Lumpy World and Race to the Bottom.

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Abstract

This paper presents a model of the New Economic Geography which integrates commuting costs and land rent and displays a dispersion - agglomeration configuration when regional and/or international trade are liberalised. Two main results are found, the first one is that dispersion Pareto dominates agglomeration, the second one is that the agglomeration rent is not bell-shaped but strictly decreasing when impediments to trade are removed. This turns out to be a convenient framework to revisit the links between tax competition, location of firms and trade integration. It is shown in particular that trade liberalization only leads to a race to the bottom in terms of taxation, and that a tax floor set at the level of the small country may be detrimental to it.

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1 Introduction

> Economic geography models are 'lumpy' by their very nature[...]. That is, agglomeration forces can turn mobile factors into quasi-fixed factors. Agglomeration forces mean that spatial concentration of economic activities - including the activity of the mobile factor - creates forces that favour further spatial concentration. Baldwin et al (2003,.p365-372)

The relationship between tax competition and integration has been at the heart of many lively debates in the past and remains important, controversial and puzzling.

It is important because the entry of ten new members in the European Union (EU) promises challenges for both old and new members. These challenges seem scary to some countries of the old EU because integration might imply delocalization of some activities and unemployment of the less skilled workers. Hence,

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to retain activities a decrease in the taxation on the mobile base might be a solution, but if this decrease is copied, and thus degenerates into a race to the bottom, then the resources of the "welfare state" might be reduced and the situation of unskilled workers could be even worse. Besides, the relationship between tax competition and integration is controversial because while the previous fears are supported by the conclusions of the Neoclassical Tax Competition Models (NTCM), the New Economic Geography (NEG) tends to prove the reverse. Indeed, NTCM finds a positive correlation between integration and race to the bottom in terms of taxations, which leads to an underprovision of the public good. On the other hand the NEG shows that before this race to the bottom occurs the agglomeration of activities generates a rent for the mobile factor that increases with the freeness of trade, so that the government which hosts this core of activities can increase its taxation without capital flight. Lastly the link between tax competition and globalization is puzzling because empirical evidence defies easy explanation : the effect of taxation on the choice of localisation seems to be very difficult to determine and dependent on the geographical level of analysis, on the choice of the mobile base and on the calculation of the tax burden. For instance, Quinn (1997) finds that financial liberalization and corporate taxation are positively linked in 64 countries, and furthermore, by using a panel regression for 17 industrialized countries, Swank (1998) also rejects the conclusion of a race to the bottom. But on the other hand, by using another proxy of corporate taxation, Rodrik (1997) and Bretschger and Hettich (2002) show that economic integration has a negative impact on capital taxes[1]. By performing a meta-analysis, de Mooij and Ederveen (2001) demonstrate that the differences between 25 studies come from differences in the type of capital data or in the tax rates adopted. The result of their analysis is that one point reduction in tax rate increases FDI by 3.3%. On a regional scale, the impact of international trade liberalization on local capital taxes seems to be even more difficult to obtain. Of course, there are some exceptions : Kirchgässner and Pommerehne (1996), for instance, find that if a race to the bottom in Switzerland appears to be a reality, no evidence of underprovision of the public good is found, which permits them to conclude that "if tax competition works well in Switzerland, there is no reason why it should have disastrous effects in a future European Union". However this result has not been generalized to other countries, for which the literature simply shows that tax policy is copied among neighboring jurisdictions (see Heyndels and Vuchelen (1998), and Revelli (2001) who find tax mimicking respectively among Belgian municipalities and UK juridictions).

To resolve the empirical puzzle, more work on the theorical link between tax competition and trade liberalization seems necessary. The present paper analyzes this link on the theoretical ground of the NEG. Antecedents in this field are relatively numerous (Andersson and Forslid (2003), Baldwin and Krugman (2004), Borck et Plüger (2005), Kind et al. (2000), Ludema and Wooton (2000),

[1] They used the effective average tax rate on capital. In order to understand the differences between these tax rates see Devereux et al. (2002) for definitions and stylised facts about the effective average and marginal tax rates and Carey et al. (2000) for the implicit tax rates.

Ottaviano and Van Ypersele (2002)) and, as we have already said, the common point of almost all of them is that, while agglomeration generates in a first step of integration an increasing rent for the mobile factor, this rent later decreases, which implies that before the race to the bottom, a race to the top occurs for intermediate levels of transaction costs. But does this bell-shaped configuration of the agglomeration rent, which is the heart and soul of conclusions when it comes to tax competition, always occur with trade liberalization?

As it turns out, this bell-shaped configuration appears to be specific and does not have a clear economic justification[2]. What we want to show here, is that in an urban economic model, the lumpiness mentioned in the opening quote is somewhat diluted when trade gets freer. And this dilution, which has some justifications like an increase in commuting costs and/or in land rent, with the coming of new residents, changes the outlook of tax competition matters. More precisely, by asking the same question as Baldwin and Krugman (2004), that is : "What is the effect of trade liberalization on tax competition in case of agglomeration?", we are going to show that governments who play a Stackelberg game are going to launch a race to the bottom when trade liberalization increases. This research is in accordance with the recent discussion concerning the future of the New Economic Geography made by Fujita and Mori (2005, p17) who point out that the Baldwin and Krugman (2004) model is central because it has set up a link between urban economics, which assigns an important role to city government and the NEG, which neglects such an entity. However, as they underline, "the next step would be to graft various urban features (such as land and housing markets, commuting, transportation networks and other urban infrastructure) onto geographical models with local governments".

Such an attempt is going to be made in three stages. The first one presents the economic geography model, while the second displays its basic results and lastly, the third step integrates tax competition in the analysis.

2 Krugman and Livas Elizondo's model revisited

2.1 Space pattern

This model is based on Krugman and Livas Elizondo (1996). There are three regions in this model, two monocentric cities and the rest of the world. Furthermore labour is the only factor of production. Entrepreneurs, (denoted h, h^*, h° in the North, South and rest of the world), own this labour and are mobile between cities, but not between cities and the rest of the world. The wage in the

[2] The agglomeration rent exists in this model because agglomerative and dispersive forces do not decrease at the same rate when trade gets freer and because each of their decreasing rate is not constant. However, as Baldwin et al. (2003, p30) has pointed out "the reason why dispersion forces erode faster than agglomeration forces is somewhat involved and cannot really be illustrated fully without resorting to equations" and concerning the apex of the bell, they note in footnote 21 p 36 "we have not been able to justify this result intuitively".

latter is taken as the numéraire. Moreover entrepreneurs are also mobile inside the city. Each of them owns one land unit and they are spread along a line, but as all firms are located in the middle of this line (called the Central Business District (CBD)) they need to commute. These commuting costs have a direct impact on the labour force that entrepreneurs supply in the CBD. As each of them owns one labour unit, the total amount supplied by an entrepreneur who lives on the fringe of the city in the North, at location x (the CBD being at location 0 by convention) is :

$$s(x) = (1 - 2\theta \mid x \mid) \tag{1}$$

where θ (with $\theta < 1$) is entrepreneurs' level of commuting costs. Furthermore, as the number of entrepreneurs is h, entrepreneurs' maximal distance from the CBD is $\frac{h}{2}$, thus the total labour supply net of commuting costs in one city is equal to:

$$L = \int_{-h/2}^{h/2} s(x)dx = h(1 - \theta h/2) \tag{2}$$

As land rent on both edges of the segments is normalized to zero, if w is entrepreneurs' wages near the CBD, then the wage net of commuting costs earned on both edges is:

$$s(h/2)w = s(-h/2)w = (1 - \theta h)w \tag{3}$$

Because consumers are identical in terms of preference and income, in equilibrium they must reach the same utility level, so that entrepreneurs who live on the fringe of the segment receive a net wage of only $(1 - \theta h)w$, but pay no land rent. On the contrary entrepreneurs who lives near the CBD do not pay significant commuting costs, but the price of the services yielded by land is higher at this location. In other words, the increase in real wage near central places offsets land rent. Figure 1 depicts this situation.

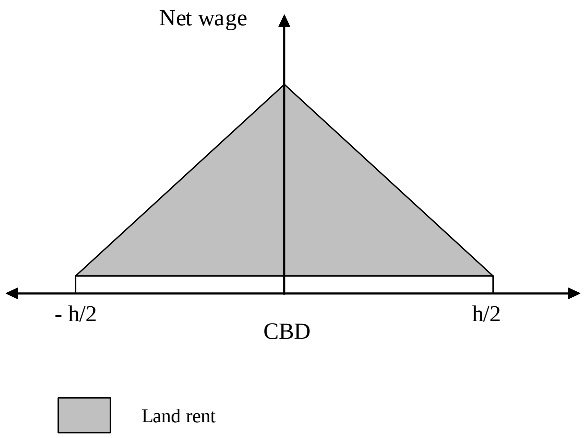

Figure 1: Land rent

In Figure 1, the vertical axis measures the net wage in the city, while the horizontal axis shows the size of this city. Because each entrepreneur owns one land unit, this size only depends on their number. Moving from the suburb to the CBD implies a decrease in commuting and therefore an increase in net wage, but also an equivalent increase in the land rent which equalizes utility among individuals. In other words, the following condition must be verified:

$$s(x) - R(x) = (1 - \theta h)w$$

where $s(x)$ is the total amount supplied by an entrepreneur who lives on the fringe of the CBD, $R(x)$ is the land rent prevailing at x, while the right term represents the wage net of commuting costs earned at both edges given by eq.(3). By using expressions (1) into this system we find the following land rent:

$$R(x) = \theta(h - 2 \mid x \mid)w \quad \text{with } x \in (-1/2, 1/2)$$

Thanks to that we can find the Aggregate Land Rents (ALR):

$$ALR = \int_{-h/2}^{h/2} R(x)dx = \theta h^2 w/2$$

While on the one hand Tabuchi (1998) assumes that there are absentee landlords, and on the other hand, Helpman (1998) assumes that the aggregate land rent is owned at global level, here Krugman and Livas Elizondo (1996) suppose that each entrepreneur owns an equal share of the ALR where they reside. Thus their non salarial income is:

$$\frac{ALR}{h} = \frac{\theta h w}{2} \tag{4}$$

We can now turn to consumers' behavior.

2.2 Consumers' behavior

All consumers share the same utility function and consume one industrial good, composite of different varieties:

$$U = M \quad with \quad M = \left[\int_0^N m_i^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}} \tag{5}$$

where M is the consumption of a manufactures aggregate, N is the large number of potential varieties and $\sigma > 1$ is the elasticity of substitution among these varieties. All the nominal income (denoted E) is spent on manufactures. The budget constraint is then given by:

$$PM = Y \tag{6}$$

$$P = [\int_{i=0}^N p_i^{1-\sigma}]^{1/(1-\sigma)} \tag{7}$$

which is a decreasing function of the number of varieties produced N (because $1-\sigma < 0$). p_i is the price of a typical variety i. The impact of N on the price index is influenced by the elasticity of substitution. The more differentiated the product varieties, the greater the reduction in the price index. The maximization problem gives the following uncompensated demand for manufactures :

$$m_i = \frac{Y}{P^{1-\sigma}} p_i^{-\sigma} \tag{8}$$

$$with\ Y = h(1 - \frac{\theta}{2}h)w \tag{9}$$

where $(1 - \frac{\theta}{2}h)$ comes from the income of land ownership $(\theta hw/2)$ and from the wage net of commuting costs $((1-\theta h)w)$. From that and the price index expression we can see that an increase in the number of industrial products depresses the demand for each variety.

We can now turn to firms' behavior.

2.3 Firms' behavior

The production of a typical variety involves a fixed cost, f, and a constant marginal cost, a, giving rise to economies of scale. The labor force required to produce this variety is then equal to:

$$L = f + aq \tag{10}$$

Because each firm produces a distinct variety, the number of firms is also the number of varieties consumed. Thus each firm is a monopolist on the production of its varieties, and faces the demand function (8). But a key feature of the Dixit-Stiglitz monopolistic competition is that firms ignore the effects of their action on income y, and on the price index P. Hence the demand curve as perceived by a typical firm is not (8), but rather:

$$q = bp^{-\sigma}$$

where $b = \mu Y/P^{1-\sigma}$ is considered as a constant by each firm. According to this behavior, by maximizing the profit $\pi = pq - (f + aq)w$ a typical firm fixes the following price:

$$p = \frac{aw\sigma}{\sigma - 1} \tag{11}$$

Because there is free entry, profits are always equal to zero, which, using eq.(11) and eq.(10), gives the level of output:

$$\bar{q} = \frac{f(\sigma - 1)}{a} \tag{12}$$

In equilibrium, a typical firm employs $f + a\bar{q}$ units of industrial entrepreneurs, so that the total demand is $n(f + a\bar{q})$, and using the level of output (12) and the fact that the total supply of labour is exactly L, the equalization gives the number of varieties produced:

$$n = \frac{L}{\sigma f} \tag{13}$$

The number of varieties produced is then proportional to the number of entrepreneurs.

2.4 Transaction costs

So far, the model has almost been described as a closed economy. The next step is to relax this assumption, trade occurring between the North, the South (denoted by *), and the rest of the world (denoted by $^\circ$). Industrial varieties are exchanged between countries under transaction costs which take the form of iceberg costs: if an industrial variety produced in the Northern market is sold at price p on it, then the delivered price (c.i.f) of that variety in the South (in the rest of the world) is going to be τp $(\tau^\circ p)$ with $\tau, \tau^\circ > 1$.

The assumption of iceberg costs implies that firms charge the same producer price in both regions, the distance does not imply 'discrimination', and 'mill pricing' is optimal. The first-order conditions for a typical firm's sales to its local market and to its export markets are:

$$\begin{aligned} p &= \frac{aw\sigma}{\sigma - 1} && (14) \\ p^* &= \tau\frac{aw\sigma}{\sigma - 1} && (15) \\ p^\circ &= \tau^\circ\frac{aw\sigma}{\sigma - 1} && (16) \end{aligned}$$

Krugman and Livas Elizondo (1996) we assume that the input-output coefficient is equal to the reverse of the mark-up. This normalization simplifies prices which are equal to wages weighted by transaction costs (see (14)). Furthermore the sum of the population (North+South) is normalized to one: $h + h^* = 1$.

Iceberg transaction costs also imply a modification of the price index (7). By using the above normalization we find:

$$P^{1-\sigma} = n^\circ \phi^\circ (w^\circ)^{1-\sigma} + n w^{1-\sigma} + \phi n^* (w^*)^{1-\sigma} \tag{17}$$
$$(P^*)^{1-\sigma} = n^\circ \phi^\circ (w^\circ)^{1-\sigma} + \phi n w^{1-\sigma} + n^* (w^*)^{1-\sigma} \tag{18}$$
$$(P^\circ)^{1-\sigma} = n^\circ (w^\circ)^{1-\sigma} + \phi^\circ n w^{1-\sigma} + \phi^\circ n^* (w^*)^{1-\sigma} \tag{19}$$

where ϕ°, ϕ, ϕ^* represents a degree of trade freeness: $\phi^\circ = (\tau^\circ)^{1-\sigma}, \phi = (\tau)^{1-\sigma}$ and $\phi^* = (\tau^*)^{1-\sigma}$

The price index in the North and in the South decreases with the size of the external market, and with international trade liberalization. Furthermore, at the symmetric equilibrium where wages are the same in North and South, an increase in n and a decrease in n^* implies, as long as there are transaction costs ($\phi < 1$), an increase in price index in the South and a decrease in price index in the North.

We now need to integrate transaction costs into the demand function.

By considering the total demand as the sum of local demand and export demand, we find:

$$q = \phi^\circ \frac{Y^\circ}{(P^\circ)^{1-\sigma}} p^{-\sigma} + \frac{Y}{P^{1-\sigma}} p^{-\sigma} + \phi \frac{Y^*}{(P^*)^{1-\sigma}} p^{-\sigma} \tag{20}$$

Ceteris paribus, the demand in the North is an increasing function of the income Y°, and a decreasing function of the price index P°. Obviously the higher the international trade liberalization, ϕ°, the higher the impact of the rest of the world on the northern demand. But considering the second and third terms we can notice that two opposite effects come from cities' size, indeed we have just seen that an increase in the population in the North decreases P and thus increases $P^{1-\sigma}$ and increases P^* and thus decreases $(P^*)^{1-\sigma}$, then South-North migration fosters a decrease in the total demand q in the North (if $\phi < 1$). But what is the effect of a modification of location on income? A glance at the following equations will give an answer:

$$Y^\circ = L^\circ w^\circ \tag{21}$$
$$Y = h(1 - \theta h/2) w \tag{22}$$
$$Y^* = h^*(1 - \theta h^*/2) w^* \tag{23}$$

An increase in h in the North, and thus a decrease in the South increases expenditure in this country and lowers it abroad, which causes as long as impediment to trade exists ($\phi < 1$), an increase in demand q.

2.5 Market clearing condition and long term analysis.

Thanks to these equations, we can now present the market clearing in a tidy form through an equalization of demand (eq.(20)) to supply (eq.(12)), prices are given by (11) which yields :

$$\sigma f w^{\sigma} = \phi^{\circ} \frac{Y^{\circ}}{(P^{\circ})^{1-\sigma}} + \frac{Y}{P^{1-\sigma}} + \phi \frac{Y^{*}}{(P^{*})^{1-\sigma}} \tag{24}$$

Unfortunately, nominal wages cannot be obtained analytically since on the Right Hand Side (RHS) of the market clearing equation wages depend on σ and moreover on the Left Hand Side (LHS), price indices also involve wages which are dependent on $1-\sigma$. However it is possible to investigate the relationships between price indices and wages by linearizing the model around the symetric equilibrium (when $h = h^{*} = 1/2$). Indeed, at the symetric equilibrium, a modification of one variable in one region is associated with an equal modification of the corresponding variable in the other region, but with an opposite sign, so by letting $\frac{dw}{w} = -\frac{dw^{*}}{w^{*}} = \widehat{w}$ an so on, we get the following expression by way of a log differentiation of price indices and wages:

$$\begin{aligned}
\widehat{P} &= Z_{\phi}\left(\frac{Z_{\theta}}{(1-\sigma)}\widehat{h} + \widehat{w}\right) && (25)\\
\sigma\widehat{w} &= Z_{\phi}(\widehat{Y} + (\sigma-1)\widehat{P}) && (26)\\
\textit{with} \quad Z_{\phi} &= \frac{1-\phi}{1+\phi}, \quad Z_{\theta} = \frac{1-\theta/2}{1-\theta/4} && (27)
\end{aligned}$$

where Z_{ϕ} can be considered as an inverse measure of trade freeness, there is autarky when $Z = 1$ and free trade for $Z = 0$ ($Z_{\phi} \in [0, 1]$) and Z_{θ} is an inverse measure of commuting costs, there is no commuting cost when $Z_{\theta} = 1$ and very high commuting costs when $Z_{\theta} = \frac{2}{3}$ ($Z_{\theta} \in [\frac{2}{3}, 1]$).

Concerning the first expression (25), if we consider that entrepreneurs' supply of labor is perfectly elastic, $\widehat{w} = 0$, then an increase in the number of entrepreneurs in the North, $\widehat{h}$, implies a decrease in the price index in this country. This effect is known as the local competition effect or as the market crowding effect. Concerning the second expression (26), we can eliminate $\widehat{P}$ by using (25), we then divide the two sides of the equation by $\widehat{Y}$ which gives:

$$\frac{\widehat{h}}{\widehat{Y}} = \frac{1}{Z_{\phi}Z_{\theta}} - \left(\frac{\sigma}{Z_{\phi}^{2}Z_{\theta}} + \frac{1-\sigma}{Z_{\theta}}\right)\frac{\widehat{w}}{\widehat{Y}} \tag{28}$$

thus by considering once again that entrepreneurs' labor supply is perfectly elastic, $\widehat{w} = 0$, we get the famous home market effect (Krugman (1980)):

$$\frac{\widehat{h}}{\widehat{Y}} = \frac{1}{Z_{\phi}Z_{\theta}}$$

Hence one percent change in the northern demand for manufactures, $\widehat{Y}$, increases entrepreneurs' employment, $\widehat{h}$, by $\frac{1}{Z_{\phi}Z_{\theta}}(>1)$ percent in the North. The novelty is that here this home market effect is reduced by commuting costs. Furthermore we can observe that an increase of $\widehat{h}$ increases $\widehat{Y}$, indeed by log differentiating the equation of income (21) we know that:

$$\widehat{Y} = Z_\theta \widehat{h} + \widehat{w}$$

Then one percent change in the entrepreneurs'employment in the North, $\widehat{Y}$, increases the northern demand by $\frac{1}{Z_\theta}$ percent in the North (with $\widehat{w} = 0$). Thus the larger manufacturing sector has a more than proportionally larger home market. Moreover we have just seen that the larger home market has a more than proportionally larger manufacturing sector, this is the backward linkage also called the demand-linked circular causality. Notice that this backward linkage decreases with commuting costs.

To sum up, two opposite forces drive relative nominal wages, on the one hand an increase of entrepreneurs in one city exacerbates local competition among firms, thus new entry triggers a slump in the price index, and thereby in operating profits too, so that in order to stay in the market firms need to remunerate their workers less (market crowding effect). But on the other hand, as the income generated by the new entrepreneurs is spent locally, sales and operating profits increase and under the 'zero profit condition' this implies a higher nominal wage (the home market effect). However, entrepreneurs do not consider the relative nominal wage when they decide to migrate but the relative real wage. Hence in the long run migration stops when real wages are equalized in case of symmetry ($h = \frac{1}{2}$), or when agglomeration in one city generates a higher relative real wage. Thus by denoting $\Omega(h, \phi, \phi^\circ)$ this relative real wage, and defining it by:

$$\Omega(h, \phi, \phi^\circ) = \frac{V(h, \phi, \phi^\circ)}{V^*(h^*, \phi, \phi^\circ)} \tag{29}$$

$$= \frac{w}{w^*} \frac{1 - \theta h/2}{1 - \theta h^*/2} (\frac{P^*}{P}) \tag{30}$$

we will have a stable total agglomeration in the North if $\Omega(1, \phi, \phi^\circ) > 1$, and a stable dispersed equilibrium if $d\Omega(1/2, \phi, \phi^\circ)/dh < 0$. Notice that in the long run (eq.(30)) two additional forces appear, on the one hand the term $(1 - \theta h/2)$, which enters multiplicatively in the indirect utility, creates a dispersive force independently of transaction costs, which is the land market crowding effect, and on the other hand the third term P^*/P which is an agglomerative force. Indeed, we know that goods are cheaper in a central place because imports are lower and thus the burden of transaction costs too. Hence, the entrepreneurs' purchasing power is higher in this location which attracts other entrepreneurs, this is the cost-linked circular causality also known as forward linkage.

3 Intermediate results

3.1 Critical points

3.1.1 When is the Core-Periphery pattern sustainable?

The sustain point is the critical point of trade liberalization below which the Core-Periphery pattern is sustainable. To determine whether the agglomeration in the North is a stable equilibrium we need to know whether a small deviation of entrepreneurs from $h = 1$ increases welfare or not. If it does, the Core-Periphery pattern is not a stable equilibrium.

In the special case of autarky ($\phi^\circ = 0$), the sustain point is very easily found, indeed when $h = 1$, price indexes are linked by the following equation:

$$P = \phi^{1/\sigma-1} P^* \tag{31}$$

And wages by:

$$w = \phi^{-1/\sigma} w^* \tag{32}$$

Thus the relative indirect utility is given by:

$$\Omega(1, \phi, \phi^\circ) = \phi^{(2\sigma-1)/\sigma(1-\sigma)}(1 - \theta/2) \tag{33}$$

which gives the following proposition:

Proposition 1 *Agglomeration is a stable equilibrium if and only if* $\phi < \phi^s = (1 - \frac{\theta}{2})^{\frac{\sigma(\sigma-1)}{2\sigma-1}}$. *Furthermore an increase in congestion costs* (θ) *and/or in the elasticity of substitution between varieties* (σ) *decreases the level of regional integration at which the agglomeration is a stable equilibrium*

Proof. From eq.(33) we have:

$$\begin{array}{rrcl} & \Omega(1, \phi, \phi^\circ) & = & 1 \quad \text{for } \phi_s = (1 - \dfrac{\theta}{2})^{\frac{\sigma(\sigma-1)}{2\sigma-1}} \\ \textit{and} & \Omega(1, \phi, \phi^\circ) & > & 1 \quad \text{for } \phi < \phi_s \end{array}$$

Furthermore it is clear from $\phi^s = (1 - \frac{\theta}{2})^{\frac{\sigma(\sigma-1)}{2\sigma-1}}$ that:

$$\frac{\partial \phi_s}{\partial \sigma} < 0 \text{ and } \frac{\partial \phi_s}{\partial \theta} > 0$$

■

This proposition has first been formulated by Krugman and Livas Elizondo (1996) and represents a new feature in the landscape of the NEG. Nevertheless, as these authors have pointed out, this sustain point is “a special case”, and says nothing about what happens when the assumption of autarky with the rest of the world is relaxed. In fact, the introduction of the rest of the world implies a particular problem for the calculation of this critical point because price index and wages are no longer linked by a simple expression as in equations (31) and (32) but by a more complex and intractable expression:

$$P^{1-\sigma} = \frac{(P^*)^{1-\sigma}}{\phi} + L^\circ \phi^\circ (1 - \frac{1}{\phi}) \tag{34}$$

$$w^\sigma = \frac{(w^*)^\sigma}{\phi} + \frac{Y^\circ}{(P^\circ)^{1-\sigma}} \phi^\circ (1 - \frac{1}{\phi}) \tag{35}$$

This expression precludes the above simplification of the analysis. What we propose here is a calculation of this critical point by assuming that the rest of the world is as big as the total population in the North and South[3], in other words $h^\circ = h + h^* = 1$. This normalization implies that $w = 1$ is a solution of the agglomerative equilibrium, which permits to find the relative price index in a very simple form:

$$\frac{P}{P^*} = \left(\frac{\phi^\circ + 1}{\phi^\circ + \phi}\right)^{1/1-\sigma} \tag{36}$$

Similarly the relative wage in the North is given by:

$$\frac{w}{w^*} = (\frac{\phi^\circ + 1}{\phi^\circ + \phi})^{1/\sigma} \tag{37}$$

These two equations imply that the ratio of indirect utilities has the following form:

$$\Omega(1, \phi, \phi^\circ) = (1 - \theta/2)(\frac{\phi^\circ + \phi}{\phi^\circ + 1})^{\frac{2\sigma-1}{\sigma(1-\sigma)}} \tag{38}$$

which gives the following proposition:

Proposition 2 *Agglomeration is a stable equilibrium if and only if* $\phi < \phi^s = (1 - \frac{\theta}{2})^{\frac{\sigma(\sigma-1)}{2\sigma-1}}(1 + \phi^\circ) - \phi^\circ$. *Furthermore international trade liberalization decreases the level of regional integration at which the agglomeration is a stable equilibrium.*

Proof. From eq.(38) we have:

$$\begin{aligned} \Omega(1, \phi, \phi^\circ) &= 1 \quad \text{for } \phi_s = (1 - \frac{\theta}{2})^{\frac{\sigma(\sigma-1)}{2\sigma-1}}(1 + \phi^\circ) - \phi^\circ \\ \textit{and} \quad \Omega(1, \phi, \phi^\circ) &> 1 \quad \text{for } \ \phi < \phi_s \end{aligned}$$

Furthermore

$$\frac{\partial \phi_s}{\partial \phi^\circ} = (1 - \frac{\theta}{2})^{\sigma(\sigma-1)/(2\sigma-1)} - 1 < 0 \text{ because } \theta < 1$$

[3] Three arguments can be put forward in order to justify this: first we work with monocentric cities, for those small cities the rest of world is often limited to the nearest big city, thus assuming that the latter entity is as large as the sum of the whole monocentric population is quite realistic. In fact if we consider that the big city is the first rank city, and monocentric cities are second-largest, our assumption follows Zipf's law at the dispersive equilibrium. Secondly this assumption is useful because it allows us to make an analysis in terms of external costs. Thirdly, this assumption is going to be relaxed in the next sections in order to understand more precisely how an increase in the world population could affect the equilibria.

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After the sustain point, we can now turn to the break point.

3.1.2 When is the symmetric equilibrium broken?

The break point is the critical point of transaction costs above which a dispersive equilibrium is broken. Suppose that entrepreneurs are equally dispersed among regions, then in order to determine whether this situation is an equilibrium we need to know if a small deviation increases welfare or not. If it does, dispersion is not an equilibrium. Thus we want to know the sign of $d\Omega(1/2, \phi)/dh$. Appendix A gives the details of the computation, the break point (ϕ_b) has the following implicit form:

$$\phi_b : Z_\phi^b = \frac{\sigma(1-\sigma)\theta}{(\sigma-1)^2\theta - (2\sigma-1)(4-2\theta)}$$

with:

$$Z_\phi^b = \frac{1}{2}\left(\frac{w}{P}\right)^{1-\sigma}(1-\phi_b)$$

where wage and price are given in the appendix.

From the previous section we know that wage and price index are respectively decreasing and increasing with the size of the rest of the world and with international trade liberalization. This higher wage and smaller price index tend to decrease Z_ϕ which fosters the dispersive equilibrium (in the appendix we show that $\frac{\widehat{V(1/2,\phi)}}{\widehat{h}} < 0$ when $Z_\phi < Z_\phi^b$). Moreover an increase in commuting costs tends to break the agglomeration incentive. This can be summarized by the following proposition:

Proposition 3 *An increase in the importance of the rest of the world (ϕ°, L°), or of commuting costs (θ), decreases the level of regional trade liberalization at which the dispersive equilibrium is broken.*

A similar proposition has been found by Fujita et al. (1999); yet they do not find the same break point because their model differs by integrating ad-hoc congestion costs instead of the explicit treatment of land rent carried out here.

3.2 Bifurcation diagram

In order to get a full understanding of how the size of regions globally changes with trade liberalization, we make numerical simulations[4] and get the so-called 'tomahawk diagram'. This diagram plots the location of entrepreneurs as a function of regional transaction costs.

[4] In this section parameters take the values $\sigma = 5$, $\theta = 0.4$, $L^\circ = 3$, $\tau^\circ = 1.5$, $f = 1$

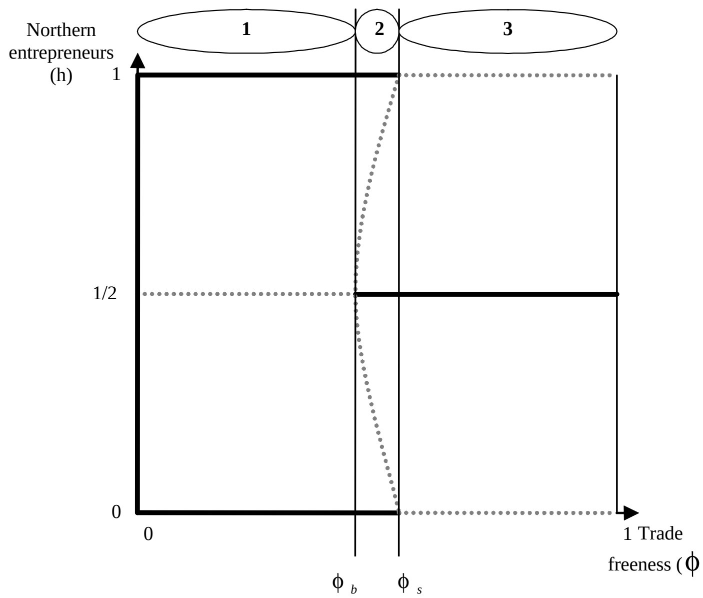

Figure 2: The tomahawk diagram

Three steps of trade liberalization are remarkable in Figure 2 : in the first step of trade liberalization regions are in relative autarky, $\phi < \phi_b$ demand and cost linkage play an important role and all activities are localized in one of the two regions, agglomeration is then the only stable equilibrium. Indeed if we plot the welfare in each region as a function of the number of entrepreneurs in the North, as in Figure 3, we clearly see that once a small deviation of entrepreneurs from the dispersive equilibrium occurs, further agglomeration is in the agents' interest because the relative indirect utility in the Core increases. Thus entrepreneurs decide to migrate because the relative welfare increases with their movement. However, if we compare their welfare at the symetric equilibrium (in A) and at the agglomerated equilibrium (in B or C), we can observe that they are worse off in this last situation. This simulation gives the following result:

Proposition 4 *Dispersion Pareto dominates agglomeration*

This result is new and comes from the substitution of the immobile factor as the dispersive force with entrepreneurs' need to commute. Indeed on the contrary, in the Krugman (1991) model agglomeration Pareto dominates dispersion for entrepreneurs (this is proposition 3 of Charlot et al. (2004)). Here things are different, entrepreneurs prefer dispersion because this equilibrium allows them to reduce the burden of urban costs. However, due to the non linearity of the model, we cannot prove such a result for all ϕ°. Nevertheless we can prove that:

Proposition 5 *If regions are in autarky with the rest of the world, $\phi^{\circ} = 0$, then whatever the level of regional transaction costs ϕ, dispersion is a Pareto improvement for entrepreneurs.*

Proof. In autarky $\phi^\circ = 0$, and at the dispersed equilibrium, $h = \frac{1}{2}$ price index are given by:

$$P^{1-\sigma} = nw^{1-\sigma}(1+\phi) \tag{39}$$

thus, by replacing n by $\frac{L}{\sigma f}$ (see eq. (13)) and by using eq.(2) we get:

$$P = (\frac{h(1-\theta h/2)}{\sigma f}(1+\phi))^{1/(1-\sigma)}w$$

thus indirect utility in the North which is given by $V(h, \phi, \phi^\circ) = \frac{(1-\theta h/2)w}{P}$ becomes equal to:

$$V(\frac{1}{2}, 0, 0) = (\frac{1+\phi}{2\sigma f})^{1/(\sigma-1)}(1-\frac{\theta}{4})^{1+1/(\sigma-1)}$$

When all entrepreneurs are agglomerated in the North, $h = 1$, the price index in this location is:

$$P^{1-\sigma} = nw^{1-\sigma}$$

thus we get:

$$P = (\frac{h(1-\theta h/2)}{\sigma f})^{1/(1-\sigma)}w$$

with this, entrepreneurs'indirect utility when they are agglomerated is given by:

$$V(1, 0, 0) = (\frac{1}{\sigma f})^{1/(\sigma-1)}(1-\frac{\theta}{2})^{1+1/(\sigma-1)}$$

Then entrepreneurs prefer dispersion if

$$\begin{aligned} V(\frac{1}{2}, 0, 0) &> V(1, 0, 0) \\ &\Leftrightarrow (\frac{1+\phi}{2\sigma f})^{1/(\sigma-1)}(1-\frac{\theta}{4})^{1+1/(\sigma-1)} > (\frac{1}{\sigma f})^{1/(\sigma-1)}(1-\frac{\theta}{2})^{1+1/(\sigma-1)} \\ &\Leftrightarrow \phi > Z_\theta^\sigma - 1 \end{aligned}$$

since $Z_\theta \in [\frac{2}{3}, 1]$ (see (27)), the inequality $\phi > Z_\theta^\sigma - 1$ is always verified, then entrepreneurs prefer dispersion for all ϕ. ■

This proposition can be considered as complementary to Murata and Thisse (2005)'s work since they use the Krugman and Livas model with $\phi^\circ = 0$.

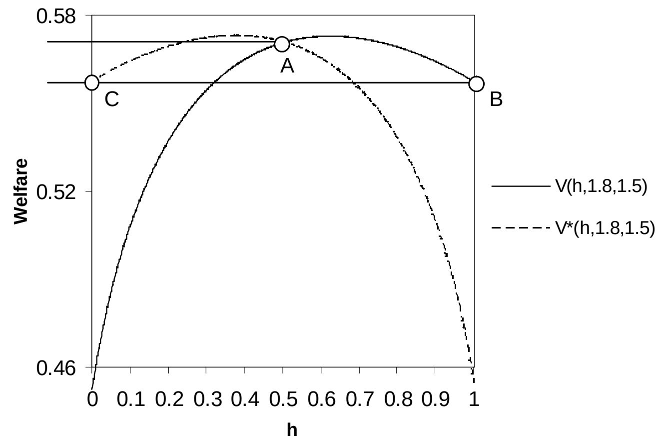

Figure 3: High trade costs

Coming back to Figure 2, we can see that in a second step of trade liberalization, between the break and sustain point, both the agglomeration and dispersion equilibria are stable. Indeed in Figure 4 at the dispersive equilibrium a small deviation from the South to the North makes the indirect utility higher in the South than in the North, thus entrepreneurs prefer to come back to the southern city. The dispersive equilibrium is stable in such a case. However if the migration shock is higher ($h > 0.86$), then they are strictly better off in the North, agglomeration occurs and becomes a stable equilibrium.

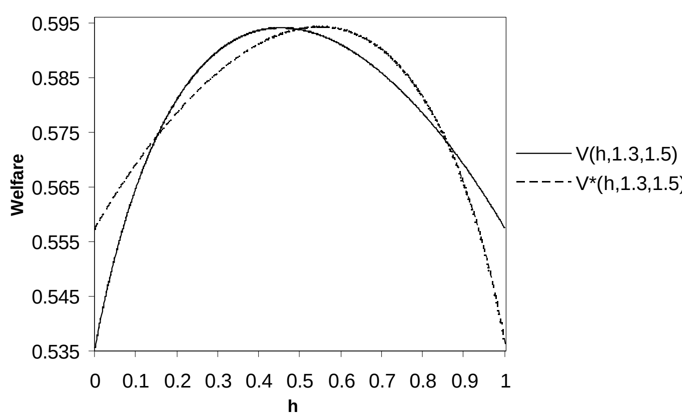

Figure 4: Intermediate trade costs

The third step, characterized by strong trade liberalization $\phi > \phi_s$, displays an equal spread of activities among regions. Indeed in Figure 5 any deviations from the dispersive equilibrium cause a decrease in the welcoming city's welfare.

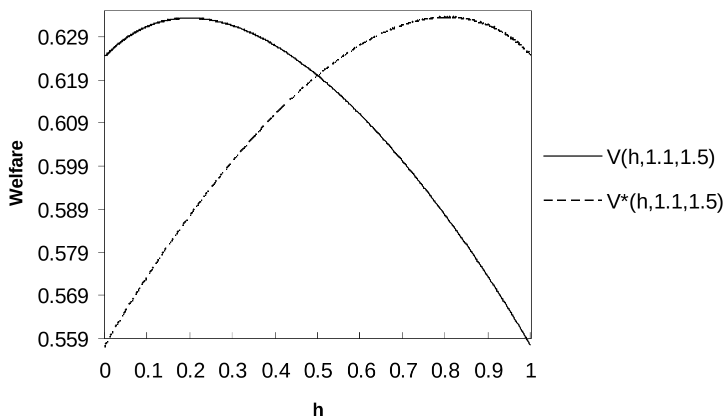

Figure 5: Low trade costs

One of the most interesting features is that these two sorts of equilibrium - corner solutions in case of agglomeration, and an interior solution for location dispersion - are also displayed by Krugman (1991)'s CP model, but not for the same transaction cost values. Indeed, in comparison with the initial Core-Periphery model, where dispersion appears before agglomeration, the situation is reversed here, but the symmetry between the two models does not come from a symmetric mechanism. Indeed, if everything was just reversed, the bell-shaped agglomeration rent, instead of being found near free-trade, would be obtained near autarky. The conclusion of race to the top for low transaction costs would then be found for high trade costs, and so on. But here the agglomeration rent is not bell-shaped.

3.3 Agglomeration rent

Previous steps have shown that agglomeration forces are stronger when the rest of the world is relatively small and trade relatively restricted, the agglomeration rent is then the highest in this case, ceteris paribus entrepreneurs strictly prefer to be located in the North. The question is to know how this rent is influenced by trade liberalization between regions. The agglomeration rent is given by (38):

$$\Omega(1, \phi, \phi^{\circ}) = (1 - \theta/2)(1 + \frac{1 - \phi}{\phi^{\circ} + \phi})^{\frac{2\sigma - 1}{\sigma(\sigma - 1)}}$$

which clearly gives the following result:

Proposition 6 *Starting from a situation of agglomeration, an increase in trade liberalization between regions or with the rest of the world, decreases the agglomeration rent.*

Proof. we have:

$$\begin{aligned}
\frac{\partial\Omega(1,\phi,\phi^{\circ})}{\partial\phi} &= -\frac{(1-\theta)(2\sigma-1)(\phi^{\circ}+1)}{\sigma(\sigma-1)(\phi^{\circ}+\phi)^{2}}\left(\frac{\phi^{\circ}+1}{\phi^{\circ}+\phi}\right)^{\frac{2\sigma-1}{\sigma(\sigma-1)}-1}<0 \quad if\ \theta\neq 1\\
\frac{\partial\Omega(1,\phi,\phi^{\circ})}{\partial\phi^{\circ}} &= -\frac{(1-\theta)\,(2\sigma-1)\,(1-\phi)}{\sigma\,(\sigma-1)\,(\phi^{\circ}+\phi)^{2}}\left(\frac{\phi^{\circ}+1}{\phi^{\circ}+\phi}\right)^{\frac{2\sigma-1}{\sigma(\sigma-1)}-1}<0\\
if\ \theta &\neq 1\ and\ \phi\neq 1
\end{aligned}$$

■

In case of prohibitive costs between regions ($\phi,\phi^{\circ}\rightarrow 0$), the agglomeration rent tends to infinity, in case of free trade ($\phi\rightarrow 1$) this rent only depends on congestion costs. From a public policy point of view this decrease in the agglomeration rent is particularly interesting and very intuitive indeed as in the CP model, wage and price index in the North are constant, while $P^{*1-\sigma}$ strictly decreases with ϕ, thus the difference between the two models comes from entrepreneurs' wage in the South, in our model, this wage is strictly increasing in ϕ because a decrease in transaction costs allows one to have better access to the varieties produced in the Core. The real wage in the South is thus an increasing function of trade liberalization and because the reverse of this real wage determines the shape of the rent, this model displays a decreasing agglomeration rent. In order to see how this rent varies with the size of the external market we make some simulations[5]. In Figure 6, the horizontal axis measures trade openness while the vertical axis measures agglomeration rent.

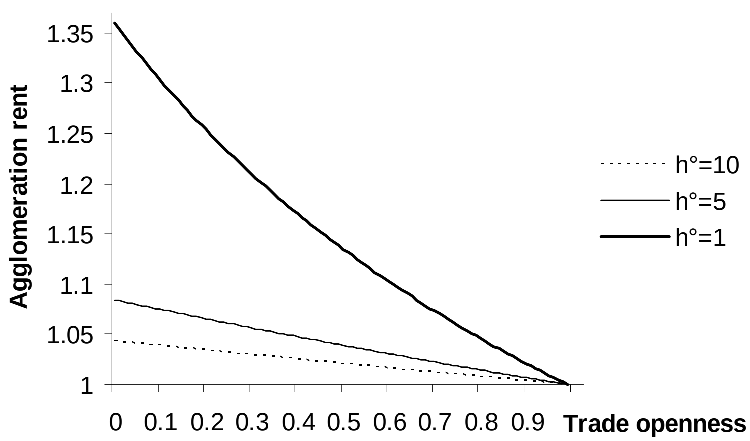

Figure 6: Agglomeration rent and growth of the rest of the world

In Figure 6 we can see that the population's growth in the rest of the world, h°, decreases entrepreneurs' agglomeration rent. Indeed, when h° is high, the

[5]Parameters take the values: $\phi^{\circ}=1$, $\theta=1$, $\alpha=1$, $h=1$

economy is outward oriented, the North is still the more attractive location on account of its larger market. However the backward linkage is weaker since a high proportion of firms' sales are now directed to the rest of the world. When international trade costs decrease it almost identical to meeting this demand from anywhere, then the agglomeration rent decreases.

4 Race to the bottom

In this section we want to analyze the tax policies between governments in the case of a total agglomeration of activities, so we henceforth limit ourselves to $\phi < \phi_b$. Preferences are given by:

$$U = MG$$

where G is the supply of local public goods. With Andersson and Forslid (2003), we assume that public goods are produced via private goods. Thus the composition of demand and all the variables that we have analyzed so far (wages and prices) are not affected by the tax. We assume that each jurisdiction supplies the same amount of public goods but the financing of these goods f and f^* can differ from one juridiction to the next (implicitly the efficiency of each government can be different[6]):

$$f = tY, \quad f^* = t^*Y^*$$

Because the supply of public goods is the same everywhere, migration stops when post-tax reward is higher in the Core. The location equilibrium condition is thus given by:

$$\frac{V}{V^*} = \frac{1-t}{1-t^*} \geq 1$$

Besides, we assume that governments maximize the following objective functions:

$$W = W(f, t), \quad W_f > 0$$

As has been pointed out by Baldwin and Krugman (2004), denoted BK for short, the common point between the Leviathan and a benevolent government is that their objective functions rise with the collected revenue and decline with the tax rate, however because the tax rate also has an impact on the revenue, a shift in it, first has a positive effect on the objective and then a negative one. Thus, the objective function needs to be a bell-shaped curve when the tax rate increases. This characteristic is verified here for the Core but not for the Periphery since $f^* = 0$ (because there are no entrepreneurs in the Periphery), therefore the objective function in this country is negative and decreasing with the tax rate. This can be interpreted by the fact that the South has a higher

[6] Another explanation of these equations and of the 'no delocation condition' has been proposed by Baldwin and Krugman (2004), they assume that the supply of public goods can differ from one jurisdiction to the next but that entrepreneurs do not take this difference into account when they decide to move.

predator behavior than the North[7]. The local governments play a Stackelberg game, the sequence of this game is the following:

1. The North sets a tax rate t
2. The South reacts through a tax rate t^*
3. Migration occurs

This game is resolved by backward induction. The third stage is already known by the previous analysis of the model. Concerning the second stage, whatever the decision of the Core concerning the level of taxation, the Periphery has almost always an incentive to steal all the activities, at most it can be indifferent. Figure 7 illustrates this. The vertical axis represents the objective function of the South, while the horizontal axis plots the level of taxation in this country.

There are two possible situations, if the South does not succeed in stealing the Core, then its revenue is going to be null, and its objective function is negative, on the contrary, if this country succeeds in attracting all the activities, then its revenue is going to be equal to t^*Y^*, and its objective function becomes bell-shaped. Total agglomeration in the North depends therefore on the potential taxation levied by the South. The Northern government can indeed be upset by a tax t_b^*, which enables the South to break the Core equilibrium:

$$t_b^* = 1 - \Omega(1, \phi)(1 - t) \tag{40}$$

This break-point tax rate rises with t and falls with $\Omega(1, \phi)$.

[7] We can imagine, for instance, that it is marginally more interesting for a small country to attact some activities than for a big one.

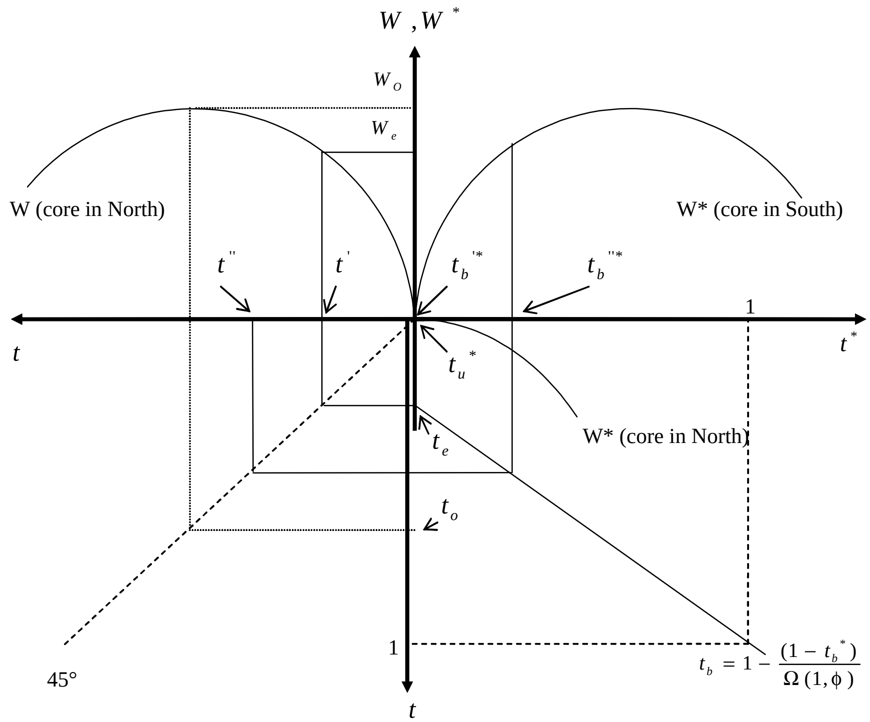

Figure 7: The tax game

Thus if we start from a situation where the Core/North sets a high tax rate, say $t^{''}$, then the break-point tax rate, denoted $t_b^{''*}$ on the diagram is also high, and thus the South can steal the Core by setting t^* equal to $t_b^{''*}$. If the North decides to choose a lower level of taxes, say $t^{'}$, then in such a case the South can steal the Core by lowering t^* to $t_b^{'}*$. However in such a case $t_b^{'*}$ is equal to zero, and thus equivalent to the tax rate that maximizes the objective function of the South without the Core, namely t_u^*, thus the South is indifferent between the Core or the Periphery. Therefore, in the first stage, if the North wants to keep the Core, it needs to set a tax below or equal to $t^{'}$, such that the South does not want to deviate from $t_u^* = t_b^{'*}$. This limit tax rate, denoted t_e, is thus equal to $t^{'}$ on the diagram and analytically found by:

$$\begin{aligned} t &\leq t_e = 1 - \frac{1 - t_b^*}{\Omega(1, \phi)} \\ where\ t_b^*\ s.t\quad W^*[t_u^* Y^*(0, \phi), t_u^*] &= W^*[t_u^* Y^*(1, \phi), t_u^*] \equiv W_e^* \end{aligned}$$

We now need to verify that the North always prefers to have the Core. This is demonstrated by the fact that the North wins W_e with the Core and nothing without, accordingly the North will always "limit tax" the South.

4.1 Equilibrium tax gap

From the previous analysis we already know that the tax gap $t_e - t_u$ is strictly decreasing with trade liberalization. Indeed, with t_b and t_u equal to zero, the tax gap only depends on t_e which decreases when $\Omega(1,\phi)$ decreases, and it has been found in proposition 7 that $\Omega(1,\phi)$ decreases with ϕ and ϕ°, thus this gives the following proposition:

Proposition 7 *International trade liberalization as well as regional trade integration leads to a race to the bottom in terms of taxation*

Proof. We have:

$$\begin{aligned}\frac{\partial(t_e - t_u^*)}{\partial\phi} &= \frac{1}{\Omega(1,\phi)^2}\frac{\partial\Omega(1,\phi)}{\partial\phi} \\ \frac{\partial(t_e - t_u^*)}{\partial\phi^{\circ}} &= \frac{1}{\Omega(1,\phi)^2}\frac{\partial\Omega(1,\phi)}{\partial\phi^{\circ}}\end{aligned}$$

and we know from proposition 7 that $\frac{\partial\Omega(1,\phi)}{\partial\phi^{\circ}} < 0$ so $\frac{\partial(t_e - t_u^*)}{\partial\phi^{\circ}} < 0$, similarly from the same proposition $\frac{\partial\Omega(1,\phi)}{\partial\phi} < 0$ so $\frac{\partial(t_e - t_u^*)}{\partial\phi} < 0$. ■

4.2 Comparison of models and observations on tax harmonisation

This model has the same characteristics as BK's model, for instance the lumpiness of the two models makes it impossible to rely on a simultaneous-move Nash tax game. Indeed, if the North considers the South's rate as given, it will want to deviate in order to attain W_o in Figure 7, but if the North does so, then the South will find it interesting to steal the Core. In other words reaction functions are discontinuous. But this model also shares some features with the Basic Tax Competition Model (BTCM). As in the Bucovetsky (1991) and Wilson (1991) analysis of "asymmetric tax competition", the big country can set a higher tax rate than the small one without losing activities. Obviously assumptions behind these results are different, in their models[8] the large country tends to set a higher tax rate than the small one since the elasticity of capital is smaller for them, whereas in the NEG models, the advantage of the Core is to supply an agglomeration rent. In our model, this agglomeration rent is strictly decreasing, which allows us to reach the same conclusion as the BTCM about a race to the bottom. This result is obtained in a model with agglomeration forces where the central parameter is not the degree of capital mobility, but the level of trade costs. Thus, if Zodrow and Mieszkowski (1986) or Wilson (1986) conclude that moving from no mobility of capital to perfect mobility leads to an underprovision of public goods, with BK we find that this underprovision concerns only the big country, indeed, when entrepreneurs are not mobile, each government

[8] The argument is close to the Kennan and Riezman (1988) model where the large country can manipulate the terms of trade.

sets its unconstrained tax rate, and thus when mobility turns up, the North needs to decrease its taxation level (in Figure 7 from t_o to t_e) in order to retain the Core, but the South keeps the same level t_u^*. Concerning tax hamonisation, we also share one of the two proposition made by BK: a common tax rate is not Pareto improving. Indeed, if this tax is set below t_e, then the North is clearly worse off, and if a common tax is set over t_e, then the tax harmonization becomes detrimental to the South since its objective function becomes negative. Concerning the proposition made by BK about a weakly Pareto improvement brought by a southern tax floor Figure 8 displays a comparison with the current model.

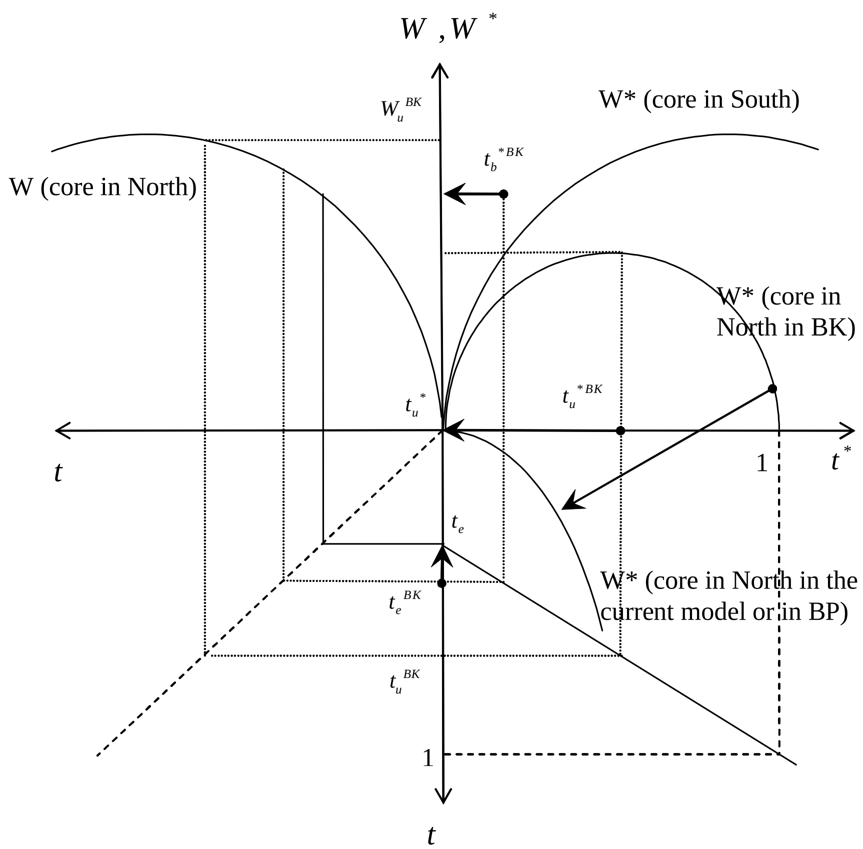

Figure 8: Tax floor scheme for the Periphery

In the BK case, there are two tax payers, entrepreneurs and immobile workers, thus the objective function in the Periphery is an inversed U-curve of t^*, even if there are no entrepreneurs in this country because the government gets revenue from the immobile workers. The unconstraint tax in the Periphery, t_u^{*BK}, is thus positive, and a tax floor set at this southern tax rate relaxes a part of the northern constraint, which can attain the welfare W_u^{BK} by increasing its tax to t_u^{BK}. However, because the traditional literature on tax competition often tests what happens when a complete set of tax instruments is not available (Wellisch (2000) for an overview), we may wonder whether BK's conclusion holds when the tax-game only concerns the mobile factor. This is the case analyzed by Borck and Pflüger (2005), BP for short, but these authors have failed to account for tax harmonization and this section can thus be understood as complementary to their work. Alternatively we can understand the BK model as an analysis of tax harmonization between countries, while our model concerns tax harmonisation between cities or regions. Indeed in the BK model, only a part of the population is mobile, which is really verified at international level, while in our model all the population is free to migrate, which is also a good approximation of what happens at a thinner spatial scale. In such a case the objective function in the Periphery becomes negative, then t_b^{*BK} and t_u^{*BK} drop toward zero and t_e^{BK} also decreases, then a tax floor is no longer a good policy as in the BK model, on the opposite :

Proposition 8 *If all the population is free to migrate (or if the tax-game only concerns the mobile factor), then a positive tax floor set for the Periphery is detrimental to this region.*

That result is strong, since the whole population is never totally mobile, however it indicates that if a positive tax floor is set, then this floor needs to be revised and lowered if agents'mobility increases.

5 Conclusion

In the tax competition literature of the New Economic Geography, agglomeration generates a rent that is bell-shaped with respect to trade liberalization, and as a direct implication when trade between nations starts to be liberalized, the Core can increase its tax rate without losing activities. In this literature, the hump-shaped agglomeration rent comes from the dispersive force consisting of the demand of immobile farmers. As has been pointed out by Helpman (1998, p54) this "centrifugal force [...] is particularly suitable for societies in which agriculture plays a major role, and in which farmers are tied to their land", but alternative modellings are also relevant, as it has been underlined by Cavailhès et al. (2004) 40% of the income of American households is spent on housing and transportation and a similar percentage can be found for the average of the 15 European Union member states (Winqvist (1999))[9], then urban costs represent a significant feature of developped societies. As a result, we have chosen to analyse a model that emphasizes commuting costs as a dispersive force. We have proved that dispersion Pareto dominates agglomeration, which is quite a common view among urban economists (Tolley and Crihfield (1987)), and we

[9]In the particular case of France, and by using the INSEE housing survey, Cavailhès et al. report that rent which reprensented 27% of income in 1984, has rosen to 70% in 1996. Furthermore, by introducing their measure of commuting costs they show that the budget share of transport communication and rent is effectively around 40% in 1996.

have shown that the agglomeration rent stricly decreases with regional and international trade liberalization. Then, if the Core can set a higher tax rate than the Periphery without tax-base loss, this tax must converge toward that of its adversary when trade is liberalized. Actually, the conclusions of the basic tax competition models also tends to be verified in a lumpy world, tax competition leads regions to a race to the bottom and there is an underprovision of public goods in the larger region. Lastly, and even if our model is much fitter to describe the regional level, it is tempting to link its conclusions concerning the zero tax rate set by the Periphery to the 0% tax rate set by Estonia on retained earnings. This model also warns about the possibility of setting a tax floor for the smaller region. Indeed if this is done without taking into account individuals' mobility then this floor can be too high and harmful to the Periphery.

Appendix A. The break point

A total differentiation of the equilibrium around the symmetry gives:

$$\widehat{w} = \frac{Z}{\sigma}(\widehat{Y} + (\sigma - 1)\widehat{P}) \tag{41}$$

$$\widehat{P} = \frac{Z}{1-\sigma}(\widehat{L} + (1-\sigma)\widehat{w}) \tag{42}$$

$$\widehat{Y} = \widehat{L} + \widehat{w} \tag{43}$$

$$\frac{\widehat{\omega}}{\widehat{h}} = \frac{\widehat{w}}{\widehat{h}} - \frac{\widehat{P}}{\widehat{h}} - \frac{\theta}{4-\theta} \tag{44}$$

with Z_ϕ given by:

$$Z_\phi = \frac{1}{2}\left(\frac{w}{P}\right)^{1-\sigma}(1-\phi)$$

where wage and price are given at the symmetric equilibrium by:

$$\begin{aligned}
w &= \left[\phi^\circ \frac{Y^\circ}{\sigma f (P^\circ)^{1-\sigma}} + \frac{Y}{\sigma f P^{1-\sigma}}(1+\phi_b)\right]^{1/\sigma} \\
Y &= (1-\theta/4)w/2, \quad Y^\circ = L^\circ \\
P &= \left[(L^\circ \phi^\circ (w^\circ)^{1-\sigma}/\sigma f) + (L w^{1-\sigma}(1+\phi_b)/\sigma f)\right]^{1/1-\sigma} \\
P^\circ &= \left[(L^\circ (w^\circ)^{1-\sigma}/\sigma f) + (2\phi^\circ L w^{1-\sigma}/\sigma f)\right]^{1/1-\sigma}
\end{aligned}$$

We insert (43) into (41), and rewrite (41) and (42) as the following system:

$$\begin{bmatrix} \sigma - Z_\phi & (1-\sigma)Z_\phi \\ (\sigma-1)Z_\phi & 1-\sigma \end{bmatrix} \begin{bmatrix} \widehat{w} \\ \widehat{P} \end{bmatrix} = \begin{bmatrix} Z_\phi \widehat{L} \\ Z_\phi \widehat{L} \end{bmatrix}$$

by using the Cramer rule, this system can be written:

$$
\begin{aligned}
\widehat{w} &= \frac{1}{\Delta}\begin{bmatrix} Z_\phi\widehat{L} & (1-\sigma)Z_\phi \\ Z_\phi\widehat{L} & 1-\sigma \end{bmatrix} = \frac{Z_\phi\widehat{L}}{\Delta}(1-\sigma)(1-Z_\phi) \qquad (45)\\
\widehat{P} &= \frac{1}{\Delta}\begin{bmatrix} \sigma - Z_\phi & Z_\phi\widehat{L} \\ (\sigma-1)Z_\phi & Z_\phi\widehat{L} \end{bmatrix} = \frac{Z_\phi\widehat{L}}{\Delta}(1-Z_\phi)\sigma \qquad (46)\\
\textit{with} \quad \Delta &= (1-Z_\phi)\left[\sigma + Z_\phi(\sigma-1)\right](1-\sigma) \qquad (47)
\end{aligned}
$$

From eq.(2) we know:

$$
\begin{aligned}
\widehat{L} &= Z_\theta \widehat{h} \\
\text{with} \quad Z_\theta &= \frac{1-\theta/2}{1-\theta/4}
\end{aligned}
$$

By inserting this into the previous system (45) (46), and by using this equation ((45) (46)) with (44) we get:

$$
\frac{V(\widehat{1/2}, \phi)}{\widehat{h}} = \frac{Z_\theta Z_\phi(1-Z_\phi)(1-2\sigma)}{\Delta} - \frac{\theta}{4-\theta}
$$

simplifying with the determinant gives:

$$
\frac{V(\widehat{1/2}, \phi)}{\widehat{h}} = Z_\theta\left[\frac{Z_\phi(1-2\sigma)}{\left[\sigma + Z_\phi(\sigma-1)\right](1-\sigma)} - \frac{\theta}{2(2-\theta)}\right]
$$

Clearly when $Z_\phi = 0$, any deviation from the dispersive equilibrium has a negative impact on net wage. More precisely:

$$
\frac{V(\widehat{1/2}, \phi)}{\widehat{h}} < 0 \Leftrightarrow \frac{Z_\phi(1-2\sigma)}{\left[\sigma + Z_\phi(\sigma-1)\right](1-\sigma)} < \frac{\theta}{4-2\theta}
$$

Which gives

$$
\frac{V(\widehat{1/2}, \phi)}{\widehat{h}} < 0 \Leftrightarrow Z_\phi < \frac{\sigma(1-\sigma)\theta}{(\sigma-1)^2\theta - (2\sigma-1)(4-2\theta)}
$$

The dispersive equilibrium is thus stable if and only if

$$
Z_\phi < Z_\phi^b = \frac{\sigma(1-\sigma)\theta}{(\sigma-1)^2\theta - (2\sigma-1)(4-2\theta)}
$$

Furthermore Z_ϕ is a decreasing function of ϕ, thus:

$$
Z_\phi < Z_\phi^b \Leftrightarrow \phi > \phi_b
$$

The dispersive equilibrium is therefore stable when $\phi > \phi_b$.

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