costs equalise nominal

[6] Since we take the range of varieties to be continuous, we speak of the 'mass' of firms with a particular marginal cost. We assume that the mass is the same for every level of marginal cost (this is demonstrated in Melitz (2003) as the outcome of an endogenous entry/exit process).

wage rates across nations and we choose the units of labour such that $w=w^*=1$.[7] This means that all differences in manufacturing firms' marginal costs boil down to differences in their a's. Moreover, firm relocation does not affect wages paid, so factor costs are never an issue in firms' location decisions.

As is well-known, Dixit-Stiglitz monopolistic competition implies that the profit-maximising producer price of a typical firm with marginal cost a_j is:

$$p_j = \frac{a_j}{1-1/\sigma}$$

and that 'mill pricing' is optimal, so the price of variety-j in the other market is just τ times the producer price p_j.

Utility maximisation generates the familiar CES demand functions in the manufactures sector.[8] For example, the demand for variety j in the North market is:

$$\textbf{(3)} \qquad p_j^{-\sigma}\tilde{B}; \qquad \tilde{B} \equiv \frac{E}{P^{1-\sigma}}, \qquad P^{1-\sigma} \equiv \int_{i\in\Theta} p_i^{1-\sigma} di$$

where $\tilde{B}$ can be thought of as the "per-firm demand" that firms take as given under Dixit-Stiglitz competition; P is the usual CES price indices in the Northern market (Θ is the set of all varieties consumed).

A second well-known property of Dixit-Stiglitz competition is that operating profit of firm-j equals $1/\sigma$ times the firm's revenue.[9,10] The firm-specific revenue of a typical North-based firm in the Northern market is just the consumption given by **(3)** times that firm-specific price. Using similar calculations for operating profit earned on Southern-market sales, the firm-specific operating profits for a North-based firm is:

$$\textbf{(4)} \qquad \pi[p] = p^{1-\sigma}(\tilde{B} + \phi\tilde{B}^*); \qquad 0 \le \phi \equiv \tau^{1-\sigma} \le 1$$

where $\tilde{B}^*$ is the Southern market version of $\tilde{B}$ in **(3)** and ϕ is the parameter that gauges the 'freeness' of trade (recalling that $1-\sigma < 0$, ϕ ranges from zero when iceberg trade costs are prohibitive, i.e. $\tau = \infty$, to unity when the trade costs are zero, i.e. $\tau = 1$).

Four features of **(4)** play important roles in the subsequent analysis. First, all firms earn positive operating profit in equilibrium (this is the reward to capital, i.e. Ricardian rent). Second, since $(1-\sigma) < 0$, the most efficient firms – i.e. those with relatively low marginal cost and thus with low relative prices – are the most profitable. Third, a North firm that finds it optimal to charge a producer price of p when it is located in the North would find it optimal to charge the same producer price if it relocated to the South (due to wage equalisation and the constant Dixit-Stiglitz mark-up). Thus its operating profit when located in the South is:

$$\textbf{(5)} \qquad \pi^*[p] = p^{1-\sigma}(\phi\tilde{B} + \tilde{B}^*)$$

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[7] This holds for all possible equilibriums only if the size difference between the nations is not too great; in particular, the small South needs to be big enough to accommodate all industry and still have some labour leftover to employ in the numeraire sector.

[8] Individual demand for a typical variety j is $c(j)=p(j)^{-\sigma}\mu/\Delta$, where $\Delta\equiv\int p(i)^{1-\sigma}di$ and the integral is over all available varieties, μ is expenditure on all varieties.

[9] Given the iceberg trade cost, the consumer/producer price gap exactly offsets the gap between the quantity of goods shipped and the quantity of goods consumed. This is a well-known feature of Dixit-Stiglitz competition.

[10] A typical first order condition is $p(1-1/\sigma)=wa$; rearranging, the operating profit, $(p-wa)c$, equals pc/σ.

The difference is that being South-based, the firm adds the iceberg trade cost to its price in the Northern market but not in its price in the Southern market. Fourth, comparing **(4)** and **(5)**, it is clear that a firm's profit depends upon its location as long as $\tilde{B}$ and $\tilde{B}^*$ are not identical.

2.2. *Locational equilibrium with capital mobility but no taxes*

Firms' locational responses to taxes are at the heart of the model, so it is useful to consider relocation tendencies in the absence of taxes. The key to a firm's location decision is the firm-level difference between operating profit earned when the firm is located in the North versus the South. Without taxes this is:

(6) $$\pi[p]-\pi^*[p] \quad = \quad p^{1-\sigma}(1-\phi)(\tilde{B}-\tilde{B}^*)/\sigma$$

Plainly the sign of the gap turns on whether the per-firm demand in the Northern market, i.e. $\tilde{B}$, is bigger than the per-firm demand in the Southern market, $\tilde{B}^*$. These, in turn, depend upon the location of firms (trade costs implies that competition is somewhat localised). In the situation at hand, no firms have moved yet so the mass of firms located in the North and South are K and K^* respectively. To calculate that P's and thus the $\tilde{B}$'s, we change variables of integration so that the Northern CES price index integral is:

$$P^{1-\sigma}=\left(1-\frac{1}{\sigma}\right)^{\sigma-1}\int_{a=0}^{1}\left(Ka^{1-\sigma}+\phi K^* a^{1-\sigma}\right)dG[a]$$

Using **(2)** to solve the Northern integral and its Southern counterpart, we get:

(7) $$P^{1-\sigma}=\left(1-\frac{1}{\sigma}\right)^{\sigma-1}\lambda\left(K+\phi K^*\right),\quad (P^*)^{1-\sigma}=\left(1-\frac{1}{\sigma}\right)^{\sigma-1}\lambda\left(\phi K+K^*\right);\qquad \lambda\equiv\frac{\rho}{1-\sigma+\rho}>0$$

where λ is a collection of parameters that is positive assuming a regularity condition, namely $(1-\sigma+\rho) > 0$, that ensures that the integrals converge.

To sign the profit gap in **(6)**, we use **(7)** and the fact that North is a scaled up version of South, so it has a share s of both world expenditure and world capital. Thus:

$$\frac{\tilde{B}}{\tilde{B}^*}\equiv\frac{1+\phi s/(1-s)}{1+\phi(1-s)/s}>1;\qquad\qquad s\equiv\frac{E}{E+E^*}=\frac{K}{K+K^*}$$

The inequality holds as long as the North is bigger, i.e. s > ½. Thus, in the initial situation where no firms have yet moved, the per-firm demand is larger in the big Northern market, i.e. $\tilde{B}>\tilde{B}^*$.[11] Intuition for this result (which is well known in trade theory) is simple. If E is 10% bigger in terms of expenditure than E^* and there are 10% more firms located in the North, then the per-firm expenditure would be equal if there were no international trade. Trade evens out the differences in competition so although competition is somewhat tougher in the North, it is less than 10% tougher so per-firm demand in larger in the North with trade but immobile firms.

To study relocation, we start from the initial situation without delocation, and allow capital/firm mobility. The trade literature has explored this issue extensively in the context of

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[11] Note that our assumption that the North is bigger, but is endowed with the same capital-labour ratio, means that $E/K=E/K^*$ (recall that E is proportional to the number of consumers in a market and this is equal to the number of labourers and thus the labour stock in each region). Consequently, we can use **(7)** to rewrite B as $(E/\lambda K)/(1+\phi K/K^*)$ and B^* as $(E^*/\lambda K^*)/(\phi+K/K^*)$. Since $0<\phi<1$ and $K>K^*$ we see that $B>B^*$. The fact that $B>B^*$ without relocation is, of course, the basic economics driving the Home Market Effect (Krugman 1980).

homogenous firms. There, the received wisdom is called the Home Market Effect (e.g. see Krugman 1980, and Davis and Weinstein, 1999, 2003), which notes that some of the firms will relocate from the small South market to the big North market. However, as firms shift to the big market, they produce a counterbalancing shift in local competition. The Northern market becomes more competitive and the South market less competitive. Relocation goes on until the operating profit gap is pushed to zero, i.e. $\tilde{B} = \tilde{B}^*$.

When firms are heterogeneous as in our model, an additional question arises: Which firms relocate first? The key is to note that large firms sell a great deal more than small firms, so large firms are most interested in reducing trade costs. More formally, the profit gap in **(6)** is greater for more efficient firms that charge a lower price and thus sell more. Following the usual logic, the Southern firms with the most to gain move first, i.e. the largest, more efficient South firms are the first to relocate to the big Northern market.[12] The relocation ends when $\tilde{B}$ equals $\tilde{B}^*$ and all firms are just indifferent to their equilibrium location, but with a range of the most efficient Southern firms having moved to the North. **Figure 2** shows the equilibrium distribution of firm efficiencies by market allowing for capital mobility.

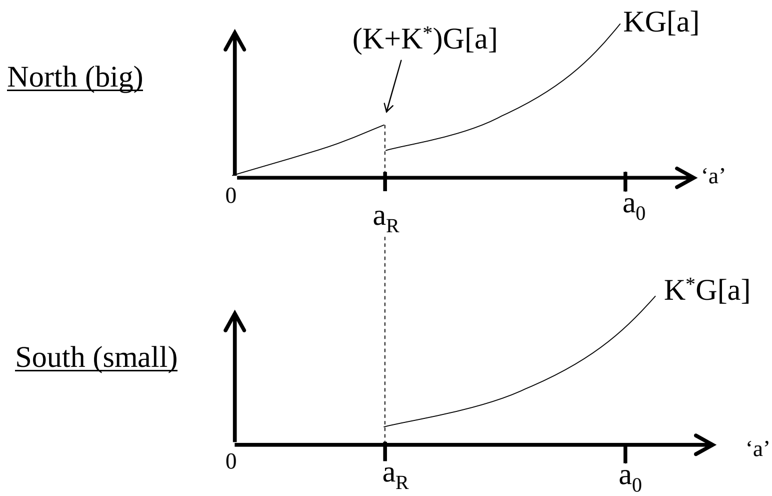

Figure 2: Geographic distribution of firm efficiency with free delocation

What we see from the diagram is that free capital/firm mobility results in the North having a disproportionate share of the world's industry, and a disproportionate share of the world's most productive firms (i.e. those with low marginal costs).

Formally, the range of firms that move northward is $[0\ldots a_R]$ where a_R is the threshold marginal cost defined by:

(8) $$1 = \frac{\tilde{B}[a_R]}{\tilde{B}^*[a_R]}$$

Note that the $\tilde{B}$'s depend upon the E's and the P's. While the E's are invariant to firm relocation, the P's adjust. For example using the mill-pricing and the definition of the North's CES price index:

$$P^{1-\sigma} = \left(1-1/\sigma\right)^{\sigma-1}\left\{K\int_0^1 a^{1-\sigma}dG[a] + K^*\{\int_0^{a_R} a^{1-\sigma}dG[a] + \phi\int_{a_R}^1 a^{1-\sigma}dG[a]\right\}$$

[12] For details see the analysis in Baldwin and Okubo (2006a,b).The basic idea is that if there are quadratic adjustment costs or other forms of congestion, then the firms with the most to gain would leave first.

Here the three integrals reflect, respectively, the local prices of Northern firms, the local prices of Southern firms that are now based in the North, and the prices of South-based firms exporting to the North. Using **(2)** to solve the integrals, **(8)** becomes:

$$1=\frac{E/\left(K+K^{*}a_{R}{}^{\alpha}+\phi K^{*}(1-a_{R}{}^{\alpha})\right)}{E^{*}/\left(\phi(K+K^{*}a_{R}{}^{\alpha})+K^{*}(1-a_{R}{}^{\alpha})\right)};\qquad \alpha\equiv 1-\sigma+\rho>0$$

Solving this tells us that a_R equals:

(9) $$a_{R}{}^{\alpha}=\frac{2\phi}{(1-\phi)(1-s)}(s-\frac{1}{2})$$

where 's' is the North's endowment share of world expenditure and capital/firms.

From **(9)** it is clear that for sufficiently free trade, i.e. ϕ near 1, a_R will be 1, which means that all firms will have left the South (recall that $a = a_0 = 1$ is the maximum marginal cost). To keep the analysis interesting, we restrict our investigations to ϕ's less than the level of freeness that would result in all firms in the North. Simple calculation reveals that this threshold ϕ is $(2s-1)/\{(1-\phi)(1-s)\}<1$.

We turn now to including capital taxation.

3. CAPITAL TAXATION AND EQUILIBRIUM LOCATION OF INDUSTRY

Large highly industrialised nations typically have higher tax rates than smaller poor, less industrialised nations. This section introduces capital taxation that reflects this outcome and sets the stage for consideration of the impact of tax reform. To simplify, the Southern capital tax rate is zero so the Northern tax rate can be thought of as the tax difference.

The simple tax scheme we consider involves a flat capital-income tax rate t that is applied to capital-income beyond a deductible, D. The tax applies to all firms located in the North regardless of their nationality and the tax is collected on worldwide capital income. Note that each firm is associated with a unit of capital and capital's reward is the firm's operating profit, so we can think of our tax as a highly simplified corporate income tax.

Taking account of t and D, the tax paid by a typical firm with marginal costs a that is located in the North becomes:

(10) $$tax[a]=\max\left\{\left(\pi[a]-D\right)t,\ 0\right\}$$

Plainly the tax paid is increasing in the size of the firm (i.e. decreasing in its marginal cost, a); a sufficiently small firm (profits less than D) pays no tax at all. The implied marginal and average tax rates are illustrated in **Figure 3**.

Given this tax scheme, firms choose their location based on their after-tax income, so the location condition with taxation will be:

(11) $$0=\begin{cases}\pi[a]-\pi^{*}[a], & if \quad \pi[a]<D\\ \pi[a]-tax[a]-\pi^{*}[a], & if \quad \pi[a]\geq D\end{cases}$$

Small firms (those with operating profits below D) compare operating profit without regard to tax while larger firms consider tax when choosing their location.

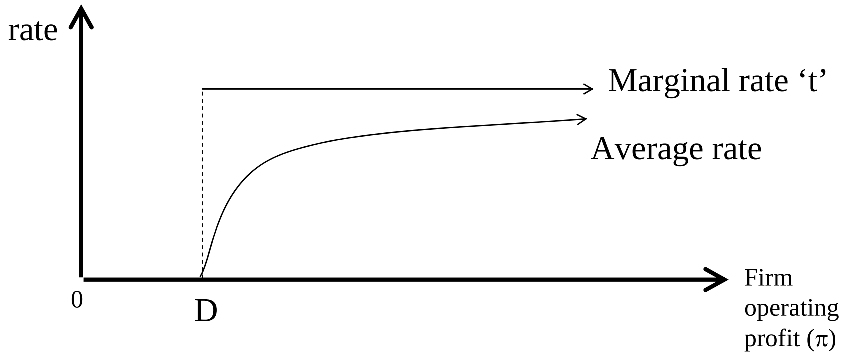

Figure 3: Marginal and average tax rates by firm size.

3.1. ***Taxation without a deductible***

To fix ideas, we first work through the simpler case where D = 0. Recall that the North can charge a higher tax rate and not lose any of its firms, since the big market is characterised by agglomeration rents as in Andersson and Forslid (2003).

Formally, the tax rate that prevents all relocation (so the number of firms in each market is fixed by the endowments K and K^*) is:

(12) $$0=\pi(1-t^{nr})-\pi^*$$

where t^{nr} is the no-relocation tax rate. The aim is to analyses the trade-offs facing a typical high tax nation, i.e. a nation that can only raise its tax rate at the cost of losing some firms to tax-driven relocation. For this reason, we start with a tax rate that is somewhat higher than the rate that would lead to no relocation of firms.

Specifically, consider a tax that is slightly higher than t^{nr} namely t^{nr} plus ε. In this case, the post-tax profit gap $\pi[a](1-t^{nr}-\varepsilon)-\pi^*[a]$ will be negative and some firms would move to the South to escape the tax which now exceeds the agglomeration rent in the big Northern market. The firms that have most to gain from leaving are the ones that sell the most and thus earn the greatest profits. To see this, consider what post-tax profit gap firms would face if none moved. By definition of t^{nr}, the post-tax profit gap, $\pi[a](1-t^{nr}-\varepsilon)-\pi^*[a]$, equals $-\varepsilon\pi[a]$ and so it will be negative for all firms. However, it is much more negative for the most efficient/profitable firms. This is why the most efficient firms will leave first. As these firms leave, they make the Southern market more competitive and the Northern one less, and the exodus continues until post-tax profits are re-equalised in the two regions for the marginal firm.

More formally, all firms with a's between zero and a_L will move to the South to escape the tax, where this threshold is defined by $0=a_L^{1-\sigma}(B+\phi B^*)(1-t)-a_L^{1-\sigma}(\phi B+B^*)$. This can be written as:

(13) $$0=a_L^{1-\sigma}\left\{B(1-t-\phi)-B^*\left(1-(1-t)\phi\right)\right\}$$

where

$$B=\frac{E/\lambda\sigma}{K+K^*a_L^\alpha+\phi K^*(1-a_L^\alpha)},\qquad B^*=\frac{E/\lambda\sigma}{\phi\left(K+K^*a_L^\alpha\right)+K^*(1-a_L^\alpha)}$$

Using the fact that North has a share *s* of both the world's *K* and *E*, and defining the tax factor as $T \equiv 1\text{-}t$, we can solve for a_R, i.e. the end of the relocation range:

$$a_R{}^{\alpha} = \frac{\left((1-s)^2\phi^2 - s(1-\phi) + s^2\right)T - \phi^2 s^2 + (s-\phi)(1-s)}{(1-\phi)(1-s)\left((s(1+\phi)-\phi)T - (1+\phi)s + 1\right)}; \qquad T \equiv 1-t$$

We take this as the starting point of our reform analysis since it reflects the typical situation where the large market has a tax rate set sufficiently above the small nation rate, so that some firms have relocated to escape the tax. At this point, the big Northern market faces a continuous trade off between raising the tax rate and losing more firms. Formally, the range of firms that relocate is those with $a \in [0, a_R]$; this range widens as *t* increases (i.e. *T* falls), as inspection of **(13)** reveals.

3.2. *Taxation with a deductible*

Next we introduce a small deductible that alters the location decisions of all firms. Before the deductible, all firms would have preferred the North – but for the tax. With the deductible, sufficiently small firms pay no tax in North, so they clearly prefer being in the North. The range of such firms that escape taxation in either market consists of those with $a \in [a_U, 1]$ where:

(14) $$D = a_U^{1-\sigma}(B + \phi B^*)$$

where we normalise $K+K^*=1$ without loss of generality and define

$$B = \frac{E/\lambda\sigma}{\phi a_L^{\alpha} + 1 - a_L^{\alpha}}, \qquad B^* = \frac{E^*/\lambda\sigma}{a_L^{\alpha} + \phi(1-a_L^{\alpha})}$$

Notice that the *K*s disappear from the equilibrium *B*'s since firms separate spatially according to the level of their efficiency. All firms with *a*'s less than a_L move to the South to escape taxation. All firms with *a*'s above this threshold move to the North to take advantage of the larger market. The firms big enough to be liable for taxation in the North are affected directly by the deductible and indirectly by the relocation that *D* induces (at the very least, the deductible induces all small firms to relocate to the North). For firms big enough to pay tax in the North, the new post-tax profit gap is $\pi - (\pi - D)t - \pi^*$, which can be written as $a^{1-\sigma}\left\{B(T-\phi) - (1-\phi T)B^*\right\} + (1-T)D$.

It is important to note that firms will now not be indifferent to location even after all adjustment occurs. The term is curly braces will be negative[13] yet the $(1\text{-}T)D$ term is positive. As a consequence, the post-tax profit gap will be strictly negative for firms with very low *a*'s but strictly positive for firms with high *a*'s. The threshold *a* that divides firms into those that prefer the North from those that prefer the South is:

(15) $$0 = a_L^{1-\sigma}\left\{B(T-\phi) - (1-\phi T)B^*\right\} - (1-T)D$$

Another way to phrase this outcome is to note that with *D*, the effective tax rate depends upon firm-efficiency, with the firm-specific rate rising with the firm's efficiency level (i.e. rising as its *a* falls). The effective-tax-rate for firms with the threshold *a* is:

[13] Before $D > 0$ was introduced, **(13)** indicated that the $\{B(T\text{-}\phi)\text{-}(1\text{-}\phi T)B^*\}$ was zero. Since the deductible induces some firms to move to the North, *B* falls and B^* rises, so the term in curly braces must be negative.

(16) $$(1-\frac{D}{\pi[a_L]})t$$

Firms that face an effective rate above this locate in the South since the advantages of producing in the large North are not sufficient to outweigh the tax. For firms facing effective rates below this, the North market is attractive despite the taxation.

To summarise, we write:

Result 1: Taxation with a deductible leads to spatial sorting; all firms that are sufficiently efficient move to the tax-free country while all others concentrate in the high-tax nation. The threshold is defined implicitly by (15).

This spatial sorting has obvious effects on the average industrial productivity of the two nations. In particular, all the most productive firms have escaped Northern taxes by moving to the South.

Result 2: The spatial sorting reduces the average productivity of firms in the taxed country and raises it in the other nation.

Tax Base. Firms that are sufficiently small pay no tax due to the deductible; the threshold size as characterised by the threshold marginal cost a_U is defined by **(14)**. Firms that are sufficiently large pay no taxes since they are located in the South, where the threshold size, as characterised by the threshold marginal cost a_L is defined by **(15)**. The Northern tax base is thus the range of firms with a's between a_L and a_U. Tax revenue in the North is:

(17) $$Tax\ revenue=\int_{a_L}^{a_U}(t\pi[a]-tD)dG[a]$$

where B and B^* are defined as in **(15)**.

The location equilibrium and Northern tax base are illustrated in **Figure 4**.

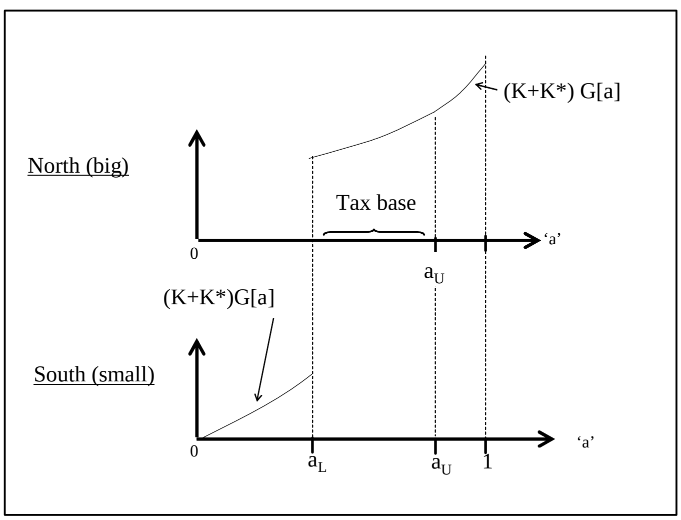

Figure 4: Location Pattern in the Equilibrium.

We next consider tax reforms including the current trends towards lower-rate-wider-base.

4. WIDER-BASE-LOWER-RATE TAX REFORM

To fix ideas, consider a tax reform that leaves unchanged the effective tax rate facing firms with a equal to the threshold a_L. It is useful to re-write the location condition as:

(18) $$0 = \pi[a_L] - \pi^*[a_L] - tax[a_L]$$

The reform is illustrated in **Figure 5**. Recalling that the tax base is determined by two thresholds, the threshold a_U above which firms do not pay taxes since they earn too little and the threshold a_L below which firms do not pay taxes since they are located in the South, we see that the Northern tax is only paid by firms that earn profits between D and $\pi[a_L]$. It is immediately obvious from the diagram that this reform raises tax revenue without inducing any firms to relocate to the low-tax nation. More formally, this is obvious from **(17)** since the average tax rate rises on all the firms paying taxes (those with a's between a_L and a_U) and it increases the range of firms paying tax since D falls.

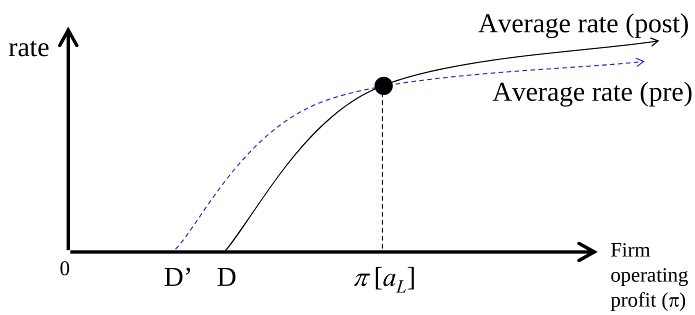

Figure 5: Rate lowering base widening reform.

To summarise:

Result 3: A rate-lowering with base-widening tax reform that keeps the effective rate constant on the marginal firm always increases tax revenue.

More generally, we consider the location impact of changing the tax rate, t, and the deduction, D, separately. Inspection of **(15)** shows that we cannot find a closed form solution for a^L, so the analysis must be by implicit differentiation. Totally differentiating the location condition **(15)** with respect to a_L, t and D:

(19) $$a_L^{-\sigma}\left\{(1-\sigma)\Big(B(T-\phi)+B^*(T\phi-1)\Big)+a_L\left((T-\phi)\frac{dB}{da_L}-(1-T\phi)\frac{dB^*}{da_L}\right)\right\}da_L$$
$$+\left\{a_L^{1-\sigma}(B+\phi B^*)-\sigma D\right\}dT \quad - \quad \left\{\sigma T\right\}dD = 0$$

where

$$\frac{dB}{da_L} = \frac{E(1-\phi)}{\lambda[(\phi-1)a_L^{\alpha}+1]^2}a_L^{\alpha-1} > 0, \qquad \frac{dB^*}{da_L} = -\frac{E^*(1-\phi)}{\lambda[(1-\phi)a_L^{\alpha}+\phi]^2}a_L^{\alpha-1} < 0$$

As long as the tax is not too high, so that T-ϕ>0, the coefficient on da_L is positive.[14] Again if the tax is not too high, some firms will be paying tax so we know a_L is less than a_U, so from **(14)** the coefficient on dT must be positive.[15] The coefficient on dD is also positive.

[14] The term $(1\text{-}T)D$ is positive, so $B(T\text{-}\phi)\text{-}(1\text{-}\phi T)B^*$ must be negative if the sum is to add to zero and since σ>1, the first term of the coefficient is negative; given the signs of dB/da_L and dB^*/da_L, the second terms is also negative if $T>\phi$.

Combining these results on the signs of the coefficients, we have:

(20) $$\frac{da_L}{dt} > 1, \qquad \frac{da_L}{dD} < 1$$

This says that raising the marginal tax rate will induce additional firms to relocate to the South to escape the higher taxes. Raising the deductible has the opposite effect since it lowers the effective tax rate on the marginal firm. Consequently, a lower marginal rate teamed with a lower deductible will attract more efficient/large Southern firms to the North while narrowing the range of small/inefficient non-tax payers. It is plain therefore that the inflow of southern efficient firms to the North induced by the tax reform could raise the average efficiency of Northern industry.

Average productivity and revenue effects. The most productive firms are in the low-tax South (**Figure 4**) so a Northern tax reform that lowers a_L – i.e. that encourages some of the Southern firms to relocate to the North – will have the rather unexpected effect of raising average productivity in <u>both</u> nations. The reason is that the marginal firm with marginal cost a_L would be the most efficient firm in the high-tax North when it moves, but would have been the lowest-productivity firm in the South before it moved. To summarise:

Result 4: Tax reforms that induce relocation into the high-tax region increase average productivity in both countries.

5. GLOBALISATION AND TAX REFORMS

Our model provides a simple and amenable framework for considering a wide range of interactions and tax reforms. The previous section analytically proved that a specific, rate-lowering-base-widening tax reform would raise tax revenue. Here we examine what happens to revenue when the tax scheme is unreformed in the face of freer trade (globalisation).

One of the key points in Andersson and Forslid (2003) is that agglomeration forces produced taxable quasi-rents with the size of the quasi-rents varying with the level of trade freeness in a hump-shaped manner. The quasi-rents are low when trade was either very closed or very open, reaching their maximum at intermediate levels of trade freeness. Since the basic agglomeration forces are in effect in our model, we also see a hump-shaped variation in quasi-rents, however, in our model firms relocate in reaction to such changes. In relocating, they alter the tax base and thus tax revenue. The net result is that globalisation – as measured by greater trade freeness (higher ϕ) – has a hump-shape impact on tax revenue for a given tax scheme (i.e. fixed t and D).

Numerical simulation of the tax-revenue impact of freer trade is shown in **Figure 6** for a constant t and D.[16] The bottom curve shows the impact for an initial level of D and t. Starting from a low level, a rise in trade freeness ϕ would increase the agglomeration rents in the North if there were no firm relocation to the Northern market. The incipient profit shift, however, induces more firms to move to the big, high-tax Northern market, so the net result is a wider tax-base and higher tax revenue as shown. Specifically, the offsetting relocation

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[15] Since $a_U^{1-\sigma}(B+\phi B^*)-\sigma D=0$, and $a_U > a_L$, then $a_L^{1-\sigma}(B+\phi B^*)-\sigma D>0$ since σ>1.

[16] The parameters we choose for the simulation are σ=2, ρ=2, E=0.6, E^*=0.4. The initial tax scheme involves t=0.3 and D=2; the reformed tax scheme involves t=0.2 and D=1.

implies that the level of profitability changes little in the North, so the tax base's upper threshold, a_U, changes little, but a_L falls.[17]

The rising attractiveness of the North in the face of freer trade, however, begins to fade for levels of ϕ beyond the peak of the hump. This is where the agglomeration rents in the North would begin to decline if there were no offsetting relocation. As before, the relocation induced by the incipient change in profitability reduces the tax base and results in lower tax revenue. The figure shows ϕ's up to the point where $1\text{-}t = \phi$. Beyond this point, there is no advantage to being in the big, high-tax nation for any tax-paying firm, so the revenue drops to zero.

It may be useful to step outside the model and conjecture that the forces at work in our simple simulation would result in tax rate changes that bear some resemblance to actual events. In this first phase of globalisation (the ϕ's corresponding to the upward sloped part of the revenue curve), the Northern government might decide to raise the tax rate in reaction to its increased attractiveness. As globalisation proceeds even further, the Northern government finds it increasingly difficult to keep its tax rates high without losing firms and so decides to cut rates. Figure 6 also shows the same calculation for a reformed tax structure that involves smaller D and t (top curve). Note that the upper limit for ϕ is now higher, but the revenue is everywhere higher for this wider-base-lower-rate scheme.

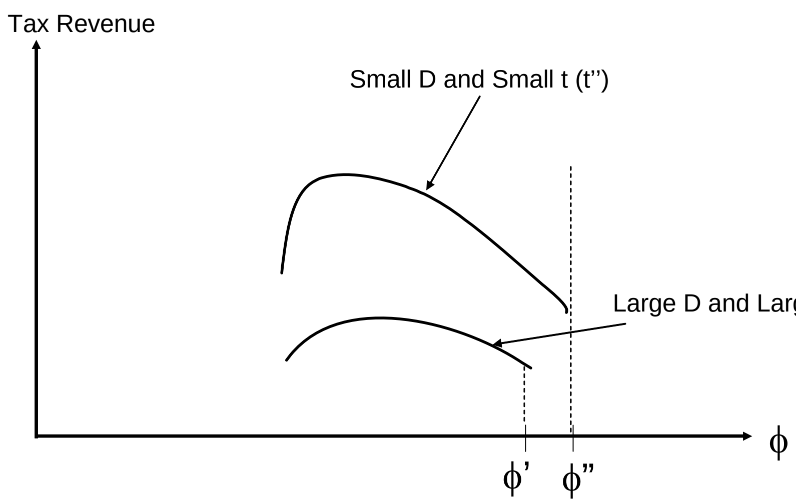

Figure 6: Globalisation and hump-shaped tax revenue.

One of the crucial features in our model is firm heterogeneity, so we briefly consider the impact of varying the degree of heterogeneity as measured by ρ. We focus on the impact of heterogeneity on the link between tax-rate cuts and tax revenue. The numerical results, shown in **Figure 7,** are generated for the same values as those in footnote 16.

According to the well-known properties of the Pareto distribution, **(2)**, firms become more heterogeneous as ρ falls. What the diagram shows is that greater heterogeneity increases the responsiveness of revenue to rate changes. Intuitively, a low ρ means that a higher fraction of industry output and profits is concentrated in the hands of the most productive firms. Thus as the tax rate attracts more firms back to the North, it has a bigger impact on the tax base and thus on revenue. In short, in industries where firms are more heterogeneous, tax reforms are more effective in the sense of boosting tax revenue.

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[17] Freer trade affects both thresholds but has a much large impact on a_L since a_L depends upon the difference in profitability in the two nations, while a_U depends only upon profitability in the North; see **(14)** and **(15)**.

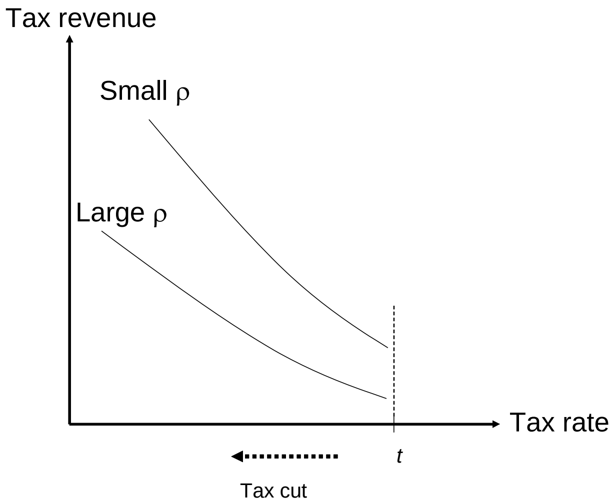

Figure 7: Firm heterogeneity and tax revenue.

6. CONCLUSION

This paper proposes a simple model in which agglomeration forces are present and firms are heterogeneous. Both extensions are useful in allowing the international tax competition literature to consider a broader range of effects than has hitherto been possible. The presence of agglomeration forces allows consideration of the international trade competition issues raised in Andersson and Forslid (2003) and Baldwin and Krugman (2004) in the context of identical firms. Allowing for heterogeneity permits a given tax scheme to have a different effect on the relocation decision of small and big firms, with the biggest firms being the most likely to relocate to escape high-taxes imposed in the big nation.

The model provides a simple and amenable framework for considering a wide range of interactions. The policy experiments we conduct in this paper concern 1) the impact of a rate-cutting-base-widening reform, and 2) the impact of freer trade (i.e. globalisation) on the tax competition. The model should also help inform future empirical research concerning the impact of tax reforms on tax revenue, firm location and average productivity using firm level data sets.

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