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# TAX REFORM, DELOCATION AND HETEROGENEOUS FIRMS

Richard Baldwin
Toshihiro Okubo

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## ABSTRACT

The standard international tax model is extended to allow for heterogeneous firms when agglomeration forces are important thus allowing us to study the relocation effects of taxes that vary according to firm size. We show that allowing for heterogeneity permits a given tax scheme to have an endogenously different effect on the location decision of small and big firms, with the biggest firms being endogenously more likely to relocate in reaction to high taxes. We show that a reform which flattens the tax-firm-size profile can raise tax revenue without inducing any relocation.

Richard Baldwin
Graduate Institute, Geneva
Cigale 2
Lausanne Switzerland 1010
and CEPR
and also NBER
baldwin@graduateinstitute.ch

Toshihiro Okubo
RIEB Kobe University
2-1, Rokkodai cho, Nada-ku, Kobe,
657-8501 JAPAN
okubo@rieb.kobe-u.ac.jp

# I. INTRODUCTION

International tax competition has been an important concern for decades, but the heightened mobility of firms in recent years has drawn renewed interest. The theoretical literature has responded by broadening the range of models with which the effects of international tax differences can be studied.

The purpose of our paper is to contribute to this broadening by developing an analytically tractable model in which we can study the effects of differential international taxes when the tax schemes have firm-specific dimensions as well as nation-specific dimensions. Specifically, our economic model allows for 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 latter allows us to consider tax schemes where the tax rate varies by firm size.

That corporate taxation varies by firm size has been widely documented since the famous "Zimmerman hypothesis" (Zimmerman 1983) which asserted that political costs explained why large US corporations paid higher effective tax rates (ETR). See Wilkie and Limberg (1990) for an evaluation of the early empirical work on US data. Recent empirical research reveals that the corporate-size-ETR link is complex – varying across nations, time periods and sectors. OECD (2003), using micro-data from Canada and Belgium, found that smaller firms had significantly lower ETRs. Similar links to size have been documented by Ahmed (2004) and Holland (1998) for the UK, and Crabbé (2006) for Italy. Using Belgian firm-level data, Vandenbussche, Janssen and Crabbé (2006) show larger firms have higher ETRs. Detailed data has been used to establish similar facts for developing nations (Baer, 2002; Shome, 2004;

Auriol and Warlters, 2005).[2]

Given that this link between firm size and tax rates exists in nations' tax policy, it would seem useful to extend the theory to allow consideration of the location effects of taxes linked to firm size.[3] Such reforms cannot be fully explored theoretically in the classic international tax competition model as it assumes homogenous firms. In particular, we show that allowing for heterogeneity permits a given tax scheme to have an endogenously different effect on the location decision of small and big firms, with the biggest firms being endogenously more likely to relocate in reaction to high taxes.

More specifically, the inclusion of firm heterogeneity permits three extensions of the theoretical analysis in the literature. First, it allows the model to capture the possibility that large/profitable firms are endogenously more likely to re-locate internationally for tax reasons. Second, it allows us to consider the revenue implications of reforms by the high-tax country that tilt the size-tax-burden profile in a setting where there is a smooth trade-off between raising tax rates and keeping firms at home. Third, since firm-size is associated with firm-level productivity in our model à la Melitz (2003), tax reform has an impact on the average productivity of firms in each nation. In particular, a reform that flattens the firm-size-ETR link tends to bring the most productive firms 'back home', thus raising average industry productivity.

The inclusion of heterogeneous firms is not entirely new to the international tax literature, since it has been already analysed by the important papers of Burbidge, Cuff and Leach

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[2] 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.

[3] Indeed, many nations include firm size as one of the elements in their micro-simulation tax model (Ahmed 2006), reflecting, inter alia, the pervasive use of special tax provisions for small and medium enterprises.

(2004, 2006). Their model, however, is quite different from ours, being a more straightforward extension of the basic tax competition model (Wilson 1986) in that it assumes perfect competition. Moreover, firm productivity differences are both firm-specific and location-specific, so a firm's productivity changes as it re-locates internationally; the authors assume some firms have a comparative advantage in one country, while other firms have it in the other. This firm-level-nation-specific productivity differences create a quasi-rent that can be taxed up to a point without firms relocating away from the higher tax. As a result, tax rates could be higher in one nation without driving out all firms – even with perfect competition.

The focus of Burbidge, Cuff and Leach (2006) is also different. They concentrate on 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 (via transfer pricing) related to foreign direct investment (FDI). 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 allowed.

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 a simple tax scheme where the ETR varies with firm size. Section 5 considers the impact of globalisation (i.e. freer trade). The last section provides our concluding remarks.

# II. 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). Specifically, we assume two nations (North and South), two sectors (manufacturing, M, and the numeraire sector, A) and two factors (Capital and

Labour). The manufacturing sector consists of firms that each produce a differentiated variety and compete in a monopolistic competition setting.

The tastes of the representative consumer in each nation are quasi-linear:

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

where $C_M$ and $C_A$ are, respectively, consumption of the composite of manufacturing sector varieties and consumption of the numeraire (good A); $\sigma$ denotes the constant elasticity of substitution between any two M-sector varieties, $\mu$ reflects the strength of preferences for manufactured goods, and $\Theta$ is the set of all varieties consumed.

Quasi-linear utility preferences are a well-known artifice for removing income effects. In economic geography models, such effects result in what is called ‘expenditure switching’ and demand-linkages that can greatly complicate the analysis – often to the extent that the model becomes analytically intractable. Since such effects merely amplify the agglomeration effects, quasi-linear preferences are useful in that they allow us to leave expenditure switching aside while we concentrate on core interactions.

These preferences also allow us to deal simply with issues of tax revenue. We assume all tax revenue is returned lump-sum to citizens. With quasi-linear preferences, it is spent only on the numeraire A-good on the margin, so the international division of tax revenue has no impact on the relative market size (manufactures) that matters for firms’ location decisions.

Firm heterogeneity in our model stems only from differences on the supply side. Each manufacturing firm requires a unit of capital as its fixed cost (a ‘blueprint’) and uses only labour in the variable costs. However, firms have heterogeneous efficiency; each blueprint implies a firm-specific marginal production cost (even though the Dixit-Stiglitz varieties are symmetric in the utility function). Thus firm *i*’s marginal cost is given by the wage rate ‘*w*’ times its firm-specific unit-labour coefficient, denoted as '$a_i$' ('$a_i$' is the inverse of the firm-$i$'s efficiency). As the '$a_i$' is associated with the firm's blueprint, a firm's marginal cost does not vary with location (i.e. the unit-labour input coefficient is firm-specific, not nation-specific).

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:

$$G[a] = (a / a_0)^{\rho}, \qquad 1 \equiv a_0 \geq a \geq 0, \quad \rho \geq 1 \qquad \textbf{(2)}$$

Here $\rho$ is the 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.

The thrust of our analysis concerns the impact of taxes on firms' location decisions. 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 nations. 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. Recalling that there is one unit of capital per firm, so each nation's mass of M-sector firms equals its capital stock, the distribution in the North is $K\,G[a]$; in the South it is $K^*$G[$a$], where $K$ and $K^*$ are the North's and South's endowment of capital.[4]

The numeraire sector is as simple as possible; it is marked by constant returns, perfect competition, costless trade, and it employs only labour. Trade in manufactures, by contrast, is subject to 'iceberg' trade costs; firms must ship $\tau > 1$ units of their good in order to sell one

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[4] 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).

unit in the other nation.

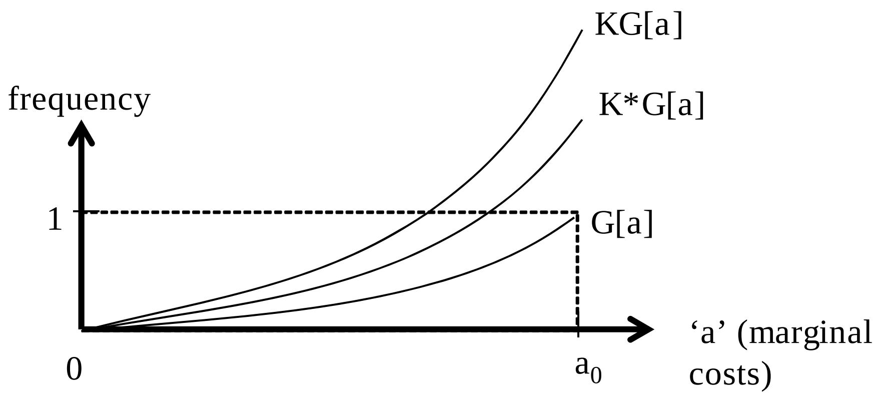


**Figure 1: Endowed distribution of capital and marginal costs in North and South.**

Finally, we describe our assumptions on factor mobility, the determination of factor rewards, and firms' location decisions. The wage 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. operating profit). Due to firm heterogeneity, different firms earn different equilibrium rewards on their capital/blueprint. As in Melitz (2003), the most efficient firms sell the most and earn the highest reward on their capital.[5] Thus in our model there is no distinction between a manufacturing firm's operating profit and the reward to its capital; a tax on a firm's income is a tax on its firm-specific capital.

In keeping with the classic tax competition setup (Wilson 1986), capital is assumed to be mobile internationally. Capital, however, is owned by immobile labour (specifically, workers hold a globally diversified portfolio of all firms). Plainly we could relax many of these assumptions and still solve the model, but doing so would force us into numerical simulation of the equilibrium.

Recalling that each firm is associated with a particular unit of capital, capital mobility is

[5] 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.

synonymous with firm mobility. To maximise their owners' income, capital/firms seek to locate in the nation that offers the highest post-tax reward to capital (which is the highest post-tax operating profit in our simple model). The capital/firm location choice is independent of cost of living considerations since capital owners are not internationally mobile and thus face the same equilibrium cost of consumption regardless of their capital's location.

### *Intuition for the basic agglomeration forces*

Most of the basic forces in the model are not directly related to the heterogeneity of firms. The manufacturing sector 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 firms want to be far from their competitor (other things equal), this is a dispersion force. 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 low price and thus sell more and earn higher operating profit. 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. The thrust of this is that large firms tend to agglomerate preferentially in the large nation (all else equal). 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.

### *Intermediate results*

Utility maximisation generates the familiar CES demand functions in the manufacturing sector. For example, the demand for variety $j$ in the North market is:

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

where $\tilde{B}$ can be thought of as the "per-firm demand" that firms take as given under Dixit-Stiglitz competition; $E = \mu$ is expenditure (we use $E$ for notational convenience), and $P$ is the usual CES price indices in the Northern market ($\Theta$ is the set of all varieties consumed). South's demands are isomorphic.

The simplified numeraire sector facilitates the analysis substantially. Constant returns, perfect competition and zero trade costs equalise nominal wage rates across nations and we choose the units of labour such that $w$=$w$*=1.[6] Consequently, all differences in manufacturing firms' marginal costs stem from their $a$'s; wage costs are never an issue in firms' location decisions in our simple model.

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: $p_j = a_j/(1-1/\sigma)$, and that 'mill pricing' is optimal, so the price of variety-$j$ in the other market is just $\tau$ times the producer

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[6] This holds for all possible equilibriums only if the size difference between the nations is not too great. One easy sufficient condition is that the small nation is big enough to accommodate all industry and still have some labour leftover to employ in the numeraire sector.

price $p_j$. A second well-known property of Dixit-Stiglitz competition is that operating profit of firm-$j$ equals $1/\sigma$ times the firm's revenue.[7] The firm-specific revenue of a typical North-based firm in the Northern market is just the consumption given by **(3)** times the 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:

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

where $\tilde{B}^*$ is the Southern version of $\tilde{B}$ in **(3)**, and $\phi$ is the parameter that gauges the 'freeness' of trade (recalling that $1\text{-}\sigma < 0$, $\phi$ 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 **(3)** and **(4)** play important roles in the subsequent analysis. First, all firms earn positive operating profit in equilibrium (this is their reward to capital, i.e. Ricardian rent). Second, since $\sigma > 1$, the most efficient firms – i.e. those with low marginal cost and thus with low prices – are the most profitable. Third, a North firm that finds it optimal to charge $p$ when it is located in the North would find it optimal to charge the same $p$ if it relocated to the South, so its operating profit when located in the South is:

$$\pi^*[p] = p^{1-\sigma}\left(\phi\tilde{B} + \tilde{B}^*\right)/\sigma \tag{5}$$

The difference between operating profit when the firm is North-based, **(4)**, and South-based, **(5)**, is driven by the trade cost as reflected in the freeness of trade parameter $\phi$. 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.

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

## *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. To study relocation, we start from the initial situation without relocation, and allow capital/firm mobility. From **(4)** and **(5)**, the firm-specific difference between operating profit earned when located in the North and the South is:

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

Plainly the sign of the gap turns on whether the per-firm demand in the Northern market, $\tilde{B}$, is bigger than the per-firm demand in the Southern market, $\tilde{B}^{*}$. These, in turn, depend upon the location of firms as per the definition of the $\tilde{B}$'s since trade costs imply that competition is somewhat localised; see **(3)**.

Starting from an initial situation where no firms have moved yet, the masses of firms located in the North and South are $K$ and $K$* respectively. To calculate the $P$'s and $\tilde{B}$'s, we change variables of integration so that the Northern CES price index integral is:

$$P^{1-\sigma}=\left(1-\frac{1}{\sigma}\right)^{\sigma-1}\int_{a=0}^{1}\left(Ka^{1-\sigma}+\phi K^{*}a^{1-\sigma}\right)dG[a] \qquad \textbf{(7)}$$

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

$$P^{1-\sigma}=\left(1-\frac{1}{\sigma}\right)^{\sigma-1}\lambda\left(K+\phi K^{*}\right),\quad (P^{*})^{1-\sigma}=\left(1-\frac{1}{\sigma}\right)^{\sigma-1}\lambda\left(\phi K+K^{*}\right);\qquad \lambda\equiv\frac{\rho}{1-\sigma+\rho}>0 \qquad \textbf{(8)}$$

where $\lambda$ is a collection of parameters that is positive assuming a regularity condition, namely $\alpha\equiv(1-\sigma+\rho)>0$, which we maintain to ensure the integrals converge.

To sign the profit gap in **(6)**, we use **(8)** and the fact that North is a scaled up version of South, so that its share of world expenditure equals its share world capital (denoted as $s$).

Rearranging:

$$\frac{\tilde{B}}{\tilde{B}^*} \equiv \frac{1+\phi s/(1-s)}{1+\phi(1-s)/s} > 1; \qquad s \equiv \frac{E}{E+E^*} = \frac{K}{K+K^*} \qquad \textbf{(9)}$$

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. $\tilde{B} > \tilde{B}^*$.[8] 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 is larger in the North with trade but immobile firms. The trade literature has explored this issue extensively in the context of 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. Without taxes, 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

[8] Note that our assumption that the North is bigger, but is endowed with the same capital-labour ratio, means that $E/K=E^*/K^*$ .Consequently, we can use **(8)** to rewrite $\tilde{B}$ as $(E/\lambda K)/(1+\phi K/K^*)$ and $\tilde{B}^*$ as $(E^*/\lambda K^*)/(\phi+K/K^*)$. Since $0<\phi<1$ and $K>K^*$ we see that $\tilde{B} > \tilde{B}^*$.

usual logic (as suggested by standard quadratic cost adjustment mechanisms), 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.[9]

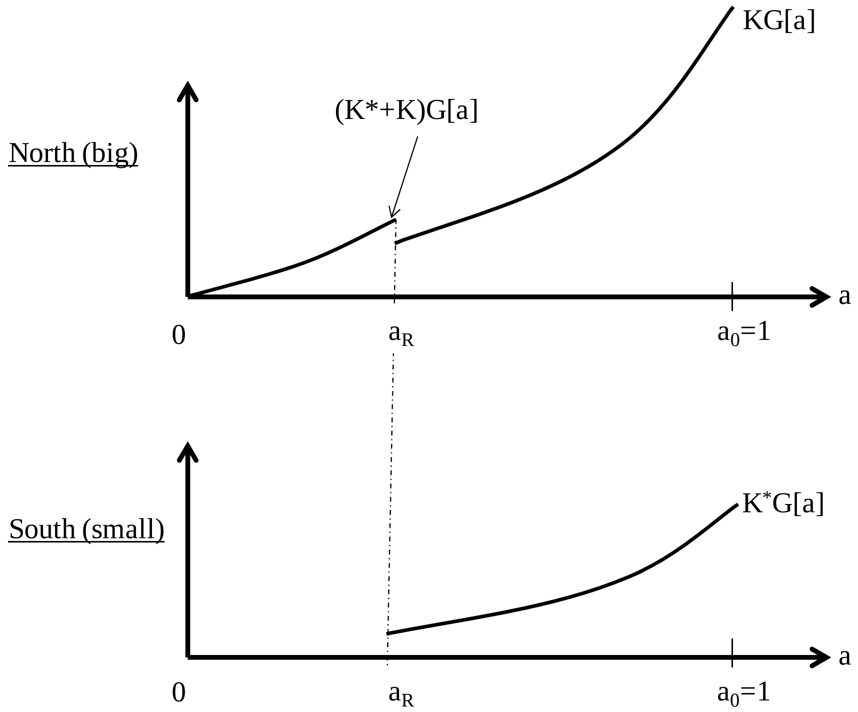


**Figure 2: Geographic distribution of firm efficiency with capital mobility; no tax case.**

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

$$1 = \tilde{B}[a_R]/\tilde{B}^*[a_R] \qquad \textbf{(10)}$$

**Figure 2** illustrates the equilibrium distribution of firms when capital mobility is allowed. What we see is that the North has a disproportionate share of the world's industry, and a disproportionate share of the world's most productive firms.

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[9] 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.

Note that the $\tilde{B}$ 's depend upon the $E$'s and the $P$'s. The $E$'s are invariant to firm relocation due to our simplifying assumptions, but the $P$'s adjust with firm location. For the Northern index for example:

$$P^{1-\sigma} = \left(1-1/\sigma\right)^{\sigma-1}\left\{K\int_0^1 a^{1-\sigma}dG[a] + K^*\{\int_0^{a_R} a^{1-\sigma}dG[a] + \phi\int_{a_R}^1 a^{1-\sigma}dG[a]\right\} \qquad \textbf{(11)}$$

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 (recall that $a = a_0 = 1$ is the maximum marginal cost). Using **(2)** to solve the integrals:

$$P^{1-\sigma} = (1-\frac{1}{\sigma})^{\sigma-1}\lambda\left(K + K^*\left(a_R^\alpha + \phi(1-a_R^\alpha)\right)\right); \qquad \alpha \equiv 1-\sigma+\rho > 0 \qquad \textbf{(12)}$$

Notice that since $\phi < 1$ and $\alpha > 0$, the Northern price index falls as $a_R$ rises. This means that Northern welfare tends to fall as firms relocate to the South; a fact that will come into play when considering government motives. Using this solution for $P$ and the corresponding formula for $P^*$, **(10)** becomes:

$$1 = \frac{E/\left(K + K^* a_R^\alpha + \phi K^*(1-a_R^\alpha)\right)}{E^*/\left(\phi(K + K^* a_R^\alpha) + K^*(1-a_R^\alpha)\right)} \qquad \textbf{(13)}$$

Solving this tells us that $a_R$ equals:

$$a_R{}^\alpha = \frac{2\phi}{(1-\phi)(1-s)}(s-\frac{1}{2}) \qquad \textbf{(14)}$$

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

From **(14)** it is clear that for sufficiently free trade, i.e. $\phi$ near 1, $a_R$ will be 1, i.e. all firms will have left the South. To keep the analysis interesting, we restrict our investigations to levels of

$\phi$ that do not result in all firms being in the North. Simple calculation reveals the threshold $\phi$ is $(2s-1)/\{(1-\phi)(1-s)\}<1$. We turn now to including capital taxation.

# III. 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 South's capital tax rate is zero so the Northern tax rate can be thought of as the tax difference.

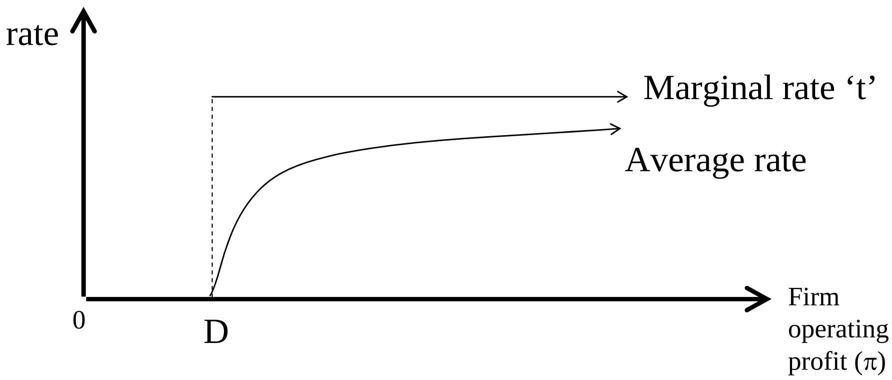


**Figure 3: Marginal and average tax rates by firm size.**

Corporate taxation is extremely complex. To link firm-size and effective tax rates as simply as possible in the model, we assume a very simple tax scheme involving a flat tax rate, *t,* that is applied to a firm's operating profit beyond a given deductible, *D*, according to the source principle (namely, firms pay the tax rate of the nation in which they are producing and pay it on operating profits earned worldwide). Thus the Northern tax applies to all firms located in the North regardless of their capital's nationality. Plainly there are many other tax schemes we could consider, but we postpone that analysis to future work. Recall that each firm is associated with a unit of capital and capital's reward is the firm's operating profit, so this tax scheme is both a capital tax and a highly simplified corporate income tax.

Specifically, taking account of *t* and *D*, the tax paid by a typical North-based firm with marginal costs of '*a*' is:

$$tax[a] = \max\left\{\left(\pi[a] - D\right) t,\ 0\right\} \qquad \textbf{(15)}$$

Plainly the tax paid is increasing in the size of the firm (i.e. decreasing in its marginal cost, *a*) assuming $D > 0$; the effective tax rate increases with firm size but sufficiently small firms pay no tax. The implied marginal and average tax rates are illustrated in **Figure 3**.

Tax revenue is returned lump-sum to workers; this has no effect on market sizes due to the quasi-linear preferences.

## *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), and Baldwin and Krugman (2004). Formally, the tax rate that prevents all relocation (so the number of firms in each market is fixed by *K* and *K**) is:

$$0 = \pi(1 - t^{nr}) - \pi^{*} \qquad \textbf{(16)}$$

where $t^{nr}$ is the no-relocation tax rate. The aim is to analyse 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.[10]

Specifically, consider a tax that is $t^{nr}$ plus $\varepsilon > 0$. 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

[10] By solving an equation like **(17)** for *t*, imposing no relocation, i.e. $a_L = 0$, we see that $t^{nr}$ is given by the very simple expression $\phi/(s(1-\phi^2)+\phi^2)$.

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 $-\varepsilon\pi[a]$ so it will be negative for all firms. However, it is more negative for the most efficient/profitable firms (since they have higher $\pi[a]$'s). This is why the most efficient firms 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 nations for the marginal firm.

More formally, all firms with *a*'s below a lower threshold, denoted as $a_L$, would move to the South to escape the tax, where $a_L$ is defined by:

$$0 = a_L^{1-\sigma}\left(B+\phi B^*\right)(1-t) - a_L^{1-\sigma}\left(\phi B + B^*\right);$$
$$B = \frac{E/\lambda}{K(1-a_L^\alpha)+\phi\left(Ka_L^\alpha + K^*\right)}, \quad B^* = \frac{E^*/\lambda}{\phi K(1-a_L^\alpha)+Ka_L^\alpha + K^*} \qquad \textbf{(17)}$$

where *B is* like $\tilde{B}$ but without the constant mark-up term. 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 $a_L$, i.e. the end of the relocation range:

$$a_L{}^\alpha = \frac{T\left((1-s)^2\phi^2 + s(1-s+\phi)\right) - \phi^2 s^2 - (s+\phi)(1-s)}{s(1-\phi)\left(T\left(s(1+\phi)-\phi\right)+1-(1+\phi)s\right)} \qquad \textbf{(18)}$$

The situation is illustrated in **Figure 4**. We take this as the starting point of our reform analysis since it reflects an interesting trade-off; a 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 $a \in$

$[0,a_L]$; this range widens as $t$ increases (i.e. $T$ falls), as inspection of **(18)** reveals.

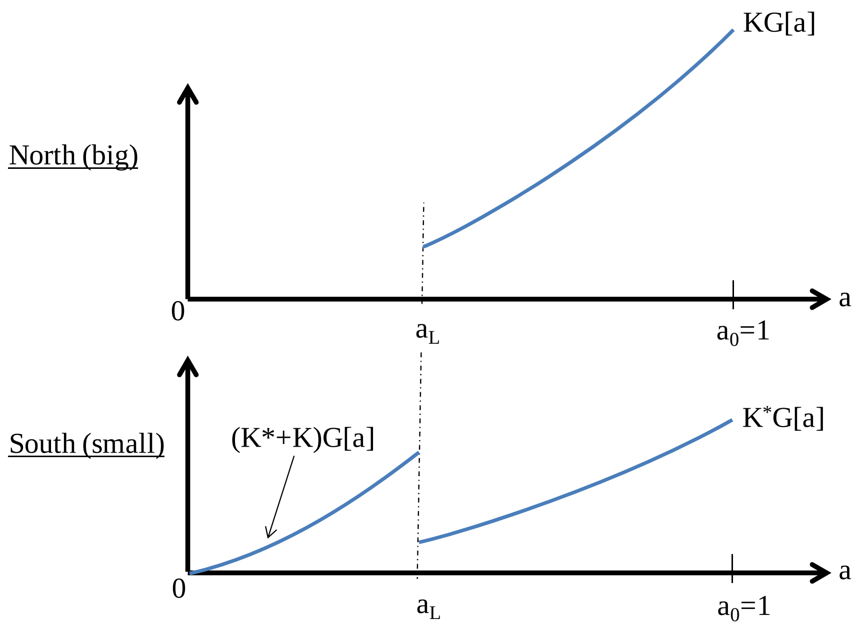


**Figure 4: Distribution of firm efficiency, tax without deductible case.**

## *Taxation with a deductible*

Next we introduce a deductible that affects firms' location decisions. Before the deductible, all firms would have preferred the North – but for the tax. With the deductible, sufficiently small firms (those with high $a$'s) pay no tax in North, so they clearly prefer being in the North. This introduces a second relocation threshold defined by the deductible; firms with sufficiently high marginal costs that earn profits that are less than $D$ and thus escape taxation in either market consist of those with $a \in [a_U,1]$ where:

$$D = a_U^{1-\sigma}(B + \phi B^*); \quad B = \frac{E/\lambda}{\phi a_L^{\alpha} + (1 - a_L^{\alpha})}, \quad B^* = \frac{E^*/\lambda}{a_L^{\alpha} + \phi(1 - a_L^{\alpha})} \qquad \textbf{(19)}$$

normalising $K$+$K^*$=1 without loss of generality. Notice that the $K$'s disappear from the equilibrium $B$'s since firms separate spatially according to the level of their efficiency. All the most efficient firms – those 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 unaffected directly by the deductible, but they are indirectly affected by the relocation that *D* induces. We turn now to finding the threshold for this relocation, with $D > 0$, namely $a_L$.

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 $a^{1-\sigma}\left\{B(T-\phi)-(1-\phi T)B^*\right\}+(1-T)D$. If no relocation took place, the term in curly braces would be negative.[11] Yet the (1-*T*)*D* term is positive, so we know that making *D* positive while not changing *t* will make the post-tax profit gap strictly negative for the most efficient firms (those with very low *a*'s). The lower threshold that divides firms into those that now prefer the North from those that prefer the South is:

$$0 = a_L^{1-\sigma}\left\{B(T-\phi)-(1-\phi T)B^*\right\}-(1-T)D \qquad \textbf{(20)}$$

Another way to understand why complete sorting occurs 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. the ETR rises as a firm's '*a*' falls). The effective-tax-rate for firms with a marginal cost equal to the threshold $a_L$ is:

$$(1-\frac{D}{\pi[a_L]})t \qquad \textbf{(21)}$$

Firms that face an effective rate above this – those with *a*'s below $a_L$ – 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. The location equilibrium and Northern tax base are illustrated in **Figure 4**.

It is important to note that firms are not, in equilibrium, just indifferent to their location –

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[11] Before $D > 0$ was introduced, **(17)** indicated that the $\{B(T-\phi)-(1-\phi T)B^*\}$ 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.

except of course, the marginal firms which we define as those whose $a$'s equal $a_L$. Firms that are smaller (i.e. those with $a > a_L$), strictly prefer North, either because they can enjoy easy access to the large market and pay no tax (those with $a$'s above $a_U$), or because they find that the advantages of accessing the large market without trade costs more than outweigh the tax disadvantages (those with $a$'s above $a_L$ but below $a_U$). The most efficient firms (those with $a$'s below $a_L$) strictly prefer the South since the trade-cost disadvantages they face when selling to the large market are more than outweighed by the tax advantages of producing in the South.

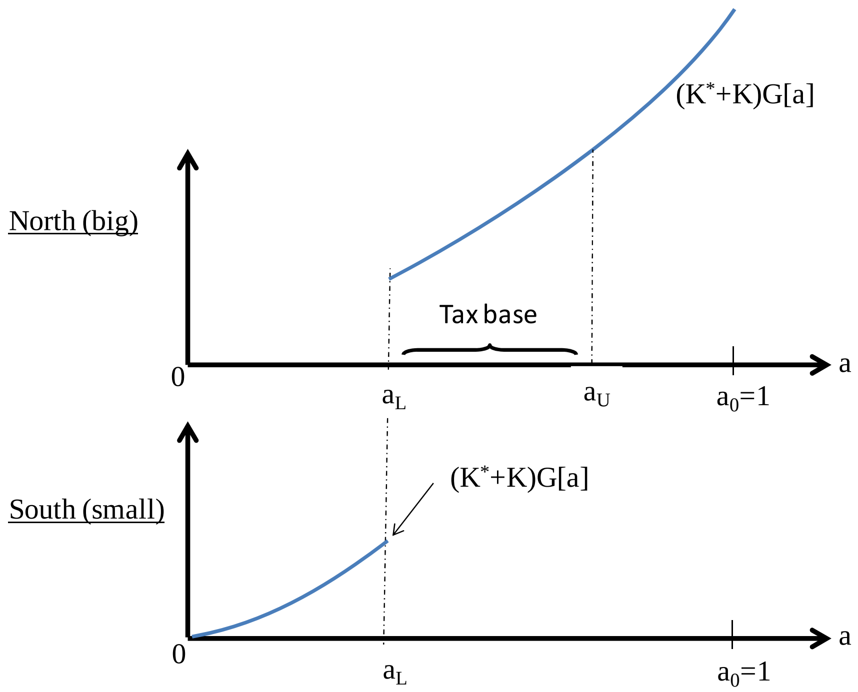


**Figure 5: Distribution of firms with tax and deductible.**

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 (20) with the *B*'s from (19).**

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.**

Turning to tax revenue considerations, recall that sufficiently small firms pay no tax (due to *D*) with the threshold size characterised by the upper threshold on marginal cost $a_U$; see **(19)**. Firms that are sufficiently large pay no taxes since they are located in the South, where the threshold size is characterised by the threshold marginal cost $a_L$ is defined by **(20)**. The Northern tax base is thus the range of firms with *a*'s between $a_L$ and $a_U$, so tax revenue is:

$$\text{Tax} \quad \text{Revenue} = \int_{a_L}^{a_U} \left( a^{1-\sigma} \left(\frac{B + \phi B^*}{\sigma}\right) - tD \right) dG[a] \qquad \textbf{(22)}$$

where *B* and *B** are defined as in **(19)**. We next consider a tax reforms that lowers the rate and the deductible thus flattening the firm-size-ETR relationship.

# IV. WIDER-BASE-LOWER-RATE TAX REFORM

We consider a very stark tax reform, one that leaves unchanged the effective tax rate facing marginal firms, i.e. those with *a*'s equal to the threshold $a_L$. Specifically, the reform changes *D* and *t* such that the effective rate on the marginal firm, namely **(21)**, is unchanged. In studying the effects, it is useful to re-write the location condition **(20)** as:

$$0 = \pi[a_L] - \pi^*[a_L] - tax[a_L] \qquad \textbf{(23)}$$

where $tax[a]$ is the function defining the tax paid as a function of marginal cost and $tax[a_L]$ indicates the tax that a marginal firm would pay. The reform is illustrated in **Figure 6**.

In reading the diagram, the first point is that the tax rate on marginal firms is unchanged by construction. This implies that the reform will induce no relocation of firms, and this, in turn, implies that the *B*'s in the definition of $a_U$, **(19)**, will not change. The second point is that the Northern tax is only paid by firms that earn profits between *D* and $\pi[a_L]$. Firms earning less than $D$ earn less than the deductible while firms earning more than $\pi[a_L]$ are located in the South and so pay no Northern tax.

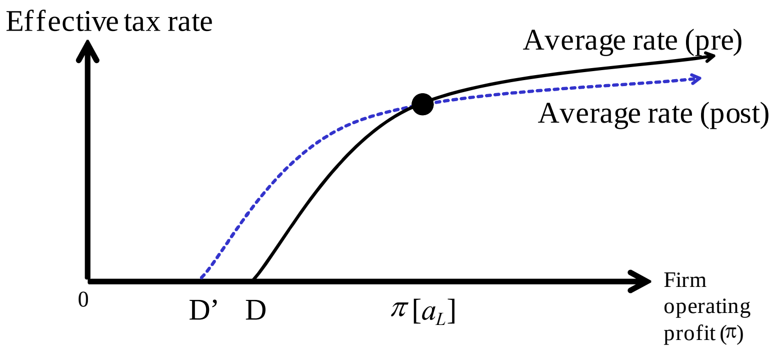


**Figure 6: Rate lowering base widening reform.**

Given this, it is clear that this reform will lead some North-based firms to begin paying taxes; they will not leave since they were not just indifferent to location before the reform. It is immediately obvious from the diagram that this specific tax reform raises tax revenue without inducing any firms to relocate to the low-tax nation. More formally, this is obvious from **(22)** 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. 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.**

## *What is the government's objective function?*

The analysis up to this point has been entirely positive in the sense that it would be valid regardless of government objectives. Taxes were not chosen by governments in our analysis. It may be useful, nevertheless, to clarify whose welfare we have in mind when discussing the impact of the reform. Theorists have a wide range of choices when it comes to government objective functions, but the simplest is the utilitarian approach where the government is concerned with the welfare of the representative citizen. The Northern indirect utility function corresponding to **(1)** is:

$$V = \mu(\ln\mu - 1) + Y - \ln P\,;$$
$$Y = L + K\int_0^1(\pi[a] - tax[a])dG[a] + K^*\int_0^1(tax[a])dG[a] + K\int_0^1(tax[a])dG[a] \qquad \textbf{(24)}$$

where $Y$ is Northern income consisting of labour income (first term), post-tax domestic capital income (second term) and taxes (third and fourth terms). Taxes paid by domestic capital, $K$, are a wash (recall that tax revenue is returned to the representative citizen who owns all the labour and capital), so reforms will be welfare improving to the extent that they boost Northern taxation of Southern capital, $K^*$, or lower the Northern price index.

For the situation at hand, with an initial tax equal to $t$ and deductible equal to $D$, and a reform that changes these to leave the ETR for marginal firms unchanged, we have complete spatial separation of firms by size. This enables simple analytic solutions. Recalling that the denominator of $B$ is the Northern price index raised to the 1-$\sigma$, and employing the $B$ from **(19)**, **(2)** and **(22)** but weighted only by the mass (number) of Southern firms located in the North, we solve the integrals to get:[12]

$$P = \left(\phi a_L^\alpha + 1 - a_L^\alpha\right)^{\frac{1}{1-\sigma}}, \quad \mathrm{R}^* = K^*\left(\frac{\mu}{\phi a_L^\alpha + 1 - a_L^\alpha} + \frac{\phi\mu^*}{a_L^\alpha + \phi(1 - a_L^\alpha)} - tD\right)\frac{a_U^\alpha - a_L^\alpha}{\sigma} \qquad \textbf{(25)}$$

where $R^*$ is tax collected from Southern firms located in the North. In the case at hand (complete spatial segmentation and a reform that does not change the range of Southern firms in the North), we can by inspection see that the specific reform improves the Northern government's objective function (i.e. Northern welfare). Specifically, the reform increases the range of Southern firms that pay tax (by raising $a_U$) without altering the number (mass) of Southern firms in the North.

Given the critical role of $R^*$ it is worth pointing out that Figure **5** and **Figure 6** can be used to

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[12] The expression to integrate is $\mathrm{R}^* = \left(\frac{E/\lambda}{\phi a_L^\alpha + (1 - a_L^\alpha)} + \frac{\phi E^*/\lambda}{a_L^\alpha + \phi(1 - a_L^\alpha)}\right)\int_{a_L}^{a_U} a^{1-\sigma}dG[a]$

illustrate the international capital flows. Figure **5**, together with the fact that we have complete spatial separation, shows that the Southern capital that flows to the North is all the South firms/unit-of-capital that have $a$'s above $a_L$. The exact mass of the capital flows is, using **(2)**, $a_L^{\rho}K^*$. **Figure 6** shows that the reform, by construction, does not produce any new capital flows.

## *General tax reforms*

More generally, we consider the location impact of changing the tax rate, $t$, and the deduction, $D$, separately. Inspection of **(20)** 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 **(20)** with respect to $a_L$, $t$ and $D$ yields:

$$a_L^{-\sigma}\left\{(1-\sigma)\Big(B(T-\phi)+B^*(T\phi-1)\Big)+a_L\left((T-\phi)\frac{dB}{da_L}-(1-T\phi)\frac{dB^*}{da_L}\right)\right\}da_L + \left\{a_L^{1-\sigma}(B+\phi B^*)-\sigma D\right\}dT \quad - \quad \left\{\sigma T\right\}dD=0 \qquad \textbf{(26)}$$

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 $T$-$\phi > 0$, the coefficient on $da_L$ is positive.[13] 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 **(19)** the coefficient on $dT$ must be positive.[14] The coefficient on $dD$ is also negative.

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

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[13] The term $(1-T)D$ is positive, so $B(T-\phi)-(1-\phi T)B^*$ must be negative if the sum is to add to zero and since $\sigma > 1$, 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 $T > \phi$.

[14] 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.

$$\frac{da_L}{dt} > 0, \qquad \frac{da_L}{dD} > 0 \qquad \textbf{(27)}$$

This says that raising the marginal tax rate will induce additional firms to relocate to the South to escape the higher taxes. Reducing the deductible has the opposite effect since it lowers the effective tax rate on the marginal firm. Consequently, it is possible to find a combination of a lower marginal rate teamed with a lower deductible that attracts 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.

The most productive firms are in the low-tax South 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 both nations. The reason is that the marginal firm is the most efficient firm in the high-tax North when it moves, but was the lowest-productivity firm in the South before it moved. To summarise:

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

## *Implications for the government objective function*

By inspection of **(24)** and **(25)**, we see that anything that lowers $a_L$, i.e. reduces the range of firms located in the South for tax reasons, will lower the Northern price index and thus boost welfare. As some of the firms that would relocate to the North when $a_L$ falls are Southern firms, there will also be implications for $R^*$. Lowering $a_L$, however, requires a reduction of the ERT on the marginal firm and this will tend to lower the taxes collected from firms already in the North. There is, therefore a fundamental trade off between attracting many firms to lower the price index and gathering a lot of revenue from foreign firms. This trade-off is not in any way novel – it is just the usual struggle between tax base and tax rate.

# V. GLOBALISATION AND TAX REFORMS

Our model provides a 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 without inducing additional relocation. 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 produce 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 is either very closed or very open, reaching their maximum at intermediate levels of trade freeness. Since the same 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 $\phi$) – 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 7** for a constant $t$ and $D$.[15] The bottom curve shows the impact for an initial level of $D$ and $t$. Starting from a low level, a rise in trade freeness $\phi$ 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 implies that the level of profitability changes little in the North, so the tax base's upper

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[15] The parameters we choose for the simulation are $\sigma = 2$, $\rho = 2$, $E = 0.6$, $E^* = 0.4$. The initial tax scheme involves $t = 0.3$ and $D = 2$; the reformed tax scheme involves $t = 0.2$ and $D = 1$.

threshold, $a_U$, changes little, but $a_L$ falls.[16]

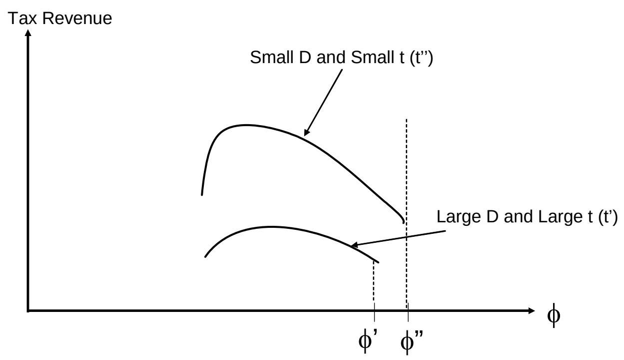


**Figure 7: Globalisation and hump-shaped tax revenue.**

The rising attractiveness of the North in the face of freer trade, however, begins to fade for sufficiently high levels of $\phi$. 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 that for sufficiently high $\phi$'s (which we can show is equal to 1-$t$) there is no advantage to being in the big, high-tax nation for any tax-paying firm, so they all leave (i.e. $a_L$ equals $a_U$) and Northern tax revenue drops to zero.

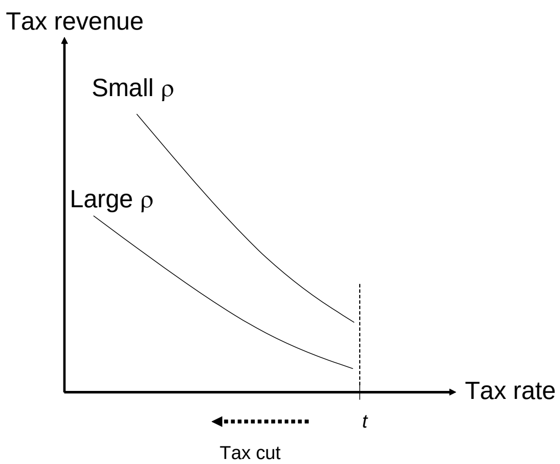


**Figure 8: Firm heterogeneity and tax revenue.**

One of the crucial features in our model is firm heterogeneity, so we briefly consider the

[16] 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.

impact of varying the degree of heterogeneity as measured by $\rho$. We focus on the impact of heterogeneity on the link between tax-rate cuts and tax revenue. The numerical results, shown in **Figure 8,** are generated for the same parameter values as those in footnote 15.

According to the well-known properties of the Pareto distribution, **(2)**, firms become more heterogeneous as $\rho$ falls. What the diagram shows is that greater heterogeneity increases the responsiveness of revenue to rate changes. Intuitively, a low $\rho$ 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.

# VI. CONCLUSION

We have proposed a simple model in which agglomeration forces are present and firms are heterogeneous. Both extensions are useful in allowing the theoretical international tax literature to consider a broader range of effects than has hitherto been possible, specifically in studying the impact of a very simple tax scheme where firm-specific effective tax rates depend upon firm size. 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, but extends them to allow for heterogeneous firms. Allowing for firm 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 theoretical 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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