

# Taxes and Regional Transfers in a New Economic Geography Setting<sup>1</sup>

Lars Brømsøe Termansen,<sup>2</sup>

Department of Economics, Copenhagen Business School;

Copenhagen Economics ApS

*This version: 31st August 2005*

The paper analyses the effects on the equilibrium properties of introducing taxes and regional transfers in a standard Core-Periphery model. A central government levies taxes on production factors and redistributes the revenue to all agents regardless of their location. In the case of Core-Periphery economy this is in effect a re-allocation of agglomeration rents.

Simulations show that taxes and transfers alter the CP-model's properties by moving the Break and Sustain points. Depending on the direction of the transfers, the range of freeness of trade with core-periphery outcomes is reduced for transfers to the periphery and increased for transfers to the core. The width of the overlap where the models exhibit hysteresis effects remains the same regardless of the transfers.

The analysis reveals that in the Core-Periphery outcome the agglomeration rents can be taxed without exhausting the core's scale effects. The tax revenues can then be redistributed such that periphery regions and the central government have incentives in promoting core regions, which function as industrial locomotives for the whole economy.

---

<sup>1</sup>Paper prepared for the ETSG 2005 Dublin, Seventh Annual Conference, 8-10 September 2005.

<sup>2</sup>*E-mail:* lbt.eco@cbs.dk

# 1 Introduction

The policy of *equalisation* is in place almost regardless of the regional scale; even small countries have transfers on the level of local governments – the municipalities – and in some cases transfers exist between nations in economic unions. Denmark, Sweden and Norway are examples of the former and The European Union of the latter. The exact design of these transfers varies from grant programs to directly equalising tax revenue, but at the core they all serve the purpose of equalising welfare or income across regions. E.g. in Denmark the richer municipalities pay a fraction of their local tax revenue to the poorer municipalities. In addition, the central government issues grants to the municipalities depending on what public services the local governments are required to supply.

In most nations there are some regions that are more well off than other regions. The common example being that urban areas are wealthier than rural areas on a per capita basis. From an egalitarian point of view, these differences in income represent undesirable differences in welfare for agents in the regions, and policy makers have implemented various instruments to address this. The issue is also to make sure that the not so well off regions have the *ability* to supply a minimum of public goods, whether it is health care services or basic infrastructure. The political desire to make citizens equally well off is widespread across the world and the most used instrument is directly transferring income from the *rich* to the *poor* regions.<sup>3</sup>

This paper is a part of a project that builds a computational general equilibrium (CGE) model, where regional transfers is an integral part. The theoretical framework is the *New Economic Geography* (NEG) literature, especially the work by Krugman (1991) and Fujita, Krugman and Venables (2001). Here I present a new extension that account for interregional transfer of tax revenue and is a contribution to the research agenda requested in Fujita and Krugman (2003) (p. 158), namely constructing CGE versions of the NEG models. It is part of a policy analysis tool using the often criticized *stylistic* models. The work is also motivated by Ottaviano (2002) (p.15) “...for policy analysis to proceed, the first step is precisely to take the models lit-

---

<sup>3</sup>See Boadway (2003) for a more in depth survey on where transfers are used and the issues of equalisation, including considerations of efficiency and fiscal equity for agents.

erally.” Baldwin, Forslid, Martin, Ottaviano and Robert-Nicoud (2003) have a comprehensive coverage of various policy aspects and are also proponents of entering into the arena of policy analysis. To understand the implications of having transfers in the models is an important step in this undertaking, especially to understand the effects before implementing more bells and whistles in CGE versions calibrated to observed data. This is my focus in the paper at hand.

In related research, two main threads are actively being pursued, all within the NEG framework. These are tax competition and regional investments.

As regards tax competition, there are a number of interesting papers. Andersson and Forslid (2003) observe that agglomeration gives rise to rents and they show that a redistributive tax between mobile and immobile workers can be imposed, and such a tax reduces the incentive for tax competition. Baldwin and Krugman (2004) analyse a tax setting game of two regions where one region is already in an agglomerated state, and find that the concentrated region can set taxes higher than the other region without losing the concentration altogether. However, this positive tax gap is only present for a specific range of transport costs and is hump shaped within that range. Ludema and Wooton (2000) also analyse redistributive taxes and they find that agglomeration reduces tax competition between regions and, furthermore, that the stronger the agglomeration forces are the more the level of equilibrium taxes is increased. Gagné and Riou (2004a) introduces fiscal equalisation schemes between regional governments. They show that when the regional tax revenue is equalised tax competition is significantly reduced promoting a rise in overall tax revenue. Gagné and Riou (2004b) find that revenue sharing between different levels of government may lead to efficient tax setting without coordination, but only for high levels of transport costs. For lower levels of transport costs the revenue sharing leads to a race to the bottom of the local taxes.

As central government grants are sometimes part of a regional equalisation scheme, effects of regional investments are also of interest. Forslid (2004) analyses two countries, where one country has two regions, and finds that improvements in national infrastructure speeds up de-industrialisation. This effect comes from the lower interregional transport cost as the international trade cost are held constant. In addition, he observes that regional subsidies only tend

to be effective when the concentration forces are weak, suggesting that regional policies will gain effectiveness as regional integration increases and the dispersion force begins to dominate. A similar setup of countries and regions is treated in Behrens, Gaigne, Ottaviano and Thisse (2005), where the authors show that a fall in interregional transport costs, e.g. investments in national infrastructure, leads to agglomeration. An opposite effect is observed with a fall in international trade costs, e.g. lowering of tariff barriers which leads to regional dispersion. On the basis of this, they feel that a two region model is misspecified for an analysis of agglomeration patterns. Continuing the thread of active grants or subsidies, the paper by Forslid and Midelfart (2005) introduces a vertical input-output structure and they show that optimal industrial policies for upstream and downstream firms differ significantly. They also find that transport costs and the degree of mobility of firms affects optimal policy design radically and are key determinants of tax and subsidy levels.

Finally, two papers should be mentioned as they deal with income and welfare in the NEG models. The paper Charlot and Gagné (2001) investigate the welfare effects of public policy. They show that policy toward the periphery region could be both equalising but also efficient in welfare terms, but *only* when transport costs are in the core-periphery range. If transport costs are outside that range, the authors cannot show justification of public policy using any welfare criterion. The paper Charlot, Caigné, Robert-Nicoud and Thisse (2004) compares the two outcomes of the Core-Periphery model using the Pareto, utilitarian and Rawlsian welfare criteria. When there are compensation schemes they fail to determine which outcome is best, and the evaluation of the *best* outcome is too heavily dependent on social perceptions and values of equality. They do suggest, however, that there could be an *over*-concentration, i.e. governments should pursue a more even distribution of activity.

The present paper continues and extends this research. As the basis, I use the standard *Core-Periphery* model from Krugman (1991). This choice is founded on the fact that the model's status is *canonical*. It describes the theoretical constructs in the simplest form, whereas other versions of geography models add more complex structures, e.g. mixed factor inputs or international capital flows as in Forslid and Ottaviano (2003) and Martin and Rogers (1995) respec-

tively. In fact, most of the above mentioned papers use the models by Forslid and Ottaviano (2003) and Martin and Rogers (1995). However, opposed to these models, the standard version can only be solved numerically. As computational power is readily available, and a full scale model is the final goal, a numerical implementation is most appropriate.

The paper continues by outlining the basic model in the following section. In section 3, I describe the extension in the form of transfers and define several scenarios that the analysis will focus on. This is followed by section 4, where I present the results of the simulations. Finally, section 5 offers conclusions and discusses areas for future research.

## 2 The Benchmark Model

The analysis is that of Krugman (1991), i.e. a closed economy with two regions. There are two production sectors, one that produces a homogeneous good and another that produces a heterogeneous, differentiated good. There are two factors of production; skilled and unskilled labour. The consumers have identical homothetic preferences, and have a two-tier utility function where the top tier is a Cobb-Douglas function over the homogeneous and heterogeneous goods and the bottom tier is a CES composite over all the varieties of the heterogeneous good. In the following only a single location is considered in order to keep the algebra manageable.

### 2.1 The Consumers

The consumers' utility function is:

$$U = A^{1-\mu} M^\mu, \quad M = \left( \sum_i^n m_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

where  $A$  is the homogeneous good and  $M$  is the heterogeneous composite of the  $n$  varieties. A single variety is denoted as  $m_i$ . The cost share of the heterogeneous composite is  $\mu$ , while  $\sigma$  is the elasticity of substitution between varieties. The consumers' problem is solved in the

usual two step approach, first minimising expenditure of the composite and then maximising the utility of the top-tier function. This reveals the following uncompensated demand for a single variety:

$$m_i = \mu E p_i^{-\sigma} P^{\sigma-1}, \quad P = \left( \sum_i^n p_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \quad (2)$$

where  $E$  is the total expenditure,  $p_i$  is the price of the variety and  $P$  is the CES price index of the composite. Assuming that the price index is unaffected by changes in the price of one variety the elasticity of demand *perceived* by agents is  $\sigma$ . If the prices for the varieties,  $p_m$ , are the same the CES price index reduces to

$$P = \left( \sum_i^n p_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}} = p_m n^{\frac{1}{1-\sigma}} \quad (3)$$

It can be easily seen that the index falls as the number of varieties increases. The strength of this effect depends on the elasticity of substitution between varieties. Turning to the homogeneous good, the uncompensated demand is the usual cost share from the Cobb-Douglas function:

$$A = (1 - \mu) E \frac{1}{p_a}, \quad (4)$$

where  $A$  is the demand and  $p_a$  is the price.

## 2.2 Producers

The sector supplying the homogeneous good produces under constant returns to scale using only unskilled labour as input. The other sector exhibits increasing returns to scale in producing varieties using only skilled labour. Firms maximise profits, and for the homogeneous sector, the usual first order condition of “marginal costs equal marginal revenue” emerges, i.e. output price is equal to the unskilled wage. With respect to the heterogeneous sector, the first order condition depends on the specific formalisation of the increasing returns technology. This is represented

in the cost functions of firms. For firm  $i$  the cost function is defined as

$$c_i = (\alpha + \beta q_i)w_s, \quad (5)$$

where  $c_i$  is the total cost of producing  $q_i$  of variety  $i$ , and  $w_s$  is the skilled wage.  $\alpha$  and  $\beta$  are the fixed and variable cost coefficients respectively. The firm acts as a monopoly in the market for the specific variety, so profit maximisation reveals the monopoly pricing rule

$$\begin{aligned} p_i \left(1 - \frac{1}{\sigma}\right) &= \beta w_s && \iff \\ p_i &= \beta w_s \frac{1}{\rho}, \end{aligned} \quad (6)$$

where  $\sigma$  is the perceived elasticity of demand from (2) and  $p_i$  is the output price of variety  $i$ . Furthermore, it is assumed that there are no barriers to entry. As long as there are opportunities for profits, new firms will establish themselves and produce new varieties. The free entry condition entails zero profits and this determines the output of each firm. The number of firms is derived from the input requirement in (5) and the available skilled labour force. I.e.

$$q^* = \frac{\alpha}{\beta}(\sigma - 1), \quad (7)$$

where  $q^*$  is the output of an active firm in the sector. By symmetry of the cost functions and demand for varieties all firms set the same price and level of output. The total number of firms is then the total skilled labour force divided by the input requirement of each firm. The input needed to produce is  $l^* = \alpha + \beta q^* = \sigma\beta$  yielding the following number of firms

$$n = \frac{L_s}{\beta\sigma}, \quad (8)$$

where  $L_s$  is the endowment of skilled labour. The monopoly power in the monopolistic competition set up is thus expressed through the number of firms and varieties instead of profits as is usual in the pure monopoly case.

Considering many locations, where there is some kind of physical distance, it is assumed that there are costs associated with consuming the heterogeneous good when importing from foreign locations. Specifically, the costs are modelled as *iceberg* transport costs where a fraction of the good *melts* in transit from location  $c$  to  $d$ . The price in location  $d$  of a variety shipped from location  $c$  is

$$p_d = t_{c,d} p_c \quad (9)$$

Then the price index from (3) becomes

$$P_d = \left( \sum_c n_c [p_c t_{c,d}]^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \quad (10)$$

Inserting the transport costs into the derivations of consumer demand for varieties, the uncompensated demand from (2) is rewritten. By symmetry, the demand is the same for each variety:

$$m_c = \mu E_d (p_c t_{c,d})^{-\sigma} P_d^{\sigma-1} \quad (11)$$

Notice that this does not change the elasticity of demand. The price setting and output profile of the firms is therefore unchanged.

### 2.3 Factor Mobility

The skilled labour is footloose, i.e. it is not tied to a specific location as opposed to the unskilled labour. The mobility of skilled workers is assumed to be driven by the desire to receive the highest real wage. At the same time the relocation of labour is not instantaneous – only a fraction of the labour force moves at a time. Denoting the share of skilled labour in location  $c$  as  $\lambda_c$ , the change in the share is given by:

$$\dot{\lambda}_c = \gamma(\omega_c - \bar{\omega}) \lambda_c, \quad \bar{\omega} = \sum_c \omega_c \lambda_c, \quad (12)$$

where  $\omega$  is the real wage and  $\bar{\omega}$  is the average real wage of the whole economy. The equation is multiplied by the share to ensure that changes in all shares sum to zero. The speed of adjustment is given by the coefficient  $\gamma$ . If the real wage in a location is lower than the average, a fraction of the skilled workers will emigrate – and vice versa – if the real wage in a location is higher, then skilled workers will immigrate to that location. As the heterogeneous sector depends on the skilled labour force for producing, the location of the labour also determines where the firms will locate. As each firm uses the same amount of skilled labour and has the same level of output, the share of the heterogeneous industry in a location is equal to the share of skilled labour. I.e. the concentration of skilled workers and the agglomeration of industry are equivalent results, and I will use the terms interchangeably in the remainder of the paper.

In the model there are three main forces that either concentrate or disperse activity. They have been given many names but I will use the ones applied by Krugman (1991)

- Firms want to locate close to the consumers of their products, i.e. the bigger market. This increases the demand for the skilled factor and raises the real wage in that region. This induces more migration into the region and makes the market bigger. This force is the *backward* linkage effect, and concentrates activity.
- Skilled workers want to locate close to where their consumer goods are produced in order not to pay the transport cost mark-up. This increases the amount of skilled labour and the number of firms increases. More varieties will be produced and the price index in the region falls, increasing the real wage. This again induces more migration. This force is the *forward* linkage effect, and also concentrates activity.
- The immobile unskilled workers' demand is spread evenly across regions and works as a dispersion force. At the same time the regional competition for consumers will drive companies away to the less concentrated region.

The final equilibrium of the model depends on the balance of these factors. If the concentrating forces dominate, the economy ends up in a core-periphery state, while a symmetric outcome will emerge if the dispersing forces dominate.

## 2.4 Implementation

The complexity of the algebra in the Core-Periphery model makes it impossible to solve analytically, therefore numerical methods has been applied to identify the model's properties. As mentioned in the introduction, other versions of NEG models have been shown to be solvable, e.g. Forslid and Ottaviano (2003) and Martin and Rogers (1995). The availability of advanced and powerful simulation software makes it possible to solve the original model quite easily while giving the researcher room for effortlessly adding extensions. This is the approach I choose in this paper.

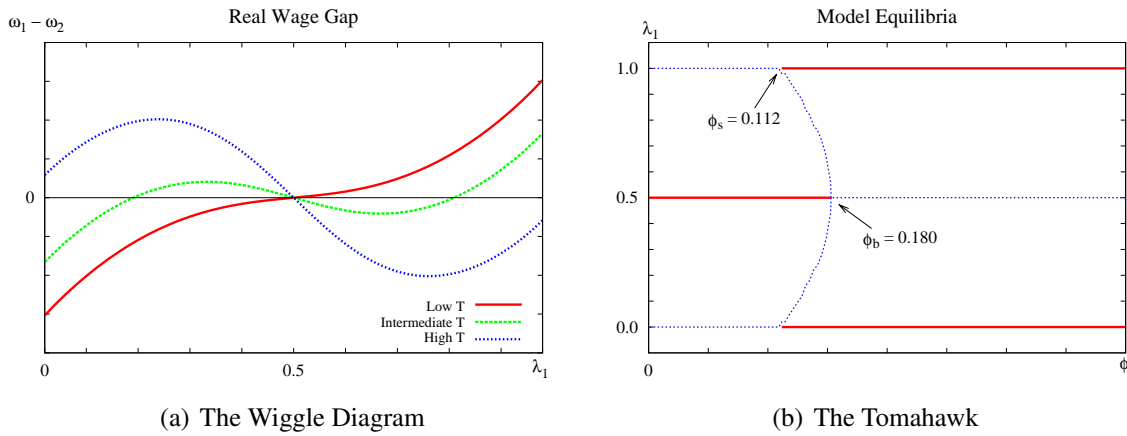
Numerical simulations require specific assumptions regarding the model's parameters, i.e. consumer preferences, production technology, level of transport costs, and factor endowments. The analysis presented in this paper uses the following values for the parameters. In the utility function the cost share of the heterogeneous good is  $\mu = 0.4$  and the elasticity of substitution between varieties is  $\sigma = 5$ . For the production technology the parameters are normalised using  $\sigma$  such to simplify the expressions in (7) and (8), i.e.  $\alpha = \frac{1}{\sigma}, \beta = \frac{\sigma-1}{\sigma}$ . Finally, for the economy as a whole, there are two locations and there is more unskilled labour relative to skilled.

The model is solved for different levels of transport costs and distributions of the skilled labour. The resulting real wages in the two locations are calculated to determine any immigration pressure. For simplicity only three runs are shown in figure 1(a). The diagram is an implicit representation of the phase diagram belonging to (12) and displays the three major types of dynamic relationships the model exhibits.

Equilibria are identified where the schedules cross the horizontal axis and where they cross the diagram's boundaries. On the edges, the economy is completely agglomerated in one location. Above the horizontal axis the migration is toward location 1,  $\lambda_1$  is increasing, moving to the right in the diagram. Equivalently, when the wage gap is below the axis, the migration is towards location 2, moving to the left. For low levels of transport costs, the economy has an unstable symmetric equilibrium and two stable agglomerated equilibria. In the case of intermediate transport costs there are three stable equilibria, the symmetric and the two agglomerated.

In addition, there are two unstable with various distribution of labour. Finally, for high transport costs, there is one stable and two unstable equilibria, the stable is the symmetric while the unstable are agglomerated.

These patterns of equilibria are condensed into the next diagram, figure 1(b). Here the horizontal axis represents the *Freeness of Trade*,  $\phi = t^{1-\sigma}$ . At the leftmost point,  $\phi = 0$ , there are prohibitive transport costs ( $t \rightarrow \infty$ ) while there is free trade at  $\phi = 1$  ( $t = 1$ ). The fully drawn lines show the stable equilibria while the dashed lines represent the unstable ones. This is the Tomahawk Bifurcation known from the literature and it gives a complete description of all equilibria present in the model, as shown by Robert-Nicoud (2005).



**Figure 1:** Dynamics of the Simple *Core-Periphery* Model

It can be seen that the model exhibits strong path dependency. If the economy is at a low level of trade freeness industry will be dispersed evenly in the two regions, the symmetric equilibrium. If a group of workers are relocated, they will experience a drop in the real wage and move back to regain the higher wage and the symmetric equilibrium is re-established. Raising the freeness of trade will not change the symmetric distribution of labour unless the initial relocation is of a significant size, i.e. enough to pass the unstable equilibrium. However, when the economy reaches a certain point, the symmetric equilibrium becomes unstable. This is denoted as the break point. From this point onwards, the economy will always agglomerate toward the region where the first group of workers moved. Starting from the other end with completely free trade, the industry will be concentrated in one region. Lowering the freeness, e.g. erecting

trade barriers, the agglomerated equilibrium is stable until the freeness is reduced to the sustain point. Here the dispersion forces dominate, i.e. the competition effect is the strongest, and the real wage of the skilled labour is the highest where it is most scarce. Migration will continue until the labour is evenly distributed and the symmetric outcome is again the stable equilibrium. Importantly, the break and sustain points overlap, such that either the agglomeration or dispersion of industry show a significant path dependency. If the trade freeness is in the intermediate zone, the exact distribution of industry crucially depends upon the previous state of the economy, i.e. *history matters* (Krugman, 1991).

So far, this is a replication of the literature on the Core-Periphery model. The rigidity of the labour force in the range of intermediate freeness of trade represents an agglomeration rent. A rent which can be extracted without causing the agglomeration to break down. In the next section, the model is extended with taxes and interregional transfers which in effect will function as means of rent extraction. The impacts of these extensions on the model's properties are shown in the next section.

### **3 Extensions: Taxes and Transfers**

The envisioned economy I analyse in this paper, is an area with distinct regions, governed by a central authority. This could either be municipalities subject to a national government, or on a higher level, the member states in a union with some kind of supranational authority. The central authority levies and collects taxes on factor income, and all tax revenue is pooled into the treasury. Then the government re-distributes the revenue back to the consumers in the regions. Depending on the profile of re-distribution this will in effect be an interregional transfer system or even a full fiscal equalisation scheme. By keeping the transfer system in this simple form the analysis actually encompasses a wide range of observed transfer regimes. From the case of the Canadian central authority that collects taxes and distributes to regions, to the case of Danish municipalities that collect local taxes and pay a fraction of their revenue to the central authority who then re-distributes the money.

As taxes are set and collected by a single government agent, there is no need for specifying a tax setting game as in Baldwin and Krugman (2004) and Gagné and Riou (2004a). In those papers, the regional governments play a game of maximising their local tax revenue subject to the tax setting of their opponent in a non-cooperative game. In this paper the central authority sets a national income tax rate, collects the taxes and then distributes the revenue to the regions according to some rule. In fact, in the specification there are no local authorities at all. Therefore, the whole game theoretic aspect is left out of the analysis and only the effects of the single government agent's decisions are considered.

Furthermore, the analysis will focus on the impacts of different policy rules, but refrain from recommending any *optimal* policy. Such a recommendation would require an assumption of an optimality criterion, e.g. a social welfare function that a government can maximise using the tax and transfer instruments, which for the time being I avoid. The purpose of this paper, then, is to analyse only the direct effects of different government initiatives using the two instruments.

The taxes in question are levied directly on factor income of all agents in the economy using the same tax rate. The redistribution of tax revenue to consumers is treated as a lump sum transfer to the agents' income. Giving the consumers a direct income transfer instead of supplying a public good eliminates the specification of a public production sector, and especially its technology. In fact, by not having a public sector but letting consumers spend the tax revenue, the agents will consume goods supplied by the private sector only.

### 3.1 A Central Government

The central government levies taxes on factor income in both regions with the tax rate  $\tau$ . All tax revenue is transferred back by to consumers using a distribution coefficient: region  $d$ 's consumers receive a fraction  $\xi_d$  of the total revenue. The tax revenue,  $G$ , is

$$G = \sum_d \tau (wL_d^u + w_d^s L_d^s), \quad 0 \leq \tau < 1 \quad (13)$$

where the first element in parenthesis is the region's total unskilled wage bill and the second element is the region's total wage bill for the skilled labour. The consumer income less taxes and including transfers is the region's total expenditure

$$E_d = (1 - \tau)(wL_d^u + w_d^s L_d^s) + \xi_d G, \quad \forall \xi_d \geq 0, \quad \sum_d \xi_d = 1 \quad (14)$$

Four types of transfer schemes are analysed to give an overview of the full spectrum of possible regimes. These four transfers range from a subsidy of the concentrating region, denoted *All to the Core* rule, to a compensation of de-industrialisation, denoted as the *All to the Periphery* rule. These represent end-points of possible transfer rules, the two other rules analysed can be considered as a convex combination of the end-points. The whole spectrum of possible transfer rules is then covered by analysing these four rules, and the results will reveal a spectrum of effects. Again, as there are no specific policy recommendations in the paper, the results will serve the purpose of understanding the workings of the economy subject to various policy initiatives, i.e. mixes of transfers and taxes. In the following sections I will go into more detail on each of the four transfer rules.

### **All to the Core**

First, when transfers are subsidising the concentrated region. The transfer of tax revenue follows the skilled work force migration pattern. Thus, when a concentration develops in a region it is reinforced by transfers from the other regions. The transfers in this regime are not intended to compensate or offer any kind of equalisation to a region that experience de-industrialisation. On the contrary, they are designed for boosting any tendency of agglomeration. E.g. if the economy is on the verge of agglomerating in one region, but cannot quite achieve the sustained concentration, the central government can induce and solidify such a concentration through a transfer subsidy. The rule is considered an end-point since there is no a priori selection of the concentrated region. The more simple rule of just transferring all tax revenue to one region, regardless of the migration pattern, requires a further assumption of which region the transfers

initially should go to. The present rule of following migration eliminates the need for this. In addition, this rule is neutralised in the case of the symmetric equilibrium, where the simple rule is not. Formally,

$$\xi_d = \lambda_d, \quad d = 1, 2 \quad (15)$$

### **No Transfers**

The tax collection functions as if the local governments are completely autonomous, almost as nation states that do not pay their revenue to a central authority. This is to get a benchmark as if there is no government at all. However, the regime is implemented as a rule in the model with a central government for easier comparison to the other cases with one tax collector and re-distributor. To allow for this, the amount to be transferred needs to be equal to the tax revenue from each region. I.e. the collection of taxes is as if the local government receives all tax revenue without any interregional transfer system. With migration, the tax revenue (and transfer) will follow the movement of the skilled labour. Formally the rule is

$$\xi_d = \frac{\tau (wL_d^u + w_d^s L_d^s)}{G}, \quad d = 1, 2 \quad (16)$$

which inserted to (14) just reduces to the standard model without a government sector. As the tax is imposed and given to the consumers as a lump sum transfer it is as if there is no tax collection at all.

### **Equal Shares**

This rule is the no frills fiscal equalisation scheme in its simplest form. There is no consideration as to the size, endowments or tax base in the regions. The total tax revenue is simply divided in equal chunks and given to the regions' consumers. In effect, the rule will function as a moderate transfer from a concentrated region to a de-industrialised region, since the tax revenue in the concentrated region is higher from both higher wages and more workers earning income. Thus, the rule takes no account of any migration pattern or location of production. In the case of a

symmetric equilibrium the rule reverts to the no transfers between regions. Formally

$$\xi_d = \frac{1}{2}, \quad d = 1, 2 \quad (17)$$

### **All to the Periphery**

Finally, the case of full transfer to the poorest region. The rule is the reverse of the first rule as the transfers follow the opposite direction of migration. Technically, the tax revenue is distributed according to the “inverse” share of labour in each region. Using this rule a region that loses skilled workers from migration is compensated by receiving more of the tax revenue continuing up to receiving all tax revenue. The Core will contribute all to the Periphery, i.e. this is the full compensation of de-industrialisation of the Periphery. For the symmetric outcome there are no transfers. The fractions are

$$\xi_d = 1 - \lambda_d, \quad d = 1, 2 \quad (18)$$

In the next section I present the results of simulations using these transfer rules.

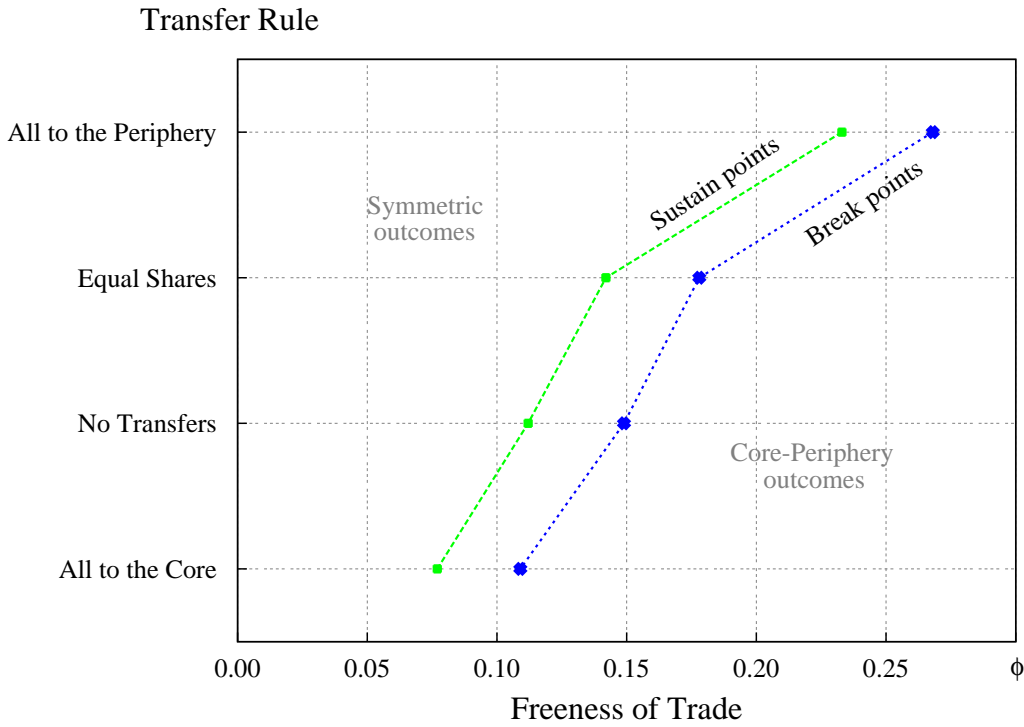
## **4 Simulation Results**

For each of the interregional transfer rules, I solve the numerical model and find the wage differentials such that the migration forces and ultimately the concentration patterns can be deduced. I set an arbitrary tax rate of 20% on factor income.

The analysis focuses especially on the impacts of transfer regimes on the break and sustain points, which is crucial for the agglomeration properties of the model. This will highlight the issue of whether large transfers are possibly forcing an agglomeration to break down.

The result of the simulations are compiled in figure 4, where the horizontal axis is the freeness of trade as in the tomahawk bifurcation. The vertical axis depicts the transfer rule ordered after the direction and level of transfers to the periphery region. Trade freeness increases when

moving to the east in the diagram, while the amount transferred to the poor region increases when moving north. The *no transfer* rule is situated between the *all to the core* and *equal shares* and represents the zero transfer or base line case.



**Figure 2:** Using Different Transfer Rules

As can be seen the break and sustain points move considerably depending on the specific transfer rule in place. The values of the break and sustain points are indicated by markers. The connecting lines are just drawn to emphasize the pattern as the vertical axis is not continuous and the distance between the rules has not been scaled. As in the tomahawk diagram in figure 1(b), the economy has a symmetric equilibrium west of the sustain points and an agglomerated equilibrium to the east of the break points. Between the two points either type of equilibrium is possible. I will denote the area west of the sustain points as the *symmetric* zone and the area east of the break points as the *agglomerated* zone. The area in the middle will be called the *hysteresis* zone, where both symmetric and agglomerated outcomes are stable and the realised equilibrium depends on the previous state of the economy.

It can be seen that the break and sustain points move east as the transfers to the poor region

is increased. Conversely, the points move to the west when the direction of transfers is reversed. Thereby, the divisions of the zones are slanted from the north east down towards the south west. In addition, the width of the *hysteresis* zone is the same for every rule, i.e. the width measured in freeness of trade which is an inverse exponential function of the transport costs. This means that measured in transport cost mark-up, the *hysteresis* range narrows down as the transfers to the poor region increase. For reference, the numerical values of the break and sustain points in both trade freeness and transport costs are shown in table 1.

**Table 1:** Using Different Transfer Rules

	Trade Freeness, $\phi$		Transport Costs, $t$	
	Sustain	Break	Sustain	Break
All to the Periphery	0.233	0.268	1.45	1.39
Equal Shares	0.142	0.178	1.63	1.54
No Transfers	0.112	0.149	1.73	1.60
All to the Core	0.077	0.109	1.90	1.74

By introducing interregional transfers into the standard Core-Periphery model, the basic properties change while the path-dependency remains. It is clear that the economy's state can change dramatically by re-distributing wealth between regions, since the movement of break and sustain points can place the economy in a completely different zone of equilibria. Regardless of whether the policy is to subsidise the concentrated region or to compensate the de-industrialised region, possible dramatic changes need to be taken into account. Considering the related Baldwin and Krugman (2004), the results presented here fit well. They show that in a tax game, the core (north) region can set taxes to just extract an agglomeration rent, without the periphery (south) *stealing* the agglomerating industry. In that paper they analyse different tax rates in the two regions. By designing appropriate transfers in the present model, a difference in *real* tax rates can be achieved, i.e. the region's after tax income being the same in the two models. Therefore, interpreting their results into this model, the core's strategy is to have a transfer rule that does *not* move the economy into the *symmetric* zone where the other region

gets the opportunity of acquiring the core.

## 4.1 Policy

In figure 4 the two axes represent the two policy instruments available for the government.

First, on the horizontal axis there is the trade freeness. In the usual interpretation in the international trade literature this represents transport costs, tariff and non-tariff barriers to trade. Here the regions in the economy are not considered to be subject to tariffs since they are part of the same country, so the trade freeness is a consequence of costs associated with the costs of hauling goods between regions. These costs can either stem directly from the geographic distance impacting on fuel costs and transport time, or stem from a more complex array of factors. I will jointly denote these obstacles as the lack of integration between the regions. Examples of the latter could be differences in the practice of the regional governments when giving authorisations for transporting dangerous goods, or if specific requirements are imposed on the transportation of goods, such as maximum lorry loads. The policy instruments that improve regional integration, e.g. investments in infrastructure, streamlining transportation rules, or reducing the authorisation bureaucracy, will move the economy along the horizontal axis in the figure, and show the government's possibilities to induce an agglomeration or move into symmetry by increasing or decreasing the regional integration respectively. If the regions under consideration is a union of nation states the aspect of tariff and non-tariff barriers are, of course, an issue with respect to the trade freeness.

Second, on the vertical axis is the degree of regional transfers. The position on the vertical axis is directly proportional to the level of transfers to the poorer region, thus it is a depiction of the actual policy instrument in use. By altering the transfer rule, the government can move the economy north and south in the diagram, and for specific intervals of trade freeness also use this instrument to either induce agglomeration or force a symmetric outcome. In addition, the slope of the sustain line shows that large transfers from the core to the periphery can undermine the agglomeration, thereby *bleeding* dry the core.

Depending on the political agenda of the government, i.e. whether it is to induce agglomeration and compensate the periphery, or to equalise regions by moving towards the symmetric zone, the government can choose an appropriate policy mix of regional transfers and regional integration to achieve the desired goal. Especially if the economy is in the *hysteresis* zone, there are a lot of possibilities for the government to influence the final outcome. The designed policy mix of the two instruments will enable the central government to move in all directions in the diagram; north, south, east and west. An example could be if the economy is in an agglomerated outcome in the *hysteresis* zone; the central government could compensate the periphery using transfers thus moving north in the diagram, but to avoid passing the sustain point, the transfer policy can be combined with enhanced regional integration to move east in the diagram and away from the sustain points line, thereby maintaining the core-periphery pattern. Equivalently, if the economy is in a dispersed state the introduction of transfers as a subsidy can induce a concentration of industry in one region (moving downwards in the diagram). Then, by utilising the inertia of the agglomerating forces the government can reverse the transfer policies and extract the agglomeration rents from the core to the periphery by designing the policy mix as not to cross the sustain boundary.

Thus, the introduction of regional transfers opens up a range of opportunities for a central government to influence the industrial concentration in the economy.

## **5 Conclusion**

This paper extends the standard (canonical) model of New Economic Geography with inter-regional transfers of tax revenues. Taxes are levied on factor income and pooled into the central government, who in turn re-distributes the revenue to the agents in the regions. The paper focuses on the impacts on the model's main properties using different rules of transfers.

The extension introduces an extra instrument for the central government to influence the concentration pattern in the economy. The unique part of this is the ability to construct a policy mix to fulfil the ambitions of the government. As mentioned earlier, many governments strive

to make its citizens equally well off, whether it is to supply the same amount of public goods to all regions or striving to equalise the consumers' welfare. The paper shows that the equalisation schemes will alter the properties of the model, specifically reduce the range of core-periphery outcomes. Thus, a core can be taxed and some of the revenue can be transferred to a periphery, but there is a limit on the level of transfers for a given trade freeness. The transfers must be restricted as not to *bleed* the core dry. However, if the ambition of the government is to maintain the core-periphery outcome, it can be achieved by combining the policy of transfers with policies that increases the integration between regions. More integration will in a sense *fortify* the agglomeration, especially if the policies move the economy far into the agglomerated zone. This way, the core functions as an industrial locomotive for the benefit of the whole economy.

With another perspective, starting from a symmetric pattern, the government can combine policies to induce an agglomeration of activity in a specific region. If increased integration is not enough to pass the break point, a policy of subsidies – as in the *All to the Core* rule – moves the economy further, and possibly into the desired concentration outcome. In turn, when the concentration is established, the inertia in the model can be utilised through a reversal of the transfer rule to subsidise the poor region. As long as the economy remains in the *hysteresis* zone, the concentration is sustained – as such the periphery region has to pay in the beginning but will benefit after the policy reversal.

By establishing these properties, the paper sheds *new* light on the complex effects of policy and is an important part in understanding a large scale Computational New Economic Geography model.

## References

Andersson, Fredrik and Rikard Forslid (2003), 'Tax competition and economic geography', *Journal of Public Economic Theory* **5**(2), 279–303.

- Baldwin, Richard and Paul Krugman (2004), 'Agglomeration, integration and tax harmonization', *European Economic Review* **48**(1), 1–23.
- Baldwin, Richard, Rikard Forslid, Philippe Martin, Gianmarco Ottaviano and Frédéric Robert-Nicoud (2003), *Economic Geography and Public Policy*, Princeton University Press, Princeton, New Jersey.
- Behrens, Kristian, Carl Gaigne, Gianmarco I. P. Ottaviano and Jacques-François Thisse (2005), Countries, regions and trade: on the welfare impacts of economic integration, Discussion Papers in Economics 05-01, Department of Economics, University of Strathclyde, Glasgow, Scotland, UK.
- Boadway, Robin (2003), The theory and practice of equalization. mimeo.
- Charlot, Sylvie, Carl Caigné, Frédéric Robert-Nicoud and Jacques-François Thisse (2004), Agglomeration and welfare: The Core-Periphery model in the light of Bentham, Kaldor and Rawls, CEPR Discussion Papers 4715, Centre for Economic Policy Research.
- Charlot, Sylvie and Carl Gaigné (2001), Regional integration, inequalities and public policy, Working Paper 3, INRA-ENESAD.
- Forslid, Rikard (2004), Regional policy, integration and the location of industry, Technical report, Stockholm University, Department of Economics.
- Forslid, Rikard and Gianmarco I.P. Ottaviano (2003), 'An analytically solvable core-periphery model', *Journal of Economic Geography* **3**(3), 229–240.
- Forslid, Rikard and Karen Helene Midelfart (2005), 'Internationalisation, industrial policy and clusters', *Journal of International Economics* **66**(1), 197–213.
- Fujita, Masahisa and Paul Krugman (2003), 'The new economic geography: Past, present and the future', *Papers in Regional Science* **83**(1), 139–164.

- Fujita, Masahisa, Paul R. Krugman and Anthony J. Venables (2001), *The Spatial Economy: Cities, Regions, and International Trade*, The MIT Press, Cambridge, Massachusetts.
- Gaigné, Carl and Stéphane Riou (2004a), Globalization, tax competition and fiscal equalization, Working Paper 9, INRA-ENESAD.
- Gaigné, Carl and Stéphane Riou (2004b), Regional integration and tax competition under upward revenue sharing, Working paper.
- Krugman, Paul (1991), 'Increasing returns and economic geography', *Journal of Political Economy* **99**(3), 483–99.
- Ludema, Rodney D. and Ian Wooton (2000), 'Economic geography and the fiscal effects of regional integration', *Journal of International Economics* **52**(2), 331–357.
- Martin, P. and C.A. Rogers (1995), 'Industrial location and public infrastructure', *Journal of International Economics* **39**, 335–351.
- Ottaviano, Gianmarco I.P. (2002), Regional policy in the global economy: Insights from new economic geography, HWWA Discussion Paper 211, Hamburg Institute of International Economics, Hamburg, Germany.
- Robert-Nicoud, Frédéric (2005), 'The structure of simple 'new economic geography' models (or, on identical twins)', *Journal of Economic Geography* **5**(2), 201–234.