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The Location of Firms in Unionized Countries*

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Abstract

This paper develops a two-country model of international trade with Cournot competition. The labor markets are unionized so that a trade union bargains efficiently with each firm over wage and employment. It is shown that if the bargaining power of unions differs among countries then, as trade costs are reduced, the country with relatively weak unions gradually acquires all firms. However, for a range of trade costs it is also a locally stable equilibrium for all firms to locate in the country with strong unions.

JEL Classification: F15, J51, R11

Keywords: Integration, agglomeration, trade unions.

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1 Introduction

The effect of increased integration on the location of economic activity has recently been analyzed within the framework of the Dixit and Stiglitz (1977)-model of monopolistic competition and increasing returns to scale, see e.g. Krugman (1991), Krugman and Venables (1995) and Puga (1999). This literature suggests that as trade costs are reduced, production will tend to agglomerate in a few regions or countries. When trade is very costly, it is important for firms to be near final demand such that production takes place in most countries, but as trade barriers are removed, firms have incentives to exploit scale economies and cost- and demand linkages that arise when firms cluster in one location.

However, this analysis has ignored that countries have different labor market structures. The manufacturing wage rate varies greatly between European countries and even if productivity levels are taken into account, there are still significant differences in production costs, c.f. Durand, Madaschi, and Terribile (1998). A conventional point of view is that trade liberalization in such a scenario will lead to agglomeration of economic activity in countries with the most competitive labor markets since firms here incur the lowest production cost, but this does not clearly conform with empirical evidence for countries in the European Union. So far, the countries with relatively high unit labor costs have managed to support a significant manufacturing base.

This paper deals with these issues. We develop a two-country model of international trade with a perfectly competitive sector and an industry in which oligopolistic rivalry among firms prevails. Hence, the widely used Dixit and Stiglitz (1977)-model of monopolistic competition and increasing returns to scale is not applied. One way to capture different labor market structures is to incorporate trade unions into the analysis. We assume that firm specific trade unions bargain efficiently with each firm over wage and employment, and that the bargaining power of unions is allowed to vary across countries. Optimal firm location is analyzed and it is found that if the bargaining power of unions differs across countries, then, as trade costs are reduced, firms will move one by one to the country with relatively weak unions. However, for a range of trade costs it is also a stable equilibrium for all firms to locate in the country with strong unions.

The mechanism that generates agglomeration consists only of a demand linkage, in the sense that when firms cluster in one location then they bring wage income, so that a relatively large part of demand comes from the industry center. This implies that firms avoid paying trade costs on a large fraction of demand. Usually models of economic geography also incorporate a cost linkage through a real wage increase for workers that move with the firms or through a lower price of intermediate inputs. Our model is concerned with international relations so there is no labor mobility between countries, and firms do not use intermediates, which according to a recent empirical study (see Haaland, Kind, and Midelfart-Knarvik (1999)) seems to be of minor importance for firm location.

Another feature of our model is that when the countries are symmetric with respect to size, preferences and union bargaining strength, then we are able to derive results concerning stability of equilibria where production is divided equally between countries and where all firms are located in one country. We find that if trade costs are reduced below a critical level, firms gradually start to relocate into one of the countries and for a sufficiently low level of trade costs all firms choose to locate in this country. This structure of equilibria differs from what is usually found in recent economic geography papers. In for example Krugman and Venables (1995) there is "catastrophic" change in the location of firms once the level of trade cost that breaks the symmetric equilibrium is reached. Whether gradual or "catastrophic" change is the most appropriate description of real world dynamics is an open question, but for the EU Brulhart and Torstensson (1996) offer some support for there being gradual change.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 considers the location of firms under symmetric and asymmetric labor market structures. The last section is a brief conclusion.

2 The model

This section develops a simple model of international trade and imperfect competition. There are two countries, Home and Foreign, and two sectors, one is perfectly competitive with constant returns to scale and the other is characterized by Cournot competition among firms. The firms in the imperfectly competitive industry produce a homogenous good z, and the markets for z in Home and Foreign are segmented by trade costs, so that each firm treats the markets separately and chooses a profit maximizing quantity for each country as in Brander and Krugman (1983). The good produced in the competitive sector is freely tradable, and it is taken as the numéraire, so due to constant returns to scale, the wage rate in this sector is also one. We now in turn describe behavior of firms, consumers and finally wage and employment determination.

2.1 Firms

In the imperfectly competitive industry there are n and n^* identical firms in Home and Foreign respectively. The number of firms, n and n^*, need not be equal, and the labor market structures may be different, but apart from that, the countries are symmetric in all respects. Firm j in Home produces y_j for domestic consumption and x_j for exports, and y_j^* and x_j^* are the corresponding quantities for firm j in Foreign.

Firms behave strategically and engage in Cournot competition in each market, but it is nevertheless assumed that they do not take into account their influence on aggregate income and demand. However, the model can easily be extended to include several industries so that the actions of a single firm only have a small impact on income and thus are neglected[1]. This extension does not alter any results, so to save notation we keep the simple model with only one imperfectly competitive industry.

The only factor of production is labor and for a firm in Home the labor input required to deliver y_j units of output to the Home market is $l_{yj} = y_j$, whereas delivery of x_j units to the Foreign market requires $l_{xj} = \tau x_j$. Trade costs, $\tau \geq 1$, are of the "iceberg" type, i.e. τ units of the good must be shipped in order to meet demand of one unit. These costs cover both those incurred from transport and other trade impediments. Total employment in firm j is $l_j = y_j + \tau x_j$ so the cost function is given by $C_j = w_j(y_j + \tau x_j) + f$, where f is a fixed set-up cost and w_j is the wage rate in firm j. The operating profit of firms therefore is

$$\pi_j = py_j + p^* x_j - w_j(y_j + \tau x_j), \quad j = 1, .., n, \tag{1}$$

and in equilibrium profits are zero due to free entry and exit of firms, i.e. $\pi_j = f$.

2.2 Consumers

There is a representative consumer in each country and they each supply one unit of labor. It is assumed that utility for the representative consumer is of the Cobb Douglas type:

[1] This is shown in the Appendix.

$$U = z^{\mu} z_0^{1-\mu}, \tag{2}$$

where z_0 is consumption of the good produced in the competitive sector. Demand for z in Home is given by

$$z = \frac{\mu Y}{p}, \tag{3}$$

where Y is national income, so equilibrium between supply and demand at the Home market requires that $z = \sum_{j=1}^{n} y_j + \sum_{j=1}^{n^*} x_j^*$, and similarly for Foreign, $z^* = \sum_{j=1}^{n^*} y_j^* + \sum_{j=1}^{n} x_j$.

2.3 Wage and employment determination

Equilibrium of the model is determined over two stages. In the first stage firms enter the imperfectly competitive sector until profits are driven down to zero (anticipating the wage and employment outcome of the second stage), after which the set-up cost, f, of the firms are sunk. Labor markets are unionized in the imperfectly competitive industry and, in the second stage, we assume that wage rates and employment in each firm are determined simultaneously through efficient Nash bargaining between the firm and a firm specific union[2]. The bargaining process is modelled in for example McDonald and Solow (1981) and applied to international trade in Mezzetti and Dinopoulos (1991). Workers can always find employment in the competitive sector at the wage rate 1, and it is assumed that the union's objective is to maximize the surplus on top of the competitive wage rate. Hence, union j in Home maximizes

$$\Omega_j = (w_j - 1)l_j, \quad j = 1, .., n, \tag{4}$$

Union j and firm j now bargain cooperatively over w_j and $l_j = y_j + \tau x_j$ taking output levels from all other firms as given, so they aim to maximize

$$\Psi_j(w_j, l_j) = \pi_j^{1-\alpha} \Omega_j^{\alpha}, \quad j = 1, .., n, \tag{5}$$

[2] Alternatively the negotiations could be over the wage rate only, leaving the employment decision unilaterally to the firm, i.e. the 'Right-to-Manage' assumption. This bargaining model is used in e.g. Bughin and Vannini (1995), but here efficient bargaing is assumed for the sake of analytical simplicity.

where α is the bargaining power of the unions, which for simplicity is assumed to be equal for all unions[3]. The bargaining power of Foreign unions, α^*, may be different.

The order of stages gives rise to short run wage contracts. Driffill and van der Ploeg (1995) incorporate monopoly unions into the Dixit and Stiglitz (1977)-model of monopolistic competition, and they analyze effects of economic integration on the behavior of unions, but in a model without income effects in demand. In their framework the two stages must be reversed, so that the wage rate is determined before entry of firms. Hence, in this sense the outcome results in long term wage contracts which may not be realistic.

It should be noted that firms in the imperfectly competitive industry can attract workers from the competitive sector because of the rent sharing. In defiance of the fact that all workers are assumed identical, the model implies that only workers employed in the unionized industry earn labor market rents, but this is actually in accordance with empirical results. For the US economy Katz and Summers (1989) have found significant inter industry wage differences and that these differences cannot be accounted for on the basis of labor quality.

Consider now stage two of the game. It is seen from (1) that the firm can treat each market independently so by substituting for $l_j = y_j + \tau x_j$ in (4) we can equivalently maximize (5) with respect to w_j, y_j and x_j. This yields the following first order conditions in Home:

$$\frac{\partial \Psi_j}{\partial w_j} = \Psi_j \left[\frac{\alpha}{w_j - 1} - \frac{(1-\alpha) l_j}{\pi_j} \right] = 0 \tag{6}$$

$$\frac{\partial \Psi_j}{\partial y_j} = \Psi_j \left[\frac{\alpha}{l_j} + \frac{1-\alpha}{\pi_j} \left(\frac{\partial p}{\partial y_j} y_j + p - w_j \right) \right] = 0 \tag{7}$$

$$\frac{\partial \Psi_j}{\partial x_j} = \Psi_j \left[\frac{\alpha \tau}{l_j} + \frac{1-\alpha}{\pi_j} \left(\frac{\partial p^*}{\partial x_j} x_j + p^* - \tau w_j \right) \right] = 0, \tag{8}$$

which gives

$$w_j = (1-\alpha) + \alpha \left(p \frac{y_j}{l_j} + p^* \frac{x_j}{l_j} \right) \tag{9}$$

$$1 = \frac{\partial p}{\partial y_j} y_j + p \tag{10}$$

$$\tau = \frac{\partial p^*}{\partial x_j} x_j + p^* \tag{11}$$

[3]The operating profit is used in Ψ_j, because the entry decision has been made in stage one, so the set-up cost, f, is sunk and is therefore not relevant in the second stage of the game.

Equation (10) says that output for domestic consumption in firm j is determined as if the wage rate equals the competitive wage. Likewise, equation (11) states that the marginal revenue of exports must equal the competitive wage plus unit costs incurred from trade. This is so because the contract curve is vertical at the competitive employment level which is also revealed in equation (9); the bargained wage is a weighted average of 1 and the average price of the firm's sales. The outcome on the contract curve is then determined by the bargaining power of the union.

Due to symmetry of firms we now drop subscripts, and also because of symmetry of countries we consider only the Home market. Equation (10) and the Foreign equivalent of (11) determine quantities at the Home market and solving these two equations for y and x^* yields the Cournot-Nash equilibrium quantities:

$$y = \frac{1 + (\tau - 1)n^*}{n + \tau n^*} \left(\frac{\mu Y}{p} \right), \tag{12}$$

and

$$x^* = \frac{\tau - (\tau - 1)n}{n + \tau n^*} \left(\frac{\mu Y}{p} \right), \tag{13}$$

where the price is given by

$$p = \frac{n + \tau n^*}{n + n^* - 1}. \tag{14}$$

The wage rate in Home is found from (9) but there is no simple closed form solution available. From (13) we obtain a condition for x^* being positive, or for firms to engage in reciprocal dumping. The condition becomes

$$\tau < \frac{n}{n-1}, \tag{15}$$

and it is fulfilled when trade costs, τ, are low and the degree of competition in the country to which the firm exports, n, is low.

We know from (6) that $\alpha \pi = (1 - \alpha)(w - 1)l$ so the operating profit of a representative Home firm, (1), can be rewritten by inserting equilibrium prices and quantities:

$$\pi = \mu(1 - \alpha) \left[\left(\frac{1 + (\tau - 1)n^*}{n + \tau n^*} \right)^2 Y + \left(\frac{\tau - (\tau - 1)n^*}{n^* + \tau n} \right)^2 Y^* \right]. \tag{16}$$

To complete the description of the model we state income in Home. Total employment in the imperfectly competitive industry is $L = nl$ so Y is given as

$$
\begin{aligned}
Y &= wL + (1 - L) \\
&= \frac{\alpha}{1-\alpha} n\pi + 1
\end{aligned}
\tag{17}
$$

In stage one, firms enter or exit the market until the operating profits equal the fixed set-up cost, i.e. $\pi - f = 0$, and such an allocation characterizes a (long run) equilibrium of the model. Note that the integer constraint on the number of firms is ignored throughout the paper, and so n is treated as a continuous variable.

If the symmetric equilibrium in which intra industry trade exists is broken by a firm that enters the Home market, then there are two main effects on the operating profit. First, the new firm creates jobs with a wage greater than the wage rate in the competitive sector. This raises income in Home (see (17)) which in turn increases demand (see (3)) from Home consumers relative to that of Foreign consumers, so the firms in Home now avoid trade costs on a larger fraction of total demand. Thus the profit of Home firms will, ceteris paribus, rise. This creates incentives for other firms to enter the Home market, and accordingly we have a demand linkage effect or a force for agglomeration.

Second, the new firm in Home increases product market competition, which lowers the price in Home (see (14)) and thus has an adverse effect on profits. This competition effect constitutes a force for dispersion which works against the force for agglomeration. At the center of our analysis is the impact of economic integration on the tension between these two opposing forces.

3 The location of firms

In this section we consider the entry and exit decisions of the firms in the imperfectly competitive industry. We want to show that the agglomeration force created by demand linkages is, under certain conditions, powerful enough to outweigh the effect of increased product market competition on profits, and thus that it induces firms to concentrate in one country. We both consider the case of identical labor market structures and that of differences on the labor markets.

3.1 Symmetric labor market structures

The location of firms is in this section analyzed under the assumption that the bargaining power, α, is equal for all unions in both countries. First stability of the

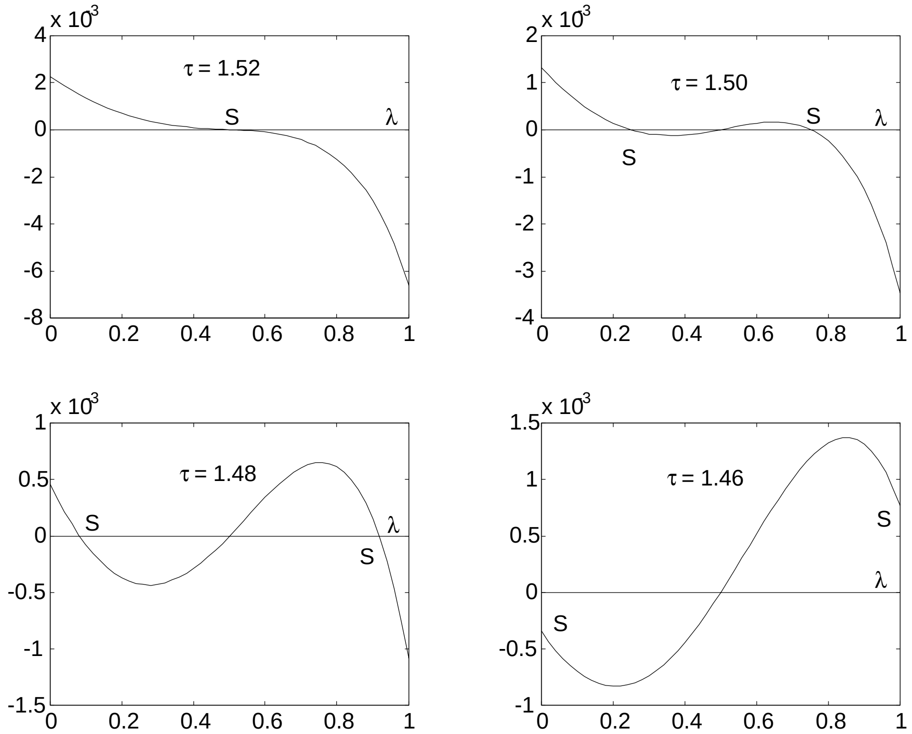

Figure 1: Home profit as a function of industry shares. $\alpha = 0.8$, $\mu = 0.8$, $f = 0.05$.

symmetric equilibrium (where the number of firms is equal in the two countries) is examined, then stability of the core-periphery equilibrium (where production is concentrated in one country). However, to see how the forces for agglomeration and dispersion interact we start out by presenting a numerical example.

The four panels of Figure 1 are calculated with a particular level of trade costs and all other parameters held constant, and they plot the net profit of a Home firm, $\pi - f$, against the share of industry in Home, $\lambda = n/(n + n^*)$, given that profits are zero in Foreign (i.e. the number of firms is determined from a given λ and the imposed zero profit condition in Foreign). In the subsequent analysis a particular location pattern, $\{n, n^*\}$ is an equilibrium if net profits are zero, i.e. $\pi - f = 0$ for all firms, and this equilibrium is locally stable if $\frac{d\pi}{d\lambda} < 0$. For high trade costs (the top left panel) it is seen that the net profit is zero for $\lambda = 0.5$, positive when less than half of industry is located in Home and negative otherwise. Firms have incentives to enter the market until net profits are eliminated so the symmetric equilibrium is globally stable ('S' for stable).

For intermediate levels of trade costs (the top right and the bottom left panel) the symmetric equilibrium is no longer stable and instead there are locally stable asymmetric equilibria where production either moves to Home or Foreign. It is a distinguishing feature of the model that asymmetric equilibria without all firms locating in the same country are possible. In addition it is seen that as trade costs are reduced, a larger share of production concentrates in the industry center. Finally, the bottom right panel of Figure 1 is calculated for a relatively low level of trade costs, and here all firms locate in one country.

Hence, it is observed that the forces for agglomeration and dispersion interact in a way such that firms gradually relocate to the country of agglomeration as trade costs are reduced. At high levels of trade costs it is important for firms to be near final demand and to minimize product market competition, but as trade is liberalized the demand linkage effect slowly come to dominate so that the periphery gradually is deindustrialized, and when trade costs are reduced sufficiently all firms choose to locate in one country. Hence, we have identified two levels of trade costs at which the structure of the equilibria changes character. The level of trade costs for which the symmetric equilibrium becomes unstable is denoted τ_S, and at τ_{CP} the core-periphery equilibrium becomes stable.

3.1.1 Stability of the symmetric equilibrium

The countries are identical with respect to preferences and size so there is always a symmetric equilibrium where the number of firms and incomes are identical, i.e. $n = n^*$ and $Y = Y^*$. The question is whether this equilibrium is locally stable. When trade costs prohibit trade ($\tau \geq \frac{n}{n-1}$), then it is stable since no firm has incentive to relocate to the other country and face a higher level of competition. When trade costs admit intra industry trade, competition minimization may no longer be sufficient to ensure stability because of the agglomeration force. So to analyze stability in this case, we consider the effect on profits of a firm that breaks the symmetric equilibrium.

By totally differentiating the operating profit in (16) and using that $dn = -dn^* = 2nd\lambda$, we obtain

$$\frac{d\pi}{d\lambda} = \frac{2(\tau^2-1)(2n-1)\left[(\tau+1)\frac{\alpha}{1-\alpha}nf - 2(\tau-1)(n-1)Y\right]}{\frac{(\tau+1)n}{1-\alpha}\left(\frac{(\tau+1)^2 n}{\mu} - (1+(\tau-1)n)\right)}. \tag{18}$$

The firm gains from breaking the symmetric equilibrium if $\frac{d\pi}{d\lambda} > 0$ in which case the equilibrium is no longer locally stable. By use of the fact that $n < \frac{\tau}{\tau-1}$, the denominator is seen to be positive, and so the sign of the derivative depends on the term in square brackets in the numerator. For $\tau = 1$ we have that $\frac{d\pi}{d\lambda} = 0$ (i.e. location does not matter), but the term in square brackets is positive so $\frac{d\pi}{d\lambda}$ must approach zero from above as τ tends to one. At the trade prohibitive level, $\tau = \frac{n}{n-1}$, the term is negative when the number of firms is sufficiently large and we assume that the fixed set-up cost is low enough to ensure this[4]. Thus, there exists a level of trade costs, $\tau_S \in]1, \frac{n}{n-1}[$, above which the symmetric equilibrium with intra industry trade is stable ($\frac{d\pi}{d\lambda}$ is negative) and below which it is unstable ($\frac{d\pi}{d\lambda}$ is positive). Therefore, as is now a standard result in models of economic geography, we have that the demand linkages dominate the effect of increased product market competition and the need to be near final demand when trade costs are reduced below a certain level, τ_S.

3.1.2 Asymmetric equilibria

In this section we investigate under what conditions the equilibrium where all firms have located in one of the countries is stable in the sense that no firm has incentive to deviate from this allocation. The number of firms in equilibrium is determined from the zero-profit condition for firms in the center, and local stability requires that a firm in the periphery cannot make a positive net profit. The operating profit of a firm in the core is found by evaluating (16) with $n^* = 0$ and using that income is given by (17):

$$\pi^C = \frac{\mu(1-\alpha)}{n^2}\left[\frac{\alpha}{1-\alpha}nf + 2\right], \tag{19}$$

whereas the obtainable operating profit in the periphery is found by evaluating the Foreign equivalent of (16) with $n^* = 0$:

$$\pi^P = \frac{\mu(1-\alpha)}{n^2}\left[\tau^{-2}(1+(\tau-1)n)^2 + (\tau-(\tau-1)n)^2\left(1+\frac{\alpha}{1-\alpha}nf\right)\right]. \tag{20}$$

The zero-profit condition, $\pi^C = f$, implies that $nf = 2\mu(1-\alpha)/(n-\alpha\mu)$ so the core-periphery equilibrium is locally stable ($\pi^P < f$) if and only if

[4]The term in square brackets in $\frac{d\pi}{d\lambda}$ is negative for $\tau = \frac{n}{n-1}$ if and only if $\mu\alpha < 2n(n-1)/(2n-1)$, where n is the number of firms in symmetry. This inequality corresponds to a similar condition in Fujita, Krugman, and Venables (1999, forthcoming) and Puga (1999), and it is for instance always satisfied for $n \geq 2$ (i.e. for low enough f). When the condition is not satisfied the force for agglomeration dominates the force for dispersion to such an extent that the symmetric equilibrium is unstable for all relevant values of trade costs.

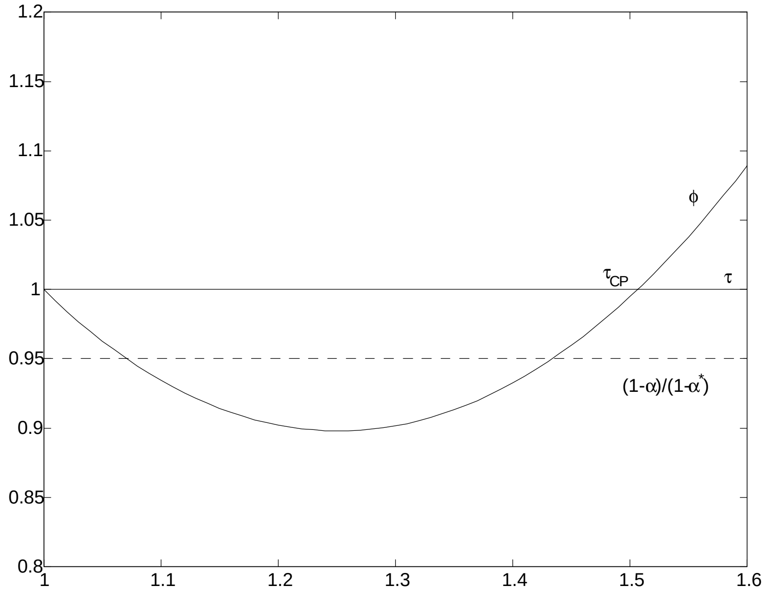

Figure 2: ϕ as a function of trade costs. $\alpha = 0.81$, $\alpha^* = 0.8$, $\mu = 0.8$, $f = 0.05$.

$$\phi(\tau) = \tau^{-2}(1 + (\tau - 1)n)^2 \frac{n - \alpha\mu}{2n} + (\tau - (\tau - 1)n)^2 \frac{n + \alpha\mu}{2n} < 1. \tag{21}$$

In order to determine whether the condition is satisfied we must characterize $\phi(\tau)$. First we note that $\phi(1) = 1$, and second that the number of firms does not depend on trade costs. Hence, the first order derivative is given by:

$$\begin{aligned} \phi'(\tau) &= \tau^{-2}(1 + (\tau - 1)n)(n - \alpha\mu) \\ &\quad -\tau^{-3}n(1 + (\tau - 1)n)^2(n - \alpha\mu) \\ &\quad -(\tau - (\tau - 1)n)(n - 1)(n + \alpha\mu), \end{aligned} \tag{22}$$

and so it is seen that $\phi'(1) = -2n(n-1) < 0$. Next, if the force for agglomeration is not extraordinarily strong relative to the force for dispersion, then it is profitable for a firm to set-up production in the periphery just at the trade prohibitive level of transport costs, i.e. $\phi(\frac{n}{n-1}) > 1$[5]. Therefore $\phi(\tau)$ is first decreasing from $\phi(1) = 1$ and then later increasing such that $\phi(\frac{n}{n-1}) > 1$ as shown in Figure 2 for a specific parameter combination.

[5] This condition is equivalent to $\alpha\mu < 1 - \frac{2n^3}{(2n-1)^2}$, and it is again satisfied when the number of firms is sufficiently large, which is ensured by assuming a low enough f.

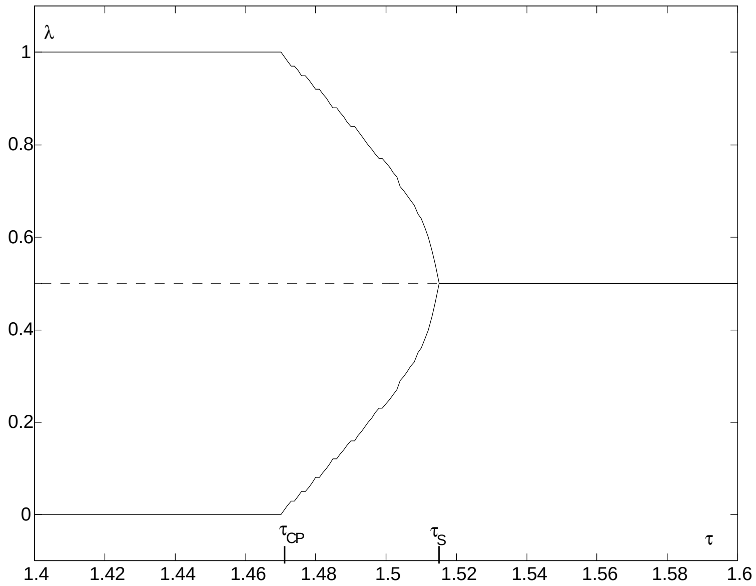

Figure 3: Industry shares as a function of trade costs. $\alpha = \alpha^* = 0.8$, $\mu = 0.8$, $f = 0.05$.

We now know that there exists a level of trade costs, τ_{CP}, below which the core-periphery equilibrium is stable and above which it is unstable. Furthermore, Figure 1 suggests that $\tau_{CP} < \tau_S$ (this is not possible to show analytically, but the result can be proved in a version of the model with a fixed number of firms). This means that there is a range of trade costs between τ_{CP} and τ_S where neither the symmetric equilibrium nor the core-periphery equilibrium is stable and that there must be asymmetric equilibria without complete deindustrialization of the periphery in this range of trade costs. Figure 3 plots equilibrium shares of industry in Home against trade costs, and on the basis of this example we conclude that integration leads to a gradual movement of production from the periphery to the core.

Taken together our results implies four distinct stages of integration. The first stage is one of high trade costs, symmetry among countries and no cross hauling of goods. Second, reducing trade costs makes it profitable for firms to engage in reciprocal dumping, but the symmetric equilibrium is still locally stable. In the third stage firms gradually start to relocate into the industry center (which could be either country) if trade costs are reduced further, and finally in the case of low trade costs the demand linkages are so powerful that the core-periphery equilibrium is locally stable and economic activity completely concentrates in one of the countries.

It should be noted that models based on the Dixit and Stiglitz (1977) monopolistically competitive framework usually give rise to a different structure of equilibria. Krugman (1991) and Krugman and Venables (1995) among others find "catastrophic" change in location once the critical level of trade costs that breaks the symmetric equilibrium is reached[6]. In addition, multiple equilibria are possible in the sense that both the symmetric and core-periphery equilibria can be stable for a range of trade costs[7].

For member countries of the EU Brulhart and Torstensson (1996) calculate locational Gini coefficients for a number of industries in 1980 and 1990 and the coefficients show a tendency for industries to be concentrated only somewhat more in 1990 than in 1980. This could be due to slow adjustment to optimal equilibria or indeed because gradual change is optimal.

3.2 Asymmetric labor market structures

In this section we analyze equilibria when unions in Home and Foreign have different bargaining strengths, and in particular we let $\alpha > \alpha^*$. Before deriving analytical results the forces at work are again illustrated by a numerical example. It is seen from the top left panel of Figure 4 that for high levels of trade costs, slightly more than half of industry is located in Foreign. This share increases gradually (λ falls) as τ is reduced until it is a locally stable equilibrium for all firms to locate in Foreign as shown in the top right panel of Figure 4. But this panel has another locally stable equilibrium where the majority of firms is located in Home, the country with relatively strong labor unions. When τ is reduced further, as in the bottom left panel, we have two locally stable equilibria where all firms are located either in Home or Foreign. Finally for τ close to one the equilibrium involving concentration of firms in Home ceases to be stable due to the difference in union bargaining power as can be seen from the bottom right panel.

The top right and the bottom left panel in Figure 4 reveal that lower trade costs actually can benefit Home in terms of attracting more firms (this is only true when α and α^* are sufficiently close to each other as in Figure 4), and this is a result

[6] It should be noted that our model exhibits "locally catastrophic" change in the sense that the slope at the bifurcation point in Figure 4, τ_S, is infinite.

[7] Fujita, Krugman, and Venables (1999, forthcoming) and Puga (1999) are exeptions in that they can have both "catastrophic" and gradual change, and no intuitive explanation is offered as to why gradual change appears. In a different set-up Baldwin, Martin, and Ottaviano (1998) also find gradual change.

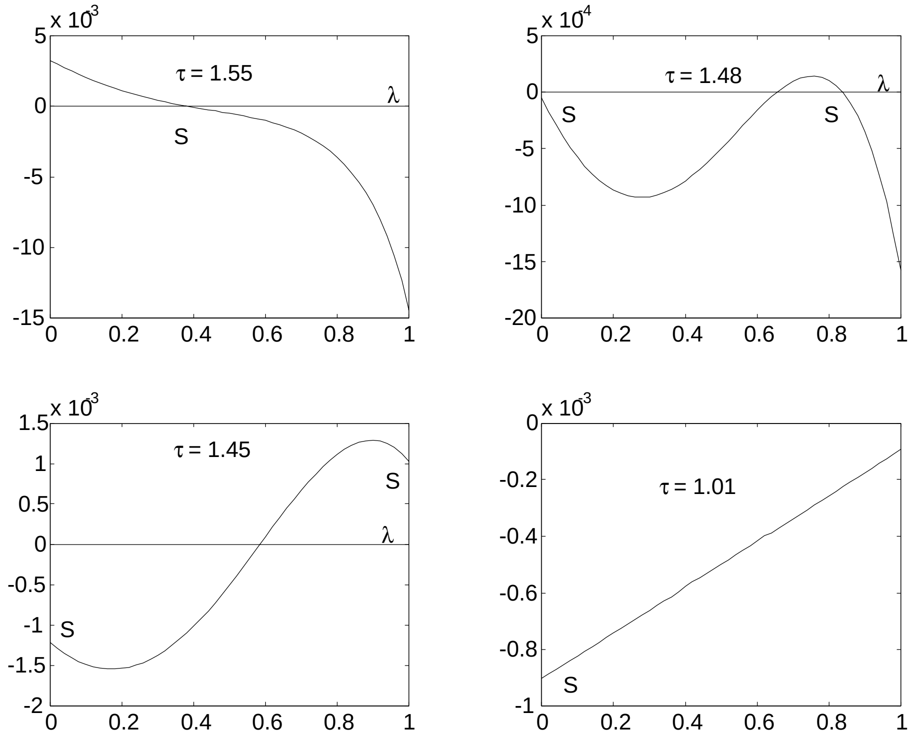

Figure 4: Home profit as a function of industry shares. $\alpha = 0.802$, $\alpha^* = 0.8$, $\mu = 0.8$, $f = 0.05$.

found in Munch and Sørensen (1998) as well. In that paper a unionized country gains from integration because the labor market distortion is reduced which in turn attracts more firms.

Figure 5 plots the equilibrium shares of industry in Home, λ, against trade costs, τ, and it is seen that there is a range of intermediate levels of trade costs for which it is an equilibrium outcome for all firms to locate in Home. The demand linkages are strongest for intermediate levels of trade costs so here the agglomeration advantages from clustering in the country with strong unions are sufficient to outweigh the disadvantage from paying higher wages. Figure 5 implies that if trade costs step by step are reduced from a high level, then the country with relatively weak unions at some point ends up with all firms in the imperfectly competitive industries, and this seems to dismiss the possibility of equilibria with all firms in Home. However, a realistic scenario is that trade unions do not come into existence until after industrialization has happened, and so equilibria involving concentration of firms in countries with relatively strong unions cannot be ruled out on that account.

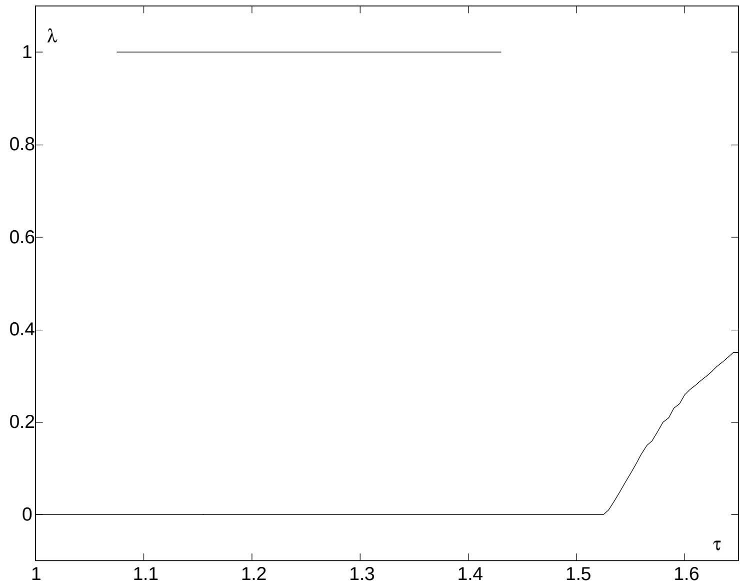

Figure 5: Industry shares as a function of trade costs. $\alpha = 0.81$, $\alpha^* = 0.8$, $\mu = 0.8$, $f = 0.05$.

Compared to the panels of Figure 1, where unions are identical in the two countries, Figure 4 indicates that the profit curves are pushed down due to the stronger unions in Home. This suggests the existence of a limit as to how different the bargaining powers can be in order for there to be stable equilibria with firms located in Home.

3.2.1 Stability of the core-periphery equilibrium in Home

We now want to show that under certain conditions it is indeed a locally stable equilibrium for all firms to concentrate in Home, i.e. in the country which gives firms an inherent competitive disadvantage due to higher bargaining power of unions. In section 3.1.2 it was shown that the core-periphery equilibrium is stable for τ satisfying $\phi(\tau) < 1$. If it is taken into account that the bargaining powers in the two countries are different, then it is easily found that the condition now becomes

$$\phi(\tau) < \frac{1-\alpha}{1-\alpha^*}, \tag{23}$$

where $\frac{1-\alpha}{1-\alpha^*} \in [0,1]$, i.e. the condition is now stronger. We already know that $\phi(1) = 1$, $\phi(\tau)$ has a negative slope for low values of τ and that $\phi(\tau)$ is positive for high values of τ. Thus we can conclude that if α is sufficiently close to α^* ($\frac{1-\alpha}{1-\alpha^*}$

close to 1), then there must be a subset of trade costs in the interval $[1, \frac{n}{n-1}]$ for which it is a stable equilibrium for all firms to locate in the country with relatively strong unions (see Figure 2)[8].

3.3 Comparative static results

We have been unable to find comparative static results for τ_{CP}, but recall that stability of equilibria depends on the relative strength of the force for agglomeration and the force for dispersion. We identified earlier the former to consist of a demand linkage effect which is tightly connected to changes in income. The latter is the competition effect which is influenced by changes in the number of firms. Hence, if we can asses how the number of firms and income in the center is affected by changes in the parameters, then it is possible to predict how τ_{CP} changes.

It is easily found from $\pi^C = f$ that the number of firms in a zero profit equilibrium reacts to changes in parameters in the following way:

$$\frac{dn}{d\alpha} < 0, \qquad \frac{dn}{d\mu} > 0. \tag{24}$$

I.e. higher bargaining power of unions makes it less profitable for firms to operate and some firms must exit the market, whereas a higher share of income spent on goods produced in imperfectly competitive industries, μ, increases profitability and thus leads to entry of firms.

After application of the zero profit condition (which implies that $nf = 2\mu(1-\alpha)/(n-\alpha\mu)$), income in the center (see (17)) can be written as

$$Y = \frac{n+\alpha\mu}{n-\alpha\mu}, \tag{25}$$

and the sign of the derivatives for Y is

$$\frac{dY}{d\alpha} > 0, \qquad \frac{dY}{d\mu} > 0. \tag{26}$$

If the bargaining power of unions rises, then there are both a direct and an indirect effect on income. Stronger unions directly affect wages in a positive direction, but at the same time the number of firms falls (see (24)), and because of increasing returns to scale this indirectly tends to increase income as well. A lower number of firms

[8] The fact that $\phi(\tau)$ has negative slope for low values of trade costs ensures that $\phi(\tau)$ at some point is smaller than $\frac{1-\alpha}{1-\alpha^*}$ (for α close to α^*), and $\phi(\frac{n}{n-1}) > 1$ implies that there exists (at least) one closed interval of trade costs where (23) is satisfied (due to continuity of $\phi(\tau)$).

alone increases income (see (25)) because the level of competition falls and the price and quantity per firm rise so that in order for there to be zero profits, the bargained wage rate must rise.

With respect to changes in μ, the signs of the direct and the indirect effects are no longer the same. The direct effect of a rise in μ is positive and the indirect effect is negative since n increases, but the overall effect remains positive (c.f. (26)).

In the case where unions are identical across countries, the force for agglomeration is strengthened and the force for dispersion is weakened if α rises because income in the center rises and the level of competition falls. It follows that the core-periphery equilibrium is more likely to be stable for higher α's, and clearly in the limit we must have that $\tau_{CP} \to 1$ for $\alpha \to 0$ because here no extra income is generated and so there is no force for agglomeration. Simulations indeed indicate that $\frac{d\tau_{CP}}{d\alpha} > 0$.

If, on the other hand, a unilateral increase in the bargaining power is observed in a country with agglomeration of industry, then there are two opposing effects. The forces for agglomeration and dispersion both reinforce concentration of firms in the center (the force for agglomeration is strengthened and the force for dispersion is weakened), but firms have incentives to move to countries with weaker unions, and in this case simulations suggest that the latter effect dominates (i.e. the range of trade costs for which it is a stable equilibrium for firms to locate in the center shrinks).

The effect from changes in μ is less straightforward because income and the number of firms change in the same direction, so that both forces are either weakened or strengthened. Consider a rise in μ. This has a positive effect on both the number of firms and income, but simulations say that τ_{CP} falls (i.e. $\frac{d\tau_{CP}}{d\mu} < 0$). Therefore a higher μ is strengthening the force for dispersion more than the force for agglomeration so that agglomeration of economic activity in the center is less likely to be a stable equilibrium.

4 Conclusion

Clearly, there are many reasons for different wage levels across countries and the framework of this paper has abstracted from other reasons than differences in the bargaining strength of trade unions. Typically, agglomeration of economic activity by itself widens the wage gap between countries due to increased demand for labor, but we take the analysis a step further and ask whether such concentrations of firms can be sustained even if there are inherent competitive disadvantages by locating in the industrial center.

Provided that unions are not too different with respect to bargaining strength across countries, the model explains how it is an equilibrium for firms to concentrate in a country with relatively strong labor unions, and this fits the observations for several European countries. In addition, it is found that economic integration may benefit high wage countries in terms of attracting more firms, but also that there is a limit as to how low trade costs can become before firms find it optimal to move to a low wage country.

The basic mechanism behind this result is that concentration of wage income creates externalities that more than outweigh the disadvantages by bargaining with relatively strong unions. Firms do not move to the country with weak unions because in doing so they would incur higher costs from transporting their goods to the country where the major part of world income is located.

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A Appendix

Suppose there are m symmetric industries with Cournot competition. Then the consumer preferences can be specified as follows:

$$U = Z^{\mu} z_0^{1-\mu}, \tag{27}$$

where Z is a CES-consumption index over the m different goods:

$$Z = m^{\frac{1}{1-\epsilon}} \left(\sum_{i=1}^{m} z_i^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}, \qquad \epsilon > 1. \tag{28}$$

The price index corresponding to the consumption index is given by

$$P = \left(\frac{1}{m} \sum_{i=1}^{m} p_i^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}, \tag{29}$$

and the demand for good i in Home can now be found to be

$$z_i = \frac{\mu Y}{m} P^{\epsilon-1} p_i^{-\epsilon}, \qquad i = 1, .., m, \tag{30}$$

With these changes equilibrium quantities and prices in a representative industry becomes

$$y = \frac{1 + (\tau - 1)\epsilon n^*}{n + \tau n^*} \left(\frac{\mu Y}{mp} \right), \tag{31}$$

$$x^* = \frac{\tau - (\tau - 1)\epsilon n}{n + \tau n^*} \left(\frac{\mu Y}{mp} \right), \tag{32}$$

and

$$p = \frac{\epsilon(n + \tau n^*)}{\epsilon(n + n^*) - 1}. \tag{33}$$

The new condition for firms to engage in reciprocal dumping therefore is

$$\tau < \frac{\epsilon n}{\epsilon n - 1}. \tag{34}$$

The operating profit of a representative Home firm in the representative industry is

$$\pi = \frac{\mu(1-\alpha)}{\epsilon m}\left[\left(\frac{1+(\tau-1)\epsilon n^*}{n+\tau n^*}\right)^2 Y\left(\frac{P}{p}\right)^{\epsilon-1} + \left(\frac{\tau-(\tau-1)\epsilon n^*}{n^*+\tau n}\right)^2 Y^*\left(\frac{P^*}{p^*}\right)^{\epsilon-1}\right], \tag{35}$$

and income takes the following form:

$$Y = \frac{\alpha}{1-\alpha} mnf + 1. \tag{36}$$

A.1 Stability of the symmetric equilibrium

Total differentiation of the operating profit in (35) and use of the fact that $dn = -dn^* = 2nd\lambda$ gives

$$\frac{d\pi}{d\lambda} = \frac{2(\tau^2-1)(2\epsilon n-1)\left[(\tau+1)\frac{\alpha}{1-\alpha}mnf - 2(\tau-1)\left(\epsilon n - 1 - \gamma\right)Y\right]}{\frac{\tau+1}{1-\alpha}mn\left(\frac{(\tau+1)^2\epsilon n}{\mu} - (1+(\tau-1)\epsilon n)\right)}, \tag{37}$$

where $\gamma = \frac{(m-1)(\epsilon-1)}{2m}$. Again it is easily checked that the denominator is positive since $\epsilon n < \frac{\tau}{\tau-1}$. As before, the numerator is zero and increasing for $\tau = 1$, and negative at the trade prohibitive level, $\tau = \frac{\epsilon n}{\epsilon n-1}$, if $\mu\alpha < 2\epsilon n(\epsilon n - 1 - \gamma)/(2\epsilon n - 1)$, which for instance is satisfied for $n \geq 2$. Thus, there exists a level of trade costs, $\tau_S \in]1, \frac{\epsilon n}{\epsilon n-1}[$, above which the symmetric equilibrium with intra industry trade is stable ($\frac{d\pi}{d\lambda}$ is negative) and below which it is unstable ($\frac{d\pi}{d\lambda}$ is positive).

A.2 Asymmetric equilibria in asymmetric labor markets

Now it is assumed that $\alpha > \alpha^*$, and we analyze the core-periphery equilibrium where $n^* = 0$. The operating profit of a firm in the core is

$$\pi^C = \frac{\mu(1-\alpha)}{\epsilon mn^2}\left[\frac{\alpha}{1-\alpha}mnf + 2\right], \tag{38}$$

whereas the obtainable operating profit in the periphery is

$$\pi^P = \frac{\mu(1-\alpha^*)}{\epsilon mn^2}\left[\tau^{-2}(1+(\tau-1)\epsilon n)^2 + (\tau-(\tau-1)\epsilon n)^2\left(1+\frac{\alpha}{1-\alpha}mnf\right)\right]. \tag{39}$$

The zero-profit condition, $\pi^C = f$, implies that $mnf = 2\mu(1-\alpha)/(\epsilon n - \alpha\mu)$ so the core-periphery equilibrium is locally stable ($\pi^P < f$) if and only if

$$\phi(\tau) = \tau^{-2}(1+(\tau-1)\epsilon n)^2\frac{\epsilon n - \alpha\mu}{2\epsilon n} + (\tau-(\tau-1)\epsilon n)^2\frac{\epsilon n + \alpha\mu}{2\epsilon n} < \frac{1-\alpha}{1-\alpha^*}. \quad (40)$$

Again we note that $\phi(1) = 1$, and that the first order derivative is given by:

$$\begin{aligned}\phi'(\tau) &= \tau^{-2}(1+(\tau-1)\epsilon n)(\epsilon n - \alpha\mu) \\ &\quad -\tau^{-3}\epsilon n(1+(\tau-1)\epsilon n)^2(\epsilon n - \alpha\mu) \\ &\quad -(\tau-(\tau-1)\epsilon n)(\epsilon n - 1)(\epsilon n + \alpha\mu). \end{aligned} \quad (41)$$

As in the text, it is seen that $\phi'(1) = -2\epsilon n(\epsilon n - 1) < 0$. If it is assumed that $2(\epsilon n)^3 < (2\epsilon n - 1)^2(\epsilon n - \alpha\mu)$ (which is satisfied for sufficiently low level of f) then we have that $\phi(\frac{\epsilon n}{\epsilon n - 1}) > 1$ so the results concerning stability of the core-periphery equilibrium carry through to the extended model.

A.3 Comparative static results

It is easily found from $mnf = 2\mu(1-\alpha)/(\epsilon n - \alpha\mu)$ that the number of firms in a zero profit equilibrium reacts to changes in parameters in the following way:

$$\frac{dn}{d\alpha} < 0, \qquad \frac{dn}{d\mu} > 0, \qquad \frac{dn}{d\epsilon} < 0. \quad (42)$$

Income in the center can be written as

$$Y = \frac{\epsilon n + \alpha\mu}{\epsilon n - \alpha\mu}, \quad (43)$$

and the sign of the derivatives for Y is

$$\frac{dY}{d\alpha} > 0, \qquad \frac{dY}{d\mu} > 0, \qquad \frac{dY}{d\epsilon} < 0. \quad (44)$$

Hence, the comparative static results are not changed, and in addition we now have another effect when the elasticity of demand, ϵ, is changed. A lower ϵ means a higher price (see (33)) which leads to entry of firms and a higher income. Simulations suggest that $\frac{d\tau_{CP}}{d\epsilon} < 0$ so in this case the force for agglomeration is strengthened more than the force for dispersion (contrary to the result for μ).

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