Trade and Race-to-the-bottom Wage Competition

Damiaan Persyn

LICOS Centre for Transition Economics, K. U. Leuven, Belgium

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Abstract

This paper looks at how increasing economic integration affects wage bargaining between unions and firms if firms are internationally mobile in the context of a simple NEG model. We find that if firms are perfectly mobile, countries are sufficiently symmetric and wages are bargained over at the firm level they are set on the competitive level. For a more centralised bargaining scheme wage demands are made even if firms can perfectly threat to relocate. If countries are asymmetric full agglomeration becomes possible and rent-sharing between unions and firms then occurs as unions are able to appropriate part of the agglomeration rents in form of higher wages. As agglomeration rents are a hump-shaped function of trade freeness in the larger country this implies the same non-monotonic relationship between wages and the level of trade freeness. We then investigate the case where wage bargaining takes place sequentially in each country. The comparative statics of the international Nash-equilibrium in wages show increased international economic integration only leads to tighter international wage competition if countries are sufficiently symmetric. For the asymmetric case the comparative advantage and relative size of the country determine whether and how economic integration leads to lower wages.

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1 Introduction

In the popular press, fears of globalisation are often expressed in a way most economists think of as naïve. When firms close down and relocate activities this tends to be blamed on 'artificially low' wages in developing countries who are thus stealing away business in an unfair manner while exploiting the local workforce. Most models on the location of economic activity consider only perfectly competitive labour markets. Wages in these models are the result of a market clearing process and foreign wages would then only be low as they reflect low labour productivity. Artificially low wages never exist in such models and the risk of massive firm relocation to low-wage countries would therefore be limited. It is well-recognised, however, that in reality wage setting is highly non-competitive in most countries.

Starting with Brander and Spencer (1988) and Mezzetti and Dinopoulos (1991), quite a few authors have analysed unionised labour markets in the context of oligopolistic competition with immobile firms or allowing for FDI such as in Konings and Vandenbussche (1998). The effect of falling trade costs on wages is a central research question for many of the papers in this strand of literature, such as for Naylor (1999), who solves for an international Nash-equilibrium in wages.

Far fewer models exist that consider the effects of unionisation on the location choice of firms in the context of models of economic geography. In the work of Toulemonde and Picard (2003, 2006), De Bruyne (2004) and Munch (2003) a Nash-bargaining framework determining wages and a NEG model explaining the location choice of firms is combined, mainly to analyse the effect of union activity on the agglomeration of firms. Being general equilibrium models, these papers greatly differ from the aforementioned in some important respects. The effect of union activity may then be very different as wage demands increase aggregate income in more industrialised countries causing unionisation to foster agglomeration. As they tend to be more restrictive, simple NEG models also allow to express key variables of the model such as the equilibrium distribution of firms more clearly compared to models with oligopolistic competition and linear demand. In this paper will therefore use a simple NEG model and focus on the wage effects of increased economic integration.

The explicit incorporation of the option to relocate in the bargaining framework makes our model rather similar to models of international tax competition with mobile firms (see for example Ludema and Wooton (2000), Andersson and Forslid (2003) and Baldwin and Krugman (2004)). In these models a government has to strike a balance when increasing taxes as it might loose some of its tax base when firms relocate abroad in response. It

is the existence of agglomeration rents which allows a government to tax without causing relocation. Depending on the utility specification of the government and the speed of relocation, however, a government might still find it optimal to tax even if this causes some firms to relocate. Similarly, we introduce two bargaining schemes which share these properties. When bargaining takes place at the firm-level, unions are able to 'tax away' a part of the firms' agglomeration rents by setting higher wages but only if there is full agglomeration. They are unable to do so if their firm can credibly threat to relocate which is the case for any long run internal distribution of firms. A union acting on a more centralised level possibly finds it optimal to set high wages despite seeing some of the firms relocate, with the actual set wage depending on the 'elasticity of relocation' of the firms.

Through the introduction of a simple NEG model we quantify agglomeration rents and the elasticity of relocation, enabling us to make predictions on the effect of decreasing trade costs on the wage bargaining outcome. If countries are perfectly symmetric, full agglomeration never occurs. This leads to zero markups for all levels of trade freeness in the firm-level bargaining case and to wage markups which are monotonically decreasing in the freeness of trade for the case of sector-level bargaining. If countries are sufficiently asymmetric full agglomeration becomes possible. Rent-sharing between unions and firms then occurs as unions are able to appropriate part of the agglomeration rents in the form of higher wages. As agglomeration rents are a hump-shaped function of trade freeness in the larger country, this implies a non-monotonic relationship between the bargained wage and the level of trade freeness.

We also consider the international strategic interaction which comes into play if the bargaining takes place sequentially in each country. This allows us to reassess the question whether increased international economic integration might lead to race-to-the-bottom wage competition. For the case of sequential international wage bargaining the comparative statics of the international Nash-equilibrium in wages also show increased international economic integration only leads to tighter international wage competition if countries are sufficiently symmetric. For the asymmetric case the comparative advantage and relative size of the country also determine whether and how economic integration leads to higher or lower wages. In general, although a larger home-market may help unions to increase wage demands for intermediate levels of trade freeness, firms eventually relocate corresponding to the comparative advantage pattern of the countries for high enough levels of trade freeness. This means economic integration eventually leads to positive wage markups only in the country with a comparative advantage in the unionised manufacturing sector. We

show wages need not act as strategic complements. Given the simplicity of the NEG model used, this is quite a surprising result as it implies that a decrease in wages abroad need not lead to a domestic wage decrease.

Throughout, we put particular attention to separating the wage bargaining framework from the NEG-part of the model. This makes it easier to understand how abstract notions of the NEG model such as the speed of firm relocation influence the wage outcome and helps keeping expressions tidy. With the aim of easing an empirical test of the theory we use a slightly more general production function then is standard in the literature and consider the effect of heterogeneity of firms as in Baldwin and Okubo (2004). Despite these additional elements the model remains highly tractable.

The next section introduces a simple NEG model, treating wages as given. We consider the effect of exogenous changes in the wage levels on firm profits and location choice. In section 3 domestic wages are endogenised through the introduction of a Nash wage-bargaining scheme and we look at the effect of parameter changes on the wage bargaining outcome in a country. In section 4 we then jointly solve for wages in both countries and properties of the international Nash-equilibria in wages are established, describing how wages are set if unions and firms in both countries sequentially respond to the bargaining outcome abroad. In section 5 we briefly consider the effect of firm heterogeneity and section 6 concludes.

2 A simple two-country model

In this section we extend the standard two-country footloose-capital model of Martin and Rogers (1995) allowing for international wage differences. In section 2.1 we first consider consumer demand and firm pricing behaviour to obtain expressions for firm profits in both countries. In section 2.2 we then determine the long-run equilibrium international distribution of firms which is characterised by the equalisation of profits in both countries. We establish how fast firms relocate in response to changes in the manufacturing wage, under which conditions all firms agglomerate in a single country and determine the agglomeration rents (international profit differential) which may exist in such a situation. Throughout this section we take the wage levels in both countries as exogenously given. Endogenising the local wage is postponed until the next section 3, where it is modelled as the outcome of wage bargaining between unions and firms and both parties take into account the results on firm behaviour established in this section.

2.1 Model Setup

Consumers There are two countries, H and F. The utility function of the representative consumer in both countries is assumed to be quasi-linear in a composite of homogeneous goods C_A and one of differentiated manufacturing goods C_M

$$U = C_A + \mu C_M, \qquad C_M = \left(\int q^{\frac{\sigma-1}{\sigma}} \, dt \right)^{\frac{\sigma}{\sigma-1}}, \qquad 0 < \mu < 1 < \sigma$$
$$C_A = \Pi_s \left(q_s^A \right)^{\gamma_s}, \qquad 0 < \gamma_s < 1, \Sigma_s \gamma_s = 1.$$

Constrained utility maximisation gives rise to the following standard total demand function for a manufacturing variety q_{jk} produced in country j and sold in country k at price p_{jk}:

$$q_{jk} = \frac{\mu}{P_k} \left(\frac{p_{jk}}{P_k} \right)^{-\sigma} M_k, \qquad j, k \in \{H, F\}, \tag{1}$$

where $P_k^M = \left[\int p^{1-\sigma} dt \right]^{\frac{1}{1-\sigma}}$ is the price-index of manufacturing goods consumed in country k and M_k is the mass of consumers. Because utility is quasi-linear the demand of the typical consumer does not depend on her income. Total demand in k therefore is simply the demand of the typical consumer times the mass of consumers in the country.[1] This specification makes income effects do not influence firm profits which greatly simplifies the analysis.

Firms The homogeneous good A-sectors are kept as simple as possible. Perfect competition and constant returns to scale production lead to marginal cost pricing. As in Trefler (1993) we assume the only technological differences across countries are caused by Leontief-type factor augmenting productivity differences. Under standard assumptions costless trade for A-sector goods then leads to productivity-equivalent factor price equalisation:

$$\alpha_{Hf} \omega_{Hf}^A = \alpha_{Ff} \omega_{Ff}^A \tag{2}$$

Here, α_{Hf} is the quantity of some input f in country H which is required to obtain one productivity-equivalent unit (higher α's mean less productive factors). We assume perfect inter-sectoral factor mobility equates nominal factor rewards across the homogeneous good sectors within both countries.

A manufacturing firm in country j faces a fixed cost in that it requires a single unit of

[1] The share of income spent on the homogeneous good C_A does depend on the income level and can determined as a residual after subtracting expenditure on manufacturing goods.

capital at price r_j irrespective of the output level. For the variable part of production one unit of a Cobb-Douglas input bundle $v_j = \Pi_f(\nu_{jf}/\alpha_{jf})^{\beta_f}$ is required per unit of output. By defining $a_j = \Pi_k \alpha_{jk}^{\beta_k}$ we have $1/a_j$ as a measure of total factor productivity and with $w_j = \Pi_k \omega_{jk}^{M\beta_k}$ as the price-index associated with the input bundle v_j we can conveniently write the representative country j, manufacturing firm's cost for producing x units of output as

$$C_j(x) = r_j + a_j w_j x. \tag{3}$$

Note that the fixed and marginal costs are paid to different factors (capital and the factors of the Cobb-Douglas bundle respectively) and that manufacturing firms possibly face different factor prices as homogeneous good producers (there is imperfect factor mobility between the homogeneous good sectors and the manufacturing sector).

Prices Manufacturing firms operate under monopolistic competition and therefore apply the standard optimal pricing rule with a fixed markup over marginal costs. The price charged by a manufacturing firm located in country j for sales in country k is

$$\begin{aligned} p_{jj} &= \eta a_j w_j \qquad && j \in \{H, F\} && \text{(local sales)} \\ p_{jk} &= \tau\eta a_j w_j = \tau p_{jj} \qquad && j, k \in \{H, F\}, \;\; j \neq k && \text{(exports)}, \end{aligned} \tag{4}$$

where we introduce $\eta = \frac{\sigma}{\sigma-1}$ for the fixed markup. Assuming symmetric iceberg transport costs $\tau > 1$ for selling abroad, exports are subject to higher marginal costs and subsequently are sold at a proportionally higher price.

Using the above pricing rules and normalising the amount of capital (and thus firms) available worldwide to one,[2] we can write the manufacturing price indices in both countries as

$$\begin{aligned} P_{H} &= \left[\int p^{1-\sigma}\, ds\right]^{\frac{1}{1-\sigma}} = \left[\int_0^n p_{HH}^{1-\sigma}\, ds + \int_n^1 p_{FF}^{1-\sigma}\, ds\right]^{\frac{1}{1-\sigma}} \\ &= \left[n p_{HH}^{1-\sigma} + (1-n) p_{FH}^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \\ &= \left[n(\eta a_{H} w_{H})^{1-\sigma} + (1-n)(\tau\eta a_{F} w_{F})^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \\ &= \eta a_{F} w_{F}\left[n\epsilon + (1-n)\phi\right]^{\frac{1}{1-\sigma}}, \\ P_{F} &= \eta a_{F} w_{F}\left[n\epsilon\phi + (1-n)\right]^{\frac{1}{1-\sigma}}. \end{aligned} \tag{5}$$

[2] If we assume the amount of capital in the world is fixed the price for it will be bid up to the level where firm profits are zero. At this level no entry or exit incentive would exist. Assuming a fixed world stock of capital then implies a fixed world number of firms.

The above price index is composed of a part stemming from sales of domestic firms and a part stemming from imports, weighted by the number of firms in each country (there are n firms in H and $1-n$ firms in F), the economical distance $\phi = \tau^{1-\sigma}$ and the relative production costs $\epsilon = [a_H w_H / a_F w_F]^{1-\sigma}$. We then have ϕ as a measure of the freeness of trade with $\phi = 0$ for prohibitively high trade costs and $\phi = 1$ for costless trade, while ϵ serves as a measure of the relative competitiveness the H country: $\epsilon = 0$ means country H has infinitely high relative unit input costs and we have $\epsilon = 1$ when unit production costs are equal in both countries. $\epsilon > 1$ implies H has a production cost advantage relative to in F.

Profits We now have everything in place to determine the reward to capital in both countries, which will be central to its location decision. It can easily be verified that because of monopolistic competition the relation between firm sales $p_{jj}x_{jj} + p_{jk}x_{jk}$, firm profits π_j and the cost of capital is simply $\pi_j = \frac{p_{jj}x_{jj}+p_{jk}x_{jk}}{\sigma} - r_j$ for a firm in country j. We make the assumption that due to the fixed amount of available capital the reward for it is bid up to the point where all firm profits accrue to capital. We therefore have $\pi_j = 0$ and $r_j = \frac{p_{jj}x_{jj}+p_{jk}x_{jk}}{\sigma}$. Substituting the optimal pricing rules and demand we then obtain following expressions for the return to capital in both countries:

$$\begin{aligned} r_H &= \frac{\mu}{\sigma}\epsilon\Big[\frac{s_E}{\Delta_H} + \phi\frac{1-s_E}{\Delta_F}\Big] \qquad & \Delta_H &= \epsilon n + \phi(1-n) \\ r_F &= \frac{\mu}{\sigma}\Big[\phi\frac{s_E}{\Delta_H} + \frac{1-s_E}{\Delta_F}\Big] \qquad & \Delta_F &= \phi\epsilon n + (1-n). \end{aligned} \tag{6}$$

Here we write s_E for the relative size of the market for manufactures in country H. As the expenditure on manufacturing is fixed given the utility specification, this is simply the exogenously given share of consumers M_H/M_W living in country H. After normalising the world mass of consumers $M_W = 1$ we have $0 < s_E < 1$ and the market size of F is then $1 - s_E$. We see the capital owner gains from a larger market size, a higher manufactures expenditure share μ and less competitive markets (lower σ). The Δ's reflect the fierceness of competition in both countries and are weighted by the economical distance $1/\phi$ to the respective markets.

2.2 Long Run Equilibrium

This paper is mainly concerned with non-market wage setting and how it is affected if firms are internationally mobile. As wages affect capital rents, a self-interested union should take into account if and to what extent wage demands cause firms to relocate. Even if firms do not relocate changes in wages still affect the relative profit differential between countries. This profit differential will play an important role in the wage bargaining process as potential foreign profits act as an outside option for the firm during negotiations. We therefore now first analyse how firms relocate in function of wage changes, under which conditions all firms concentrate in a single country and, if they do, determine the size of the resulting profit differential (the agglomeration rents).

Internal equilibrium The unique interior international long-run equilibrium share of capital (and therefore firms) in country H is n^* and is characterised by the equality of capital rents in both countries:

$$r_{_H} = r_{_F} \text{ if } 0 < n^* < 1.$$

Combining this condition with the definitions from equation (6) we can obtain

$$n^* = \frac{\epsilon(1-\phi^2)s_{_E} + \phi(1-\epsilon\phi)}{(\epsilon-\phi)(1-\epsilon\phi)} \tag{7}$$

In the appendix we prove this equilibrium is relevant in the sense that it is locally stable. Without loss of generality we will from now on assume H has a larger market size so we have $s_{_E} > 1/2$. Following intuitive results can then be shown to hold:

Proposition 1 *For a given level of trade freeness ϕ the share of manufacturing firms in a country j is non-increasing in its production costs $a_j w_j$ and non-decreasing in its market size ($s_{_E}$ for country H).*

The effect of ϕ on n^* is more complicated. If countries are perfectly symmetric, we have $a_{_H} w_{_H} = a_{_F} w_{_F}$ ($\epsilon = 1$) and $s_{_E} = 1/2$ and therefore $n^* = 1/2$, an equal international distribution of firms for all levels[3] of trade freeness $\phi < 1$.

If there exist asymmetries $s_{_E} \neq 1/2$ and/or $\epsilon \neq 1$ and ϕ is close to zero both countries are more or less autarkic. Local firms in the high cost country are able to maintain high

[3]Excluding perfectly free trade $\phi = 1$ where location becomes irrelevant in the case of symmetric countries.

prices to compensate for high costs without facing massive import competition. Therefore the production cost handicap ϵ does not play a large role in determining the international distribution of firms if ϕ is close to zero. The share of manufacturing firms which locates in a country will approximately equal its exogenously given market share.

If, in the other extreme, ϕ is close to one we have next to free trade. In the presence of a cost asymmetry all firms would prefer to locate in the low-wage country and costlessly ship products to wherever consumers are. Therefore only the wage asymmetry matters to the firms' location choice if ϕ is close to one and all manufacturing firms will locate in the low-wage country.[4]

For intermediate levels of ϕ both previous reasonings still play a role, but firms will also more than proportionally prefer to locate in the larger market due to the home-market effect. The condition for which there exists an interval of ϕ where H (the larger country) gains from increased integration can be determined by differentiating (7) with respect to ϕ, evaluating at $\phi = 0$ and solving for s_E. This shows the relative share of H in the total amount of manufacturing firms n^* is positively affected by ϕ if its market share is large enough compared to its wage handicap such that $s_E > 1/(1+\epsilon^2)$.

If H has an even larger market size advantage compared to its cost handicap, so that $\epsilon > 2\sqrt{(1-s_E)s_E}$ there will exist intermediary levels of $\phi \in [\phi^{CPH1}, \phi^{CPH2}]$ (to be determined later) for which all industry agglomerates in H. The right hand side of the inequality is clearly decreasing in the H-market size s_E (if $s_E > 1/2$): the larger the H country market, the larger wage handicap (lower ϵ) it can support without seeing any firm relocate within the intermediate interval of ϕ. If $\epsilon < 2\sqrt{(1-s_E)s_E}$ no such interval exists.

The effect of ϕ on the international distribution of firms n^* is summarised in following proposition and illustrated in figure 1.

Proposition 2 *Starting from $\phi = 0$, increasing economic integration first leads to more firms locating in the larger market if its market size is sufficiently large compared to its cost handicap so that $s_E > 1/(1+\epsilon^2)$. If the size asymmetry is so large we have $\epsilon < 2\sqrt{(1-s_E)s_E}$ there exists an intermediate interval of trade freeness $[\phi^{CPH1}, \phi^{CPH2}]$ where all firms agglomerate in H. If country H has higher production costs ($\epsilon < 1$) firms start relocating to the low-cost country F for $\phi^{CPH2} < \phi < \phi^{CPF}$ and fully agglomerate in F for $\phi^{CPF} < \phi$. If country H has lower production costs ($\epsilon > 1$) ϕ^{CPH2} is never reached and all*

[4]It can be shown that if H has a cost handicap ($0 < \epsilon < 1$) there exists a level $\phi^{CPF} < 1$ at which all industry agglomerates in F. The relative market size of H, s_E, increases this level ϕ^{CPF} but it is always strictly smaller than 1. This holds only if F contains at least some consumers. But even if *all* consumers are located in H so that $s_E = 1$, for perfectly free trade $\phi = 1$ all firms will relocate to country F.

firms locate in H for $\phi^{CPH1} < \phi < 1$.

Corner solutions and agglomeration rents We now determine the exact conditions under which all firms agglomerate in a single country. If country H is sufficiently large compared to its cost handicap it will contain all firms (the core) for some intermediate interval of trade freeness $[\phi^{CPH1}, \phi^{CPH2}]$. The boundaries of this interval are found by setting $n^* = 1$ in (7) and solving for ϕ. It turns out that the expression in terms of ϵ is easier to work with.

$$\begin{aligned} \phi^{CPH1} &= \frac{\epsilon - \sqrt{\epsilon^2 - 4s_E(1-s_E)}}{2s_E} \qquad \phi^{CPH2} = \frac{\epsilon + \sqrt{\epsilon^2 - 4s_E(1-s_E)}}{2s_E} \\ \epsilon^{CPH} &= \frac{1 - s_E(1-\phi^2)}{\phi}. \end{aligned} \tag{8}$$

By equating both boundary levels of ϕ we indeed see such an interval only exists if H is sufficiently large compared to its cost handicap in the sense that $\epsilon > 2\sqrt{(1-s_E)s_E}$.

If H has a relative production cost handicap, firms eventually relocate to F for sufficiently free trade. We determine the level of trade freeness at which all industry accumulates in F by evaluating (7) at $n^* = 0$ and solving for ϕ.[5] Again the expression in terms of the production cost handicap ϵ turns out to be easier to work with.

$$\phi^{CPF} = \frac{1 - \sqrt{1 - 4\epsilon^2 s_E(1-s_E)}}{2\epsilon(1-s_E)} \qquad \epsilon^{CPF} = \frac{\phi}{\phi^2 + s_E(1-\phi^2)}. \tag{9}$$

ϵ^{CPF} is the highest value of ϵ for which country H contains some firms. Similarily, ϵ^{CPH} is the lowest level of ϵ for which the F country contains some firms. All equations for interior solutions are therefore only valid under the condition $\epsilon^{CPF} < \epsilon < \epsilon^{CPH}$.[6]

If we are at a corner solution all firms locate in a single Country. As this prevents relocation to act as adjustive arbitrage profit equalisation need no longer hold. The resulting international profit gap or agglomeration rents will be central in the wage bargaining process we turn to in the next section. Taking the ratio of capital rents in both countries from equation (6), we can conveniently express the agglomeration rents of locating in country

[5] Only one of the roots is economically relevant (smaller than one).

[6] It can be easily verified that $\epsilon > \epsilon^{CPF}$ implies $\epsilon - \phi > 0$ and $\epsilon < \epsilon^{CPH}$ implies $1 - \epsilon\phi > 0$. These conditions often turn to be strong enough to sign equations.

H as:

$$\begin{aligned} z_H = r_H/r_F = \tfrac{\epsilon\phi}{(1-s_E+\phi^2 s_E)} = \epsilon/\epsilon^{CPH} \qquad & \text{if} \quad n^* = 1 \\ z_H = r_H/r_F = 1 \qquad & \text{if} \quad 0 < n^* < 1. \end{aligned} \tag{10}$$

Obviously, at $\epsilon = \epsilon^{CPH}$ and for internal equilibria there are no agglomeration rents and firms earn equal profits in both countries. The expression for country F is isomorphic. Some comparative statics of the agglomeration rents in the core-periphery configuration $n^* = 1$ will prove useful in the next section:

$$\frac{\partial z_H}{\partial \epsilon} > 0 \qquad \frac{\partial z_H}{\partial s_E} > 0 \qquad \frac{\partial z_H}{\partial \phi} = \frac{\epsilon(1 - s_E - \phi^2 s_E)}{[\phi^2 s_E + 1 - s_E]^2} \lesseqgtr 0 \text{ if } n^* = 1.$$

Investigating $\frac{\partial z_H}{\partial \phi}$ we see z_H is monotonically increasing in ϕ iff $s_E \leq 1/2$ and is a hump-shaped with a top at $\phi^* = \sqrt{\frac{1-s_E}{s_E}}$ iff $s_E > 1/2$. We obtain following standard results:

Proposition 3 *In a core-periphery configuration:*

- *The relative gain for a firm located in the core country increases with the core's market size and decreases with its production costs.*
- *If the larger country contains the core, the relative gain of locating there (the agglomeration rents) are a hump-shaped function of the freeness of trade ϕ.*
- *If the country containing the core is relatively small or equal in size, agglomeration rents are increasing in the freeness of trade.*

Also note that the wage differential ϵ affects the size of the differential z_H and its sensitivity to trade costs, $\frac{\partial z}{\partial \phi}$, but not level of trade-freeness ϕ^* where the rents are the largest, the top of the hump.

Relocation Elasticity We already mentioned an increase in a country's production cost decreases its share of firms for interior equilibria. It is convenient to calculate an elasticity of relocation expressing exactly how fast changes in wages -which directly affect the relative production costs- cause international relocation of firms. For the share of firms in H we have (assuming constant productivity a_H)

$$\begin{aligned} \epsilon^H_{\text{reloc}} = \frac{\partial n^*}{\partial \omega_H}\frac{\omega_H}{n^*} &= \beta_l \epsilon \epsilon^{CPF}(\sigma - 1)\frac{s_E(1-\epsilon^2)(1-\phi^2) - (1-\epsilon\phi)^2}{(\epsilon - \phi)(1-\epsilon\phi)(\epsilon - \epsilon^{CPF})} < 0 \text{ if } 0 < n^* < 1 \\ &= 0 \text{ if } n^* = 1 \end{aligned} \tag{11}$$

and ϵ^{CPF} is the level of ϵ at which all firms locate in country F.[7] A similar expression can be written for changes in ω_F from the point of view of the foreign country. Obviously, the sensitivity of n^* to changes in wages increases with the weight of labour in production β_l: the lower the share of labour in production the less important wages are in inducing firms to relocate. We also see $|\epsilon^H_{\text{reloc}}|$ approaches ∞ as ϵ approaches ϵ^{CPF}. Other properties of the elasticity of relocation are harder to prove. From now on we will refer to $|\epsilon^H_{\text{reloc}}|$ as the elasticity of relocation.

As increased economic integration is often blamed for making firms more footloose (and thereby limiting the scope for wage demands) an interesting question is how the relocation elasticity relates to changes in transport cost, the freeness of trade. The effect of ϕ on both $|\epsilon^H_{\text{reloc}}|$ and $|\epsilon^F_{\text{reloc}}|$ is shown by the dotted lines in figure 1 and formalised in following proposition

Proposition 4 *For interior equilibria the relocation elasticity $|\epsilon^H_{reloc}|$ is increasing in ϕ in the larger country H. With complete agglomeration the elasticity is locally zero. The elasticity becomes infinitely large as all industry locates abroad. In the smaller F country the elasticity* may *decrease as firms start relocating there.*

As the elasticity becomes very large when a country is almost completely deserted by the manufacturing firms, the elasticity of relocation in the smaller country may briefly decline when transport costs are even lower and firms start returning to a low-cost smaller country. In both panels of figure 1, $s_E > 1/(1+\epsilon^2)$, so initially H gains from increased economic integration. In the left panel $\epsilon < 2\sqrt{(1-s_E)s_E}$ and therefore there does not exist an intermediate interval of trade freeness where H can attract the core: its wage handicap is too large. Although H attracts a more than proportionate share of manufacturing firms for some levels of ϕ, both $|\epsilon^H_{\text{reloc}}|$ and $|\epsilon^F_{\text{reloc}}|$ are monotonically increasing in ϕ. In the right panel $\epsilon > 2\sqrt{(1-s_E)s_E}$ so the wage handicap is relatively moderate. Here, H attracts the core for some intermediate interval of ϕ. As all firms agglomerate in H, $\epsilon^F_{\text{reloc}}$ reaches infinity but then declines again when firms return to F, beyond ϕ^{CPH2}.

[7] To see the expression is negative, note that for interior solutions the denominator must be positive. If $1-\epsilon < 0$, the denominator is clearly negative so the result holds. For the case where $1-\epsilon > 0$ note that the numerator is increasing in s_E. When we use the maximum value $s_E = 1$ the result $-(\epsilon-\phi)^2$ is still negative and forms an upper bound for the numerator.

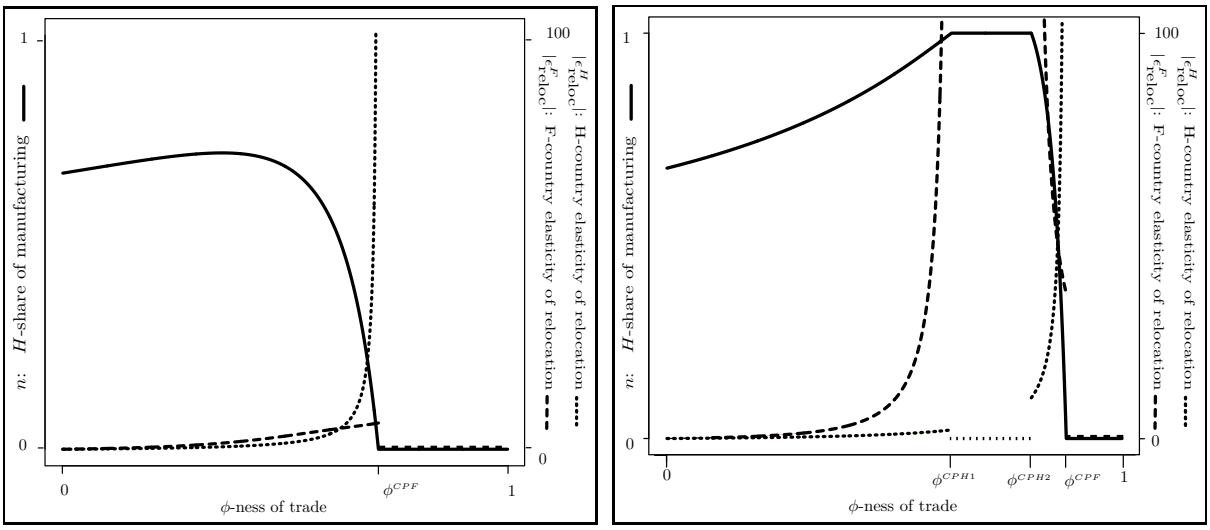

Figure 1: The share of manufacturing firms in country H (left scale) and the sensitivity of this share to changes in productions costs $|\epsilon^H_{\text{reloc}}|$ (dotted line, right scale), both as a function of trade freeness. The left panel shows the case of a large wage handicap in country H ($\epsilon = 0.85$) with $s_E = 2/3$. The right panel shows the case of a more moderate wage handicap $\epsilon = 0.96$.

3 Wage determination

In standard NEG-models prices for immobile variable inputs are exogenously given and assumed equal in both countries. In this paper, however, we are interested in non-market wage setting and how it relates to firm relocation. We will model wages as resulting from a 'right to manage' bargaining process between unions and firms, similar to for example Toulemonde and Picard (2006, 2003), and Konings and Vandenbussche (1998).

We two different bargaining frameworks:

- Decentralised bargaining on the firm-level. As firms are atomistic, both union and firm ignore the effect of their decisions on the equilibrium distribution of firms and the price indices. Only changes in firm level labour demand and wages (for the union) and profits (for the capital owner) are considered. This leads to a model very similar to Toulemonde and Picard (2006), but by explicitly taking into account the fact firms have the option to relocate in the bargaining framework we obtain results quite different from these authors.

- Bargaining at the level of a group firms. Here we assume the group of firms is small enough so effects on the price level are still ignored by its members. As bargaining

takes place for a group of firms, however, a union now might opt to raise wage demands despite the fact some firms in the group will relocate in response.

For both bargaining frameworks, we solve for the wage bargaining outcome and look at some comparative statics. We show increased economic integration (higher ϕ) does not always lead to lower wages for both bargaining frameworks. Also, for the case of sector level bargaining, we show that a decrease in wages abroad need not lead to a lower domestic wage bargaining outcome.

3.1 Firm level bargaining

When goods market clear, the pricing rules in (4) and the demand for goods from equation (1) are sufficient to determine firm factor demand and profits given factor prices ω_k:

$$\begin{aligned} l_{H}^{d} &= \frac{\beta_l}{\omega_{Hl}} \frac{(a_H w_H)^{1-\sigma}}{\eta} \mu [s_E P_H^{\sigma-1} + (1-s_E) P_F^{\sigma-1}] \\ k_{H}^{d} &= \frac{\beta_k}{\omega_{Hk}} \frac{(a_H w_H)^{1-\sigma}}{\eta} \mu [s_E P_H^{\sigma-1} + (1-s_E) P_F^{\sigma-1}] \\ &\dots \\ r_H &= \frac{(a_H w_H)^{1-\sigma}}{\sigma} \mu [s_E P_H^{\sigma-1} + (1-s_E) P_F^{\sigma-1}]. \end{aligned} \tag{12}$$

Some notation already introduced in previous sections includes $w_H = \Pi_k \omega_{Hk}^{\beta_k}$ for the price of the Cobb-Douglas input bundle used in the variable part of production, β_l for the labour share in the bundle, ω_{Hl} for wages[8] and s_E for the share of consumers of country H.[9] The P's are the price indices from equation (5), but as firms are atomistic they ignore the dependency of P on p and ω_H. We have explicitly written the firm's manufacturing price as $p_{HH} = (a_H w_H)^{1-\sigma}$ to emphasise agents take into account its dependency on the factor bundle price w_H and thereby the wage level.

Under firm level bargaining we assume the owner of the single firm (the provider of capital) and a labour union bargain over the distribution of the 'rest of the rents': the total revenue created by the firm minus payments to the variable factors of production except labour: $px - \Sigma_{k,-l} \omega_k \nu_k$, where ω_k and ν_k are the price and quantity of factor k respectively. The above equations then allow to determine the reaction of the firm to changes in factor prices and unions and firms take this into account when bargaining over wages.

[8] We drop the subscript l where it is obvious the input price we are referring to is the wage.

[9] Or, equivalently, the share of expenditure or the relative market size of country H

As standard in the literature, the solution to the wage bargaining game is calculated as the wage maximising following Nash-product (see, for example, Layard, Nickell, and Jackman (1991)):

$$\omega_H = \arg\max_{\omega_H} \left[U_H - U_H^o\right]^{\theta_H} \left[V_H - V_H^o\right]^{1-\theta_H}$$
$$s.t. \quad U_H > U_H^o \text{ and } V_H > V_H^o,$$

where $0 < \theta_H < 1$ represents the union bargaining power in country H, U_H is the utility of the union and U_H^o is the union fall-back utility in case of continued disagreement. V_H and V_H^o represent the capital owner utility and fall-back utility respectively. In order to solve for ω_H we now first fix functional forms for U_H, U_H^o, V_H and V_H^o.

To the best of our knowledge other models of economic geography with incomplete labour markets and firm level bargaining such as Toulemonde and Picard (2006) have set $V_H^o = 0$ for the fall-back utility of the capital owner. We believe this is inconsistent with the assumed perfect mobility of firms: if firms can threaten to relocate, potential profits in the other country are highly relevant to the wage bargaining process and can act as the firms' fall-back utility in the case of negotiation failure. Ignoring this outside option leads to the fixed wage-markup of Toulemonde and Picard (2006) who work with firm-level bargaining with homogeneous and perfectly mobile firms. The question should be why in such a setting a rational union makes the same fixed wage demand, even if the firm on the other side of the negotiation table credibly threats to relocate unless wages are lowered. We therefore specifically take into account the firm has the option to relocate by setting the firm outside option to real foreign profits: $V_H^o = r_F/P_H$.[10]

For the utility of the capital owner we follow the literature and simply take real capital rents so we have $V_H = r_H/P_H$. For the union utility we also follow a standard specification where union utility equals the total real wages paid to manufacturing workers: $U(\omega_H) = l_H^d \omega_H / P_H$ where l_H^d is the demand for labour as defined in (12). As workers can always fall back on working in the CRS sector earning ω_H^A we have $U^o = l_H^d \omega_H^A / P_H$ for the union outside option. Substituting these specifications in the Nash-product gives:

$$\omega_H = \arg\max_{\omega_H} \Omega(\omega_H) = \left[l_H^d(\omega_H - \omega_H^A)\right]^{\theta_H} \left[r_H - r_F\right]^{1-\theta_H} / P_H.$$

As firms are atomistic under monopolistic competition the price indices P_j are perceived as independent of ω_H if bargaining is on the firm level. The effect of ω_H on P_H, P_F and

[10]Note that we assume only the footloose capital moves internationally, while the capital owner is immobile and therefore the H-country price index is relevant to calculate her real income.

r_F is therefore ignored in the bargaining process. Solving the first order condition for the wage bargaining solution then gives

$$\begin{aligned} &\frac{\partial \Omega}{\partial \omega_H} = \frac{\theta_H}{\omega_H - \omega_H^A} + \frac{\theta_H |\epsilon_{l^d,\omega}|}{\omega_H} - (1-\theta_H)\frac{l_H^d}{r_H - r_F} = 0 \\ &\text{or } \boxed{\frac{\omega_H - \omega_H^A}{\omega_H^A} = \frac{\theta_H}{(|\epsilon_{l^d,\omega}| - 1)}\delta} \text{ where } \delta = \frac{z_H - 1}{z_H - \theta_H} \in [0,1] \text{ and } z_H = \frac{r_H}{r_F} \end{aligned} \tag{13}$$

where we write $|\epsilon_{l^d,\omega}|$ for the wage elasticity of labour demand. For the model introduced in the previous section, $|\epsilon_{l^d,\omega}| = \beta_l(\sigma-1)+1 > 1$ in both countries, but it must be emphasised the above would hold for any model on firm location. z_H is the relative gain of being in country H compared to moving to country F, the agglomeration rents. The expression for the particular NEG model introduced in the previous section was given in equation (10), but again, the above holds more generally. The notation with δ is particularly insightful: as δ is strictly increasing in the agglomeration rents the wage markup is also strictly increasing in the agglomeration rents. In an internal long-run equilibrium profits in both countries are equal ($r_F = r_H$), implying $z_H = 1$, $\delta = 0$ and therefore $\omega_H = \omega_H^A$. In a world with perfectly mobile firms no self-interested firm-level union can afford to demand a wage markup without seeing its firm relocate. If relocation were impossible we would have $r_F = 0$ and therefore $z_H = \infty$ and $\delta = 1$ and our solution would be identical to Toulemonde and Picard (2006) where wages are fixed wage markup over the alternative wage.[11] The agglomeration rents are thus shared between unions and firms.

Unfortunately, we cannot express ω_H explicitly as a function of the model parameters as ω_H appears to the non-integer power $1-\sigma$ in z_H in the above expression. Nevertheless, all relevant comparative static results on the behaviour of ω_H can be established by implicit derivation. Following appealing properties of the equilibrium bargained wage are proved in the appendix.

Proposition 5 *With firm-level bargaining*

- *With costless relocation the wage markup is zero in a long run equilibrium with incomplete agglomeration.*
- *The wage markup is positive only in a country that attracts all firms. There, it is increasing in the union bargaining power θ_H and the alternative wage ω_H^A and*

[11] These authors use $\omega_A = \beta_l = 1$.

decreasing in the labour elasticity (and therefore in the labour share in production and product market elasticity).

Firm level bargaining only results in a wage markup over ω_H^A in the short run (say just after some shock to the system occurred and firms did not respond by relocating) or in a corner solution where all industry has agglomerated in a single country. These are the only situations in which there are agglomeration rents which can be shared. The economic geography model we set up in the previous section provides a model on how the agglomeration rents and therefore wages behave when the underlying parameters change.

As we argued in proposition 3 agglomeration rents in a relatively large country are a hump-shaped function of the freeness of trade parameter ϕ. If agglomeration occurs in the smaller country rents are monotonically increasing in the level of trade freeness. Although the NEG model in the previous section is extremely simple, these properties of the agglomeration rents are shared by most NEG models. As equation (13) provides a simple link between agglomeration rents and wages following proposition, similar to proposition 3, then holds for most NEG models:

Proposition 6 *With firm-level wage bargaining, in a core-periphery configuration:*

- *The bargained wage in the core country increases with its market size and decreases with its cost handicap.*
- *If the larger country contains the core, its equilibrium wage is a hump-shaped function of the freeness of trade ϕ.*
- *If the country containing the core has a relatively small or equal market size compared to the peripheral country, its equilibrium bargained wage is increasing in the freeness of trade.*

Figure 2 illustrates this relationship between trade costs and the bargained wage, for agglomeration in the larger country (left panel) and agglomeration in the smaller country (right panel).

For completeness we briefly consider the effect of a change in the foreign wage on the domestic wage bargaining outcome. Where this will turn out to be nontrivial in the sector-level bargaining case, for firm-level bargaining changes in the wages abroad have no effect on domestic wages for interior solutions as we always have $\omega_j = \omega_j^A$. For complete agglomeration, a foreign wage increase always leads to higher domestic wages as higher foreign wages imply larger agglomeration rents.

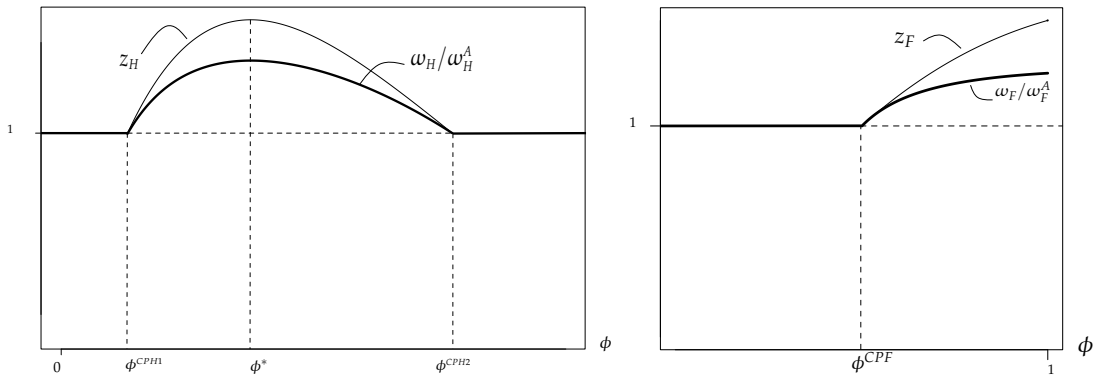

Figure 2: Agglomeration rents and wages with firm-level bargaining. The left panel shows agglomeration rents and wages if full agglomeration occurs in the larger country (for $\phi^{CPH1} < \phi < \phi^{CPH2}$), the right panel for full agglomeration in the smaller country (for $\phi > \phi^{CPF}$). Only if full agglomeration occurs there exists a wage markup $\omega_H > \omega_H^A$. For interior solutions ($0 < n^* < 1$), $z_H = \omega_H/\omega_H^A = 1$.

3.2 Sector level bargaining

With firm-level bargaining firms can perfectly threat to relocate in an internal international equilibrium distribution of firms as it is defined by equal cross-country profits and foreign profits act as the firms' outside option during wage negotiations. We saw no wage demands can be made by a firm-level union unless all firms agglomerate in a single country. Full agglomeration prevents firm relocation to equate profits internationally, creating an international profit differential (agglomeration rents) which can be shared between union and firm without inducing the firm to relocate.

We see decentralised bargaining leads to very low union wage demands if relocation is costless. In reality, of course, relocation does occur and unions nevertheless set wages at non-competitive levels. This is probably at least to some extent due to the fact unions bargain over wages at a more centralised level, for a group of firms, and thus might find it optimal to set higher wages despite the resulting relocation of some these firms. Although relocation might be a perfectly credible threat for each separate firm, a centralised union knows not all firms relocate when wages are increased as tighter competition abroad and softer domestic competition and will often equate profits in both countries before all firms relocated.

It is, however, not the case that more centralised bargaining must always lead to higher wage demands. It is well known that if bargaining takes place on the country level this generally leads to low wage demands. A union bargaining on the country level should take

into account that higher wages also lead to higher prices, making nominal wage increases do not automatically translate into a real wage increase. A union bargaining on the country level will therefore have more moderate wage demands. As shown in Layard, Nickell, and Jackman (1991) (pp. 135) in the context of a classical trade model, competitive wages and full employment are the standard outcome of country-level wage bargaining. If bargaining takes place on an intermediate level wage demands are the highest: here firms ignore the effect of wages on the price levels as in the firm-level case and at the same time are willing to sacrifice employment of some firms to increase wages. This is the case we will consider.

We loosely define a sector as a group of manufacturing firms. We assume a large number of identical employer federations seek to maximise the joint profits $\overline{r_H} = \frac{n}{\kappa} r_H$ of their member firms located in the country H. Here, κ is the large number of federations, so each federation ignores the effect of its actions on the aggregate price level. Each federation bargains with a union that seeks to maximise aggregate employment $\overline{l^d} = \frac{n}{\kappa} l^d$ and wages ω_H over the same group of firms. Both parties take into account the firms' labour adjustment to wage changes and also the fact that some firms will relocate to the foreign country as wages are increased. Again, the wage resulting from such a bargaining process is modelled as the wage maximising a Nash-product:

$$\omega_H = \arg\max_{\omega_H} \Omega(\omega_H) = \left[\overline{l^d}(\omega_H - \omega_H^A)\right]^{\theta_H} \left[\overline{r_H}\right]^{1-\theta_H} / (\kappa P_H).$$

Note that although r_F does not directly appear in the above expression, the assumption of perfect capital mobility is nevertheless made as $\overline{l^d}$ and $\overline{r}$ adjust as firms relocate costlessly. The resulting wage markup over the competitive wage can be found from solving the first order condition

$$\frac{\partial \Omega}{\partial \omega_H} = \frac{\theta_H}{\omega_H - \omega_H^A} + \frac{|\epsilon_{\overline{l^d},\omega}|\theta_H}{\omega_H} - (1-\theta_H)\frac{\overline{l^d}}{\overline{r_H}} = 0$$

$$\text{or} \quad \frac{\omega_H - \omega_H^A}{\omega_H^A} = \frac{\theta_H}{\theta_H(|\epsilon_{l^d,\omega}| - 1) + (1-\theta_H)|\epsilon_{r_H,\omega}| + |\epsilon^H_{\text{reloc}}|(\theta_H \epsilon_{l,n} - (1-\theta_H)\epsilon_{r_H,n})}.$$

Here we write $|\epsilon_{r_H,\omega_H}|$ for $\frac{\partial \overline{r_H}}{\partial \omega_H}\frac{\partial \omega_H}{\partial \overline{r_H}}$ and $\epsilon^H_{\text{reloc}} = \frac{\partial n^*}{\partial \omega_H}\frac{\omega_H}{n^*}$ is the elasticity of the share of firms located in country H with respect to H-wages. For the specific NEG model introduced in the previous section this was derived in equation (11). If utility would not have been quasi-linear in our NEG model demand for manufacturing goods in a country would depend on the income level of a typical consumer in that country and this income in turn depends on the number of firms in a region. It is obvious expressions for $|\epsilon^H_{\text{reloc}}|$ and $|\epsilon_{r_H,\omega}|$ then

become rather complicated as equilibrium number of firms in a country depends on the wage level in a nontrivial way and this then again has to be substituted into the above expressions. As we already saw in the case of firm-level manufacturing, however, we obtain non-trivial results even in the absence of income effects. We therefore choose to focus on a NEG without this complication. For our specific NEG, we have $\epsilon^H_{\text{reloc}} = -\epsilon_{r_H,\omega} - 1$ and $\epsilon_{l,n} = \epsilon_{r_H,n}$. Also, as all firms in a sector face increasing wages, all firms increase prices. This leads to a lower decrease in demand as compared to the firm level case. The lower elasticity of demand leads to a lower elasticity of labour demand and can be shown to equal -1. The above expression then simplifies to

$$\boxed{\frac{\omega_H - \omega^A_H}{\omega^A_H} = \frac{\theta_H}{|\epsilon^H_{\text{reloc}}|(1 + |\epsilon_{r_H,\omega}|)}}. \tag{14}$$

A first important comparative static result is on the effect of changes in the freeness of trade parameter ϕ on the wage bargaining outcome. For interior equilibria there exists a positive wage markup for which is decreasing in ϕ, as ϵ_{reloc} is increasing in ϕ. The situation for full agglomeration is more difficult. Looking at the left panel of figure 1, considering the change in the elasticity of relocation depicted there and the role of this elasticity in equation (14) one might believe that starting from $\phi = 0$ the equilibrium wage will steadily decline as ϕ increases, until all firms agglomerate in H, where the elasticity of relocation drops to zero and by (14) the equilibrium wage then should jump up. This seems strange and indeed this reasoning is wrong: as all industry agglomerates in H, we arrive at a corner solution of the maximisation problem. An elaborate discussion of the corner solutions to the bargaining process and a graphical illustration can be found in the appendix 6. Here, we will suffice by pointing out that for full agglomeration wages then are set at the ϵ^{CPH} level, the borderline wage level at which all industry just remains in the H country

In the case of full agglomeration (for example in the H country) we have $z_H|_{n^*=1} = \epsilon/\epsilon^{CPH}$. Therefore, if in the corner solution to the Nash-problem we have $\epsilon = \epsilon^{CPH}$ we must have $z_H = 1$. This has a simple interpretation: although all firms agglomerate in a single country, sector-level unions are able to appropriate all agglomeration rents, making firms indifferent between locations. We therefore again have hump shaped wages for agglomeration in the larger country and monotonically increasing rents and wages for agglomeration in the smaller country as in the firm-level bargaining case. The effect of increasing economic integration on the wage bargaining outcome is summarised in following proposition:

Proposition 7 *For the larger country, starting from $\phi = 0$ we have an interior solution and an increase in ϕ leads to lower wage markups as ϵ_{reloc} is strictly increasing in ϕ. When a core-periphery structure emerges, wages are set such that $z_H = 1$ and therefore proposition (6) holds. If the core returns to the smaller country for higher levels of ϕ, the elasticity of relocation is possibly decreasing in ϕ implying decreasing wages in the small country. When all firms relocated to the smaller country, again proposition (6) holds.*

The following then also holds:

Corollary 3.1 *Sector-level wage bargaining leads to higher wages compared to firm level bargaining.*

For the case of an internal equilibrium, this is clear as there is no wage markup in the case of firm-level bargaining and a strictly positive markup for sector-level bargaining. For corner solutions, the wage markup with sector level bargaining is set such that $z_H = 1$, keeping firms just indifferent between locations and this implies a higher wage than the firm-level case where firms still are able to appropriate a share of the agglomeration rents.

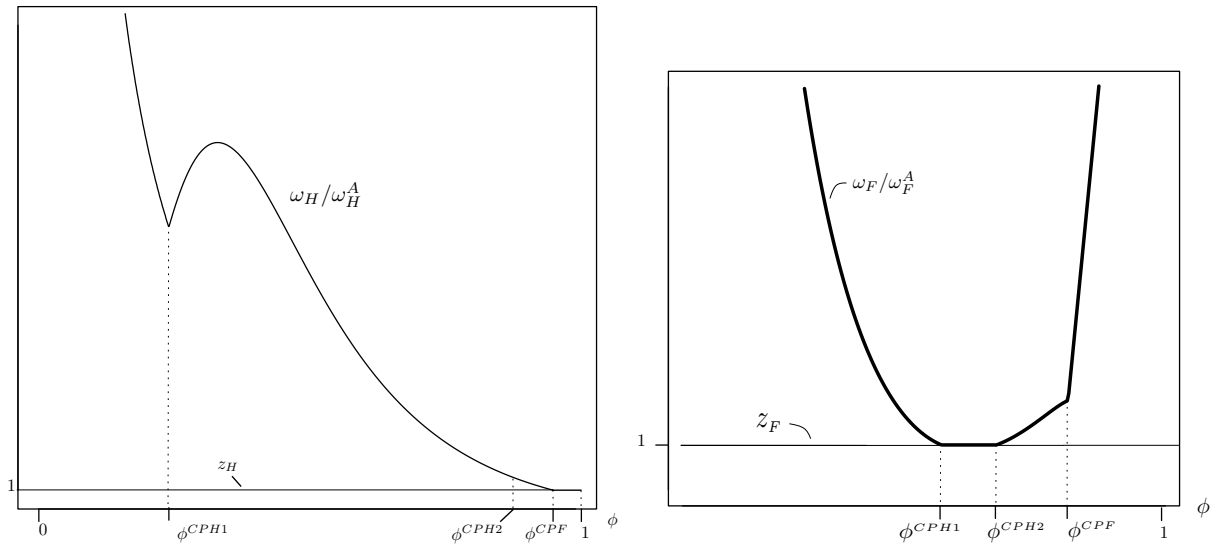

Figure 3: Agglomeration rents and wages with sector-level bargaining in the larger country (left panel) and the smaller country (right panel). Unless a country is completely deserted, there exists a wage markup $\omega_j > \omega_j^A$. Note that even for interior solutions wages in the smaller country are not always decreasing in ϕ. Note all agglomeration rents are appropriated by the unions ($z_H = 1$)

A last but important comparative static we look at is on the effect of a change in the foreign wage on the home country wage bargaining outcome. Again, the results for

sector-level bargaining are quite different from the firm-level case. For the case of sector level bargaining, the elasticity of relocation ϵ_{reloc} is the key variable to the wage bargaining outcome for interior solutions. Maybe counter-intuitively, it turns out that an increase in the foreign wage does not always lead to a decrease in the responsiveness of firms to international production cost differences and therefore need not imply a higher local wage bargaining outcome. Taking the implicit derivative of the home-country wage bargaining solution with respect to a change in the foreign wage ω_F shows

$$\frac{d\omega_H}{d\omega_F} = -\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \Big/ \frac{\partial^2 \Omega_H}{\partial {\omega_H}^2} \gtrless 0 \tag{15}$$

The above equation shows the slope of the home country reaction curve. A similar expression holds for the foreign country. If the expression would be positive, wages in both countries act as strategic complements: an increase in the foreign bargained wage then always increases the home bargained wage.

Unfortunately the sign of (15) is ambiguous and it is impossible to find explicit expressions for boundaries of the parameter space for which the sign is known. The expression in the denominator corresponds to the SOC of the bargaining problem and is negative at the bargaining solution, but the sign of the numerator depends directly on the effect of wage increases on the elasticity of relocation and this cannot be straightforwardly signed. Increasing wages does not always cause firms to relocate faster and faster as expressed by the elasticity of relocation. Looking at expression (11) it is obvious the derivative with respect to ϵ or ω_H is a complicated function. Nevertheless, it can be shown the elasticity approaches minus infinity when the economy reaches full agglomeration in the foreign country, reaches a global unique maximum (minimum in absolute values) at a certain wage level and then declines again.[12]

Following graphs show how firms relocate in function of changes in exogenous changes in the foreign country wage level and the endogenous home-country wage bargaining outcome (left panel). The right panel shows the wage bargaining outcome in function of the same exogenous changes in the foreign country wage level. The sensitivity of firm relocation to changes in ω_F as expressed by ϵ_{reloc} reaches a minimum at $\omega_F^{\dagger}$, which is (by equation (14) why the wage bargaining solution ω_H reaches a maximum at this point.

[12]It can be shown the elasticity does not have such an interval over which it is decreasing in wages if trade costs are larger than $1/\sqrt{2}$.

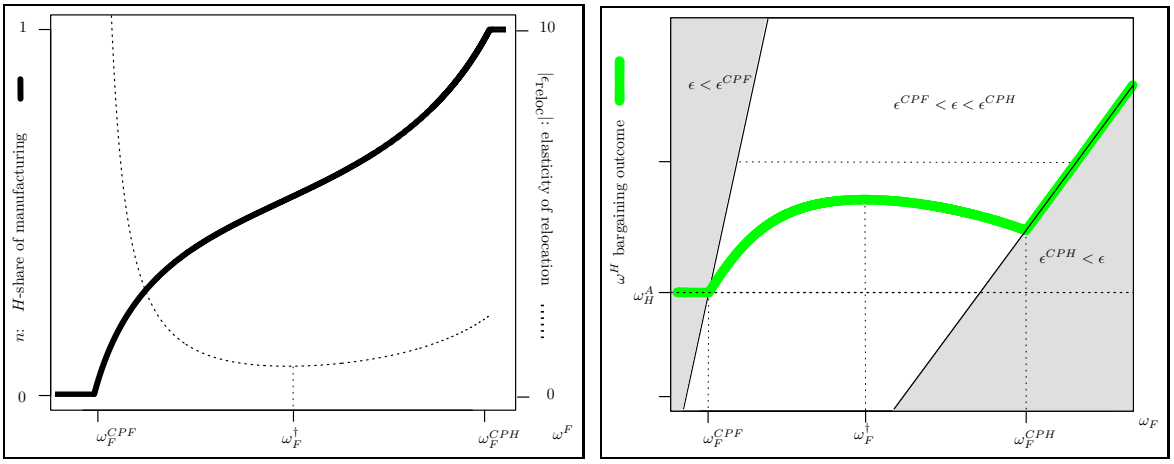

Figure 4: The international distribution of firms and the relocation elasticity (left panel) and the wage bargaining solution in country H (right panel) as a function of the foreign wage ω_F.

4 International wage competition

So far we have taken wages abroad as given in the bargaining problem. An interesting question is how wages would be set if the bargaining parties in a country take into account their actions can trigger a reaction abroad, where a similar bargaining process takes place. A straightforward approach is to interpret the wage bargaining outcome in both countries in function of the foreign wages as reaction functions and solve for a pure strategy international Nash-equilibrium in wages. We will investigate the stability of this equilibrium by a so-called Cournot tatônnement where the agents in both countries are short-sighted and sequentially bargain over wages, taking the bargaining outcome of the other country from the previous period as given. Investigating the outcome of such a sequential wage bargaining game provides a stability criterion of the international Nash-equilibrium and provides an appealing illustration to the question whether countries engage in race-to-the-bottom wage competition.

Simultaneously solving for the wage bargaining outcomes in both countries provides us with following expressions for the Nash-equilibrium for the case of sector-level bargaining: (14).

$$\left.\begin{aligned}\frac{\partial \Omega_H(\omega_H,\omega_F)}{\partial \omega_H} &= 0\\ \frac{\partial \Omega_F(\omega_F,\omega_H)}{\partial \omega_F} &= 0\end{aligned}\right\} \Rightarrow \begin{aligned}\frac{\omega_H^{NE}-\omega_H^A}{\omega_H^A} - \frac{\theta_H}{(|\epsilon^H_{l^d,\omega}|-1)+|\epsilon^H_{\text{reloc}}(\omega_H^{NE},\omega_F^{NE})|} &= 0\\ \frac{\omega_F^{NE}-\omega_F^A}{\omega_F^A} - \frac{\theta_F}{(|\epsilon^F_{l^d,\omega}|-1)+|\epsilon^F_{\text{reloc}}(\omega_H^{NE},\omega_F^{NE})|} &= 0\end{aligned} \tag{16}$$

where we write ξ to group all model parameters.

If countries are asymmetric, possibly different wage levels are needed both countries to solve (16) complicating matters significantly. We therefore first consider the easier case of symmetric countries.

4.1 International wage competition with symmetric countries

Under perfect symmetry we know the same reaction function and thus wage prevail in both countries, implying $\omega_{H} = \omega_{F}$ or $\epsilon = 1$ and we also have $s_{E} = \frac{1}{2}$. We then obtain for the equilibrium wage in both countries:

$$\frac{\omega^{NE} - \omega^{A}}{\omega^{A}} = \frac{\theta_{H}}{|\epsilon_{l^{D},\omega}| + |\epsilon_{\text{reloc}}|_{\epsilon=1}}, \qquad |\epsilon_{\text{reloc}}|_{\epsilon=1} = \frac{2(\sigma-1)\phi}{(1-\phi)^{2}}. \tag{17}$$

As we already saw for the more general asymmetric case the relocation elasticity is strictly increasing in freeness of trade ϕ and reaches infinity for $\phi = 1$. This leads to the following important result:

Proposition 8 *(Race-to-the-bottom for perfect symmetry) With symmetrical countries and national unions setting wages non-cooperatively, lower trade costs (higher ϕ) lead to lower international Nash-equilibrium wage-markups. For perfectly free trade ($\phi = 1$), wages are set at the competitive level.*

As we saw above, increasing the freeness of trade leads to lower wage demands in a country for a given foreign wage through increasing the elasticity of relocation. The above proposition generalises this to the international non-cooperative Nash-equilibrium in wages for the case of symmetrical countries. In this context employed workers should fear globalisation. The CRS-workers would benefit from freer trade as the resulting lower wages translate into more employment opportunities in the high wage manufacturing sector.

Note that if countries are perfectly symmetric complete agglomeration of firms does not occur, excluding agglomeration rents to play a role in the bargaining outcome. This implies firm-level bargaining with symmetric countries leads an international Nash-equilibrium with zero wage-markups over the competitive wage.

4.2 International wage competition with asymmetric countries

International asymmetries regarding the wage setting such as θ and ω^{A} or the country size s_{E} make it impossible to straightforwardly calculate the Nash-equilibrium wage levels and

derive their properties.

As we saw above, an increase in the foreign wage in general need not lead to an increase in the home country wage bargaining outcome. This means wages do not act as strategic complements. Strategic complementarity would greatly simplify the analysis as the comparative static properties of models with strict strategic complements[13] are well established and simple to apply (see for example Milgrom and Roberts (1994) or Vives (1999)). With strategic complements, anything which shifts the reaction function in one country upwards increases the wages in both countries, e.g. in the Nash-equilibrium an increase in the union bargaining power or alternative wage in one country would always lead to higher wages in *both* countries.

The fact international wage competition for the sector level bargaining case is not strictly super or sub-modular forces us to use implicit differentiation to analyse the properties Nash-equilibrium (see for example Dixit (1986) or Vives (1999)).

We first address the stability of the equilibrium described by (16) by considering the situation where wage bargaining happens sequentially in both countries, taking the wage level in the other country as given in every period.[14] Wages will then locally converge to the Nash equilibrium over time if at the Nash-equilibrium

$$\begin{vmatrix} \frac{\partial^2 \Omega_H}{\partial {\omega_H}^2} & \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \\ \frac{\partial^2 \Omega_F}{\partial \omega_F \partial \omega_H} & \frac{\partial^2 \Omega_F}{\partial {\omega_F}^2} \end{vmatrix} > 0. \tag{18}$$

It is impossible to sign this expression analytically but we confirmed numerically that (18) holds at $\omega_H^{NE}, \omega_F^{NE}$. This proves the Nash equilibrium as described in (16) is stable in that sequential international wage bargaining would result in wages locally converging to $\omega_H^{NE}, \omega_F^{NE}$.

The comparative statics of the Nash-equilibrium $(\omega_H^{NE}, \omega_F^{NE})$ are obtained from totally differentiating (16) for some parameter, say ξ, and solving (for example for the H country) for $\frac{\partial \omega_H^{NE}}{\partial \xi}$:

$$\frac{\partial \omega_H^{NE}}{\partial \xi} = \begin{vmatrix} -\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \xi} & \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \\ -\frac{\partial^2 \Omega_F}{\partial \omega_F \partial \xi} & \frac{\partial^2 \Omega_F}{\partial {\omega_H}^2} \end{vmatrix} \Bigg/ \begin{vmatrix} \frac{\partial^2 \Omega_H}{\partial {\omega_H}^2} & \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \\ \frac{\partial^2 \Omega_F}{\partial \omega_F \partial \omega_H} & \frac{\partial^2 \Omega_F}{\partial {\omega_F}^2} \end{vmatrix}. \tag{19}$$

We already numerically confirmed the denominator is positive at the Nash-equilibrium,

[13] Also known as super-modular games.

[14] This is a so-called Cournot tatônnement. It is well known such simple discrete sequential adjustment supposes limited rationality of the agents in both countries. This, however, might be seen as an advantage or disadvantage of this approach.

the condition for tatônnement stability. For the comparative statics of parameters which appear only in the optimisation problem of a single country, say H, we have $\frac{\partial^2 \Omega_F}{\partial \omega_F \partial \xi} = 0$ and therefore the sign of $\frac{\partial \omega_H^{NE}}{\partial \xi}$ will equal the sign of $-\frac{\partial^2 \Omega_F}{\partial {\omega_F}^2} \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \xi}$. As $\frac{\partial^2 \Omega_F}{\partial {\omega_F}^2}$ is negative because of the SOC, we have

$$\text{sign}\left(\frac{\partial \omega_H^{NE}}{\partial \xi_H}\right) = \text{sign}\left(\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \xi_H}\right) \tag{20}$$

In words: if a parameter only appears in a single country's bargaining problem the effect of a rise in on this country's Nash-equilibrium wage depends on how the parameter affects the output in isolation. As we already discussed many comparative statics for countries in isolation in the above sections, these still hold for the nash equilibrium wage levels. For example, with $\xi = \omega_H^A$, an increase in the alternative wage in a country was shown to always increase the equilibrium bargained wage level with the foreign wage taken as given. The above derivations generalise this to the international Nash-equilibrium wage level of country H.

The effect on the foreign country wage level similarly can be determined as:

$$\text{sign}\left(\frac{\partial \omega_F^{NE}}{\partial \xi_H}\right) = \text{sign}\left(-\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \xi_H} \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F}\right). \tag{21}$$

As we argued above the sign of $\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F}$ is ambiguous. Therefore, the change in a parameter appearing in a foreign country's bargaining process has an ambiguous effect on the Nash-equilibrium wage level in the home country.

The freeness-of-trade parameter ϕ is common to the wage bargaining process of both countries and from the above we can then derive the direction of the effect on the equilibrium wage as (substituting out ξ for ϕ in equation (19)):

$$\text{sign}\left(\frac{\partial \omega_F^{NE}}{\partial \phi}\right) = \text{sign}\left(\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \frac{\partial^2 \Omega_F}{\partial \omega_F \partial \phi} - \frac{\partial^2 \Omega_F}{\partial {\omega_F}^2} \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \phi}\right). \tag{22}$$

We showed in the previous section an increase in ϕ always lowers wage demands in the larger country for interior solutions, but might increase wage demands in the smaller country if the core starts returning to the smaller country. Therefore $\frac{\partial^2 \Omega_F}{\partial \omega_F \partial \phi} \gtrless 0$ and $\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \phi} > 0$. Because the sign of $\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F}$ is ambiguous and because there exists no explicit expression for the wage bargaining outcomes, we cannot analytically proof the sign of $\frac{\partial \omega_j^{NE}}{\partial \phi}$. Numerous numerical simulations strongly indicate the same results as in the single country case hold for the Nash-equilibrium: increases in ϕ always lead to lower *internal* international Nash-

equilibrium wage levels in the larger country but might lead to higher wage demands in the smaller country. If ϕ is at a level where a country cannot attract any firms even when lowering its wage to the outside-option level ω_H^A we have full agglomeration and the same results as in the single-country case hold: hump-shaped or monotonically increasing wages for the larger and smaller country respectively, with a possible cap. The effect of ϕ on the international Nash-equilibrium in wages is summarised in the following proposition.

Proposition 9 *With asymmetrical countries, lower trade costs lead to lower Nash-equilibrium wage-markups in the larger country as long as both countries contain some firms. For levels of* $\phi_{NE}^{CPH1} < \phi < \phi_{NE}^{CPH2}$ *and* $\phi_{NE}^{CPF} < \phi$ *we have full agglomeration and the same results as in the single-country case hold as summarised in proposition (4). For the smaller country, the Nash-equilibrium wage markup might be increasing for internal equilibria over the small interval* $\phi_{NE}^{CPH2} < \phi < \phi_{NE}^{CPF}$*-interval if the country was almost deserted and firms then start returning.*

These critical levels of ϕ are now defined (implicitly) by evaluating equations (8) and (9) at $\omega = \omega^A$ for the deserted country and the country attracting all industry setting its wage optimally given this level.

The left panel of figure 5 illustrates how a decrease in trade costs lead to lower Nash-equilibrium wages in both countries as long as both countries contain some firms and asymmetries are not too large (the figure considers a symmetric case). Starting from a situation with relatively high trade costs $\phi = 0.2$ (dotted lines), a jump of trade freeness to $\phi = 0.5$ leads to a decrease in the wages markup $\frac{\omega - \omega^A}{\omega^A}$ from 0.19 to 0.06 in both countries. Note that the property of tatônnement stability of equation (18) assures the slopes of the reaction functions are not too large, making sequential international wage bargaining will eventually lead to the new Nash-equilibrium. In the right panel the H country is larger ($s_E = 0.8$), making almost all firms agglomerate in H for the initial situation (dotted lines) with ϕ=0.69. A further increase in ϕ to 0.78 then leads to a decrease of the wage markup in H from 0.096 to 0.013 and an increase of F's markup from 0.004 to 0.016. It is no coincidence these numbers are small: in general, an increase in the Nash-equilibrium wage level only occur in the smaller country and for levels of ϕ so high markups are already very low.

For ϕ approaching 1 only the production cost advantage plays a role in firm location and the core will therefore eventually locate in the country which is able to lower wages such that its total production costs are below the foreign production costs in the manufacturing sector. It must be clear that unions in a country would only be willing to see all firms

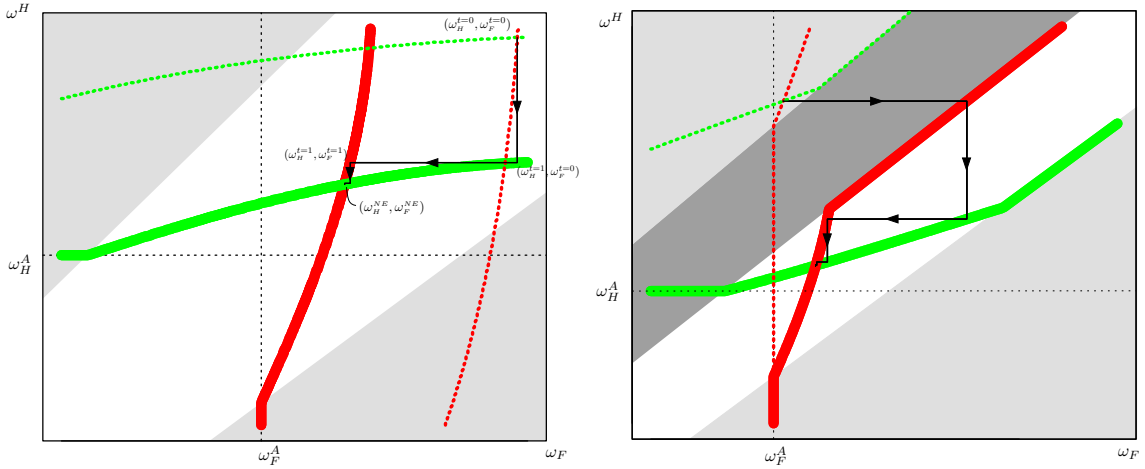

Figure 5: In the symmetrical case, lower trade costs always lead to lower international wage markups (left panel). If one country is smaller and has a lower reservation wage it might see higher wages if trade costs decrease, even for internal equilibria.

leave their country when even without any wage demand ($\omega_j = \omega_j^A$) all firms still prefer to locate in the other country. Writing down this condition explicitly, we have that if $a_j w_j^A < a_k w_k^A$ agglomeration will eventually occur in country j for free enough trade. If the FPE condition from equation (2) holds perfectly, $w_j^A a_j^A = w_k^A a_k^A$ and after solving this for w_F^A and substituting in the previous inequality gives the following condition for the existence of a level of ϕ above which full agglomeration always occurs in country j

$$\frac{a_H}{a_H^A} < \frac{a_F}{a_F^A},$$

which is simply the definition of a comparative advantage of country j in the manufacturing sector. We therefore conclude:

Proposition 10 *For low enough trade costs, firms agglomerate in the country with a comparative advantage in manufacturing.*

This non-monotonic relationship between equilibrium wages and trade costs are the core result of our paper. The next section now shows that in the absence of relocation costs the introduction of firm heterogeneity does not affect any of the above results.

5 Extension: Firm Heterogeneity

In reality firms are non-homogeneous. A first step in taking this into account in economic modelling was to assume an underlying distribution of firm specific total factor productivities as in Melitz (2003). Using a pareto distribution in a monopolistic competition framework then produces an equilibrium with the empirically observed skewness of firm productivity and size distributions where we usually see a large number of relatively unproductive small firms and few very productive large firms.[15] The pareto distribution also has nice theoretical properties, keeping the expressions manageable.

Firm heterogeneity was already introduced in a NEG model by Baldwin and Okubo (2004). In the following we simply adopt their model to allow for international wage differences. We assume firms are heterogeneous in that the firm specific total factor productivity parameter $1/a$ is pareto distributed. This implies for the distribution $f[a]$ of the firm specific marginal costs a:

$$f[a] = \rho a^{\rho-1} \quad 0 \leq a \leq 1 \leq \rho.$$

The cost function (3) then becomes

$$C_{ij}(x) = r_j + a a_j w_j x. \tag{23}$$

From which we derive the new pricing equations similar to (4)

$$\begin{aligned} p_{ijj} &= \eta a a_j w_j && j \in \{H, F\} && \text{(local sales)} \\ p_{ijk} &= \tau \eta a a_j w_j = \tau p_{ijj} && j, k \in \{H, F\} \;\; j \neq k. && \text{(exports)} \end{aligned} \quad , \tag{24}$$

where we see firms with higher costs a_i charge higher prices. Baldwin and Okubo (2004) show that under realistic assumptions, the most productive firms will relocate first. As the profit gap is decreasing in the mass of relocating firms, there exists a firm with 'cut-off' cost parameter a_R which is the last firm to relocate before profits are equalised internationally (unless we are in a corner solution where all firms agglomerate in a single country). The

[15] See for example Cabral and Mata (2003). For the pareto distribution skewness increases with ρ. For $\rho = 1$ the distribution is uniform.

price indices can then be determined as

$$\begin{aligned}
P_{H} &= \Big[\int p(z)^{1-\sigma}\,dz\Big]^{\frac{1}{1-\sigma}} \\
&= \Big[\int_0^{\frac{1}{2}}\!\!\int_0^{a_R} [\tau\eta a w_F]^{1-\sigma} f(a)\,da\,dz \quad + \quad \int_0^{\frac{1}{2}}\!\!\int_{a_R}^{1} [\eta a \omega_H]^{1-\sigma} f(a)\,da\,dz \\
&\quad + \int_{\frac{1}{2}}^{1}\!\!\int_0^{1} [\tau\eta a w_F]^{1-\sigma} f(a)\,da\,dz\Big]^{\frac{1}{1-\sigma}} \\
&= \eta a_{F} \omega_{F} \big(\frac{\lambda}{2}\big)^{\frac{1}{1-\sigma}} \Big[\phi a_R^{1-\sigma+\rho} + \epsilon(1-a_R^{1-\sigma+\rho}) + \phi\Big]^{\frac{1}{1-\sigma}}, \\
P_{F} &= \eta a_{F} \omega_{F} \big(\frac{\lambda}{2}\big)^{\frac{1}{1-\sigma}} \Big[1 + a_R^{1-\sigma+\rho} + \epsilon\phi(1-a_R^{1-\sigma+\rho})\Big]^{\frac{1}{1-\sigma}}.
\end{aligned} \tag{25}$$

The interpretation is still rather intuitive: in the country H, a share of $a_R^{1-\sigma+\rho}$ of capital (the lower tail of the a distribution, the most productive firms) relocates to F and therefore is able to produce without the cost handicap (hence no ϵ). These firms must now pay transport costs on their sales in H (now imports), hence the ϕ. A share of $(1-a_R^{1-\sigma+\rho})$ of the home country firms stays put. On this share of consumption no transport costs must be paid but as it is produced at a higher cost because of H's wage handicap we multiply by ϵ. The remaining part of the price index consists of imports from the original F-firms.

The rents from equation (6) must also be adapted accordingly:

$$\begin{aligned}
r_{H} &= \frac{2\mu a^{1-\sigma}}{\sigma\lambda}\,\epsilon\big[\frac{s_{E}}{\Delta_{H}} + \phi\frac{1-s_{E}}{\Delta_{F}}\big] \qquad & r_{F} &= \frac{2\mu a^{1-\sigma}}{\sigma\lambda}\big[\phi\frac{s_{E}}{\Delta_{H}} + \frac{1-s_{E}}{\Delta_{F}}\big], \\
\Delta_{H} &= \phi a_R^{1-\sigma+\rho} + \epsilon(1-a_R^{1-\sigma+\rho}) + \phi \qquad & \Delta_{F} &= 1 + a_R^{1-\sigma+\rho} + \epsilon\phi(1-a_R^{1-\sigma+\rho}).
\end{aligned} \tag{26}$$

Equating the return to capital and solving for a_R gives

$$a_R^{*\,1-\sigma+\rho} = \frac{(1-\epsilon^2)\phi - 2\epsilon(1-\phi)(s_{E}-\frac{1}{2})}{(1-\epsilon\phi)(\epsilon-\phi)}, \tag{27}$$

which can also be easily shown to be locally stable. Comparing to the homogeneous case from equation (7) this might seem quite different. It turns out, however, that this is not the case.

We first confirm firm heterogeneity does not affect the levels of trade freeness at which

the entire economy agglomerates in a single country.

$$\epsilon^{CPH} = \frac{1 - s_E(1-\phi^2)}{\phi} \qquad \epsilon^{CPF} = \frac{\phi}{\phi^2 + s_E(1-\phi^2)}. \tag{28}$$

The expression for agglomeration in country F is obtained by setting $a_R = 1$ in equation (27) and solving for ϕ. For country H we have to switch labels.[16] Baldwin and Okubo (2004). It was already emphasised by Baldwin and Okubo (2004) that the full agglomeration points in the model with heterogeneous firms exactly corresponds to the homogeneous case. We now see this still holds when we allow for international wage differences and asymmetric countries $s_E \neq 1/2$. As we are not only interested in the NEG-model properties per-se but rather how they interrelate to the wage bargaining process, we now turn to the two variables of the NEG model which are central to the wage bargaining process: the agglomeration rents z and the relocation elasticity ϵ_{reloc}.

Here too, it turns out firm heterogeneity by itself does not have any effect. For the agglomeration rents, this is obvious, as the only firm-specific parameter a_i cancels out when we take the ratio r_H/r_F. The agglomeration rents are then still given by (taking the ratio of (26)

$$z_F = \frac{r_F}{r_H}\Big|_{a_R=1} = \frac{\phi}{\epsilon(\phi^2 + s_E - \phi s_E^2)} = \frac{\epsilon^{CPF}}{\epsilon}. \tag{29}$$

Again we have the problem we can only describe agglomeration in F in this framework, so we have to relabel H and F by changing ϵ into $1/\epsilon$ and s_E into $(1 - s_E)$ to obtain:

$$z_H = \frac{r_H}{r_F}\Big|_{a_R=1} = \frac{\phi\epsilon}{\phi^2 s_E + 1 - s_E} = \frac{\epsilon}{\epsilon^{CPH}}, \tag{30}$$

which is identical to the homogeneous case.

The relocation elasticity was important to a union bargaining on the sector level as it expresses how fast the unions 'tax-base' relocates in response to its wage demands. When calculating the aggregate labour demand our utilitarian union now no longer can simply multiply the number of firms by the labour demand of the representative firm nl^d, but rather has to calculate the integral of labour demands over the entire mass of remaining firms. As all firms with a marginal cost shifter less than a_R relocated, the remaining aggregate labour demand is $\int_{a_R}^{1} l(a)f(a)da$ where $l(a)$ is the firm level labour demand for a

[16] To derive the expression for agglomeration in country H, we have to use a trick as the heterogeneous model was only defined for relocation from H to F. Setting $a_R = 1$ in equation (27) we can solve for the intermediate levels of trade freeness at which all firms agglomerate in F. Changing the H and F labels in this expression amounts to changing ϵ into $1/\epsilon$ and s_E into $(1 - s_E)$, which then gives the result

firm with cost parameter a and $f(a)$ is the pareto distribution of this parameter. We then have

$$\int_{a_R}^{1} l(a)f(a)da = \frac{\rho}{1-\sigma+\rho}\big[1 - a^{1-\sigma+\rho}\big]l^d \tag{31}$$

where l^d is the simple labour demand from the homogeneous case. It is obvious $\frac{\rho}{1-\sigma+\rho}[1 - a^{1-\sigma+\rho}]$ plays the same role as n did in the aggregate labour demand (nl^d) for the homogeneous case and we therefore define the relocation elasticity for the heterogeneous case as

$$\epsilon^{H}_{\text{reloc}} = \frac{\partial(1-a^*_{pR})}{\partial\omega_{H}}\frac{\omega_{H}}{(1-a^*_{pR})} = \beta_l\epsilon\epsilon^{CPF}(\sigma-1)\frac{s_{E}(1-\epsilon^2)(1-\phi^2)-(1-\epsilon\phi)^2}{(\epsilon-\phi)(1-\epsilon\phi)(\epsilon-\epsilon^{CPF})} < 0. \tag{32}$$

As this is again identical to the homogeneous firm case, we conclude

Proposition 11 *With costless relocation, firm heterogeneity has no influence on the wage bargaining outcome.*

We explicitly note relocation has to be costless. Assuming costly relocation greatly alters the result.

Heterogeneous firms and relocation costs All above results were derived for the case of costless relocation. To model relocation costs we redefine z as

$$z = \gamma\frac{r_{H}}{r_{F}-\chi}, \tag{33}$$

where $0 < \gamma < 1$ reflects the existence of costs which are proportional to the firm size and we have $\chi > 0$ if there are fixed costs to relocation, independent of firm size. Some straightforward algebra then leads to following result:

Proposition 12 *If the cost of relocation is purely proportional to firm revenue ($\chi = 0$) so that the whole ($\gamma = 1$) or a fraction ($\gamma < 1$) of the foreign revenue is be obtained after relocation*[17] *all firms will pay equal wages, irrespective of their productivity level. If on the contrary there exists some fixed relocation cost ($\chi \neq 0$), more productive firms will pay* lower *wages.*

Proof In the definition of z, with $\chi = 0$, we see the firm productivity parameter a_i cancels out in the ratio r_{Hi}/r_{Fi}. In equation (13) with ω_{Hi} independent of a_i we have $\omega_{Hi} = \omega_{H}\ \forall\ i$ as there is no other form of heterogeneity.

[17] for example because a firm becomes proportionally less productive after relocating

If $\chi \neq 0$, z is increasing in a_i and therefore $\omega_{Hi}(a_1) > \omega_H(a_2)$ iff $a_1 > a_2$. ∎

This result is intuitive: as the fixed costs of relocation are more important to small, unproductive firms, the threat of relocation becomes less relevant for them which makes the capital owner has a weaker bargaining position. However interesting the case with heterogeneous wages, the fact that the relationship between firm-specific productivity and wage cannot be expressed as a function, makes it impossible to calculate the price indices. This implies total demand, the return to capital and other key variables of the model can no longer be solved analytically. We therefore leave this to future research.

6 Conclusion

In this paper we investigated the relationship between the mobility of firms and the outcome of wage bargaining between unions and firms. We first established results on firm behaviour in terms of labour demand and location choice in a two-country NEG model, allowing for international differences in productivity, market size and wages. We then proceeded by formulating two simple wage bargaining frameworks where we assume negotiations take place on the firm and sector level respectively. Here, both parties involved in the bargaining process take into account the results on optimal firm behaviour established before, taking wages abroad as given.

The results on firm level bargaining are simple in that no wage demands can be made for interior solutions, where both countries contain some firms. The reason is that as long as profits are equalised internationally and relocation is costless foreign profits provide firms with a perfect outside-option during negotiations and therefore no wage demands can be made. If all firms agglomerate in a single country, an international profit differential may exist and unions will then be able to appropriate part of these agglomeration rents in the form of higher wages. It was shown that because these rents are a hump-shaped function of trade freeness in the larger market this therefore leads to hump-shaped wages. If agglomeration occurs in the smaller country (because it has some cost advantage), wages are monotonically increasing in the freeness of trade.

For sector level bargaining, we showed that positive wage markups are made even for interior equilibria where profits are equal internationally. This can occur because despite the fact some firms relocate in response to wage demands, sector level unions may still prefer to increase wages in the remaining firms. It was shown that the wage bargaining outcome depends in a very simple way on the elasticity of relocation, a measure for the

speed by which firms relocate internationally. The relation between trade freeness and the wage bargaining outcome can be quite complicated for the case of sector level firm bargaining because of corner solutions in the bargaining process. It turns out that with sector level bargaining lower trade costs need not lead to lower wage demands, even for interior solutions for the case of sector level bargaining.

We then investigated wage bargaining for the case where sector-level wage bargaining in both countries takes place sequentially. Wages were shown to locally converge to a unique international Nash-equilibrium in wages. For sufficiently symmetric countries, wages act as strategic complements. Parameter changes which would lead to higher wages in a country in isolation, such as an increase in the union bargaining power, then lead to higher wages in both countries. Lower trade costs then lead to lower wage demands in both countries. If countries are quite asymmetric, lower trade costs can lead to higher Nash-equilibrium wage demands in a smaller country with a comparative advantage in the manufacturing sector, once trade costs are low enough to induce a large relocation to this smaller low-cost country, even if both countries contain some firms. For the case of complete agglomeration the same results as for the case with exogenous foreign wages was obtained with, for example, the same complicated non-monotonic relationship between trade costs and the wage bargaining outcome.

We then investigated whether our results are robust to the addition of a simple model of firm heterogeneity. It was shown that for costless relocation, none of the above results change. For the case of a fixed cost of relocation, we did not solve the complete model, but it was shown that, quite surprisingly, in equilibrium larger, more productive firms pay lower wages.

Apart from showing increased economic integration need not lead to race-to-the-bottom wage competition in the presence of size asymmetries, this paper provides a simple framework linking imperfect labour markets internationally. Quite a large number of studies have analysed links between for example, labour demand in one country and domestic and foreign wage setting empirically [TODO konings]. The model introduced in this paper provides clear hypothesis on exactly how these effects are expected to materialise. One could for example learn from the model that increases in foreign wages mostly lead to increases in domestic wages, a decrease in firm level labour demand in both countries, but not necessarily a decrease in aggregate labour demand (as firms relocate internationally, the most productive firms first). An important further step then would be to investigate empirically whether and how countries compete internationally in wages and look at the

effects of this on both firm and sector level.

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Appendix

stability of the LR-equilibrium We now investigate whether the equilibrium described by equation (7) is relevant in the sense that it represents a stable equilibrium. In an unstable equilibrium a minor shift in industry toward the foreign country would induce a rise in the relative reward to capital in the foreign country and therefore cause further delocalisation. This idea has been introduced by Fujita, Krugman, and Venables (1999). To investigate the stability we have to differentiate the rent differential with respect to the borderline a_{pR} and evaluate it at the long run equilibrium.

$$\frac{\partial(r_F - r_H)}{\partial n}\Big|_{n\ =n^*} = -\frac{(\epsilon-\phi)^2(1-\epsilon\phi)^2\mu}{\epsilon^2(1-\phi)^2(1+\phi)^2\sigma} < 0 \tag{34}$$

At the equilibrium n^* from equation (7) $r_F - r_H = 0$ holds by definition. Because $\frac{\partial r_F - r_H}{\partial n} < 0$ at the long run equilibrium, the movement of a single firm to F from the equilibrium will make capital rents in the H relatively higher and therefore discourage firms to move to F. Therefore we can conclude the equilibrium is always stable as in the standard FC-model.

some comparative statics using implicit derivation For a fixed foreign wage we reshuffle (13) to have only ω_H on the left hand side and take the derivative to determine the comparative statics of the bargained wage of country H. Importantly, we have to take into

account δ depends on ω_H through z_H and $\frac{d\delta}{d\omega_H} > 0$. For the effect of a change in θ_H we then obtain::

$$\begin{aligned} \frac{d\omega_H}{d\theta_H} &= \frac{\omega_H^A}{(|\epsilon_{l^d,\omega}| - 1)\delta} - \frac{\theta_H \omega_H^A}{(|\epsilon_{l^d,\omega}| - 1)\delta^{-2}} \frac{d\delta}{d\omega_H} \frac{d\omega_H}{d\theta_H} \\ \frac{d\omega_H}{d\theta_H} &= \frac{\omega_H^A}{(|\epsilon_{l^d,\omega}| - 1)\delta} \Bigg/ \left(1 + \frac{\theta_H \omega_H^A}{(|\epsilon_{l^d,\omega}| - 1)\delta^{-2}} \frac{d\delta}{d\omega_H}\right) > 0. \end{aligned} \tag{35}$$

And similarly for the effect of a change in the alternative wage ω_H^A:

$$\frac{d\omega_H}{d\omega_H^A} = \left(1 + \frac{\theta_H}{(|\epsilon_{l^d,\omega}| - 1)\delta}\right) \Bigg/ \left(1 + \frac{\omega_H^A}{(|\epsilon_{l^d,\omega}| - 1)\delta^2} \frac{d\delta}{d\omega_H} \frac{d\omega_H}{d\omega_H^A}\right) > 0. \tag{36}$$

Corner Solutions of the Nash-bargaining Problem

If all firms agglomerate in a single country, the elasticity of relocation only drops to zero, but only *locally*, for small changes in wages. Maximising (14) assuming overall firm immobility can lead to wage demands high enough so to induce firms to relocate invalidating the assumption under which the result was derived. When all industry agglomerates in a single country, a corner solution arises for the maximisation of the Nash product. For full agglomeration wages then are set at the ϵ^{CPH} level, the borderline wage level at which all industry remains in the H country.

This is illustrated in the following figure, showing the value of Ω from equation (14) both for the case of an internal equilibrium where $\epsilon_{\text{reloc}} \neq 0$, denoted $\Omega(\omega) -$ internal and the case of complete agglomeration denoted $\Omega(\omega) -$ CP. The figure is drawn for a very large H country ($s_E = 4/5$)[18].

As we already discussed in the main text, at very high trade costs internal equilibria will prevail as the firms are very much tied to where consumers are, even to the few consumers in F. This is the situation depicted in the left panel of the figure. The optimal wage is decreasing in the freeness of trade because -as we proved above- the relocation elasticity increases when trade costs decline. As wages decrease, ϵ increases. If trade costs keep falling, however, ϵ^{CPH} will also decline. For intermediate levels of trade freeness firms prefer to locate close to consumers and this implies the large H country can afford a larger wage handicap ϵ and still contain all firms. Generally, there will be a point at which ϵ^{CPH} will drop below the ϵ corresponding to chosen wage, in the internal equilibrium version of equation (14), the point maximising $\Omega(\omega) -$ internal in the figure.

[18]Other parameters are $\sigma = 3.5$, $\beta_l = 0.5$, $\theta_H = 0.5$, $\omega_a = 1.5$, $\omega_F = 1.5$

If this happens, the solution of (14) with $\epsilon_{\text{reloc}} = 0$ becomes relevant *iff* this solution is indeed a wage level at which complete agglomeration occurs and therefore $\epsilon_{\text{reloc}} = 0$. In the right panel of the figure ϵ^{CPH} is indeed below the ω that would be chosen when maximising $\Omega(\omega)-$internal, but at the same time the wage chosen by maximising $\Omega(\omega)-$CP is so high, it would imply an ϵ low enough to induce some firms to locate in F. As $\Omega(\omega)-$internal is valid only below ϵ^{CPH} and $\Omega(\omega)-$CP only above this value, we obtain a corner solution at $\epsilon = \epsilon^{CPH}$. As trade costs further decline, ϵ^{CPH} might further decline (implying higher wage) as the agglomeration rents are further increasing.[19]

If trade costs become quite low, however, we proved above, agglomeration rents will start falling again, implying a larger ϵ^{CPH}. From this point onward, the equilibrium wage will keep falling along with the rise in ϵ^{CPH}, just enough to keep all firms in country H. Only for perfectly free trade, we reach $\epsilon = 1$, and no wage demands above the foreign wage can be made.[20] The main conclusion is that, despite some non-continuities, the sector-level wage bargaining-solution is well defined and depends on the freeness of trade in the following way:

Proposition 13 *For sufficiently asymmetric countries the sector-level wage bargaining solution will first decline, then increase and then again decline in trade freeness.*

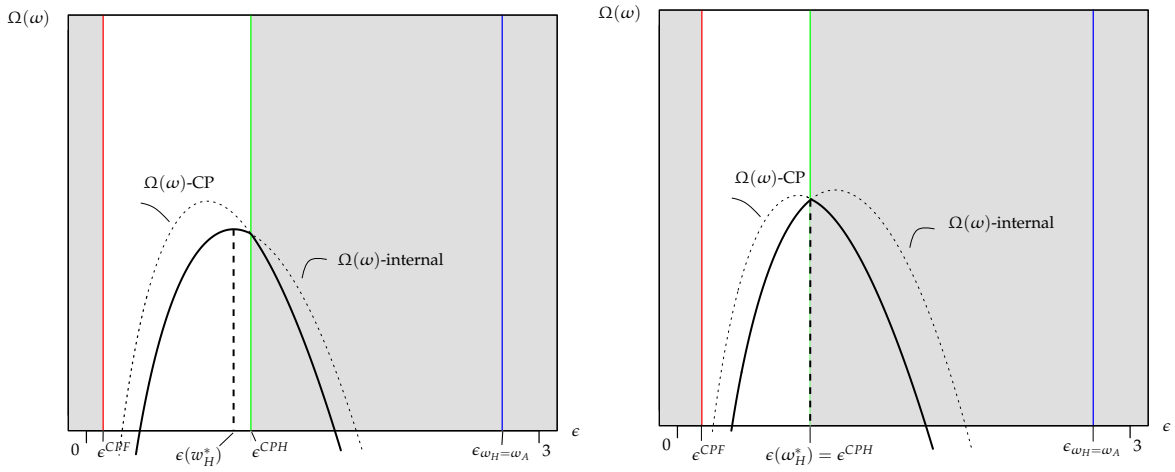

Figure 6: Sector level wage bargaining. In the left panel ($\phi = 0.1$) the internal solution is chosen. In the right panel ($\phi = 0.13$) the wage is set at the CP-level.

[19] Note that as countries sizes are not very different such a point might not be reached

[20] Unless, of course, the alternative wage is high enough so that all manufacturing workers prefer to work in the CRS sector before we reach that point.