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Determining the level of transportation costs in the core-periphery model: a majority voting approach*

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Abstract

We analyse the political determination of transportation costs in an analytically solvable core-periphery model. In a benchmark case with certainty about where agglomeration takes place, we find that a majority of voters prefers low trade costs and the resulting equilibrium is an industrialised core and a de-industrialised periphery. Allowing for uncertainty we show that a high trade cost candidate, that guarantees the initial symmetric equilibrium, may defeat the core-periphery equilibrium candidate. The reason is that a coalition of risk-averse immobile factors of production votes for status quo due to uncertainty about which region that will attract industrial activity.

Keywords: core-periphery model, majority voting, new economic geography, political economy

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1. Introduction

This paper is directed at an unsatisfactory feature of the models in the *new economic geography*[1]. In that literature the level of trade costs is one of the key parameters determining the equilibrium allocation of industrial production. However, it is simply an exogenously given parameter that the modeller is free to change at will. This is fine considering that the original aim of the literature was to analyse the determinants of industrial location and pinpoint the various forces at work in the agglomeration process. Many complex modelling issues were avoided by assigning trade costs the role of a parameter, and answers to the questions the field was occupied with were obtained. Furthermore, the trade cost parameter in the *new economic geography* models is thought of as capturing all potential impediments to trade. These include tariffs, import quotas, transportation costs (delays due to congestion and bottlenecks, gasoline bills, insurance costs, and road tolls), differing national legislation and technical standards, language differences and red tape at borders. All these components have been lumped together into one single measure of trade barriers, which is determined outside the model.

Yet, negotiations about tariffs, quotas, voluntary export restraints etc, have always been at the top of the political agenda of many countries. In the post-war era this has been manifested by the birth of numerous free trade areas, customs unions, and international organisations governing and monitoring common rules of world trade. Furthermore, while the implementation of the European Union's single market has rendered the question about reduced intra-union tariff barriers on industrial products obsolete, an inadequate common transportation system and inconsistent technical regulations, especially regarding the railway system,

[1] Fujita et al. (1999) provide a synthesis of the field.

are still major obstacles to European economic integration.[2] As a result the European Commission presented a White Paper laying out an action programme, containing some 60 specific measures to be taken at Community level, to implement the common transport policy established in the Rome treaty.[3] Some of the proposed measures are pure investments aimed at improving infrastructure.[4] Others deal with harmonisation of national safety and technical standards, while some are concerned with enforcing existing Community competition rules ensuring that regulatory and technical barriers to entry in the transport sector are eliminated. Finally, some measures aim at creating new administrative bodies to govern and monitor progress, and to facilitate co-operation between various concerned players.

Now that the *new economic geography* has fulfilled its early aims, it seems appropriate to address the determination of the level of trade costs within that framework; to make the level of trade costs endogenous. As tariffs have been significantly reduced between the member states, we will focus on the European Union's effort to lower transportation costs. Because there are clearly winners (firms and consumers in the core) and losers (the periphery) in the *new economic geography* models, it seems natural to apply a political economy approach to determine the level of trade costs. Specifically, trade costs are imperative in determining which region gets the industrial core. Because this affects various factors of production differently, a natural extension would be to use a political economy approach to model how these different interest groups compete for influence in trying to get the core established in their own region. This means that government in some form has to be introduced into the models.

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[2] See COM (2002) 18 for the challenges facing the EU in creating an integrated European railway area.
[3] The European Commission (2001).
[4] Like implementing the trans-European transport network and completing the remaining 11 special projects selected by the Essen European Council 1994.

This has been done by others in different trade-and-location settings in order to analyse *tax competition* between regions (Andersson and Forslid, 2003, Kind et al., 2000, Ludema and Wooton, 2000, and Baldwin and Krugman, 2001). The general picture emerging from these contributions is that tax competition is attenuated as agglomeration economies give rise to a taxable rent for the region hosting the industrial core. Another recent study that analyses regional policy in a model of agglomeration is Robert-Nicoud and Sbergami (2004), where voters have preferences over policy (a subsidy to capital) and over a political dimension (ideology). They show that the big region will attract the core if its relative economic strength (due to its larger size) overcomes its relative political weakness (stemming from a higher dispersion of the population along the political dimension). However, none of the papers mentioned above address the determination of trade costs, which is the purpose of the present work.

One paper that treats trade policies as endogenous in a new economic geography setting is Thede (2003). Allowing for country-specific trade costs she shows that the Nash-equilibria in a trade policy game between welfare-maximising governments are high protection levels. As a result economic activity will always be dispersed. Baldwin et al. (2003) contains a major treatment of public policy in a new economic geography framework. Issues ranging from unilateral trade policy and preferential trade agreements to regional policies, such as infrastructure policies, are analysed using a gallery of analytically solvable models. Our study takes a different route from Baldwin et al. (2003) and Thede (2003). It introduces a political game where voter groups with competing interests struggle to get as much industrial activity as possible located in the region where they live. Specifically, we will incorporate a majority voting game[5] in the analytically solvable core-periphery model developed by Forslid and Ottaviano (2003). Starting from a symmetric equilibrium with industry equally divided between two regions within a country, two political candidates announce their positions on a single policy issue (the level of transportation costs). The policy proposal gaining a majority of votes will then be implemented and, depending on the winning level of transport costs, industry will either relocate or stay put. Due to uncertainty about which region will attract industrial activity (an inherent feature of all new economic geography models), a coalition of agents may vote for a high trade cost candidate ensuring that the symmetric equilibrium is maintained.

The basic idea is the same as in Fernandez and Rodrik (1991), where uncertainty about the distribution of the gains and losses of trade reform gives rise to a bias against efficiency-enhancing reforms. In the present paper, immobile factors of production do not know beforehand (i.e. when they vote) if they will live in the industrialised centre (with its lower cost of living), or in the de-industrialised periphery (where they have to pay transportation costs for imports). As in Fernandez and Rodrik (1991), this uncertainty may prevent a socially efficient equilibrium from materialising, even though such an equilibrium would gain support *ex post*. Moreover, although risk-aversion increases the possibility of *status quo* it is not necessary: all results carry through if agents are risk-neutral.

The rest of this paper is organised as follows. The next section lays out the structure of the core-periphery model. Section 3 adds the majority voting approach to the picture and contains an analysis of the political determination of trade costs. The welfare implications of the election outcome are then compared

[5] Majority voting has been applied to a wide range of policy issues. Examples include Mayer (1984) for the formation of import tariffs, and Fuest and Huber (2001) to explain why countries may fail to coordinate capital taxes.

in section 4 to a social planner's choice of trade costs. Some tentative conclusions are offered in section 5.

2. The Basic Framework

A country consists of two regions, labelled 1 and 2. The population of the country is normalised to unity. There are two factors of production in each region, skilled workers (L^S) and unskilled workers (L^U), and two sectors, *X* and *A*. The sector *A* is perfectly competitive and produces a homogeneous good under constant returns to scale, employing unskilled labour only. The monopolistically competitive *X* sector produces a horizontally differentiated good under increasing returns to scale and employs both skilled and unskilled labour. Consumer preferences are represented by

$$(1) \qquad U(Z)=\begin{cases} \dfrac{Z^{1-\gamma}}{1-\gamma}, \text{if } \gamma \geq 0, \gamma \neq 1 \\ \ln Z, \text{if } \gamma = 1 \end{cases}, \; Z = C_A^{1-\mu} C_X^{\mu}, \; C_X = \left(\int_{i=0}^{n_1+n_2} x(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}},$$

where C_A is the consumed quantity of the agricultural product, C_X is the manufacturing aggregate, $x(i)$ is the consumption of variety i, n_j is the number of produced varieties in region *j*, and $\sigma > 1$ is the elasticity of substitution between any pair of the differentiated products and, by implication, the elasticity of demand. What is new in equation (1), compared to the original model developed in Forslid and Ottaviano (2003), is the use of the constant relative risk aversion (CRRA) utility function, $U(Z)$[6]. The consumers' attitude toward risk is

[6] This is a positive, monotonic transformation of the original utility function. Consumer choice is therefore unaffected by this transformation.

measured by the coefficient of relative risk aversion, $\frac{-U^{''}(Z)Z}{U^{'}(Z)}$, which equals γ. A higher γ implies that consumers are more risk-averse; if γ = 0, then consumers are risk-neutral.

Unskilled labour is assumed to be geographically immobile, whereas skilled workers move freely between the regions. The supply of unskilled labour in each region is equal and fixed; the world supply of skilled labour is constant, but can be distributed differently between the two regions:

(2) $L_1^U = L_2^U = L^U$, $L_1^S + L_2^S = L_W^S$, $2L^U + L_W^S = 1$.

Agricultural production (Q^A) is linear in unskilled labour; specifically, we assume that agricultural production in region *j* is $Q_j^A = L_j^{U,A}$, $L_j^{U,A} < L^U$. Due to free trade in sector *A*'s goods, choosing the homogeneous good as the *numéraire* yields

(3) $w^U = p_A = 1$

for both regions, where w^U is the wage paid to unskilled labour and p_A is the price of the homogeneous good. Each firm in the *X*-sector in region *j* needs both skilled and unskilled workers in production. Specifically, to produce x_j units it needs a fixed amount of α units of skilled labour and βx_j units of unskilled labour. The total cost function for an *X*-sector firm producing in region *j* is hence

(4) $TC_j = w_j^S\alpha + \beta x_j$,

where w_j^S is the return to skilled labour in region *j*. Units are chosen so that $\alpha = 1$, i.e. there is a one-to-one relation between firms and skilled workers. Profit-maximisation ensures that the price set by firms in region *j* is $p_j = (1 - 1/\sigma)^{-1}\beta$. Choosing units of *x* so that[7] $\beta = 1 - 1/\sigma$ gives the *producer* prices as

(5) $$p_1 = p_2 = 1.$$

Free entry and exit in the *X*-sector determine the equilibrium quantity of each firm in region *j* as

(6) $$x_j^e = w_j^S \sigma .$$

Trade in differentiated products is subject to costs of the iceberg type: $\tau > 1$ units of each variety must be shipped for one unit to arrive. As only a fraction $1/\tau$ of any shipped variety arrives, the price of a variety produced in region *j* for consumers living in region *k* is τp. Consumers in region *j* spend a share μ of income on differentiated goods when preferences are represented by the utility function in (1). Demand for each variety in region *j* then becomes

(7) $$d_j = \frac{p_j^{-\sigma}\mu Y_j}{P_j^{1-\sigma}} + \frac{\phi p_j^{-\sigma}\mu Y_k}{P_k^{1-\sigma}}, \ j \neq k,$$

where Y_j is income in region *j*, $\phi \equiv \tau^{1-\sigma}$ is a measure of trade freeness that ranges between 0 (autarky) and 1 (free trade), and

[7] This normalisation is not needed for any of the results in section 2. In the political game in section 3, however, we would need to assign a numerical value to β. Hence, the normalisation.

(8) $$P_j = \left(n_j p_j^{1-\sigma} + \phi n_k p_k^{1-\sigma}\right)^{\frac{1}{1-\sigma}},\ j \neq k,$$

is the unit price of the manufacturing aggregate in region *j*. Finally, the income in region *j* is

(9) $$Y_j = L^U + w_j^S L_j^S.$$

This completes the description of the model. We next turn to a characterisation of short-run equilibrium.

2.1. Short-Run Equilibrium

The short-run equilibrium is defined by immobility of *skilled* labour. Furthermore, it is assumed that there is an instantaneous adjustment of firms so profits are always zero. Due to the one-to-one relation between firms and skilled workers, the equilibrium in the market for skilled labour is:

(10) $$n_j = L_j^S.$$

From equation (10) it is clear that the endowment of skilled labour determines the size of the manufacturing sector. It also determines the amount of unskilled labour that is allocated to manufacturing in equilibrium. To see this note that the total amount of unskilled workers needed in manufacturing in region *j* is $L_j^{U,X} = n_j \beta x_j^e$. Substituting x_j^e and n_j from (6) and (10) gives $n_j \beta x_j^e = (\sigma - 1) w_j^S L_j^S$. We assume that world demand for the agricultural good is "large enough", ensuring that sector *A* is always operating in both regions:

$(\sigma - 1)w_j^S L_j^S < L^U$. Using the expression for skilled labour's wage (see section 2.2 below), this is the case provided that $\mu < \dfrac{\sigma}{2\sigma - 1}$.

The market for differentiated goods is in equilibrium when $x_j^e = d_j$:

$$(11) \quad x_j^e = \frac{p_j^{-\sigma}\mu Y_j}{P_j^{1-\sigma}} + \frac{\phi p_j^{-\sigma}\mu Y_k}{P_k^{1-\sigma}}, \; j \neq k.$$

Using the equations (5), (6), and (8) in (11) gives

$$(12) \quad w_j^S\sigma = \frac{\mu Y_j}{n_j + \phi n_k} + \frac{\phi\mu Y_k}{\phi n_j + n_k}, \; j \neq k.$$

The short-run equilibrium values of the six endogenous variables w^U, *p*, *x*, *Y*, *n*, and w^S are jointly determined for each region by the equations (3), (5), (6), (9), (10) and (12).

2.2. Long-Run Equilibrium

In the long run skilled labour is mobile between the regions and the supply of it in each region becomes endogenous. Skilled workers maximise their indirect utilities, $\omega_j \equiv k w_j^S P_j^{-\mu}$, where $k = \mu^\mu (1-\mu)^{1-\mu}$, by moving to the region with the higher utility. A long-run equilibrium with both regions producing manufactured goods will exist only if skilled workers' indirect utilities in the two regions are equal:

$$(13) \quad \frac{w_1^S}{P_1^{\mu}} = \frac{w_2^S}{P_2^{\mu}}.$$

To solve the long-run equilibrium we only need to add equation (13) and the variable L_j^S to the system characterising the short-run equilibrium. Consider first the case when all of manufacturing is located in one region, say in region 1. Then we have $n_1 = L_W^S$, $n_2 = 0$, $P_1 = \left(L_W^S\right)^{\frac{1}{1-\sigma}}$, $P_2 = \tau P_1$, $Y_1 = \frac{(\sigma+\mu)}{(\sigma-\mu)} L^U$, $Y_2 = L^U$, $x_1 = \frac{\sigma\mu 2L^U}{(\sigma-\mu)L_W^S}$, and $w_1^S = \frac{\mu 2L^U}{(\sigma-\mu)L_W^S}$. Note that income in region 1 is greater than income in region 2. On the other hand, if manufacturing production is symmetrically distributed between the two regions we have $n = \frac{L_W^S}{2}$,

$$P = \left(\frac{L_W^S}{2} + \phi\frac{L_W^S}{2}\right)^{\frac{1}{1-\sigma}}, \quad Y = \frac{\sigma}{(\sigma-\mu)} L^U, \quad x = \frac{\sigma\mu 2L^U}{(\sigma-\mu)L_W^S}, \quad \text{and} \quad w^S = \frac{\mu 2L^U}{(\sigma-\mu)L_W^S}.$$

Income in region 1 (region 2) is now lower (higher); region 1 now produces fewer varieties, but the equilibrium output and wage paid to skilled workers are the same; the price index in region 1 (region 2) is now higher (lower).

2.3. Stability

To see whether the symmetric equilibrium is stable, we consider a move by a small mass of skilled workers from one region to the other. If the post-shock real wage is lower in the receiving region than in the sending region, then workers would wish to move back and restore the symmetric equilibrium. Conversely, if the move of skilled labour raises the real wage, then they want to stay and the symmetric equilibrium is unstable.

2.3.1. The Cases of Free Trade and Prohibitive Trade Costs

Solving the model when trade is free ($\phi = 1$) reveals that any distribution of skilled workers between the regions results in equal real wages. Any allocation of skilled workers is thus an equilibrium allocation. At the other extreme, when trade costs are infinite ($\phi = 0$), the relative real wage becomes

$$(14) \quad \frac{\omega_1}{\omega_2} = \left(\frac{L_1^S}{L_2^S} \right)^{\frac{1-\sigma+\mu}{\sigma-1}} .$$

A rise in L_1^S / L_2^S will decrease region 1's relative wage provided that $1 - \sigma + \mu < 0$, which is assumed to hold[8]. The symmetric equilibrium under autarky is thus stable.

2.3.2. The Case of General Trade Costs

Solving the model when $0 < \phi < 1$ gives the relative wage as[9]

$$(15) \quad \frac{\omega_1}{\omega_2} = \frac{-\lambda\mu\left(\phi^2 - 1\right) - \lambda\sigma(\phi - 1)^2 + (\sigma + \mu)\phi^2 + (\sigma - \mu)}{\lambda\mu\left(\phi^2 - 1\right) + \lambda\sigma(\phi - 1)^2 + 2\sigma\phi} \left(\frac{\phi\lambda + 1 - \lambda}{\lambda + \phi(1 - \lambda)} \right)^{\frac{\mu}{1-\sigma}} ,$$

where $\lambda \equiv \frac{L_1^S}{L_1^S + L_2^S}$ is region 1's share of skilled workers. Depending on the level of trade costs, the relative wage may be increasing or decreasing in λ. Specifically, when trade costs are high (low), the symmetric equilibrium is

[8] This is the no-black-hole condition. Agglomeration forces will always prevail if the condition is not met.

[9] See the Appendix.

stable (unstable). The level of trade costs where the symmetric equilibrium becomes unstable, is obtained by evaluating the derivative of (15) with respect to λ at $\lambda = \frac{1}{2}$; setting the result to zero, and solving for ϕ:

$$(16) \quad \phi^{\text{break}} = \frac{(\sigma - \mu)(\sigma - 1 - \mu)}{(\sigma + \mu)(\sigma - 1 + \mu)}.$$

When the level of trade freeness is below or equal to the *break point*, $\phi \leq \phi^{\text{break}}$, dispersion of industry is a stable equilibrium. For trade freeness higher than the break point the centripetal forces start to dominate the centrifugal ones, the equilibrium becomes unstable and skilled workers move to one of the regions. Which one is indeterminate, a feature of the model that gives rise to uncertainty and is crucial to the analysis that will follow later on.

On the other hand, a core-periphery equilibrium (all of industry is agglomerated in one of the regions) is only sustainable for trade freeness above the *sustain point*. This level of trade freeness is obtained by setting (15), evaluated at $\lambda = 0$ or $\lambda = 1$, equal to unity. The sustain point is implicitly defined by

$$(17) \quad 2\sigma\left(\phi^{\text{sustain}}\right)^{\frac{\sigma-1-\mu}{\sigma-1}} - (\sigma + \mu)\left(\phi^{\text{sustain}}\right)^2 - \sigma + \mu = 0.$$

It can be verified[10] that $\phi^{\text{sustain}} < \phi^{\text{break}}$. This completes the description of the model's geographical features, which can be summarised as follows. For low levels of trade freeness skilled workers are symmetrically distributed between the two regions. Raising the level of trade freeness above the break point induces skilled workers to move to one of the regions as the benefits of

[10] Forslid and Ottaviano (2003).

agglomeration start to dominate the benefits of being close to the demand of the immobile factor of production. Once a core-periphery equilibrium is reached, it will be sustainable for all levels of trade freeness above the sustain point. However, in every *new economic geography* model this process of economic integration is a completely exogenous experiment, used only to illustrate the forces at work and the different equilibria that may result. The rest of the present paper aims at endogenously determining the actual level of trade freeness using a very simple political economy approach. We introduce the political game in the next section.

3. The Political Determination of Transportation Costs

The political game is assumed to be the simplest possible[11]. Society faces a single policy decision: choosing a level of trade freeness from a set of feasible alternatives. These feasible levels are a continuum ranging from autarky to (nearly) free trade, corresponding to the points on the segment $\phi \in [0, \bar{\phi}]$ of the real line, where $\phi^{break} < \bar{\phi} < 1$. We impose this upper restriction on the level of trade freeness for two reasons. First, trade is never completely free in the real world: there are always some costs of transportation associated with shipping goods.[12] Second, the problem becomes uninteresting if trade is completely free: location is indeterminate and transportation costs do not matter for welfare. This exogenously imposed bound only serves to ensure that there is some minimum

[11] The set-up of the political game is taken from Grossman and Helpman (2001, ch. 2). Some of the difficulties we avoid, such as multidimensional policy space and strategic voting, are discussed there.

[12] At first sight this may seem contradictory to the assumption of free trade in the *A*-sector. As Fujita et al. (1999, ch. 7) show, introducing costly trade for the homogeneous products eliminates the break point: a symmetric equilibrium never becomes unstable. One way around this problem is to assume that the homogeneous goods are also differentiated, in which case the familiar bifurcation diagram reemerges. Instead of introducing these two assumptions, yielding the same qualitative behaviour of the model, we stick with the original assumption of free trade in the *A*-sector.

positive level of transport costs in the model. The actual choice of $\phi \in [0, \bar{\phi}]$ remains completely endogenous.

There are two political candidates, each of whom cares only about winning the election (and not about which policy is implemented). In a two-stage game, the candidates simultaneously announce their position on a single policy (which they are committed to carrying out in case of an electoral success) in the first stage, and then the voters cast their votes for one candidate or the other in the second stage. The policy proposals can be thought of as reform programs aiming at improving infrastructure and harmonising different regulatory frameworks, which in our model translate into higher trade freeness (a higher ϕ). As the following analysis will show these reforms may be resisted *even though they are free and need no financing*. If the candidates take the same position each voter tosses a (fair) coin to decide which of them to vote for. The candidate who captures a majority of the votes assumes office and implements his policy proposal. With this set-up we know that, if a voting equilibrium exists, the candidates will announce the same policy (i.e. the alternative that wins over all other alternatives in a pair-wise vote) and face a fifty-fifty chance of being elected.

At the time of the election the economy is in equilibrium with the stock of skilled workers equally distributed between the regions. After the election, ϕ may be increased and there are two possible equilibria. Either the *X*-sector will remain divided between the regions (i.e. the wining proposal's level of trade freeness is below or equal to the break point) or it will agglomerate[13] in one of them (the winning proposal's level of trade freeness is above the break point). In the former case (referred to as *status quo*) there are four voter groups: skilled

[13] We assume that industry relocates instantaneously.

and unskilled labour in both regions. In the latter case (which may be the result of the election) there are three voter groups: skilled workers in the core and unskilled workers in both the core and the periphery. The location outcome will be of great importance for the immobile factor of production, which risks being stuck in a de-industrialised region with its higher cost of living. Note that, when the election takes place, the unskilled workers do not know if they will live in the industrialised centre or in the peripheral region after the election.

Before the election each worker is able to determine his ideal ϕ, taking location effects into account. That is, they determine their preferred level of transport costs in the current (symmetric) equilibrium. They then examine what their preferred level would be in the agglomerated equilibrium, which could *potentially* materialise after the election.[14] Comparing the two they prefer the alternative yielding the highest indirect utility. The Condorcet winner, if it exists, is the policy that is preferred by a majority to any other policy. The rest of section 3 aims at examining the various voter groups' preferred level of trade freeness; then we look for the Condorcet winner. In the next subsection we first investigate what the voter groups want under certainty and risk-neutrality. In section 3.2 we allow for uncertainty and risk-averse agents and perform the same analysis.

3.1. The Case of Certainty and Risk-Neutral Agents ($\gamma = 0$)

This section contains a benchmark case, a clear-cut and simple example that the analysis in the next section will be compared to. There is no uncertainty; all factors of production know which region the *X*-sector will agglomerate in.

[14] Note that this implies that the factors of production are forward-looking regarding voting, whereas skilled labour is myopic regarding its location decision. This inconsistency has to be dealt with, either by introducing forward-looking behaviour among skilled workers or by letting the factors' voting decision be myopic too.

Specifically, we assume that region 1 will become the industrial core. Although not explicitly modelled, we can think of region 1 as having some small advantage (like a port) that will induce skilled workers to move there. We will concentrate on two different equilibrium allocations of industrial activity. The first is when we have a symmetric distribution of the *X*-sector; the other when we have an agglomeration of the *X*-sector in region 1. We split the analysis into these two cases for expositional clarity.

3.1.1. Symmetric Equilibrium

Note that the equilibrium is only symmetric if trade freeness is below or equal to the break point, $\phi \in \left[0,\ \phi^{\text{break}}\right]$, so here we restrict the analysis to this interval of transportation costs. When industrial production is symmetrically distributed there are two types of voter groups in each region, skilled and unskilled workers, making it four in total. However, each group in one region wants the same thing as the corresponding group in the other region due to symmetry. This effectively reduces the number of voting groups to two in the analysis that follows. The indirect utility of unskilled workers in region *j* is $IU_j^U \equiv \frac{kw^U}{P_j^{\mu}} = \frac{k}{\left(L_j^S + \phi L_k^S\right)^{\frac{\mu}{1-\sigma}}}$,

where $L_j^S = L_k^S = \frac{L_W^S}{2}$ and, in the long run, the allocation of skilled workers depends on the level of trade costs, $L_j^S(\phi)$. For unskilled workers in region *j* we then have[15]

[15] See the Appendix.

$$(18)\quad \frac{dIU_j^U}{d\phi}=\frac{k\mu\left[\varepsilon_{L_j^S,\phi}\dfrac{\lambda_j}{\phi}+\left(1-\lambda_j\right)\left(1+\varepsilon_{L_k^S,\phi}\right)\right]}{\left[\lambda_j+\phi\left(1-\lambda_j\right)\right](\sigma-1)\left(L_j^S+\phi L_k^S\right)^{\frac{\mu}{1-\sigma}}},$$

where $\varepsilon_{L_j^S,\phi}\equiv\dfrac{dL_j^S}{d\phi}\dfrac{\phi}{L_j^S}$ is the responsiveness of skilled labour in region j to changes in trade freeness, and $\lambda_j=\dfrac{L_j^S}{L_j^S+L_k^S}$ is region j's share of skilled labour. We know that skilled labour is insensitive to changes in trade costs for trade freeness below the break point: if $\phi<\phi^{\text{break}}$, then $\varepsilon_{L_j^S,\phi}=0$, j = 1, 2. Evaluating (18) we have $\left.\dfrac{dIU_j^U}{d\phi}\right|_{\varepsilon_{L_j^S,\phi}=\varepsilon_{L_k^S,\phi}=0,\lambda_j=\frac{1}{2}}=\dfrac{\mu k}{(1+\phi)(\sigma-1)\left(L_j^S+\phi L_k^S\right)^{\frac{\mu}{1-\sigma}}}>0$. Unskilled workers' indirect utility is strictly increasing in ϕ over the interval $\left(0,\ \phi^{\text{break}}\right)$, and they have a most preferred policy level at the symmetric equilibrium from which deviations monotonically decrease welfare. Specifically, in the range $\phi\in\left[0,\ \phi^{\text{break}}\right]$ their indirect utility is highest at the break point.

Next, let us look at the skilled workers' voting incentive in the symmetric equilibrium. The wage of skilled workers in region j is $w_j^S=\dfrac{\mu L^U}{(\sigma-\mu)L_j^S}$ and the price index in region j is $P_j=\left(L_j^S+\phi L_k^S\right)^{\frac{1}{1-\sigma}}$, where again $L_j^S=L_k^S=\dfrac{L_W^S}{2}$. The indirect utility of skilled workers in region j is $IU_j^S\equiv\dfrac{kw_j^S}{P_j^\mu}=\dfrac{k\mu L^U}{(\sigma-\mu)L_j^S\left(L_j^S+\phi L_k^S\right)^{\frac{\mu}{1-\sigma}}}$. Then

(19)

$$\frac{dIU_j^S}{d\phi}=\frac{-k\mu L^U\left[\frac{\varepsilon_{L_j^S,\phi}}{\phi}\left[\lambda_j+\phi\left(1-\lambda_j\right)\right]+\frac{\mu}{(1-\sigma)}\left[\frac{\varepsilon_{L_j^S,\phi}}{\phi}\lambda_j+\left(1-\lambda_j\right)\left(1+\varepsilon_{L_k^S,\phi}\right)\right]\right]}{\lambda_j(\sigma-\mu)\left(L_j^S+\phi L_k^S\right)^{\frac{\mu}{1-\sigma}+1}}.$$

The effect of improving infrastructure on the indirect utility of skilled workers in any symmetric equilibrium for trade freeness below the break point, is obtained by setting $\varepsilon_{L_j^S,\phi}=0$, j = 1, 2 and $\lambda_j=\frac{1}{2}$:

$$\left.\frac{dIU_j^S}{d\phi}\right|_{\varepsilon_{L_j^S,\phi}=0,\lambda_j=\frac{1}{2}}=\frac{k\mu^2L^U}{(\sigma-\mu)(\sigma-1)\left(L_j^S+\phi L_k^S\right)^{\frac{1-\sigma+\mu}{1-\sigma}}}>0.$$

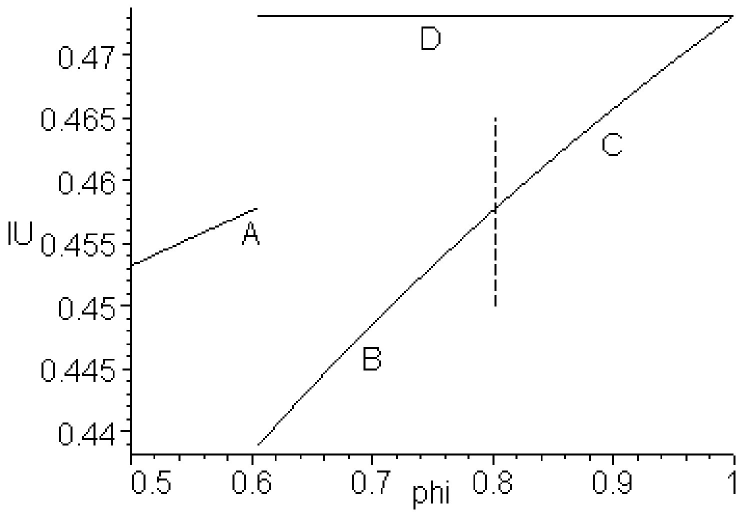
Skilled workers' indirect utility is also strictly increasing in the interval $\phi\in\left(0,\ \phi^{\text{break}}\right)$ and they prefer as high trade freeness (i.e. as low trade costs) as possible over that interval. The reason is simple. The nominal wage earned by both skilled and unskilled labour is unaffected by falling transport costs. Imports, however, become cheaper, reducing the price index and increasing individual welfare. The implication of the analysis above is that all four groups of voters (skilled and unskilled in the two regions) prefer transportation costs to be set at the break point in the symmetric equilibrium. Any other candidate in the range $\phi\in\left[0,\ \phi^{\text{break}}\right)$ would lose in a pairwise vote against the break point. This candidate should hence be compared to the winning candidate at the agglomerated equilibrium.

3.1.2. Agglomerated Equilibrium

The agglomerated equilibrium will only materialise if trade freeness is pushed above the break point. Since we have ruled out the possibility of completely free trade, the analysis is focused on the interval $\phi\in\left(\phi^{\text{break}},\ \bar{\phi}\right]$, $\bar{\phi}<1$. There are three types of voter groups should industrial production be concentrated in region 1: skilled workers in the core, unskilled workers in the core, and unskilled workers in the periphery. We analyse each of them in turn. By assumption, all of industry is located in region 1. Then region 1 does not import any differentiated goods from region 2 and the indirect utilities of unskilled and skilled workers in that region are unaffected by economic integration. Specifically, we have $IU_1^S = \frac{k\mu 2L^U}{(\sigma-\mu)\left(L_W^S\right)^{\frac{1-\sigma+\mu}{1-\sigma}}}$ and $IU_1^U = \frac{k}{\left(L_W^S\right)^{\frac{\mu}{1-\sigma}}}$, hence $\frac{dIU_1^S}{d\phi} = 0$ and $\frac{dIU_1^U}{d\phi} = 0$. The voter groups in the core are indifferent between all the levels of transport costs in the interval $\phi \in \left(\phi^{\text{break}},\ \overline{\phi}\right]$. However, it is easy to show that their welfare is higher in absolute terms at the concentrated equilibrium whenever transportation is costly ($\phi < 1$), which is always the case. They would thus vote for any $\phi \in \left(\phi^{\text{break}},\ \overline{\phi}\right]$ when pitted against the break point.

For unskilled labour left in the periphery we have, from (18), $\left.\frac{dIU_2^U}{d\phi}\right|_{\varepsilon_{L_1^S,\phi}=\varepsilon_{L_2^S,\phi}=0,\lambda_2=0} > 0$. They prefer as high trade freeness as possible, i.e. $\phi = \overline{\phi}$. To ascertain whether their indirect utility is higher than in the symmetric equilibrium, we need to compare the absolute levels. It is straightforward to show that unskilled workers in the periphery are better off in the agglomerated equilibrium if $\overline{\phi} > \frac{1+\phi^{\text{break}}}{2}$. Figure 1 below summarises the results of the preceding analysis for unskilled labour.[16]

Figure 1. Unskilled workers' welfare: the case of certainty



In Figure 1 we plot the indirect utility of unskilled workers against ϕ. The curve *A* displays the indirect utility of unskilled workers in the two regions at the symmetric equilibrium. The indirect utility is continuous on the interval $\left[0,\ \phi^{\text{break}}\right]$; it is increasing in ϕ and attains its maximum value at the break point. At the break point, the indirect utility of unskilled workers in the periphery (core) jumps down (up) and is displayed by the curve *BC* (the line *D*). The point where the dotted vertical line cuts *BC* is the level of ϕ where unskilled workers in the periphery are indifferent between the break point (ϕ^{break}) and the agglomerated equilibrium's candidate ($\overline{\phi}$). This level of transportation costs, which we call ϕ^{indiff}, is equal to $\dfrac{1+\phi^{\text{break}}}{2}$. To the left of ϕ^{indiff}, at the part labelled *B*, the indirect utility is lower than at the break point; to the right of ϕ^{indiff}, at the part labelled *C*, it is higher. Hence, the figure reveals that if the agglomerated equilibrium's transportation cost candidate is to the left of ϕ^{indiff}

[16] All the numerical values assigned to the parameters can be found in the Appendix.

($\bar{\phi} < \phi^{\text{indiff}}$), then unskilled workers stuck in the periphery prefer the break point. If it is to the right ($\bar{\phi} > \phi^{\text{indiff}}$), they prefer $\bar{\phi}$ to the break point. Unskilled workers in the core, however, enjoy a higher indirect utility in the concentrated equilibrium (*D* > *A*). Hence, they prefer any level to the right of the break point. The same is true for skilled workers; their indirect utility is higher at the concentrated equilibrium and they will prefer any $\phi \in \left(\phi^{\text{break}}, \bar{\phi}\right]$ to the break point. The only group that will potentially vote for the break point is the immobile factor in the periphery (L_2^U). As equation (2) makes clear, however, their number can never exceed (or equal) one half of the population (if this was the case there would be no skilled workers in the economy; the model would collapse). We are now ready to summarise our findings:

Proposition 1. A majority favouring the break point will never be reached when there is certainty about where the core will be established. The Condorcet winner will be low transportation costs and industry will agglomerate in one of the regions.

A corollary of the proposition is the following observation. Suppose the economy is in the core-periphery equilibrium when the election takes place. Then a majority vote against the agglomerated equilibrium will never be reached, since only one of the factors will potentially gain from lower trade freeness. This implies that, despite the absence of single-peakedness in preferences over ϕ (due to the discontinuity at the break point), there can be no cycles in the voting outcomes. We next introduce uncertainty and risk-aversion into the model.

3.2. The Case of Uncertainty and Risk-Averse Agents[17]

The major difference when we allow for uncertainty is that unskilled workers do not know *ex ante* (i.e. when they vote) in which region industry will agglomerate for high levels of trade freeness. Since *all* unskilled workers beforehand risk being stuck in the periphery with lower welfare, they may prefer a low level of trade freeness preserving the symmetric equilibrium. As before we analyse the symmetric and the agglomerated equilibria separately.

3.2.1. Symmetric Equilibrium

The indirect utility of unskilled workers in region j is now $IU_j^U \equiv \frac{\left(kw^U\right)^{1-\gamma}}{(1-\gamma)P_j^{\mu(1-\gamma)}} = \frac{k^{1-\gamma}}{(1-\gamma)\left(L_j^S + \phi L_k^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}}$, and so

$$(20) \quad \frac{dIU_j^U}{d\phi} = \frac{k^{1-\gamma}\mu\left[\varepsilon_{L_j^S,\phi}\frac{\lambda_j}{\phi} + \left(1-\lambda_j\right)\left(1+\varepsilon_{L_k^S,\phi}\right)\right]}{\left[\lambda_j + \phi\left(1-\lambda_j\right)\right](\sigma-1)\left(L_j^S + \phi L_k^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}}.$$

Using (20) we have that $\left.\frac{dIU_j^U}{d\phi}\right|_{\varepsilon_{L_j^S,\phi}=\varepsilon_{L_k^S,\phi}=0,\lambda_j=½} = \frac{k^{1-\gamma}\mu}{(\sigma-1)\left(L_j^S + \phi L_k^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}(1+\phi)} > 0$. As in the previous section, the indirect utility is increasing in ϕ over the interval $\left(0, \phi^{\text{break}}\right)$ and reaches its maximum at the break point. It is straightforward to show that the same is true for skilled workers. As in section 3.1.1., all the four voter groups in

[17] We assume that $\gamma \neq 1$. The analysis is qualitatively the same if $\gamma = 1$ and $U(Z) = \ln Z$.

the symmetric equilibrium prefer the break point to any other candidate in the interval $\phi \in \left[0,\ \phi^{\text{break}}\right]$. The question is whether it will win a pairwise comparison against the agglomerated equilibrium's candidate?

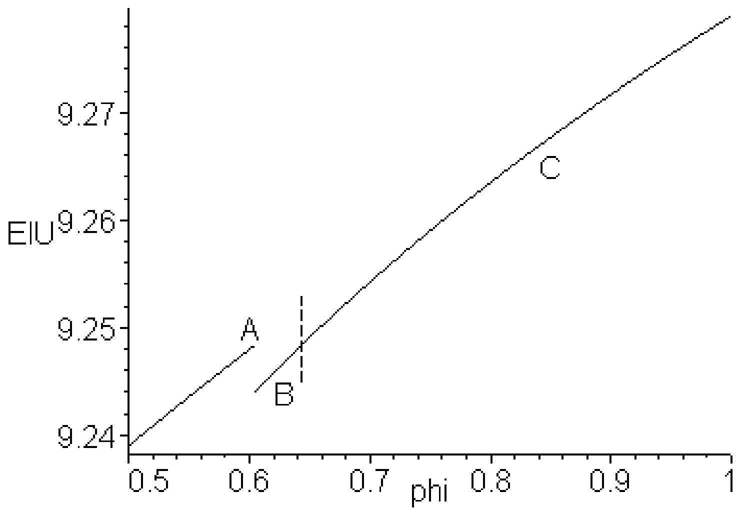
3.2.2. Agglomerated Equilibrium

Things are the same for skilled workers as in section 3.1.2. They always end up in the core and their indirect utility at the concentrated equilibrium is unaffected by changes in transport costs. They are hence indifferent between all the candidates $\phi \in \left(\phi^{\text{break}},\ \bar{\phi}\right]$. However, whenever trade is costly their welfare is higher in absolute terms at the concentrated equilibrium and they would vote for any $\phi \in \left(\phi^{\text{break}},\ \bar{\phi}\right]$ when pitted against the break point.

Turning to unskilled workers, there is a very important difference. When the election takes place they do not know where the core will be established should they vote for high trade freeness. The expected indirect utility of unskilled workers in region j equals $EIU_j^U = pIU_{j,C}^U + (1-p)IU_{j,P}^U$, where $IU_{j,C}^U = \dfrac{k^{1-\gamma}}{(1-\gamma)\left(L_W^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}}$ is indirect utility if region j becomes the core; $IU_{j,P}^U = \dfrac{k^{1-\gamma}}{(1-\gamma)\left(\phi L_W^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}}$ is indirect utility if region j becomes the periphery, and p is the probability that region j becomes the core. Because the two regions are identical at the symmetric equilibrium, there is a fifty-fifty chance that either of them will become the core, hence p = 1/2. We then have

$$\frac{dEIU_j^U}{d\phi} = \frac{k^{1-\gamma}\mu}{2(\sigma-1)\left(\phi L_W^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}\phi} > 0$$; expected indirect utility at the concentrated equilibrium is increasing in the range $\phi \in \left(\phi^{\text{break}}, \bar{\phi}\right)$ and attains its maximum at $\bar{\phi}$. Note that this is valid for *all* unskilled workers; they all prefer $\bar{\phi}$ in the interval $\phi \in \left(\phi^{\text{break}}, \bar{\phi}\right]$. Their voting behaviour depends on a comparison of the absolute level of indirect utility at the break point with the expected indirect utility at the concentrated equilibrium. Figure 2 graphically illustrates the situation for unskilled workers.

Figure 2. Unskilled workers' expected indirect utility: the case of uncertainty and risk-averse agents



In Figure 2, *A* denotes the indirect utility of unskilled workers in both regions at the symmetric equilibrium, whereas *BC* shows the *expected* indirect utility of unskilled workers in both regions at the concentrated equilibrium. As in Figure 1, the dotted vertical line is drawn at the level of trade freeness, ϕ^{indiff}, where unskilled workers are indifferent between the break point and $\bar{\phi}$. The major difference, compared to Figure 1, is that expected welfare jumps down for *all* workers at the break point. The curve increases in trade freeness to the right of the break point. Along the *B* segment expected welfare is lower than in the symmetric equilibrium and *all* unskilled workers would prefer the break point to any level in the range $\overline{\phi} \in \left(\phi^{\text{break}},\ \phi^{\text{indiff}}\right)$.

On the other hand, they would prefer any $\phi \in \left(\phi^{\text{indiff}},\ \overline{\phi}\right]$ to the break point, yielding the level $C > A$ of expected indirect utility. Note that if agents become more risk-averse (γ increases), then the possibility increases that the break point is preferred to the concentrated equilibrium candidate. That is, if we increase γ then the *BC* curve shifts down, ϕ^{indiff} increases and the interval $\left(\phi^{\text{break}},\ \phi^{\text{indiff}}\right)$ widens, increasing the *B* segment at segment *C*'s expense. The possibility that the expected indirect utility for unskilled workers is lower in the agglomerated equilibrium, compared to the initial equilibrium, hence rises. There is, however, an upper bound on *B*'s expansion. To see this we use the fact that the indirect utility at the break point is greater than the expected indirect utility at $\overline{\phi}$ if $\left[2\left(\frac{1+\phi^{\text{break}}}{2}\right)^{\frac{\mu(1-\gamma)}{\sigma-1}}-1\right]^{\frac{\sigma-1}{\mu(1-\gamma)}} > \overline{\phi}$. Taking the limit of the left-hand side (i.e. letting $\gamma \to \infty$, see the Appendix) we arrive at $\frac{1+\phi^{\text{break}}}{2} > \overline{\phi}$. If the agglomerated equilibrium's candidate is *greater* then the left-hand side of the last inequality, then even infinitely risk-averse unskilled workers will vote for reform. Whether or not the break point wins against $\overline{\phi} \in \left(\phi^{\text{break}},\ \phi^{\text{indiff}}\right)$ depends on the share of unskilled workers in the economy. If $L^U > \frac{1}{4}$, then a majority of unskilled workers will vote for the break point; if $L^U < \frac{1}{4}$ a majority of skilled workers will vote for $\overline{\phi}$. Finally, at the point of indifference ($\overline{\phi} = \phi^{indiff}$), each unskilled worker tosses a coin to decide which alternative to vote for. Since there is a continuum of unskilled workers, half of them will vote for ϕ^{break} and the other half for $\overline{\phi}$. Because skilled workers will vote for $\overline{\phi}$ in this case, it will win against the break point. Our findings in this section are summarised in proposition 2:

Proposition 2. When the distribution (across production factors) of the gains and losses from improving infrastructure is uncertain, a majority of the factor at risk of being hurt by reform may resist it. This is more likely to happen the higher the risk-aversion among agents. As a result industry will remain equally divided between the regions.

Compared to the case of certainty, the political game becomes qualitatively different when we incorporate uncertainty. From proposition 1 we know that under certainty low transport costs will always prevail, giving rise to agglomeration. However, when identifying the winners and losers of reform (improving infrastructure, harmonising regulatory frameworks etc) is uncertain, the initial symmetric equilibrium may be the result of the political process. Note that this is so even if the reform package is free of charge.[18] Two final points are worth noting. The first is that it is more likely that *status quo* prevails if voting on reform is gradual in nature and voters are myopic. That is, if voting on reform occurs in several small steps, then it is more likely that the immobile factor will vote against the reform package. Second, if agglomeration is

[18] Introducing costs for improving infrastructure would seem like an interesting extension. We conjecture, however, that this would reinforce our result. In the present framework there is resistance against reforms even if they need no financing. Intuition suggests that if, on top of that, the immobile factor of production would have to pay for reforms to be adopted, then resistance would be greater.

desirable from society's point of view (something we examine in the next section), then measures to compensate potential losers in the periphery (à la Structural Funds of the EU) could be used to reduce resistance to reform (decreasing γ).

4. Welfare Analysis: the Election Outcome versus a Social Planner's Choice

In this section we compare the total welfare of the election outcome with the total welfare a social planner would achieve. The social planner is utilitarian, striving to maximise society's aggregate indirect utility. None of the groups is more important to the planner than any other. As before, we need to look at two subintervals due to the discontinuity at the break point. Total welfare at the symmetric equilibrium is

$$TWS = \frac{2L^U k^{1-\gamma}}{(1-\gamma)\left(\frac{L_W^S + \phi L_W^S}{2}\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}} + \frac{L_W^S\left(k\mu 2L^U\right)^{1-\gamma}}{(1-\gamma)\left[(\sigma-\mu)L_W^S\right]^{1-\gamma}\left(\frac{L_W^S + \phi L_W^S}{2}\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}},$$ which

is strictly increasing over $\phi \in \left(0, \phi^{\text{break}}\right)$ and attains its maximum at the break point. The corresponding expression at the concentrated equilibrium is

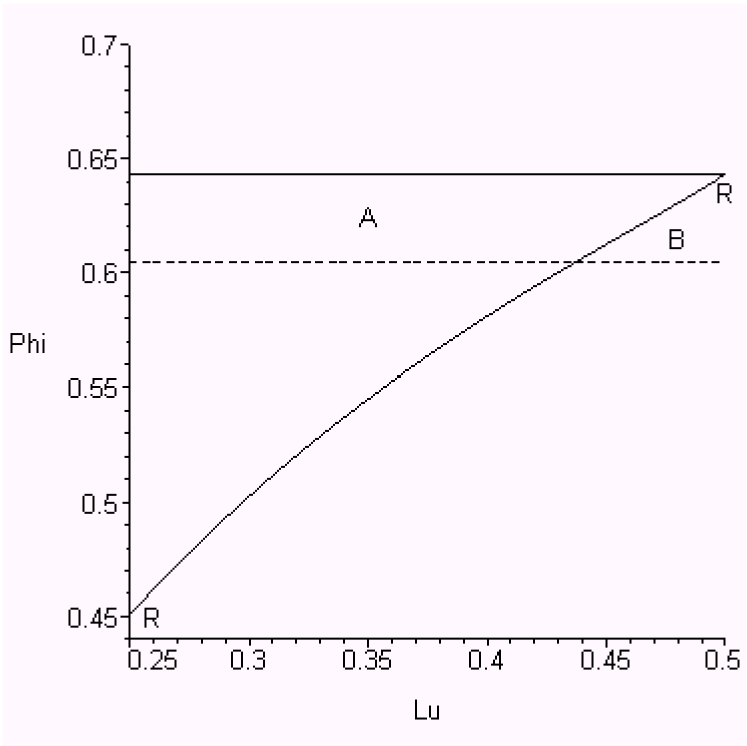
$$TWA = \frac{L^U k^{1-\gamma}}{(1-\gamma)\left(\phi L_W^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}} + \frac{L^U k^{1-\gamma}}{(1-\gamma)\left(L_W^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}} + \frac{L_W^S\left(k\mu 2L^U\right)^{1-\gamma}}{(1-\gamma)\left[(\sigma-\mu)L_W^S\right]^{1-\gamma}\left(L_W^S\right)^{\frac{\mu(1-\gamma)}{1-\sigma}}},$$

where $\phi = \overline{\phi}$. The precise condition ensuring that total welfare is higher in the agglomerated equilibrium, *TWA* > *TWS*, is

$$(21)\quad \overline{\phi} > \left[\left[\left(\frac{1+\phi^{\text{break}}}{2}\right)^{\frac{\mu(1-\gamma)}{\sigma-1}}(1+C) - C\right]2 - 1\right]^{\frac{\sigma-1}{\mu(1-\gamma)}},$$

where $C \equiv \left(\frac{1-2L^U}{2L^U}\right)^{\gamma}\left(\frac{\mu}{\sigma-\mu}\right)^{1-\gamma}$ and $\overline{\phi}$ is the concentrated equilibrium trade freeness candidate. If the inequality (21) holds, and a majority of unskilled workers votes for the break point, then the election outcome is inefficient. In Figure 3, we plot the right-hand side of (21) against L^U.

Figure 3. The election outcome vs. a social planner's choice



On the vertical axis we have ϕ. The horizontal dotted line in Figure 3 is the break point; the upper solid line is the critical level of trade freeness, $\left[2\left(\frac{1+\phi^{\text{break}}}{2}\right)^{\frac{\mu(1-\gamma)}{\sigma-1}}-1\right]^{\frac{\sigma-1}{\mu(1-\gamma)}}$, where unskilled workers are indifferent between the two candidates. As before, call this level ϕ^{indiff}. If the agglomerated equilibrium's trade freeness candidate is below this critical level ($\overline{\phi} < \phi^{\text{indiff}}$), then unskilled workers will vote for the break point, maintaining the symmetric equilibrium. If $\overline{\phi}$ is above it, then they will vote for $\overline{\phi}$, yielding agglomeration. The curve *RR* is the right-hand side of (21). It can be shown analytically that the solid line always lies above *RR* (the condition is $\phi^{\text{break}} < 1$, which is always true). The implication is that if unskilled workers choose to vote for $\overline{\phi}$, yielding agglomeration, then the equilibrium will be efficient (i.e. if $\overline{\phi} > \phi^{\text{indiff}}$ holds, then inequality (21) also holds since $\phi^{\text{indiff}} > RR$).

On the other hand, if $\overline{\phi} < \phi^{\text{indiff}}$, then two possibilities arise. Either we will have a case such as *A* in Figure 3, where $\phi^{\text{indiff}} > \overline{\phi} > RR$. The outcome of the election will be continued dispersion of industry, which is not what the social planner would choose since $\overline{\phi} > RR$ is equivalent to inequality (21): the symmetric equilibrium is inefficient. Or we will have the situation depicted in *B* ($\phi^{\text{indiff}} > RR > \overline{\phi}$), which also implies maintained regional symmetry in industrial structure. This case, however, is efficient (inequality (21) does not hold) and would be chosen by a social planner. The difference between the cases *A* and *B* is the number of unskilled workers in the economy. We see that the curve *RR* is below the break point for low values of L^U. Since $\overline{\phi}$ is greater than the break point by construction we know for sure that the inequality in (21) holds for low values of L^U: a social planner would favour the agglomerated equilibrium. For real high values of L^U, however, it becomes possible that the election outcome is efficient (i.e. that (21) does not hold). The reason is that when skilled workers (the only factor that gains for sure if industry should agglomerate) become very few, then that factor's welfare becomes very small in society's total welfare. Conversely, if unskilled workers are (almost) the only factor of production in the economy, then their interest coincides with society's and their choice of ϕ will be efficient. As seen in Figure 3 the most likely outcome is that (21) holds, and that the symmetric equilibrium is inefficient.

5. Conclusions

The *new economic geography* literature highlights the role played by backward and forward linkages in causing agglomeration of economic activity. Specifically, for high levels of trade costs the centrifugal forces dominate the centripetal ones, giving rise to an equal distribution of factors of production. For low levels of trade costs the benefits of agglomeration overcome the need to locate close to final demand and mobile firms may cluster, creating industrial centres and de-industrialised peripheral regions. The role of trade costs in determining the final pattern of industrial production is thus very important.

The aim of this paper is to make the choice of trade costs endogenous by extending an analytically solvable core-periphery model with a political economy approach. Specifically, the level of trade costs is politically determined using a majority voting rule. As a benchmark case, we analyse the political process under certainty, meaning that all factors of production know where the core will end up. The winning level of trade costs will be the one guaranteeing that agglomeration occurs in one of the regions: all trade costs ensuring the symmetric equilibrium will be defeated in a majority vote. When we allow for uncertainty, however, another possible outcome of the political process emerges. Due to the uncertainty about which region will become the industrialised core, immobile factors of production may vote for a level of transportation costs that preserves the initial equilibrium featuring a symmetric distribution of firms. The reason is that whether this production factor gains or loses from improved infrastructure (lower transportation costs) is uncertain, since there is nothing that guarantees that the core will end up in its home region, introducing a bias for *status quo*. This outcome may be inefficient in comparison with a social planner's choice of trade costs.

Appendix

Finding the relative real wage for a general level of trade costs

Inserting the equations (9) and (10) in (12) gives

$$\text{(A1)} \quad w_j^S \sigma = \frac{\mu\left(L^U + w_j^S L_j^S\right)}{L_j^S + \phi L_k^S} + \frac{\phi\mu\left(L^U + w_k^S L_k^S\right)}{\phi L_j^S + L_k^S}, \; j \neq k .$$

The above system, two equations in two unknowns, can be solved to yield

$$\text{(A2)} \quad \begin{cases} w_1^S = \dfrac{\mu L^U\left[\sigma(a+b\phi) - \mu L_2^S\left(1-\phi^2\right)\right]}{d} \\ w_2^S = \dfrac{\mu L^U\left[(b+a\phi)d + a\phi L_1^S \mu\left[\sigma(a+b\phi) - \mu L_2^S\left(1-\phi^2\right)\right]\right]}{bd\left(\sigma a - \mu L_2^S\right)} \end{cases},$$

where $a \equiv \phi L_1^S + L_2^S$, $b \equiv L_1^S + \phi L_2^S$ and $d \equiv \left(\sigma b - \mu L_1^S\right)\left(\sigma a - \mu L_2^S\right) - \mu^2\phi^2 L_1^S L_2^S$. Using (A2) and the price index for each region we have, after some algebraic manipulations, that $\dfrac{\omega_1}{\omega_2} \equiv \left(\dfrac{w_1^S}{P_1^\mu}\right) / \left(\dfrac{w_2^S}{P_2^\mu}\right)$ is equal to $\left[\dfrac{\sigma(a+b\phi) - \mu L_2^S\left(1-\phi^2\right)}{\sigma(b+a\phi) - \mu L_1^S\left(1-\phi^2\right)}\right]\left(\dfrac{a}{b}\right)^{\frac{\mu}{1-\sigma}}$. Factoring out $L_1^S + L_2^S$ in the numerators and the denominators of both factors, and defining $\lambda \equiv \dfrac{L_1^S}{L_1^S + L_2^S}$, yield (15) in the text.

Deriving equation (18) in the text

For unskilled workers in region j we have $IU_j^U = \dfrac{k}{\left(L_j^S + \phi L_k^S\right)^{\frac{\mu}{1-\sigma}}}$. Then

$\dfrac{dIU_j^U}{d\phi} = \dfrac{\mu k\left[\dfrac{dL_j^S}{d\phi} + L_k^S + \phi\dfrac{dL_k^S}{d\phi}\right]}{(\sigma-1)\left(L_j^S + \phi L_k^S\right)^{\frac{\mu}{1-\sigma}+1}}$. The sign depends on the expression within square brackets, which can be manipulated to give $\left[\dfrac{dL_j^S}{d\phi}\dfrac{\phi}{L_j^S}\dfrac{L_j^S}{\phi} + L_k^S\left(1 + \dfrac{dL_k^S}{d\phi}\dfrac{\phi}{L_k^S}\right)\right]$. Factoring $L_j^S + L_k^S$, and defining the responsiveness of skilled labour to changes in trade costs in region j as $\varepsilon_{L_j^S,\phi} \equiv \dfrac{dL_j^S}{d\phi}\dfrac{\phi}{L_j^S}$, we arrive at equation (18) in the text. Equation (19) is obtained in a similar way; equation (20) is merely a positive monotonic transformation of (18).

Parameter values used for the Figures 1 to 3

In Figure 1 we set $\gamma = 0$, $\mu = 0.3$, $\sigma = 3$, $L_j^S = L_k^S = 0.2$.

In Figure 2 we raised γ to 0.9.

In Figure 3 we set $\gamma = 0.9$, $\mu = 0.3$, $\sigma = 3$.

Taking the limit

Welfare for an unskilled worker at the break point is greater than expected welfare at the agglomerated equilibrium if $\left[2\left(\frac{1+\phi^{\text{break}}}{2}\right)^{\frac{\mu(1-\gamma)}{\sigma-1}}-1\right]^{\frac{\sigma-1}{\mu(1-\gamma)}} > \bar{\phi}$.

Setting $f \equiv \frac{1+\phi^{\text{break}}}{2}$, $f \in \left(\frac{1}{2}, 1\right)$, $g \equiv \frac{1}{f} > 1$ and $x \equiv \frac{\mu(\gamma-1)}{\sigma-1}$ we have $\left(2g^x - 1\right)^{-\frac{1}{x}} > \bar{\phi}$. If $\gamma \to \infty$, then $x \to \infty$ so $\lim_{x\to\infty} \left(2g^x - 1\right)^{-\frac{1}{x}} = \lim_{x\to\infty} e^{-\frac{1}{x}\ln\left(g^x\right)-\frac{1}{x}\ln\left(2-\frac{1}{g^x}\right)} = e^{\ln\left(\frac{1}{g}\right)} = f$.

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