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“Trade and Race-to-the-bottom Wage Competition”

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Trade and Race-to-the-bottom Wage Competition

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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. Using 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 threaten 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.

JEL-codes: J50, J31, F16

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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 also solves for an international Nash-equilibrium in wages.

Fewer models consider the effects of unionisation on the location choice of firms in the context of fully mobile firms. For example [Toulemonde and Picard \(2003, 2006\)](#), [De Bruyne \(2004\)](#) and [Munch \(2003\)](#) combine a Nash-bargaining framework determining wages and a NEG model explaining the location choice of firms, 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 be very different as wage demands increase aggregate income in more industrialised countries which could cause unionisation to foster agglomeration. As they tend to be more restrictive in the assumptions on the market structure, simple NEG models also allow to express key variables of the model such as the equilibrium distribution of firms more clearly as compared to models with for example oligopolistic competition and linear demand. In this paper we 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 lose 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 threaten to relocate which in our model 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 causing some relocation, 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 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 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 also 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 than 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 cooperative Nash wage-bargaining scheme and we look at the effect of parameter changes on the wage bargaining outcome. In section 4 we then jointly solve for wages in both countries and establish properties of the international non-cooperative Nash-equilibrium, 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

$$U = C_A + \mu C_M, \quad C_M = \left(\int q^{\frac{\sigma-1}{\sigma}} dt \right)^{\frac{\sigma}{\sigma-1}}, \quad 0 < \mu < 1 < \sigma$$

$$C_A = \Pi_s (q_s^A)^{\gamma_s}, \quad 0 < \gamma_s < 1, \Sigma_s \gamma_s = 1.$$

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} :

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

where $P_k = \left[\int p^{1-\sigma} dt \right]^{\frac{1}{1-\sigma}}$ 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.¹ Total demand in country k therefore is simply the demand of the typical consumer times the mass of consumers in the country. This specification makes changes in wages do not influence income and demand 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 between both countries:

$$\alpha_{Hf} \omega_{Hf}^A = \alpha_{Ff} \omega_{Ff}^A \quad (2)$$

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

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

inter-sectoral factor mobility equates 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 capital at price r_j irrespective of the output level. For the variable part of production one unit of a Cobb-Douglas input bundle $v_j = \prod_f (\nu_{jf}/\alpha_{jf})^{\beta_f}$ is required per unit of output. By defining $a_j = \prod_k \alpha_{jk}^{\beta_k}$ we have $1/a_j$ as a measure of total factor productivity of manufacturing firms in country j and with $w_j = \prod_k \omega_{jk}^{\beta_k}$ 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

$$C_j(x) = r_j + a_j w_j x.$$

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

$$\begin{aligned} p_{jj} &= \eta a_j w_j & j &\in \{H, F\} & \text{(local sales)} \\ p_{jk} &= \eta \tau a_j w_j = \tau p_{jj} & j, k &\in \{H, F\}, j \neq k & \text{(exports),} \end{aligned} \tag{3}$$

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

²If 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.

as

$$\begin{aligned}
P_H &= \left[\int p^{1-\sigma} ds \right]^{\frac{1}{1-\sigma}} = \left[\int_0^n p_{HH}^{1-\sigma} ds + \int_n^1 p_{FH}^{1-\sigma} ds \right]^{\frac{1}{1-\sigma}} \\
&= [np_{HH}^{1-\sigma} + (1-n)p_{FH}^{1-\sigma}]^{\frac{1}{1-\sigma}} \\
&= [n(\eta a_H w_H)^{1-\sigma} + (1-n)(\tau \eta a_F w_F)^{1-\sigma}]^{\frac{1}{1-\sigma}} \\
&= \eta a_F w_F [n\epsilon + (1-n)\phi]^{\frac{1}{1-\sigma}}, \\
P_F &= \eta a_F w_F [n\epsilon\phi + (1-n)]^{\frac{1}{1-\sigma}}.
\end{aligned} \tag{4}$$

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 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 for a firm in country j 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 $\pi_j = \frac{p_{jj}x_{jj} + p_{jk}x_{jk}}{\sigma} - r_j$. 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:

$$\begin{aligned}
r_H &= \frac{\mu}{\sigma} \epsilon \left[\frac{s_E}{\Delta_H} + \phi \frac{1-s_E}{\Delta_F} \right] & \Delta_H &= \epsilon n + \phi(1-n) \\
r_F &= \frac{\mu}{\sigma} \left[\phi \frac{s_E}{\Delta_H} + \frac{1-s_E}{\Delta_F} \right] & \Delta_F &= \phi \epsilon n + (1-n).
\end{aligned} \tag{5}$$

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 then

equals $1 - s_E$. We see the capital owner gains from a larger market size and expenditures on manufactures μ . 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 may affect profits, 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 , n , 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 (5) we obtain

$$n = \frac{\epsilon(1 - \phi^2)s_E + \phi(1 - \epsilon\phi)}{(\epsilon - \phi)(1 - \epsilon\phi)}. \quad (6)$$

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 levels³ 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 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 (6) 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 (recall we assumed $s_E > 1/2$): 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 on page 13.

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 such that $s_E > 1/(1 + \epsilon^2)$. If the relative size asymmetry is so large we have*

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

⁴It can be shown that if H has a cost handicap ($0 < \epsilon < 1$) there exists a level $\phi^{CPF} < 1$ above 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 .

$\epsilon > 2\sqrt{(1-s_E)s_E}$ 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 $\phi^{CPF} < \phi \leq 1$. If country H has lower production costs ($\epsilon > 1$) ϕ^{CPH2} is never reached and all firms locate in H for $\phi^{CPH1} < \phi \leq 1$.

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 (6) and solving for ϕ . It turns out that the expression in terms of ϵ is easier to work with.

$$\begin{aligned}\phi^{CPH1} &= \frac{\epsilon - \sqrt{\epsilon^2 - 4s_E(1-s_E)}}{2s_E} & \phi^{CPH2} &= \frac{\epsilon + \sqrt{\epsilon^2 - 4s_E(1-s_E)}}{2s_E} \\ \epsilon^{CPH} &= \frac{1 - s_E(1 - \phi^2)}{\phi}.\end{aligned}\tag{7}$$

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 $\epsilon > 2\sqrt{(1-s_E)s_E}$ as claimed above.

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 (6) 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.

$$\phi^{CPF} = \frac{1 - \sqrt{1 - 4\epsilon^2 s_E(1-s_E)}}{2\epsilon(1-s_E)} \quad \epsilon^{CPF} = \frac{\phi}{\phi^2 + s_E(1-\phi^2)}.\tag{8}$$

ϵ^{CPF} is the highest value of ϵ for which country H contains some firms. Similarly, 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

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

⁶It 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 out to be strong enough to sign equations.

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 (5), we can conveniently express the agglomeration rents of locating in country H as:

$$\begin{aligned} z_H = r_H/r_F = \epsilon/\epsilon^{CPH} & \quad \text{if } n = 1 \\ z_H = r_H/r_F = 1 & \quad \text{if } 0 < n < 1. \end{aligned} \tag{9}$$

Obviously, at $\epsilon = \epsilon^{CPH}$ and in an internal equilibrium firms earn equal profits in both countries and there are no agglomeration rents. If production costs in H are low enough such that $\epsilon > \epsilon^{CPH}$ firms have a preference for locating in H and we have $z_H > 1$. 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:

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

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 $\phi^* = \sqrt{(1 - s_E)/s_E}$ 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 relative 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

$$\begin{aligned}\epsilon_{\text{reloc}}^H &= \frac{\partial n^*}{\partial \omega_H} \frac{\omega_H}{n} = \beta_l \epsilon \epsilon^{CPF} (\sigma - 1) \frac{s_E (1 - \epsilon^2)(1 - \phi^2) - (1 - \epsilon\phi)^2}{(\epsilon - \phi)(1 - \epsilon\phi)(\epsilon - \epsilon^{CPF})} < 0 \quad \text{if } 0 < n < 1 \\ &= 0 \quad \text{if } n = 1\end{aligned}\tag{10}$$

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 $|\epsilon_{\text{reloc}}^H|$ approaches ∞ as ϵ approaches ϵ^{CPF} because the sensitivity to wages is expressed with respect to an ever smaller base of firms. From now on we will refer to $|\epsilon_{\text{reloc}}^H|$ 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 $|\epsilon_{\text{reloc}}^H|$ and $|\epsilon_{\text{reloc}}^F|$ is shown by the dotted lines in figure 1 on the next page and formalised in following proposition.

Proposition 4 *For interior equilibria the relocation elasticity $|\epsilon_{\text{reloc}}^H|$ 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 to F .*

As the elasticity becomes very large when a country is almost completely deserted by the manufacturing firms, the elasticity of relocation in a smaller low-cost country may decline over a small interval of ϕ when firms start returning as trade costs become low enough. In both panels of figure 1 on the following page, $s_E > 1/(1 + \epsilon^2)$, 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 $|\epsilon_{\text{reloc}}^H|$ and $|\epsilon_{\text{reloc}}^F|$ are monotonically

⁷To 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.

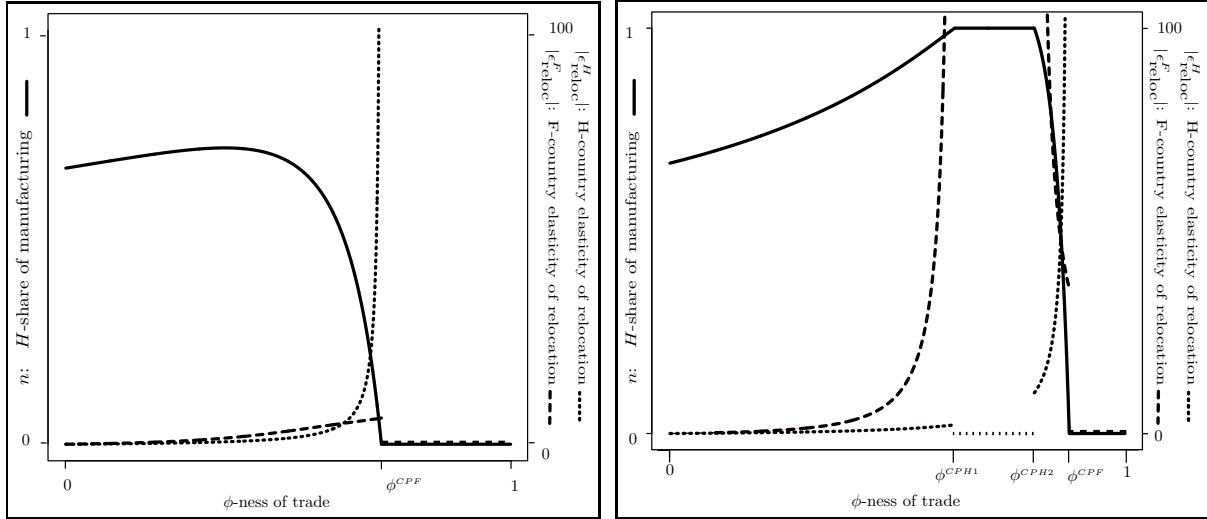


Figure 1: The share of manufacturing firms in country H (left scale, full line) and the sensitivity of this share to changes in production costs $|\epsilon_{\text{reloc}}^H|$ (dotted line, right scale), both as a function of trade freeness. The left panel shows the case of a large wage handicap in country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

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 , $|\epsilon_{\text{reloc}}^F|$ becomes infinitely large but then declines again when firms return to F , beyond ϕ^{CPH2} .

3 Wage determination

In standard NEG-models prices for immobile variable inputs are often 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 Vandebussche (1998).

When goods market clear, the pricing rules in (3) and the demand for goods from

equation (1) are sufficient to determine firm factor demand and profits given factor prices:

$$\begin{aligned}
r_H &= \frac{(a_H w_H)^{1-\sigma}}{\sigma} \mu [s_E P_H^{\sigma-1} + (1-s_E) P_F^{\sigma-1}] \\
l_H^d &= \frac{\beta_l (a_H w_H)^{1-\sigma}}{\omega_{Hl} \eta} \mu [s_E P_H^{\sigma-1} + (1-s_E) P_F^{\sigma-1}] = \frac{\beta_l (\sigma-1)}{\omega_{Hl}} r_H \\
k_H^d &= \frac{\beta_k (a_H w_H)^{1-\sigma}}{\omega_{Hk} \eta} \mu [s_E P_H^{\sigma-1} + (1-s_E) P_F^{\sigma-1}] = \frac{\beta_k (\sigma-1)}{\omega_{Hk}} r_H \\
&\dots
\end{aligned} \tag{11}$$

Some notation 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 wages⁸ and s_E for the share of consumers or the relative market size of country H . The P 's are the manufacturing price indices from equation (4). The above equations then allow to determine the reaction of firms to changes in factor prices and both unions and firms take this into account when bargaining over wages.

We consider two different bargaining frameworks, which differ importantly in how the bargaining agents perceive which of the above quantities depend on the set wage.

- 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 n and the manufacturing price indices P . Only changes in firm level labour demand and wages (for the union) and profits (for the capital owner) are considered.
- Bargaining at the sector level. Here we assume the number of firms in a sector is small enough so effects on aggregate quantities such as the overall price level are still ignored. As bargaining takes place for a group of firms, however, a union now might opt to raise wage demands despite the fact some firms will relocate in response.

The firm-level bargaining framework is 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 quite different results. For both frameworks we model the wage bargaining as a cooperative Nash bargaining game. The resulting wage is calculated as the wage maximising following Nash-product (see, for example, Layard, Nickell, and

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

Jackman (1991)):

$$\begin{aligned} \omega_H = \arg \max_{\omega_H} [U_H - U_H^o]^{\theta_H} [V_H - V_H^o]^{1-\theta_H} \\ \text{s.t. } U_H > U_H^o \text{ and } V_H > V_H^o, \end{aligned} \quad (12)$$

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.

We will now fix functional forms for U_H, U_H^o, V_H and V_H^o for both frameworks, 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

For the utility of the capital owner we follow the literature and simply take real capital rents $V_H = r_H/P_H^*$, where P_H^* is the overall price level in country H . For the union utility we also follow a standard specification where union utility equals 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 (11). 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.

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 assumption of perfect mobility of firms in the NEG model. If firms can threaten to relocate, potential profits in the other country are highly relevant to the wage bargaining process and act as the firms' fall-back utility in the case of negotiation failure. Leaving out 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 a rational union should make the same fixed wage demand, even if the firm on the other side of the negotiation table credibly threatens to relocate unless wages are lowered. We take into account the option to relocate by setting the firm outside option to real foreign profits: $V_H^o = r_F/P_H^*$. As we assume only the footloose capital is internationally mobile while the capital owner is immobile the H -country price index is relevant to calculate her real income. Substituting these specifications in the Nash-product

gives:

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

As firms are atomistic under monopolistic competition and bargaining takes place on the firm level the manufacturing price indices P_j and the overall price level P_H^* are perceived as independent of ω_H . Solving the first order condition for the wage bargaining solution then gives

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

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 holds in general. z_H is the relative gain of being located 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 (9), 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 or $r_F = r_H$, 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 positive 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 a fixed markup over the alternative wage.⁹ 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 The wage markup is zero in a long run inter-*

⁹These authors use $\omega_A = \beta_l = 1$.

nal equilibrium. The wage markup is positive only if there exists an international profit differential. If a markup exists it is increasing in the union bargaining power θ_H and the alternative wage ω_H^A and decreasing in the elasticity of labour demand.

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. 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 on the next page 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.

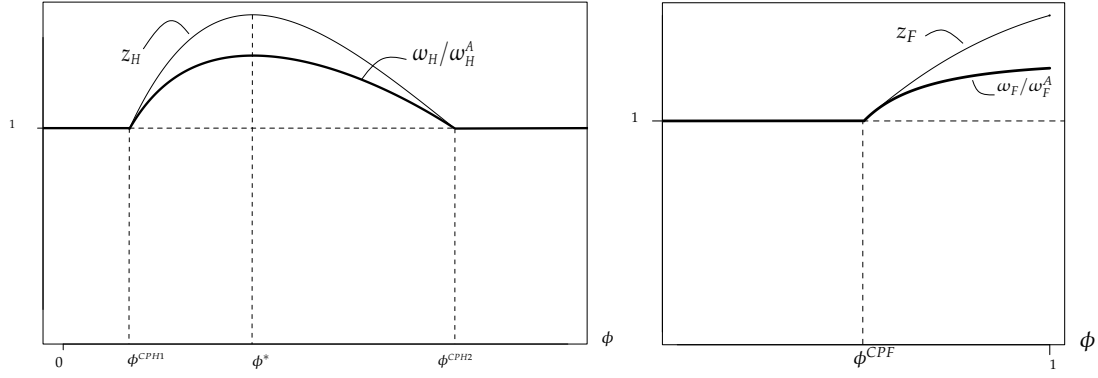


Figure 2: Agglomeration rents and wages with firm-level bargaining. The left panel shows agglomeration rents and wages if full agglomeration occurs in the larger country (for $\phi^{CPH1} < \phi < \phi^{CPH2}$), the right panel for full agglomeration in the smaller country (for $\phi > \phi^{CPF}$). Only if full agglomeration occurs there exists a wage markup $\omega_j > \omega_j^A$. For interior solutions ($0 < n < 1$), $z_j = 1$ and by equation (13) $\omega_j = \omega_j^A$.

3.2 Sector level bargaining

With firm-level bargaining firms can perfectly threaten to relocate in an internal international equilibrium distribution of firms as such an equilibrium 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 not the case, however, 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 a higher overall price level, 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 overall price level 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 assume an employer federation seek to maximise the joint profits of the firms located in country H . In terms of the cooperative Nash-bargaining framework of equation (12) this implies $V_H = \bar{r}_H/P_H^* = nr_H/P_H^*$. This federation bargains with a representative union maximising total wages paid to manufacturing workers or $U_H = \bar{l}^d/P_H^* = nl^d\omega_H/P_H^*$. As all manufacturing workers have the option to work in the CRS-sector at wage ω_H^A we have $U_H^o = l^d\omega_H^A/P_H^*$. Both parties take into account the firms' labour adjustment to wage changes and also the fact that firms will relocate to the foreign country as wages are increased. Both parties, however, ignore the effect of their actions on the aggregate price level P_H^* .¹⁰ Again, the wage resulting from such a bargaining process is modelled as the wage maximising a Nash-product:

$$\omega_H = \arg \max_{\omega_H} \Omega(\omega_H) = [\bar{l}^d(\omega_H - \omega_H^A)]^{\theta_H} [\bar{r}_H]^{1-\theta_H} / P_H^*. \quad (14)$$

The resulting wage markup over the competitive wage can be found from solving the first order condition

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

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

In our specific NEG-model, because of the quasi-linear structure of utility, aggregate demand and profits in a country are not influenced by wages, prices or the number of firms in equilibrium. If all firms face the same increase in wages, all firms respond by increas-

¹⁰This assumption is reasonable if expenditures on manufacturing are a small part of total income or, alternatively, if we would extend the model with multiple relatively small manufacturing sectors in stead of the single sector we used so far.

ing prices. Although firms face decreasing demand, their market shares and profits are not affected (unlike in the firm-level case). We therefore have $\epsilon_{r_H,\omega} = \epsilon_{r_H,n} = \epsilon_{l,n} = 0$. Also, because of the Cobb-Douglas structure of the variable part of production, we have $l^d = (\sigma - 1)\beta_l r_H / \omega_H$. As r_H is unaffected by wages in equilibrium we have $l^d = c / \omega_H$ where c does not depend on wages and consequently $|\epsilon_{l^d,\omega}| = 1$. The above expression then simplifies to

$$\boxed{\frac{\omega_H - \omega_H^A}{\omega_H^A} = \frac{\theta_H}{|\epsilon_{\text{reloc}}^H|}} \quad (15)$$

A first important comparative static result of the wage bargaining outcome we want to establish is on the effect of changes in the freeness of trade parameter ϕ . For the larger country and for interior equilibria there exists a positive wage markup which is decreasing in ϕ as $|\epsilon_{\text{reloc}}|$ is increasing in ϕ . The situation for full agglomeration is more complicated. Looking at the right panel of figure 1 on page 13, considering the change in the elasticity of relocation depicted there and the role of this elasticity in equation (15) one might think that when all firms agglomerate in H the elasticity of relocation drops to zero and 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. The elasticity of relocation only drops to zero *locally*, for small changes in wages. Maximising (15) assuming overall firm immobility would lead to wages high enough to induce firms to relocate. This is illustrated in figure 3, showing the value of Ω (the Nash-product we are maximising) from equation (14) both for the region of wages leading to of an internal equilibrium, where $\epsilon_{\text{reloc}} \neq 0$, denoted by $\Omega(\omega)$ -internal and the region of wages leading to complete agglomeration denoted by $\Omega(\omega)$ -CP.¹¹ In the left panel, trade costs are relatively high with $\phi = 0.2$. As we argued above, countries then are relatively autarkic making relatively high wage demands can be made without inducing massive firm relocation. We see wages are set such that both countries contain some firms. In the right panel trade costs are relatively low ($\phi = 0.5$) and the wage bargaining outcome is the corner solution $\epsilon = \epsilon^{CPH}$. The fact that Ω -CP is always increasing in ϕ assures either the internal equilibrium prevails or the corner solution.

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*

¹¹The figure is drawn for a large H country ($s_E = 4/5$), other parameters are $\sigma = 2$, $\beta_l = 0.5$, $\theta_H = 0.5$, $\omega_a = 1.5$, $\omega_F = 1.5$

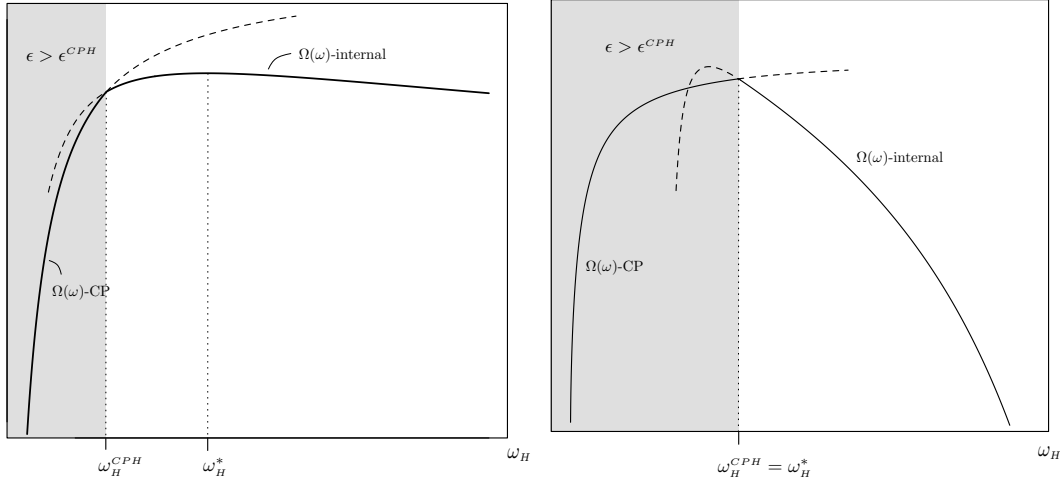


Figure 3: Sector level wage bargaining. In the left panel ($\phi = 0.1$) the internal solution is chosen. In the right panel ($\phi = 0.13$) the wage is set at the CP-level.

and an increase in ϕ leads to lower wage markups as $|\epsilon_{reloc}|$ is strictly increasing in ϕ . When a core-periphery structure emerges, wages are a hump-shaped function of ϕ if agglomerations forces are strong and strictly decreasing otherwise. 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 wages are monotonically increasing in ϕ .

As trade costs decrease, ω_H^{CPH} will first increase then decrease. It depends on the size asymmetry and the foreign wage level, however, whether the corner solution will be chosen for the entire interval of trade-freeness over which ω_H^{CPH} is hump-shaped, only for the decreasing part or not at all. Analytical parameter boundaries cannot be established, but in general, the larger the size and production cost advantage of the larger country, the more likely $\omega_H = \omega_H^{CPH}$ will be chosen for some interval of ϕ and the more likely wages will be hump-shaped for some interval. This is illustrated in figure 5 on page 23. The left panel shows the case with large agglomeration forces $\sigma = 1.2$, the right panel for $\sigma = 2$. The shaded area shows combinations of foreign wages (horizontal axis) and the market size (vertical axis) for which the corner solution is chosen. For parameter combinations in the darker area, the corner solution is chosen even for relatively low levels of ϕ , making wages a hump-shaped function of ϕ over some interval of ϕ . We see that only in the presence of large agglomeration forces the wage bargaining outcome is a hump-shaped function of the

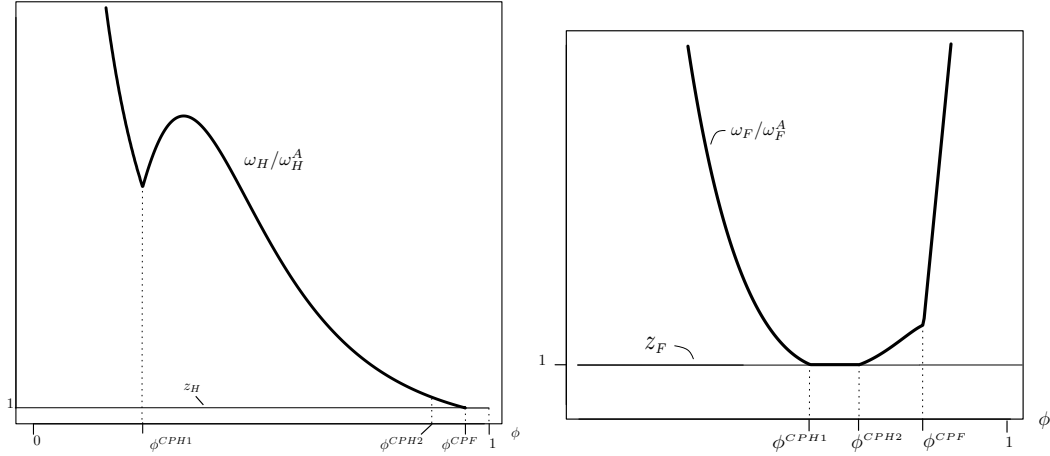


Figure 4: Agglomeration rents and wages with sector-level bargaining in the larger country (left panel) and the smaller country (right panel). Unless a country is completely deserted, there exists a wage markup $\omega_j > \omega_j^A$. Note that even for interior solutions wages in the smaller country are not always decreasing in ϕ . Note all agglomeration rents are appropriated by the unions ($z_H = 1$)

freeness of trade in the case of firm level bargaining.¹²

Comparing the sector and firm level wage bargaining outcome, it is obvious that sector-level wage bargaining leads to higher equilibrium wages. 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.

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

¹²This is also due to the fact $|\epsilon_{l^d, \omega}| = -1$. In a model without linear utility, $|\epsilon_{l^d, \omega}| < -1$, there is some constant present in the denominator of (15) and wages are overall lower for internal equilibria. Wages then reach the corner solution for lower levels of ϕ and are hump-shaped for a much larger set of parameter combinations.

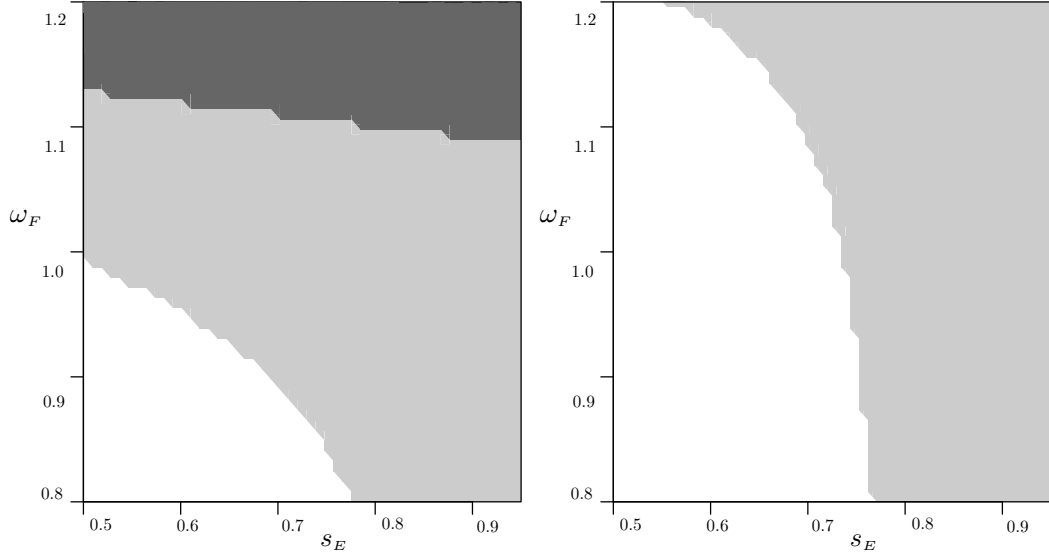


Figure 5: The grey areas show combinations of s_E and ω_F for which the corner solution $\omega_H = \omega_H^{CPH}$ is chosen for some level of ϕ . Only if agglomeration forces are strong enough (left panel, $\sigma = 1.2$) there exist combinations of s_E and ω_F (dark-grey area) for which H -country wages are a hump-shaped function of ϕ . If agglomeration forces are weaker (right panel, $\sigma = 2$) there exists no such interval.

solution with respect to a change in the foreign wage ω_F shows

$$\frac{d\omega_H}{d\omega_F} = -\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \bigg/ \frac{\partial^2 \Omega_H}{\partial \omega_H^2} \geq 0 \quad (16)$$

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 (16) 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 (10) 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.¹³

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 $|\epsilon_{\text{reloc}}|$ reaches a minimum at ω_F^\dagger , which is (by equation (15)) why the wage bargaining solution ω_H reaches a maximum at this point.

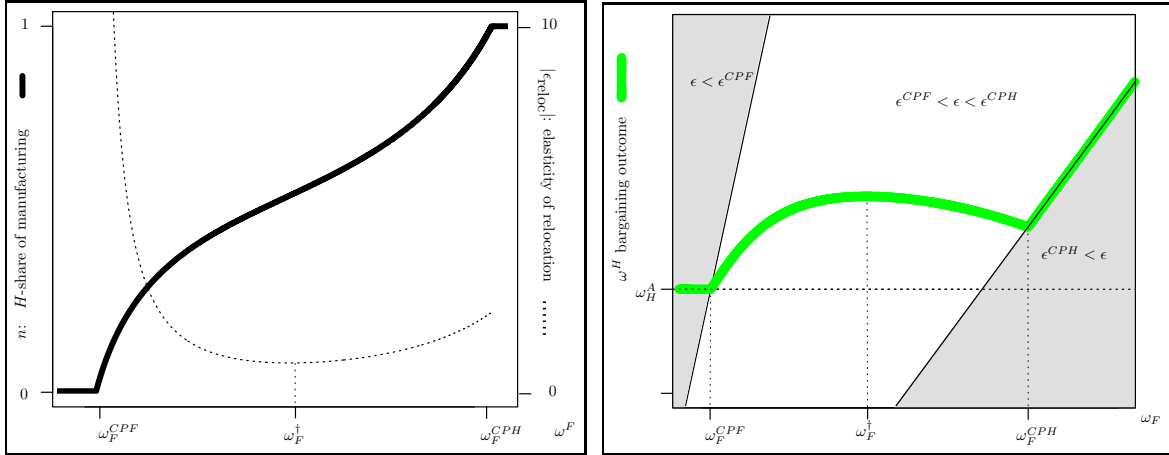


Figure 6: The international distribution of firms and the relocation elasticity (left panel) and the wage bargaining solution in country H (right panel) as a function of the foreign wage ω_F .

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 investigate the stability of this equilibrium by considering a so-called Cournot tatōnement where the agents in both countries are short-sighted and sequentially bargain over wages, taking the bargaining outcome of the other

¹³It can be shown the elasticity does not have such an interval over which it is decreasing in wages if trade costs are larger than $1/\sqrt{2}$.

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 system of equations for the international non-cooperative Nash-equilibrium in wages for the case of sector-level bargaining: (15).

$$\left. \begin{aligned} \frac{\partial \Omega_H(\omega_H^{NE}, \omega_F^{NE})}{\partial \omega_H} = 0 \\ \frac{\partial \Omega_F(\omega_F^{NE}, \omega_H^{NE})}{\partial \omega_F} = 0 \end{aligned} \right\} \Rightarrow \begin{aligned} \frac{\omega_H^{NE} - \omega_H^A}{\omega_H^A} - \frac{\theta_H}{|\epsilon_{\text{reloc}}^H(\omega_H^{NE}, \omega_F^{NE})|} = 0 \\ \frac{\omega_F^{NE} - \omega_F^A}{\omega_F^A} - \frac{\theta_F}{|\epsilon_{\text{reloc}}^F(\omega_H^{NE}, \omega_F^{NE})|} = 0 \end{aligned} \quad (17)$$

If countries are asymmetric possibly different wage levels are needed both countries to solve (17) which complicates matters significantly. We therefore first consider the more simple case of symmetric countries.

4.1 International wage competition with symmetric countries

Under perfect symmetry have $s_E = 1/2$ and under the assumption of productivity equivalent factor price equalisation, as both countries have the same reaction functions we must have equal wage bargaining outcomes and therefore $\omega_H = \omega_F$ or $\epsilon = 1$. We then obtain for the equilibrium wage in both countries:

$$\frac{\omega^{NE} - \omega^A}{\omega^A} = \frac{\theta_H}{|\epsilon_{\text{reloc}}|_{\text{symm}}}, \quad |\epsilon_{\text{reloc}}|_{\text{symm}} = 2(\sigma - 1)\beta_l \frac{\phi}{(1 - \phi)^2}. \quad (18)$$

The symmetric relocation elasticity is clearly 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 Nash-equilibrium wages are decreasing in ϕ . For perfectly free trade ($\phi = 1$), wages are set at the competitive level.*

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 never occurs, excluding agglomeration rents to play a role in the bargaining outcome. This also implies firm-level bargaining with symmetric countries leads to 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 sector level 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 complements¹⁴ 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 more classical means such as 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 (17) 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.¹⁵ Wages will then locally converge to the Nash equilibrium over time if at the Nash-equilibrium

$$\left| \begin{array}{cc} \frac{\partial^2 \Omega_H}{\partial \omega_H^2} & \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \\ \frac{\partial^2 \Omega_F}{\partial \omega_F \partial \omega_H} & \frac{\partial^2 \Omega_F}{\partial \omega_F^2} \end{array} \right| > 0. \quad (19)$$

We confirmed numerically that condition (19) holds at $\omega_H^{NE}, \omega_F^{NE}$. This proves the Nash equilibrium as described in (17) is stable in that sequential international wage bargaining

¹⁴Also known as super-modular games.

¹⁵This is a so-called Cournot tatōnement. 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.

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 (17) for some parameter, say ξ , and solving (for example for the H country) for $\frac{\partial \omega_H^{NE}}{\partial \xi}$:

$$\frac{\partial \omega_H^{NE}}{\partial \xi} = \left| \begin{array}{cc} -\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \xi} & \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \\ -\frac{\partial^2 \Omega_F}{\partial \omega_F \partial \xi} & \frac{\partial^2 \Omega_F}{\partial \omega_H^2} \end{array} \right| \bigg/ \left| \begin{array}{cc} \frac{\partial^2 \Omega_H}{\partial \omega_H^2} & \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \\ \frac{\partial^2 \Omega_F}{\partial \omega_F \partial \omega_H} & \frac{\partial^2 \Omega_F}{\partial \omega_F^2} \end{array} \right|. \quad (20)$$

We already numerically confirmed the denominator is positive at the Nash-equilibrium, 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 $-\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \xi} \frac{\partial^2 \Omega_F}{\partial \omega_F^2}$. As $\frac{\partial^2 \Omega_F}{\partial \omega_F^2}$ is negative at the bargaining solution because of the SOC, we have

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

In words: if a parameter only appears in a single country's bargaining problem direction of the effect of a rise in it on the country's Nash-equilibrium wage depends on how the parameter affects the wage bargaining outcome 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 such parameters. For example with $\xi_H = \omega_H^A$ 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 to equal

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

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

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 equilib-

rium wage as

$$\text{sign} \left(\frac{\partial \omega_F^{NE}}{\partial \phi} \right) = \text{sign} \left(\frac{\partial^2 \Omega_H}{\partial \omega_H \partial \omega_F} \frac{\partial^2 \Omega_F}{\partial \omega_F \partial \phi} - \frac{\partial^2 \Omega_F}{\partial \omega_F^2} \frac{\partial^2 \Omega_H}{\partial \omega_H \partial \phi} \right). \quad (23)$$

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 $\frac{\partial^2 \Omega_F}{\partial \omega_F \partial \phi} \geq 0$ 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 decreasing wages for the agglomeration in the larger country and monotonically increasing wages for agglomeration in the smaller country respectively. 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 (7) and (8) 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 7 on the following page 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 $\phi = 0.5$ (full lines) 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 (19) assures the slopes of the reaction functions are not too large, making sequential international wage bargaining will eventually lead to the new Nash-equilibrium as illustrated in the figure. 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 $\phi=0.69$. 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 occurs in the smaller country and for levels of ϕ so high markups are already very low.

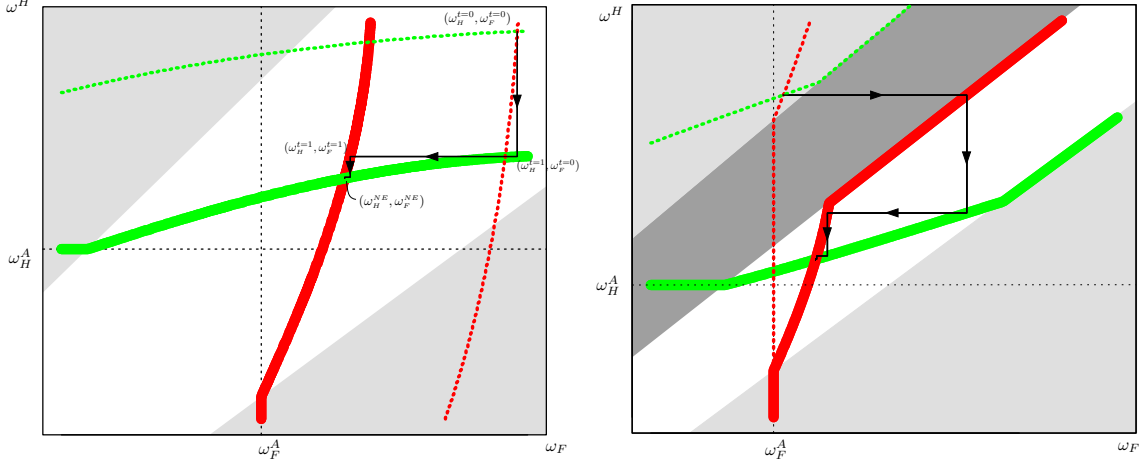


Figure 7: In the symmetrical case, lower trade costs always lead to lower international wage markups (left panel). If one country is smaller and has a lower reservation wage it might see higher wages if trade costs decrease, even for internal equilibria.

For ϕ approaching 1 trade is next to free and only the production cost advantage plays a role in firm location. All firms will therefore eventually locate in the country which is able to lower wages such that its total production costs are below the foreign one. It should be clear that the union in the peripheral country would only be willing to see all firms leave their country if 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 productivity equivalent factor price equalisation condition holds perfectly we have $w_j^A a_j^A = w_k^A a_k^A$. Solving for w_F^A and substituting in the previous inequality then gives as a 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.*

The fact firms locate in function of a country's comparative advantage if trade costs become low enough is quite unsurprising. The more important results of this section and the paper as a whole are the non-monotonic relationship between equilibrium wages and trade costs or the fact wages need not act as strategic complements in an international setting. 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.¹⁶ 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 (2.1) then becomes

$$C_{ij}(x) = r_j + a_i a_j w_j x. \tag{24}$$

¹⁶See for example Cabral and Mata (2003). For the pareto distribution skewness increases with ρ . For $\rho = 1$ the distribution is uniform.

From which we derive the new pricing equations similar to equation (3)

$$\begin{aligned}
p_{ijj} &= \eta a_i a_j w_j & j &\in \{H, F\} & \text{(local sales)} \\
p_{ijk} &= \tau \eta a_i a_j w_j = \tau p_{ijj} & j, k &\in \{H, F\} \quad j \neq k. & \text{(exports)} \quad ,
\end{aligned} \tag{25}$$

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 manufacturing price indices can then be written as

$$\begin{aligned}
P_H &= \left[\int p(z)^{1-\sigma} dz \right]^{\frac{1}{1-\sigma}} \\
&= \left[\int_0^{\frac{1}{2}} \int_0^{a_R} [\tau \eta a w_F]^{1-\sigma} f(a) da dz + \int_0^{\frac{1}{2}} \int_{a_R}^1 [\eta a \omega_H]^{1-\sigma} f(a) da dz \right. \\
&\quad \left. + \int_{\frac{1}{2}}^1 \int_0^1 [\tau \eta a w_F]^{1-\sigma} f(a) da dz \right]^{\frac{1}{1-\sigma}} \\
&= \eta a_F \omega_F \left(\frac{\lambda}{2} \right)^{\frac{1}{1-\sigma}} \left[\phi a_R^{1-\sigma+\rho} + \epsilon (1 - a_R^{1-\sigma+\rho}) + \phi \right]^{\frac{1}{1-\sigma}}, \\
P_F &= \eta a_F \omega_F \left(\frac{\lambda}{2} \right)^{\frac{1}{1-\sigma}} \left[1 + a_R^{1-\sigma+\rho} + \epsilon \phi (1 - a_R^{1-\sigma+\rho}) \right]^{\frac{1}{1-\sigma}}.
\end{aligned} \tag{26}$$

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 (5) must also be adapted accordingly:

$$\begin{aligned}
r_H &= \frac{2\mu a^{1-\sigma}}{\sigma \lambda} \epsilon \left[\frac{s_E}{\Delta_H} + \phi \frac{1-s_E}{\Delta_F} \right] & r_F &= \frac{2\mu a^{1-\sigma}}{\sigma \lambda} \left[\phi \frac{s_E}{\Delta_H} + \frac{1-s_E}{\Delta_F} \right], \\
\Delta_H &= \phi a_R^{1-\sigma+\rho} + \epsilon (1 - a_R^{1-\sigma+\rho}) + \phi & \Delta_F &= 1 + a_R^{1-\sigma+\rho} + \epsilon \phi (1 - a_R^{1-\sigma+\rho}).
\end{aligned} \tag{27}$$

Equating the return to capital and solving for a_R gives

$$a_R^{*1-\sigma+\rho} = \frac{(1-\epsilon^2)\phi - 2\epsilon(1-\phi)(s_E - \frac{1}{2})}{(1-\epsilon\phi)(\epsilon - \phi)}, \quad (28)$$

which can also be easily shown to be locally stable. Comparing to the homogeneous case from equation (6) 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.

$$\epsilon^{CPH} = \frac{1 - s_E(1 - \phi^2)}{\phi} \quad \epsilon^{CPF} = \frac{\phi}{\phi^2 + s_E(1 - \phi^2)}. \quad (29)$$

The expression for agglomeration in country F is obtained by setting $a_R = 1$ in equation (28) and solving for ϕ . For country H we have to switch labels.¹⁷ 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 (27)

$$z_F = \frac{r_F}{r_H} \Big|_{a_R=1} = \frac{\phi}{\epsilon(\phi^2 + s_E - \phi s_E^2)} = \frac{\epsilon^{CPF}}{\epsilon}. \quad (30)$$

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:

$$z_H = \frac{r_H}{r_F} \Big|_{a_R=1} = \frac{\phi\epsilon}{\phi^2 s_E + 1 - s_E} = \frac{\epsilon}{\epsilon^{CPH}}, \quad (31)$$

¹⁷To 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 (28) 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

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

$$\int_{a_R}^1 l(a)f(a)da = \frac{\rho}{1 - \sigma + \rho} [1 - a^{1-\sigma+\rho}] l^d \quad (32)$$

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

$$\epsilon_{\text{reloc}}^H = \frac{\partial(1 - a_{pR}^*)}{\partial\omega_H} \frac{\omega_H}{(1 - a_{pR}^*)} = \beta_l \epsilon^{\text{CPF}} (\sigma - 1) \frac{s_E(1 - \epsilon^2)(1 - \phi^2) - (1 - \epsilon\phi)^2}{(\epsilon - \phi)(1 - \epsilon\phi)(\epsilon - \epsilon^{\text{CPF}})} < 0. \quad (33)$$

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

Proposition 11 *With costless relocation, in the context of the simple NEG model introduced in this paper, 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

$$z = \gamma \frac{r_H}{r_F - \chi}, \quad (34)$$

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 obtained after relocation¹⁸ 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.

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

¹⁸for example because a firm becomes proportionally less productive after relocating

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 equalised internationally. This can occur because although some firms relocate in response to wage demands a sector level union may still prefer higher wages in the remaining firms. It was shown that as long as both countries contain some firms the wage bargaining outcome depends directly 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 is different for the case of sector level firm bargaining because of corner solutions in the bargaining problem. It turns out that with sector level bargaining lower trade costs need not lead to lower wage demands. Wages generally decrease as transport costs become lower. If asymmetries are large enough and agglomeration forces are strong enough, however, wages can be hump-shaped in a fully agglomerated country, as in the firm-level case. If agglomeration occurs in the smaller country (if it has a comparative advantage) wages there increase if trade costs become even lower. If the shift from the larger country to the country with a comparative advantage is fast enough as trade costs become lower, wages in the smaller country can be increasing even if both countries contain some firms.

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 complete agglomeration becomes possible and the same results as for the case with exogenous foreign wages was obtained, with a possible non-monotonic relationship between trade costs and the wage bargaining outcome. We showed wages need not act as strategic complements if asymmetries are large enough. This is an interesting result as it implies, for example, that stronger foreign unions will lead to higher foreign wages but this might translate into a lower equilibrium domestic 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.

The main point of this paper is that in the presence of asymmetries increased economic integration need not lead to race-to-the-bottom wage competition and foreign wage decreases need not lead to domestic wage decreases. The model we used provides a simple framework linking imperfect labour markets internationally. Quite a large number of studies have empirically investigated the link between for example, labour demand in one country and domestic and foreign wage setting. The model introduced in this paper provides clear hypothesis on exactly how these effects can be expected to materialise. One prediction would be for example that for sufficiently symmetric countries 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 move first). An interesting venue for future research 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 (6) 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.

$$\left. \frac{\partial(r_F - r_H)}{\partial n} \right|_{n=n} = -\frac{(\epsilon - \phi)^2(1 - \epsilon\phi)^2\mu}{\epsilon^2(1 - \phi)^2(1 + \phi)^2\sigma} < 0 \quad (35)$$

At the equilibrium n from equation (6) $r_F - r_H = 0$ 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::

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

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

$$\frac{d\omega_H}{d\omega_H^A} = \left(1 + \frac{\theta_H}{(|\epsilon_{l^d,\omega}| - 1)\delta} \right) \left/ \left(1 + \frac{\omega_H^A}{(|\epsilon_{l^d,\omega}| - 1)\delta^2} \frac{d\delta}{d\omega_H} \frac{d\omega_H}{d\omega_H^A} \right) \right. > 0.\tag{37}$$