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Unionized Wage Setting and the Location of Firms

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Abstract

We analyze how unionized wage setting affects the location of firms. We find that the degree of 'centralization' (at firm or sectoral level) and 'regionalization' (at regional or supra-regional level) is crucial. We show that wage setting at the firm level is the best policy to attract firms when trade costs are low, while wage setting at a more centralized level is most effective to attract firms when trade costs are high. Moreover, wage setting at the supra-regional level is beneficial for the already more agglomerated region and hurts the peripheral region.

Keywords: location, unions, regionalization, centralization

JEL classifications: J51, R12, R3, F12

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NON-TECHNICAL SUMMARY

The presence of unions and immobile labour are two key aspects of European labour markets. The model in this paper addresses the importance of these features for the location decisions of firms. We first of all show that, under these assumptions, the relationship between agglomeration and trade costs remains an inverted U-shaped curve as in the seminal New Economic Geography models. There is no agglomeration at high trade costs, the emergence of a core-periphery at intermediate costs and finally a reversion to dispersed manufacturing to take advantage of low wages at low trade costs.
Secondly, and more importantly, we analyze how unionized wage setting affects the location of firms. We find that the degree of ‘centralization’ (at firm or sectoral level) and ‘regionalization’ (at regional or supra-regional level) is crucial. We show that wage setting at the firm level is the best policy to attract firms when trade costs are low, while wage setting at a more centralized level is most effective to attract firms when trade costs are high. Moreover, wage setting at the supra-regional level is beneficial for the already more agglomerated region and hurts the peripheral region.

De aanwezigheid van vakbonden en immobiele arbeiders is kenmerkend voor Europese arbeidsmarkten. Het model in deze paper analyseert het belang van deze kenmerken voor locatiebeslissingen van ondernemingen. In de eerste plaats tonen we aan dat het verband tussen agglomeratie en handelskosten een omgekeerd U-vormig verloop kent – net als in de basismodellen van Nieuwe Economische Geografie. Ondernemingen verspreiden zich indien handelskosten hoog of laag zijn en agglomereren indien handelskosten intermediair zijn.
Bovenal analyseren we echter hoe loonzetting door vakbonden de locatiebeslissing van bedrijven beïnvloedt. We stellen vast dat de mate van ‘centralisatie’ (op ondernemings- of sectorieel niveau) en ‘regionalisatie’ (op regionaal of supra-regionaal niveau) cruciaal is. Loonzetting op het ondernemingsniveau blijkt het beste te zijn om bedrijven aan te trekken indien handelskosten laag zijn, terwijl een meer centrale loonzetting optimaal is om bedrijven aan te trekken bij hoge handelskosten. Bovendien blijkt loonzetting op een supra-regionaal niveau gunstig te zijn voor de meest geagglomereerde regio en in het nadeel te spelen van de periferie.

1 Introduction

The first generation of New Economic Geography (NEG) models assumes perfect labour markets and perfect labour mobility between regions. These assumptions, made in seminal NEG models as the ones of Krugman (1991) and Venables (1996), are however hard to reconcile with the overwhelming empirical evidence that labour markets in Europe are far from perfect (Layard et al., 1991) and that labour mobility remains limited (Decressin and Fatas, 1995). The main question we want to answer in this paper is whether the forces determining the location of firms change when we assume labour to be immobile and labour markets to be imperfect.

The key feature of the model is the introduction of the degree of centralization of wage setting, reflected by the number of unions. In our opinion, this reflects an important characteristic of the European labour market; the Nordic countries, for instance, have a highly centralized wage setting while in the UK, wages are rather set at a decentralized level.

As in most existing NEG models, the relationship between trade costs (TC)[1] and agglomeration (most of the time) turns out to be an inverted U-shaped curve: a symmetric outcome is stable at both high and low trade costs while agglomeration is stable for intermediate trade costs. Note that in the benchmark NEG models, agglomeration is stable for low trade costs too. However, introducing extra dispersion forces in these models renders agglomeration unstable again for low trade costs. In our model we also have an extra dispersion force that stems from imperfections in the labour market.

Furthermore, we show that the degree of 'centralization' – at the firm or sectoral level – and the degree of 'regionalisation' – at regional or supra-regional level – of wage setting affects the wage level in a significant way. Location decisions of firms will therefore be influenced by these institutional factors. Based on these outcomes, our model allows us to make some policy recommendations as far as the attraction of new firms is concerned. We show that wage setting at the firm level is the best policy to attract firms when trade costs are low, while wage setting at a more centralized level is the most effective way to attract firms when trade costs are high. Moreover, wage setting at the supra-regional level will be beneficial for the more agglomerated region and hurt the peripheral region.

[1] We use trade costs to refer to all possible costs prohibiting trade, e.g. transportation costs, tariffs, information costs and/or communication costs

Picard and Toulemonde (2002 and 2003) were, as far as we know, the first authors to introduce imperfect labour markets in NEG models. However, our model differs from theirs in several respects. The most important difference between the models is the agglomeration force. Picard and Toulemonde (2002) - like us - assume the home market effect to be the agglomerative force. Picard and Toulemonde (2003) introduce technological externalities as the agglomerative force and exclude income effects. We however believe that income effects cannot be dismissed: as consumers earn more, they are able to spend more and increase their demand.

A second important difference is the modelling of the demand side. Picard and Toulemonde (2002) use iso-elastic demand functions as is most common in seminal NEG models. They however assume wages to be set at the national level and therefore wages can not differ between regions. This shortcoming is adressed in Picard and Toulemonde (2003) where the possibility of regional wage setting is taken into account. In this paper the authors opt for linear demand functions. We however want to follow the large strand of literature that uses an iso-elastic demand function and analyze whether the results of Picard and Toulemonde (2003) would still hold. Unlike Picard and Toulemonde (2002), we however also take the possibility of regional wage setting into account.

A last difference concerns the modelling of the labour market. We assume wages to be set unilaterally by unions. Both papers by Picard and Toulemonde introduce wage setting at firm (2002) or industry level (2003). We on the other hand treat the number of unions as a variable in the model. This is the new aspect in the paper and allows us to focus better on our main topic of interest, i.e. the relationship between the location decisions of firms and the degree of centralization of wage setting in the countries considered.

The structure of the paper is as follows. The model is presented in section 2. In section 3 we derive the conditions for agglomeration and symmetry to be stable equilibria and relate these conditions to the number of unions. In section 4 we dig deeper into the role of unions: we show that the degree of 'centralization' and 'regionalisation' of wage setting affects the wage level in a significant way, and we make policy recommendations as far as the attraction of new firms is concerned. The last section states the conclusions and offers some ideas for future research.

2 The model

We assume two regions, denoted by H (Home) and F (Foreign), and two kinds of goods, denoted by A (agriculture), and M (manufacturing). The agricultural sector is competitive, while the manufacturing sector is characterized by monopolistic competition. There is no interregional labour mobility, but there is perfect intersectoral labour mobility within each region. Finally, we assume wages in the manufacturing sector to be set by unions. Workers who do not get a job in the unionized manufacturing sector spill over to the non-unionized agricultural sector where wages are market-clearing. In setting up the model, we first focus on the demand side. In the second section, we analyze the production decision in both sectors. Wage setting by unions is the topic of the third section.

2.1 Consumption

Every region is populated by I agents, indexed by $i = 1, ..., I$, each with the following Cobb-Douglas utility function

$$U_i = C_{Ai}^{1-\alpha} C_{Mi}^{\alpha} \qquad 0 < \alpha < 1$$

where C_{Ai} is consumption by agent i of the agricultural good and C_{Mi} is his manufacturing consumption index, defined as

$$C_{Mi} = \left(\int_{j=0}^{n+n^*} C_{ji}^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}} \qquad \sigma > 1$$

where C_{ji} is agent i's consumption of variety j of the manufacturing good, n (n^*) is the number of varieties (and the mass of firms) in the home-region (foreign-region) and σ is the constant substitution elasticity between any two varieties. The total number of firms equals N $(n + n^*)$.

The optimization problem of agent i is

$$\left| \begin{array}{l} \text{maximize } U_i = C_{Ai}^{1-\alpha} \left(\int_{j=0}^{n+n^*} C_{ji}^{\frac{\sigma-1}{\sigma}} dj \right)^{\alpha \frac{\sigma}{\sigma-1}}, \\ \text{under the constraint } p_A C_{Ai} + \int_{j=0}^{n+n^*} p_j C_{ji} dj = Y_i \end{array} \right.$$

where p_A is the price of the agricultural good, p_j is the price of the j-th variety of the manufactured good and Y_i is agent i's nominal income. Using a two-stage budgeting procedure, we can derive the well-known demand equations:

$$C_{Mi} = \alpha \frac{Y_i}{p_M} \qquad \text{and} \qquad C_{Ai} = (1-\alpha)\frac{Y_i}{p_A}, \tag{1}$$

$$C_{ji} = \left(\frac{p_j}{p_M}\right)^{-\sigma} C_{Mi} \qquad \text{where} \qquad j = 1, ..., n+n^*, \tag{2}$$

where p_M is the manufacturing price index

$$p_M = \left(\int_{j=0}^{n+n^*} p_j^{1-\sigma} dj\right)^{\frac{1}{1-\sigma}} \tag{3}$$

Each agent i has one unit of agent-specific labour which is supplied either to the agricultural sector or to the manufacturing sector. Hence all agents are fully employed and we have that

$$I = L_A + L_M$$

where L_A is total labour input in agriculture, and L_M is total labour input in manufacturing.

2.2 Production and price setting

Firms in the agricultural sector operate under constant returns to scale: in order to produce one unit of output, one unit of labour is required. We denote by z_A the production of this sector, and by W_A the nominal wage. Since profits are zero, $p_A z_A - W_A z_A = 0$, it follows that $W_A = p_A$. We take the agricultural good as the numeraire, so we can set $W_A = p_A = 1$.

We consider a continuum of manufacturing firms $j \in (0, n)$. Each firm produces a quantity z_{Hj} of a differentiated good j and in order to produce one unit of the good, the firm needs one unit of labour.

The profit of firm j in region H is:

$$\Pi_{Hj} = q_{Hj} z_{Hj} - W_{Hj} z_{Hj} - E \tag{4}$$

where q_{Hj} is the mill price of variety j produced in region H, z_{Hj} is the total demand for this variety, W_{Hj} denotes the nominal wage and E represents the fixed costs.

We first consider the total demand for variety j. We have that $z_{Hj} = C_{Hj} + \frac{1}{\tau}C_{Fj}$, where C_{Hj} (C_{Fj}) refers to total consumption of good j of agents residing in region H (F). The parameter τ captures the iceberg transport cost; if a unit is shipped to another region, only $\tau < 1$ units actually arrive at that region. For the agents of region H the consumption price equals the mill price, i.e. $p_{Hj} = q_{Hj}$. For agents of the other region, the consumer price equals $p_{Fj} = q_{Hj}/\tau$. Using the demand functions (1) and (2), we get the following expression for total sales

$$z_{Hj} = \left(\frac{q_{Hj}}{p_{HM}}\right)^{-\sigma} \frac{\alpha Y_H}{p_{HM}} + \frac{1}{\tau}\left(\frac{q_{Hj}}{\tau p_{FM}}\right)^{-\sigma} \frac{\alpha Y_F}{p_{FM}} = \left(\frac{q_{Hj}}{p_{HM}}\right)^{-\sigma} G_H \tag{5}$$

where

$$G_H = \alpha \left[\frac{Y_H}{p_{HM}} + \tau^{\sigma-1}\left(\frac{p_{HM}}{p_{FM}}\right)^{-\sigma} \frac{Y_F}{p_{FM}}\right] \tag{6}$$

can be interpreted as the “total” world demand for the manufacturing goods produced in region H and p_{HM} (p_{FM}) is the manufacturing price index in region H (region F).

The optimization problem of firm j in region H can then be written as:

$$\left| \begin{array}{l} \text{maximize } \Pi_{Hj} = q_{Hj} z_{Hj} - W_{Hj} z_{Hj} - E, \\ \text{such that } z_{Hj} = \left(\frac{q_{Hj}}{p_{HM}}\right)^{-\sigma} G_H \end{array} \right.$$

from which we derive the profit maximizing mill price:

$$q_{Hj} = \frac{\sigma}{\sigma - 1} W_{Hj} \tag{7}$$

We get the well-known result that prices will be set as a markup over the wage.

Substituting (7) in (5), and the result in (4), it follows that profits can be written as

$$\Pi_{Hj} = \frac{1}{\sigma - 1}\left(\frac{\sigma}{\sigma - 1}\right)^{-\sigma} W_{Hj}^{1-\sigma} p_{HM}^{\sigma} G_H - E \tag{8}$$

2.3 Wage setting

In this section we use the monopoly-union model: a trade union sets the wage for its members but it faces a downward sloping labour demand curve. We assume K (K^*) unions in region H (F), setting the wage for a set of firms of measure $\frac{n}{K}$ $\left(\frac{n^*}{K^*}\right)$. Their number is 'intermediate' in the following sense: each union is small in that it takes aggregate income or aggregate demand as given, but the union is large enough to take into account the effect of its wage on the price of manufactures. We therefore exclude the possibility of a national union ($K = 1$). When K equals n, wages are set at the firm level. For intermediate values of K ($1 < K < n$), wages are set at a (sub)sectoral level. It can be argued that given the number of firms n, a higher K reduces the strength of each individual union as there are more unions to 'compete' with.

We assume union k to have a Stone-Geary utility function

$$\frac{W_{Hk} - 1}{p_{HM}^{\alpha}} L_{Hk},$$

where W_{Hk} is the union's wage applying to all of its members and L_{Hk} is the demand for union k's labour. The union maximizes the real rent of its members, i.e. the difference between the real wage bill in the unionized sector and the competitive sector[2]. In Appendix A we show that the optimal wage turns out to be the same for all unions in region H and satisfies

$$\frac{W_H}{W_H - 1} = \sigma + \frac{1}{K} \left(\frac{n W_H^{1-\sigma}}{n W_H^{1-\sigma} + n^* W_F^{1-\sigma} \tau^{\sigma-1}} \right) (\alpha - \sigma) \tag{9}$$

and a similar expression holds for the wage in region F

$$\frac{W_F}{W_F - 1} = \sigma + \frac{1}{K^*} \left(\frac{n^* W_F^{1-\sigma}}{n^* W_F^{1-\sigma} + n W_H^{1-\sigma} \tau^{\sigma-1}} \right) (\alpha - \sigma) \tag{10}$$

This expression for the wage differs quite drastically from the one obtained by Picard and Toulemonde (2002). The major reason for this difference is not that these authors use a bargaining model instead of a monopoly-union model, but rather that they do not allow wages to influence the manufacturing price index. In Picard and Toulemonde (2002), wages are equalized across regions, independent of the firms' location decisions. In our model, it is obvious that wages do depend on firms' location decisions and, more interestingly, on the number of unions. This latter characteristic is crucial as it allows us to analyze the relation between location and the centralization of wage setting. Picard and Toulemonde (2003) allow wages to influence the price index such that wages in that paper do depend on the number of firms too. However, we cannot directly compare our outcome with theirs since we assume iso-elastic demand functions while they opt for linear demand functions.

Applying the implicit function theorem to the system of equations (9) and (10), one can

[2] The consumption-based price index in the union's utulity function actually equals $\alpha^{-\alpha} (1-\alpha)^{\alpha-1} p_{HM}^{\alpha} p_A^{1-\alpha}$ but since $p_A = 1$, the irrelevant constants are dropped from the utility function.

derive the following comparative static results, which will prove to be useful in the sequel:

$$\frac{\partial W_H}{\partial n} > 0, \frac{\partial W_F}{\partial n} < 0 \; ; \frac{\partial W_H}{\partial n^*} < 0, \frac{\partial W_F}{\partial n^*} > 0 \; ; \frac{\partial W_H}{\partial \tau} < 0, \frac{\partial W_F}{\partial \tau} < 0 \; ; \frac{\partial W_H}{\partial K} < 0, \frac{\partial W_F}{\partial K} < 0$$

More firms in one region - and therefore a higher labour demand - increases the wage in that region and decreases it in the other region. Lower trade costs decrease the wage in both regions since competition becomes stronger. This result is in line with Driffil and van der Ploeg (1993) who state that decreasing trade costs may indeed bid wages downwards. They continue to argue that this may provide an incentive for unions to cooperate with unions in other regions. We come back to this point in section 4. Our main point of interest is however the influence of the degree of centralization of wage setting: a greater number of unions in one region will result in lower wages in both regions. The relationship between the number of unions and the wage in our model differs somewhat from the relationship that Calmfors and Driffil (1988) have established. They found a hump-shaped relationship: wages are highest for an intermediate number of unions. We obtain a negative relationship and the reason for this is quite obvious. Recall that we assume an 'intermediate' number of unions: each union is small in that it takes aggregate income as given, but the union is large enough to take into account the effect of its wage on the price of manufactures. This indeed implies that we exclude a (very) small number of unions and hence disregard the first part of the hump-shaped relationship of Calmfors and Driffil.

Since the expressions (9) and (10) for the wage are too complicated to analyze firms' location decisions in general, we only focus at two extreme cases, agglomeration and symmetry. These wage expressions are essential to analyze the location decisions of firms in the next section. Full agglomeration implies that all firms are located in one region. In a symmetric case we assume both the number of firms and the number of unions in the two regions to be equal.

If there is *full agglomeration* in region H, $n^* = 0$, and it follows from (9) that

$$W_H = \frac{\sigma (K-1) + \alpha}{\sigma (K-1) + \alpha - K}. \tag{11}$$

For the wage in the home region to be positive, the following condition should hold:

$$K > \frac{\sigma - \alpha}{\sigma - 1} \tag{12}$$

Note that (12) implies that there definitely has to be more than one union. A single national union is therefore not an option. Moreover, from expression (11) it follows that

$W_H > 1$, implying that manufacturing wages are higher than agricultural wages. If there is full agglomeration in region H, it follows from (10) that wages in region F will be given by

$$W_F = \frac{\sigma}{\sigma - 1}, \tag{13}$$

which again is higher than the agricultural wage of one. Note that in both regions the wage is independent of the number of firms. As long as we assume full agglomeration, the number of firms does not influence the wage level.

In the case of *full symmetry*, $K = K^*, n = n^*$, it follows from (9) and (10) that

$$W_H = W_F = \frac{\sigma K \left(1 + \tau^{\sigma-1}\right) + \alpha - \sigma}{\left(\sigma - 1\right) K \left(1 + \tau^{\sigma-1}\right) + \alpha - \sigma}. \tag{14}$$

For wages to be positive, the following condition has to hold:

$$K > \frac{\sigma - \alpha}{\left(\sigma - 1\right)\left(1 + \tau^{\sigma-1}\right)} \tag{15}$$

Expression (14) reveals that manufacturing wages are higher than agricultural wages. And once more, the wage level is independent of the number of firms. As long as we assume an equal number of firms in both regions, their number is irrelevant for wage setting.

Both the wage at symmetry (14) and the wage at agglomeration (11) are influenced by the number of unions, K, and the degree of competition, σ. It is easily shown that as product market competition increases, unions lower their wage demands. Indeed, as the substitution elasticity σ between the different varieties increases, firms are confronted with more severe competition and therefore have to lower their prices. Unions take this into account and lower their wage demands.

3 Agglomeration and symmetry

In this section we focus on the stability properties of extreme location outcomes. As in other NEG models, the (in)stability of the location outcomes is of course directly related to trade costs, and particular attention is paid to how the extreme location outcome changes as the world gets more integrated, i.e. as trade costs continue to decrease. However, our model permits to highlight another important explanatory factor, i.e. the number of unions in the region. We will show that the interplay between the height of the trade costs and the level of centralization of wage setting will ultimately be responsible for the emergence of one or the other of the extreme location outcomes.

In order to analyze the location decision of a firm we look at the profit differential which, using (8) and dropping irrelevant constants, can be written as

$$\Delta\Pi_j = \Pi_{Hj} - \Pi_{Fj} = W_H^{1-\sigma} p_{HM}^{\sigma} G_H - W_F^{1-\sigma} p_{FM}^{\sigma} G_F \tag{16}$$

If the differential is positive, firms prefer to locate in the home region while if the differential is negative, firms settle in the foreign region. We therefore have to determine the sign of the profit differential for the two extreme location outcomes - full agglomeration and full symmetry. Recall that we want to analyze first of all the (in)stability of agglomerated and symmetric outcomes in function of *trade costs.* However, since we are also interested in the impact of the *level of wage setting* on location, we also dig deeper on how the number of unions affect the location outcome.

3.1 Agglomeration

The main results can be stated in the following two propositions:

Proposition 1 *In a NEG model with unionized wage setting, agglomeration is unstable for both zero and infinite trade costs and (possibly) stable for intermediate values of trade costs.*

Proposition 2 *In a NEG model with unionized wage setting, when the number of unions increases, agglomeration is (possibly) stable for a larger range of (intermediate) trade costs.*

Proof It is shown in Appendix B that the following inequality has to hold for agglomeration to be a stable equilibrium:

$$F(\tau) = \left(\frac{\sigma \left[\sigma \left(K-1 \right) + \alpha - K \right]}{\left(\sigma - 1 \right) \left[\sigma \left(K-1 \right) + \alpha \right]} \right)^{\sigma-1} \tag{17}$$

$$-\tau^{1-\sigma} \frac{\left[\sigma^2 (K-1) + \alpha\sigma \right] \left[1 + \tau^{2(\sigma-1)} \right] - \alpha K (\sigma - 1) \left[1 - \tau^{2(\sigma-1)} \right]}{2 \left[\sigma^2 (K-1) + \alpha\sigma \right]} > 0$$

Expression (17) is extremely hard to signal in general, so we first look at two extreme cases. If there are *no trade costs*, we have that

$$F(1) = \left(\frac{\sigma \left[\sigma \left(K-1 \right) + \alpha - K \right]}{\left(\sigma - 1 \right) \left[\sigma \left(K-1 \right) + \alpha \right]} \right)^{\sigma-1} - 1 < 0$$

This expression is negative because of (12).

If *trade costs are infinite*, we get from (17) that

$$\lim_{\tau\to 0} F(\tau) = \lim_{\tau\to 0} -\frac{\left[\sigma^2 (K-1) + \alpha\sigma\right]\left(1+\tau^{2(\sigma-1)}\right) - \alpha K (\sigma-1)\left(1-\tau^{2(\sigma-1)}\right)}{\tau^{\sigma-1}} = -\infty$$

Therefore, both for zero and for prohibitive trade costs, agglomeration turns out to be an unstable equilibrium.

For *intermediate values of trade costs*, an analytic solution cannot be derived, and we have to resort to simulations in order to obtain results. It turns out that $F(\tau)$ is smaller the higher is σ (more competition on the goods market), the lower is α (a smaller demand effect) and the lower is K (and therefore the higher is W_H).

This result is as expected. Agglomeration becomes more unstable the higher the competition (dispersion force), the smaller the demand effect (agglomerative force) and the higher the wage (dispersion force)[3]. However, since the contribution of this paper is to analyze the importance of unions for firms' location decisions, we mainly focus on the impact of K. In order to get a better insight in the forces, we resort to simulations and plot $F(\tau)$ as a function of τ putting $\sigma = 2, \alpha = 0.8$ and $K = 30000$ or $K = 60$ in Figure 1.

We observe that for high trade costs (low τ), agglomeration is definitely not an equilibrium. When trade costs decline, agglomeration becomes stable, but when trade costs decline further, agglomeration becomes unstable again. Moreover, the range of trade costs for which agglomeration is stable decreases as the number of unions decreases. Indeed, if there are fewer unions in region H, wages are higher thus also increasing the cost of locating there. ■

As in Fujita, Krugman and Thisse (1999) we can also define the sustain point(s) for this model. The sustain point in general is defined as that level of the trade cost where the agglomerated outcome, once established, can be sustained. We call $\tau^*(S)$ the sustain point for increasing trade costs (the point in Figure 1 where the graph of $F(\tau)$ first crosses the X-axis) and $\tau^{**}(S)$ the sustain point for decreasing trade costs (the point in Figure 1 where the graph of $F(\tau)$ crosses the X-axis for the second time)[4].

[3]Simulations show that a combination of a high σ, a small α and a small K even render agglomeration unsustainable for all values of trade costs.

[4]Recall that τ reflects the number of units that arrive after shipping and is therefore inversely related to TC.

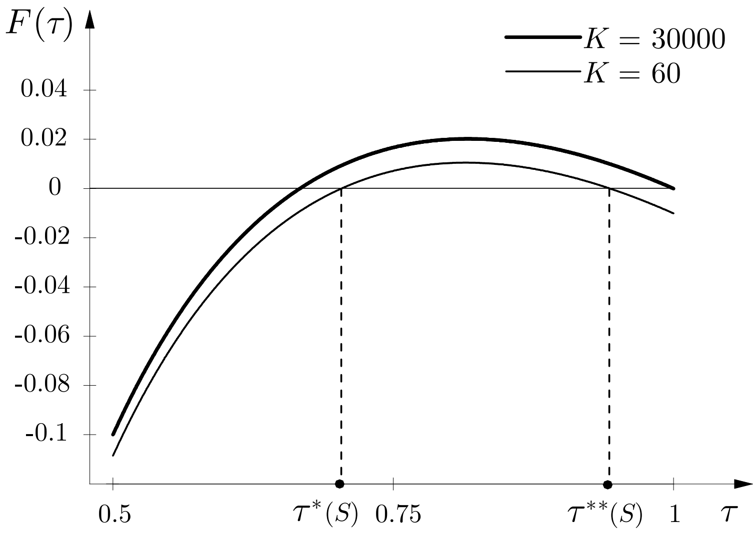

Figure 1: **(In)stability of agglomeration**

3.2 Symmetry

The following propositions summarize our main results.

Proposition 3 *In a NEG model with unionized wage setting, symmetry is stable for both zero and infinite trade costs and (possibly) unstable for intermediate values of trade costs.*

Proposition 4 *In a NEG model with unionized wage setting, when the number of unions increases, symmetry is (possibly) unstable for a larger range of intermediate trade costs.*

Proof We start from a fully symmetric equilibrium where $K = K^*$ and $n = n^*$. We define

$$\hat{n} = \frac{n}{n^*}, \hat{W} = \frac{W_H}{W_F}, \hat{Y} = \frac{Y_H}{Y_F}, \hat{p}_M = \frac{p_{HM}}{p_{FM}}, \text{etc...}$$

The symmetric equilibrium will be unstable if, as a consequence of a reallocation of some firms to region H, i.e. $d\hat{n} > 0$, the profit differential widens, i.e. $d\Delta\Pi_j$ (or $d(\Pi_{Hj} - \Pi_{Fj})) > 0$. We have that

$$d\Delta\Pi_j = W^{1-\sigma} p_M^\sigma G \left[(1 - \sigma) \, d\hat{W} + \sigma d\hat{p}_M + d\hat{G} \right]$$

Now, since $W^{1-\sigma} p_M^\sigma G > 0$, the symmetric equilibrium is unstable if

$$(1 - \sigma) \, d\hat{W} + \sigma d\hat{p}_M + d\hat{G} > 0$$

We show in Appendix C that this condition can alternatively be stated as

$$F = (1-\sigma)\, d\hat{W} + \varphi d\hat{Y} + \varphi(\sigma - 1)\, d\hat{p}_M > 0$$

where $\varphi = \frac{1-\tau^{\sigma-1}}{1+\tau^{\sigma-1}}$.

Note that we therefore have to find expressions for $d\hat{W}$, $d\hat{p}_M$ and $d\hat{G}$. Assuming $d\hat{n}$ to be positive (i.e. firm(s) move from region F to region H), it can be shown that $d\hat{W} > 0, d\hat{p}_M < 0$ and $d\hat{Y} > 0$.

Recalling that $0 < \alpha < 1$ and $\sigma > 1$, we see that the first term of F, $\left\{(1-\sigma)\, d\hat{W}\right\}$, is negative, the second term $\left\{\varphi d\hat{Y}\right\}$ is positive, while the last term is negative again $\{\varphi(\sigma-1)\, d\hat{p}_M\}$. The second term is obviously the agglomeration force that draws firms to the H region. If more firms move to H, wages increase and so does income - attracting new firms to the region because of the *home market effect*. The first and last term are dispersion forces. The first term is what we call the *cost effect*. When more firms move into H, wages rise, thus inducing firms to move to the other region. The last term reflects the *competition effect* - when more firms move into H, the competition becomes stronger such that firms have to lower their prices.

As in the agglomeration case, we would like to know for which values of trade costs the symmetric equilibrium is (un)stable. We again first investigate the extreme cases of infinite and no trade costs.

As *trade costs are infinite*, $F(0)$ becomes:

$$F(0) = -d\hat{n} < 0$$

As *trade costs are zero*, we get:

$$F(1) = (1-\sigma)\frac{2K(\sigma-\alpha)\, d\hat{n}}{4K^2(\sigma-1)\sigma - (\sigma-\alpha)\left[2K\sigma - (\sigma-\alpha)\right]} < 0$$

because of (12). So both for zero and infinite trade costs the symmetric equilibrium is stable.

For *intermediate values of trade costs* an analytic solution cannot be derived, and we have to simulate in order to arrive at interpretable results. We allow the values for α, σ and K to vary. We investigate how $F(\tau)$ changes when $d\hat{n} = 1$, i.e. if there are (some) firms relocating to region H. Symmetry turns out to be unstable for intermediate values of trade costs if α is high (home market effect plays a big role), σ is small (competition effect does not really play a role) and K is high (more unions, hence a lower wage in H, and therefore the cost effect is not that important).

These results are again as expected. If the home market effect plays an important role and there is an extra firm moving into region H, this increases wages (and incomes) and therefore attracts more firms to this region. Moreover, if the competition effect is less strong, firms do not 'mind' to be located close to other firms (in region H). Finally, when there are more unions in H, competition among the unions decreases wage demands and therefore decreases the dispersion force originating from the cost side. For high values of α, low values of σ and a high number of unions K, the agglomerative force (home market effect) can dominate the dispersion forces (competition effect and cost) and thus render the symmetric equilibrium unstable[5].

However, since the contribution of this paper is to analyze the importance of unions in firms' location decisions, we mainly focus on the impact of K. In order to get a better insight in the forces we therefore plot $F(\tau)$ - as in the agglomeration case - as a function of τ putting $\sigma = 2; \alpha = 0.8$ and $K = 60$ or $K = 30000$ in Figure 2.

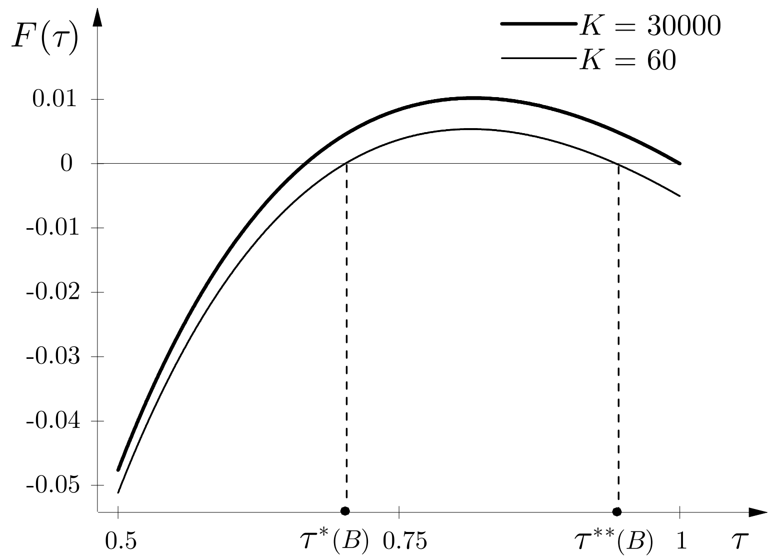

Figure 2: **(In)stability of symmetric equilibrium**

[5]Again note that simulations show that the combination of a high σ, a small α and a small K renders symmetry stable for all values of trade costs (and as we saw before, agglomeration is in that case unsustainable for all values of trade costs).

We observe that for high trade costs (low τ), symmetry is a stable equilibrium. When trade costs decline, symmetry becomes unstable, but when trade costs decline further, symmetry becomes stable again. Moreover, the range of trade costs for which symmetry is unstable decreases (or the possibility of a stable symmetric equilibrium increases) when the number of unions decreases. Indeed, if there are fewer unions in region H, wages are higher thus also increasing the cost of (re)locating there. ■

As in Fujita, Krugman and Thisse (1999) we can also define the break point(s) for this model. The break point in general is the point at which symmetry between the regions gets broken because the symmetric equilibrium becomes unstable. We call $\tau^*(B)$ the break point for decreasing trade costs (the point in Figure 2 where the curve first crosses the X-axis) and $\tau^{**}(B)$ the break point for increasing trade costs (the point in Figure 2 where the curve crosses the X-axis for the second time).

3.3 Agglomeration and symmetry combined

Now that we analyzed the 'extreme' location decisions of firms separately, we combine the results for both symmetry and agglomeration in order to be able to say something about location in general and to compare the outcomes of this model with those of the other models discussed in the first section of this paper.

From simulations we derive that for a certain combination of parameters α, σ and K, symmetry is the only stable outcome. More in particular, the combination of a high σ (competition effect is important), a low α (home market is not important) and a low K (higher wage in H, and therefore important cost effect) renders agglomeration completely unattractive for firms. Indeed, they would have to cope with heavy competition, high wages and they would moreover not really benefit from a large demand effect.

For lower values of σ, higher values of α and a larger number of unions we however derive that $\tau^*(B) < \tau^*(S)$ and $\tau^{**}(B) > \tau^{**}(S)$. Note however that the differences between the respective break and sustain points in these cases are very small[6]. In this case a partial agglometared outcome is an equilibrium. In what follows we focus our attention on these last simulation results. Table 1 summarizes the possible location outcomes for different levels of trade costs (TC). At intermediate levels of trade costs, only agglomeration is stable.

[6] Recall that τ (the amount of the good that arrives after shipping) can vary between 0 and 1. Simulations with different values for α, σ and K reveal that the range of τ-values where symmetry gets broken and agglomeration is not yet sustainable is at most 0.01.

At very high or very low trade costs, symmetry is the only stable outcome. Moreover, there are small intervals of trade costs (between the respective break and sustain points) for which neither of the two extreme location outcomes is stable. For these values of trade costs we thus obtain stable partially-agglomerated outcomes.

Table 1: **(In)stability of symmetry and agglomeration**

$0 \leq \tau < \tau^*(B)$	$\tau^*(B) \leq \tau \leq \tau^*(S)$	$\tau^*(S) \leq \tau \leq \tau^{**}(S)$	$\tau^{**}(S) \leq \tau \leq \tau^{**}(B)$	$\tau^{**}(B) < \tau \leq 1$
high TC region		medium TC region		low TC region
symm stable	symm unstable	symm unstable	symm unstable	symm stable
aggl unstable	aggl unstable	aggl stable	aggl unstable	aggl unstable

The information in Table 1 is also visualized in Figure 3. The bifurcation diagram is now a pitchfork.

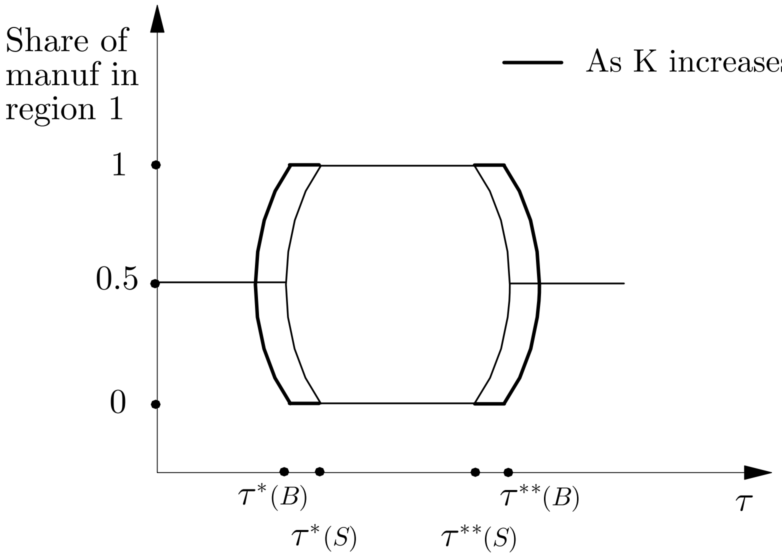

Figure 3: **Bifurcation diagram**

If initially there is agglomeration (e.g. due to historical facts), economic activity remains agglomerated as long as we are in the medium trade costs region, but the agglomeration is no longer sustainable when trade costs rise (into the high trade costs region) or decrease (into the low trade costs region). So, assuming that trade costs continue to decrease in view of the mounting worldwide integration we would expect full agglomeration to become unstable. For a limited range of trade costs we then obtain an outcome with intermediate agglomeration: we initially still have more industry in the previously agglomerated region, but we also get some industry in the previously peripheral region. Economic activity continues to spread out gradually as trade costs decline, until we obtain a symmetric outcome. As soon as the economy reaches a perfect symmetrical division of the industry, this remains an equilibrium.

On the other hand, if we start from a symmetric equilibrium we maintain it only in the high and (very) low trade costs region. Once entering the medium trade costs region, the symmetry gets broken and full agglomeration - if reached - is stable. Note again that intermediate agglomeration is also a possible outcome here for a small range of trade costs.

We now want to compare our location outcome to the ones from the models discussed previously. Both the Krugman (1991) and the Venables (1996) model find that the relationship between trade costs and agglomeration tends to be an inverted U-shaped curve: no agglomeration at high trade costs, the emergence of a core-periphery at intermediate trade costs and finally a reversion to dispersed manufacturing to take advantage of low wages at low trade costs. Picard and Toulemonde (2002) find that symmetry is stable at high trade costs and agglomeration is stable at low(er) trade costs - there is no 'reversion' to a stable symmetry at very low trade costs. The reason for this outcome is that in their model wages are the same in both regions. The (wage) cost-dispersion force therefore does not play here and cannot render agglomeration unstable at very low trade costs. Picard and Toulemonde (2003) finally also find a pitchforked bifurcation diagram.

We can therefore conclude that our results are largely similar to the ones of the existing NEG models with factor market competition. However, the interesting feature about this model is the introduction of the effect that the level at which wages are set (the number of unions) has on the location of economic activity. When there are more unions in a region - the wages are set at firm rather than at sectoral or more centralized level - agglomeration in this region is more likely. Indeed, agglomeration turns out to be a stable equilibrium for a larger range of trade costs when the number of unions increases. This is also illustrated in Figure 3. Picard and Toulemonde (2003) also show that stronger unions enhance symmetry. In the last section, we look more specifically at the effects different types of wage setting have on location.

4 Wage setting and location

Note that in our analysis we interpret the level of wage setting in two different ways. The *first* one is the one that has been used throughout this chapter so far. Does it matter whether wages are set at sectoral or firm level? In other words, can a government attract firms by opting for the 'right' level of wage setting? The *second* level of wage setting we analyze is different. We would like to know whether wages differ when they are set at the regional level or rather at the supra-regional level.

In order to make a clear distinction between the two cases we refer to the first one as 'centralization' of wage setting and to the second one as 'regionalization' of wage setting. Our focus point is now whether the degree of centralization/regionalization of wage setting affects the level of the wages and therefore the location decisions of firms.

4.1 'Centralization' of wage setting

Does it matter for location whether wages are set at a centralized or rather at a decentralized level? We prove that the following proposition holds:

Proposition 5 *In a NEG model with unionized wage setting, more unions - and therefore wage setting at a lower (firm) level - may be a good policy to attract firms in a world with decreasing trade costs. If trade costs between countries remain high however, it might be advisable to set wages at a higher level in order to attract more firms.*

Proof In order to analyze and prove this proposition, we want to see what happens to profits in both regions as the degree of centralization decreases in one of the regions - in other words when there are more unions in this region.

We start from two initially symmetric regions and analyze what happens if the symmetry gets broken due to an increase in the number of unions in region H - assuming the number of unions remains the same in F. Thus, $dK^* = 0$, $dK = 1$ and therefore $Kd\hat{K} = dK$. In order to know how the location decision of firms will change, we analyze the effect of a change in K on the profit differential between the two regions. We assume that initially no firm moves (i.e. $d\hat{n} = 0$) but that they will move as a reaction to a profit differential. If the profit differential does not change, symmetric equilibrium remains. If the change in the profit differential is positive, firms will relocate to the region with the largest number of unions (and therefore the lowest wage).

The way to proceed is as before, when we derived the condition for the stability of the symmetric equilibrium. Recall that the sign of the following expression equals the sign of the change in the profit differential ($d\left(\Delta\Pi_j\right)$):

$$F = (1-\sigma)\, d\hat{W} + \varphi d\hat{Y} + \varphi\,(\sigma - 1)\, d\hat{p}_M \tag{18}$$

When (18) is positive, firms locate in H (the low wage region) and when (18) is negative, firms locate in F (the high wage region). Finally, when (18) equals zero, the symmetric outcome remains.

We want to analyze how profits (and therefore location) change when there are more unions in H. As mentioned before, initially we therefore keep the number of firms constant.

Assuming *infinite trade costs,* the expression for F becomes:

$$F(0) = \frac{\alpha\,(\sigma-1)\,\{K\,(\sigma-1) - \sigma\,(\alpha-1)\}}{\sigma^2\,[K-1] - \alpha\,(\sigma-1)\,K} \frac{-K(\sigma-\alpha)d\hat{K}}{[\sigma K - (\sigma-\alpha)]\,[\sigma K - (\sigma-\alpha) - K]} < 0$$

This expression is always negative, implying that when there are more unions in H, firms want to relocate to F.

If *trade costs are zero*, we get:

$$F(1) = (1-\sigma)\,\frac{-2K(\sigma-\alpha)d\hat{K}}{[2\sigma K - (\sigma-\alpha)]\,[2\sigma K - (\sigma-\alpha) - 2K] + 2K\,(\sigma-\alpha)\,(\sigma-1)} > 0$$

This expression is always positive, implying that when there are more unions in H, firms want to relocate to H.

For *intermediate trade costs* we get the following expression after tedious computations[7] ($t = 1 - \tau^{\sigma-1}$):

$$\begin{aligned} F(\tau) \;&=\; -\,(\sigma-1)\,K(\sigma-\alpha)(1+t)\left\{\varphi\frac{\alpha\,\{K\,(1-t)\,(\sigma-1)\,\varphi - \sigma\,(\alpha-1)\}}{\sigma^2\,[K\,(1+t)-1] - \alpha\,(\sigma-1)\,K\,(1-t)} - 1 + \varphi^2\right\} \\ &\cdot\frac{d\hat{K}}{[\sigma K\,(1+t) - (\sigma-\alpha)]\,[\sigma K\,(1+t) - (\sigma-\alpha) - K(1+t)] - 2K\,(\sigma-\alpha)\,t(1-\sigma)} \end{aligned}$$

Since this expression cannot be solved analytically, we simulate it in order to obtain some tentative results. We investigate how F changes when $d\hat{K} = 1$. For all values of α, σ and K, the change in profit differential turns out to be negative for high values of trade

[7] The way to proceed is to assume $d\hat{n} = 0$ and to derive the expressions for $d\hat{W}$, $d\hat{Y}$ and $d\hat{p}$. These expressions are then substituted into (18)

costs and positive for small and intermediate values of trade costs. This implies that when trade costs are high, firms prefer to relocate to the high wage region since they prefer to be close to their demand. When trade costs decline however, the location of final demand is less of an issue and firms prefer to relocate to the low-wage region to minimize their costs. There is only one value of trade costs for which the symmetry remains unbroken - which is therefore a highly unlikely scenario. ■

Note that the model does not allow us to predict whether once the symmetry is broken, it will be restored or we will rather end up in an agglomerative outcome. The only thing we can tell is that symmetry will be broken when the number of unions changes. Depending on the level of trade costs this will initially benefit one or the other region. Although our model does not allow us to analyze what happens after this initial movement of firms, we might predict some future developments. Once the relocation to one of the regions has started, this may lead to further concentration in this region due to other mechanisms that are not taken up in this model - like for instance vertical input-output linkages between firms.

Picard and Toulemonde (2003) reach a similar conclusion: they prove that as unions become stronger, symmetry becomes a more likely location outcome. In their 2002 paper, they however reach a different conclusion: stonger unions enhance agglomeration. Given their assumptions in that paper this indeed is obvious. Since wages are the same in both regions, there is no dispersion force originating from lower wages in the peripheral region. Only the home market effect plays a role - thus fostering agglomeration.

4.2 'Regionalization' of wage setting

Finally we analyze whether regionalization of wage setting affects firms' location decisions. If we consider two symmetric regions, it is obvious that the wage - and therefore the location decisions - will be the same no matter at what level the wage is set[8]. Interesting insights are therefore only to be expected when we assume one region to have initially a different number of firms. Assume for now that we have more firms in region H than in region F ($n > n^*$). We prove that the following proposition holds:

Proposition 6 *In a NEG model with unionized wage setting, supra-regional instead of re-*

[8]Indeed, the union's objective function would just be a monotonic transformation thus the wage (outcome of the maximisation problem) would be the same.

gional wage setting will increase the wage in both (non-symmetric) regions and may be a good policy to attract more firms to the more agglomerated region (and therefore a devastating policy for regions that lag behind).

Proof From the derivation in section 2.3, we know that when wages are set at the *regional level* each union in region H and region F sets the wage W_H and W_F as:

$$\begin{aligned}\frac{W_H}{W_H-1} &= \sigma+\frac{1}{K}\left(\frac{nW_H^{1-\sigma}}{nW_H^{1-\sigma}+n^*W_F^{1-\sigma}\tau^{\sigma-1}}\right)(\alpha-\sigma)\\ \frac{W_F}{W_F-1} &= \sigma+\frac{1}{K}\left(\frac{n^*W_F^{1-\sigma}}{n^*W_F^{1-\sigma}+nW_H^{1-\sigma}\tau^{\sigma-1}}\right)(\alpha-\sigma)\end{aligned}$$

We know from the comparative static results that, when $n > n^*$, $W_H > W_F$[9].

Now assume each union k to operate at the supra-regional level and setting a nominal wage W_k for all its members whether they are employed in region H or F. The number of unions K remains the same, and each union sets the wage for a number of firms equal to $(n+n^*)/K$.

As before, the union cares about the real rent of its employed members. Here, however, a complication arises since the true price index differs between the two regions. This implies that the objective function of union k now becomes:

$$\frac{W_k-1}{p_{HM}^{\alpha}}L_{Hk}+\frac{W_k-1}{p_{FM}^{\alpha}}L_{Fk}$$

After some computation (cfr. Appendix D), we obtain the following wage expression:

$$W=\frac{\sigma(K-1)+\alpha}{\sigma(K-1)+\alpha-K} \tag{19}$$

which is - not surprisingly - the same result as under agglomeration. Indeed, when a union determines the wage supra-regionally, it is as if it sets the wage in one agglomerated region.

The question we are interested in now is whether the wage is higher or lower when it is set at the supra-regional rather than at the regional level. Since it is difficult to compare the expression for W_H and W_F with the expression for W (19) - the 'agglomeration'-wage, we resort again to simulations. Simulations (cfr. Appendix D) reveal that $W > W_H > W_F$. This finding can be demonstrated more generally as follows. First note that regional and supra-regional wage setting yields the same result $W = W_H = W_F$ in the limit case of

[9] As $n = n^*$, wages in both regions are equal (symmetric outcome). From the comparative statics we know that W_H increases and W_F decreases as n increases - which establishes our result.

$\tau = 0$. Indeed, when trade costs are infinite, each region can be considered as a fully agglomerated region.[10] Furthermore, from the comparative static results we know that when trade costs decrease, wages decrease too:

$$\frac{\partial W_H}{\partial \tau} < 0 \quad \text{and} \quad \frac{\partial W_F}{\partial \tau} < 0,$$

which establishes our result. ■

The reasoning behind the proposition is simple. Initially the peripheral region has a lower wage than the more agglomerated region. This is to the benefit of the peripheral region because the lower production costs make it still profitable for firms to produce there and ship (part of) their goods to the more agglomerated region. However, when wages are set at the supra-regional level they will increase to the same level in both regions. This implies that the initial cost-advantage of the peripheral region disappears such that all firms tend to move into the already more agglomerated region.

Finally, note that this result is in line with Driffil and van der Ploeg (1993), who argue that decreasing trade costs will decrease wages and therefore provides an incentive for unions to cooperate with other unions. We indeed also obtain the result that supra-regional wage setting allows unions to set a higher wage.

5 Conclusion

The presence of unions and immobile labour are two key aspects of European labour markets. The model in this paper addresses the importance of these features for the location decisions of firms. The novelty of the model concerns the introduction of the degree of centralization of wage setting, reflected by the number of unions present (more unions implies wage setting at a more decentralized level).

We first of all illustrate that when the number of unions increases, the wage decreases. Secondly, like in other NEG models with an extra dispersion force, we find that the relationship between trade costs and agglomeration indeed tends to be an inverted U-shaped curve: no agglomeration at high trade costs, the emergence of a core-periphery at intermediate costs and finally a reversion to dispersed manufacturing to take advantage of low wages at low trade costs. This finding strengthens again the relevance of the inverted U-shaped

[10] Recall that the wage under full agglomeration is independent of the number of firms in the region.

curve. Even if labour markets are imperfect and labour is immobile, this standard result of the NEG theories remains valid.

In the last section, we show what the merits are of the model we developed - more importantly what role unions (can) play in location decisions. We focus on the impact of the degree of 'centralization' (at firm or sectoral level) and 'regionalization' (at regional or supra-regional level) of the wage setting on the wage level. Location decisions of firms are influenced by both the fact whether wages are set at a more or less centralized level ánd whether they are set in each of the regions separately or rather at a coordinating level. We show that - given our assumptions - wage setting at the firm level is the best policy to attract firms when trade costs are low, while wage setting at a more centralized level is most effective to attract firms when trade costs are high. Moreover, wage setting at the supra-regional level is beneficial for the already more agglomerated region and hurts the peripheral region.

These are of course strong policy recommendations that depend on the assumptions we made in our model. Although it remains a partial equilibrium model, we do believe that it helps us to gain a better insight in the role that the level of wage setting can play in location decisions of firms.

Appendix A. Wage Setting

Union k maximizes

$$\frac{W_{Hk}-1}{p_{HM}^{\alpha}}L_{Hk}$$

Note that

$$p_{HM}=\left[nq_H^{1-\sigma}+n^*\left(\frac{q_F}{\tau}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}=\frac{\sigma}{\sigma-1}\left[\sum_{l=1}^{K}\frac{n}{K}W_{Hl}^{1-\sigma}+n^*\left(\frac{W_F}{\tau}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{20}$$

where the first equality uses (3) and the relation between the mill price and the consumer price, and the second equality uses (7) and the partition of firms over the unions. Furthermore, we have that

$$L_{Hk}=\frac{n}{K}z_{Hj}=\frac{n}{K}\left(\frac{q_{Hj}}{p_{HM}}\right)^{-\sigma}G_H=\frac{n}{K}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}W_{Hk}^{-\sigma}p_{HM}^{\sigma}G_H \tag{21}$$

where the second equality uses (5), and the third uses (7).

Union k is small in the sense of neglecting the effect of his wage on G_H. Hence, using (21) the union's objective function can be written as

$$\frac{W_{Hk}-1}{p_{HM}^{\alpha}}W_{Hk}^{-\sigma}p_{HM}^{\sigma}$$

It follows from (20) that

$$\frac{\partial p_{HM}}{\partial W_{Hk}}=\frac{n}{K}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{W_{Hk}}{p_{HM}}\right)^{-\sigma}, \tag{22}$$

so that we get the following first order condition for the union's optimization problem:

$$\frac{W_{Hk}}{W_{Hk}-1}=\sigma+\frac{n}{K}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{W_{Hk}}{p_{HM}}\right)^{1-\sigma}(\alpha-\sigma)$$

It can be readily verified that all unions will set the same wage. Substituting p_{HM} by the first equality of (20), q_H by (7), and similarly for q_F yields expression (9) in the text.

Appendix B. Stability of agglomeration

It follows from (16) that, for agglomeration in region H to be a stable equilibrium, the following condition should hold:

$$\left(\frac{W_H}{W_F}\right)^{1-\sigma}>\left(\frac{p_{HM}}{p_{FM}}\right)^{-\sigma}\frac{G_F}{G_H} \tag{23}$$

Furthermore, the definitions

$$G_H = \alpha\left[\frac{Y_H}{p_{HM}} + \tau^{\sigma-1}\left(\frac{p_{HM}}{p_{FM}}\right)^{-\sigma}\frac{Y_F}{p_{FM}}\right], \qquad G_F = \alpha\left[\frac{Y_F}{p_{FM}} + \tau^{\sigma-1}\left(\frac{p_{FM}}{p_{HM}}\right)^{-\sigma}\frac{Y_H}{p_{HM}}\right] \tag{24}$$

$$p_{HM} = \left[nq_H^{1-\sigma} + n^* q_F^{1-\sigma}\tau^{\sigma-1}\right]^{\frac{1}{1-\sigma}}, \qquad p_{FM} = \left[n^* q_F^{1-\sigma} + nq_H^{1-\sigma}\tau^{\sigma-1}\right]^{\frac{1}{1-\sigma}} \tag{25}$$

imply that, in case of agglomeration in region H, and hence $n = N, n^* = 0$,

$$\begin{aligned} p_{HM} &= \tau p_{FM}, \\ G_H &= \alpha\left[\frac{Y_H}{p_{HM}} + \frac{Y_F}{p_{HM}}\right], \\ G_F &= \alpha\tau\left[\frac{Y_F}{p_{HM}} + \tau^{2(\sigma-1)}\frac{Y_H}{p_{HM}}\right]. \end{aligned}$$

Hence condition (23) can be written as

$$\left(\frac{W_H}{W_F}\right)^{1-\sigma} > \tau^{1-\sigma}\frac{Y_F + \tau^{2(\sigma-1)}Y_H}{Y_F + Y_H} \tag{26}$$

Total income in the home region is given by

$$Y_H = I - L_{HM} + W_H L_{HM} + \frac{1}{2}\left(n\Pi_{Hj} + n^*\Pi_{Fj}\right) \tag{27}$$

and consists of the wage bill in the agricultural sector, $I - L_{HM}$, the wage bill in manufacturing and profits, where it is assumed that half of the profits of each region accrue to the residents of the other region. We have that $L_{HM} = nz_{Hj}$ and $\Pi_{Hj} = (q_{Hj} - W_H)\, z_{Hj} - E = \frac{1}{\sigma-1}W_H z_{Hj} - E$, where use was made of the price-setting equation (7), so that (27) can be written as

$$Y_H = I - \frac{1}{2}(n + n^*)\, E + \left[\frac{2\sigma - 1}{2(\sigma-1)}W_H - 1\right] nz_{Hj} + \frac{1}{2(\sigma-1)}W_F n^* z_{Fj} \tag{28}$$

A similar expression can be derived for total income in region F

$$Y_F = I - \frac{1}{2}(n + n^*)\, E + \left[\frac{2\sigma - 1}{2(\sigma-1)}W_F - 1\right] n^* z_{Fj} + \frac{1}{2(\sigma-1)}W_H n z_{Hj} \tag{29}$$

So in case of agglomeration in region H we get

$$Y_H = I - \frac{1}{2}NE + \left[\frac{2\sigma - 1}{2(\sigma-1)}W_H - 1\right] Nz_{Hj} \tag{30}$$

$$Y_F = I - \frac{1}{2}NE + \frac{1}{2(\sigma-1)}W_H N z_{Hj} \tag{31}$$

Furthermore,

$$z_{Hj} = \left(\frac{q_{Hj}}{p_{HM}}\right)^{-\sigma} G_H = \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} W_H^{-\sigma} p_{HM}^{\sigma} G_H, \tag{32}$$

which, in case of agglomeration in region H becomes

$$z_{Hj} = \frac{\sigma-1}{\sigma} N^{-1} W_H^{-1} \alpha \left(Y_H + Y_F\right). \tag{33}$$

Substituting (33) and (11) in (30) and (31) yields

$$\begin{aligned} Y_H &= I - \frac{1}{2}NE + \left[\frac{\sigma\left(K-1\right)+\alpha+2K\left(\sigma-1\right)}{2\sigma\left[\sigma\left(K-1\right)+\alpha\right]}\right]\alpha\left(Y_H+Y_F\right) \\ Y_F &= I - \frac{1}{2}NE + \frac{1}{2\sigma}\alpha\left(Y_H+Y_F\right) \end{aligned}$$

Substituting the solution of this system of equations and (11) and (13) in (26), one finally arrives, after tedious computations, at the following condition for agglomeration in region H to be a stable equilibrium

$$\left(\frac{\sigma\left[\sigma\left(K-1\right)+\alpha-K\right]}{\left(\sigma-1\right)\left[\sigma\left(K-1\right)+\alpha\right]}\right)^{\sigma-1} > \tau^{1-\sigma}\frac{\left[\sigma^2(K-1)+\alpha\sigma\right]\left[1+\tau^{2(\sigma-1)}\right]-\alpha K(\sigma-1)\left[1-\tau^{2(\sigma-1)}\right]}{2\left[\sigma^2(K-1)+\alpha\sigma\right]}$$

Appendix C. Stability of symmetry

As stated in the text, the symmetric equilibrium will be unstable if, as a consequence of a reallocation of some firms to region H, i.e. $d\hat{n}>0$, the profit differential widens, i.e. if

$$\left(1-\sigma\right)d\hat{W} + \sigma d\hat{p}_M + d\hat{G} > 0 \tag{34}$$

In order to check whether this condition holds, on needs expressions for $d\hat{W}, d\hat{p}_M$ and $d\hat{G}$. In what follows, we merely state the main steps in the derivation of these expressions; the detailed computations are lengty and tedious and are therefore not spelled out.

Total differentiation of (9) and (10), the wage expressions for the home and the foreign region, evaluating the resulting expressions at the symmetric equilibrium, we arrive at the following result:

$$d\hat{W} = \frac{2Kt(\sigma-\alpha)}{\left[\sigma K\left(1+t\right)-\sigma+\alpha\right]\left[\left(\sigma-1\right)K\left(1+t\right)-\sigma+\alpha\right]+2K\left(\sigma-\alpha\right)t(\sigma-1)}d\hat{n}$$

where t is a shorthand notation for $\tau^{\sigma-1}$.

Totally differentiating $p_M = \frac{p_{HM}}{p_{FM}}$, where p_{HM} and p_{FM} are defined in (25), and where in the latter expression q_H and q_F are replaced by the price setting equation (7) and its analogue for the foreign region, evaluating the resulting expression at the symmetric equilibrium, we get the following result:

$$d\hat{p}_M = \frac{\varphi}{1-\sigma}\left[(1-\sigma)\, d\hat{W} + d\hat{n}\right]$$

where φ is a shorthand notation for $\frac{1-t}{1+t}$.

Total differentiation of $\frac{G_H}{G_F}$, where G_H and G_F are defined in (24), evaluating the resulting expression at the symmetric equilibrium, we can show that

$$d\hat{G} = \varphi d\hat{Y} + \varphi\,(\sigma - 1)\, d\hat{p}_M - \sigma d\hat{p}_M \tag{35}$$

The term $d\hat{Y}$ appears in this last expression and needs to be spelled out. The procedure is the same: total differentiation and evaluation of the outcome outcome at the symmetric equilibrium. We use (28), (29), (32) and the analogue of the latter expression for the foreign region and we derive:

$$d\hat{Y} = \alpha\frac{\sigma-1}{\sigma}\left\{\frac{W-1}{W}\left(d\hat{G} + \sigma d\hat{p}_M - \sigma d\hat{W} + d\hat{n}\right) + d\hat{W}\right\}$$

Note that, by using (35), condition (34) can alternatively be stated as

$$(1-\sigma)\, d\hat{W} + \varphi d\hat{Y} + \varphi\,(\sigma-1)\, d\hat{p}_M > 0$$

It can be shown that $d\hat{W} > 0$ because of (12). Furthermore, $d\hat{p} \leq 0$ and $d\hat{Y} \geq 0$.

Appendix D. 'Regionalization' of wage setting

Assuming each union k to operate at the supra-regional level and setting a nominal wage W_k for all its members whether they are employed in region H or F, the union maximizes

$$\frac{W_k - 1}{p_{HM}^{\alpha}} L_{Hk} + \frac{W_k - 1}{p_{FM}^{\alpha}} L_{Fk}$$

where W_k is the union's wage applying to all of its members and L_{Hk} (L_{Fk}) is the demand for union k's labour in region H (F).

We assumed each union k to be small in the sense of neglecting the effect of its wage on G_H. The maximisation problem of the union can therefore be rewritten as

$$\frac{W_k - 1}{p_{HM}^{\alpha}} W_k^{-\sigma} p_{HM}^{\sigma} + \frac{W_k - 1}{p_{FM}^{\alpha}} W_k^{-\sigma} p_{FM}^{\sigma} \tag{36}$$

From (20) and (21) we obtain the following expression for prices and labour demand in both regions.

$$p_{HM} = \frac{\sigma}{\sigma - 1} \left[\sum_{l=1}^{K} \frac{n}{K} W_l^{1-\sigma} + \sum_{l=1}^{K} \frac{n^*}{K} \left(\frac{W_l}{\tau} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

$$p_{FM} = \frac{\sigma}{\sigma - 1} \left[\sum_{l=1}^{K} \frac{n^*}{K} W_l^{1-\sigma} + \sum_{l=1}^{K} \frac{n}{K} \left(\frac{W_l}{\tau} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

$$L_{Hk} = \frac{n}{K} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} W_k^{-\sigma} p_{HM}^{\sigma} G_H$$

$$L_{Fk} = \frac{n^*}{K} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} W_k^{-\sigma} p_{FM}^{\sigma} G_F$$

Maximising (36) using

$$\frac{\partial p_{HM}}{\partial W_k} = \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} p_{HM}^{\sigma} W_k^{-\sigma} \left[\frac{n}{K} + \frac{n^*}{K} \tau^{\sigma-1} \right]$$

$$\frac{\partial p_{FM}}{\partial W_k} = \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} p_{FM}^{\sigma} W_k^{-\sigma} \left[\frac{n^*}{K} + \frac{n}{K} \tau^{\sigma-1} \right]$$

we get the following first order condition:

$$\{K[W-\sigma(W-1)]+(W-1)(\sigma-\alpha)\}\left(p_{HM}^{\sigma-\alpha}+p_{FM}^{\sigma-\alpha}\right)=0$$

which can only be satisfied if

$$K[W-\sigma(W-1)]+(W-1)(\sigma-\alpha)=0$$
$$\Longrightarrow W=\frac{\sigma(K-1)+\alpha}{\sigma(K-1)+\alpha-K}$$

which is the same result as under agglomeration (not surprisingly).

Our simulation results are based on the following parameter configurations: $K=10, \tau=0.7, \alpha=0.9, n=100, n^*=50$.

	W_H	W_F	W
$\sigma=3$	1.5458	1.5283	1.5587
$\sigma=4$	1.3655	1.3553	1.3717
$\sigma=5$	1.2751	1.2687	1.2786
$\sigma=6$	1.2207	1.2166	1.2227
$\sigma=7$	1.1844	1.1817	1.1855

These simulations reveal that $W>W_H>W_F$.

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