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Union Wage Demands with Footloose Firms[☆]

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Abstract

This paper analyses the wage demands of a sector-level monopoly union facing internationally mobile firms. A simple two-country economic geography model is used to describe how firms relocate in function of international differences in production costs and market size. The union sets wages in function of the firm level labour demand elasticity and the responsiveness of firms to relocate internationally. If countries are sufficiently symmetric lower foreign wages and lower trade costs necessarily lead to lower union wage demands. With asymmetric countries these intuitive properties do not always hold. But even for symmetric countries it holds that small increases in market size or trade costs makes union wages more sensitive to the foreign wage level.

Key words: Unions, globalisation, economic geography JEL: J50, J31, F16

1. Introduction

After a period of spiralling inflation, rising labour costs, numerous firm closures and increasing unemployment the Belgian government decided to impose a nation-wide maximum yearly wage increase for sectoral labour agreements in 1988. It was hoped such legislation would promote employment and pre-emptively secure the international competitiveness of the country. Since 1996 this maximum wage increase has been calculated bi-yearly as an explicit function of the average wage evolution in the neighbouring countries. Employees

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and unions tend to be less supportive of limiting wages as a means of securing employment and some rather point to 'artificially low' wages in foreign countries as the main cause of unemployment and firm relocation. What is common in the view of government and workers, however, is the perception of local and foreign wages as being strategic variables which can be used to attract foreign firms and increase employment. Viewing wages as strategic variables raises many questions: is lowering wages instrumental to attracting firms and increasing employment? Does tying wages to the foreign level secure employment? Does freer trade lead to race-to-the-bottom wage competition between countries?

Such questions are immaterial in classical models of international trade as they mostly rely on perfect product and labour markets where there are no firm profits and wages are purely competitive. Starting with Brander and Spencer (1988) and Mezzetti and Dinopoulos (1991), however, quite a few authors have analysed unionised labour markets in the context of oligopolistic competition with immobile firms, or allowing for FDI as in the model of Konings and Vandenbussche (1998). The effect of falling trade costs on wages is a central research question in this strand of literature, such as for Naylor (1999) who also solves for the international Nash-equilibrium with wage bargaining occurring simultaneously in two symmetric countries.

Picard and Toulemonde (2003, 2006), De Bruyne (2004) and Munch (2003), among others, consider the effects of unionisation on the location choice of firms within economic geography models. In this paper we also use a NEG model with perfectly mobile firms, but rather focus on how the firms' location choice affects union wage demands. We start from a simple NEG model explaining where firms locate in function of international differences in market access, wages, labour productivity and trade costs. Unions then fully take into account how their wage demands affect labour demand and the international distribution of firms. The fact unions are explicitly aware of the possibility of firm relocation makes our model quite different from a part of the existing literature on union behaviour in an economic geography context, and our findings point out some inconsistencies in popular models.

Our approach is related to models of international tax competition with mobile firms such as 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 some of the tax base is lost when firms start relocating in response. When all firms prefer to locate in a single country where they earn higher profits, however, this international profit differential allows a government to tax without causing relocation. Similarly, in our model, if all firms prefer to locate in a single country the existence of agglomeration rents

allows wages to be increased up to a certain level without causing firm relocation. But a union acting on the sector level might find it optimal to set higher wages despite the relocation of some firms. We show the exact wage demand then depends on how many firms relocate for a given wage change. Through the introduction of a simple NEG model we are able to quantify both the 'wage elasticity of firm relocation' and the size of the agglomeration rents which determine union wage demands in case both countries contain firms and when all firms locate in a single country, respectively.

A key question we address using this model is whether lower trade costs necessarily lead to a lower wage demand. We find this intuition only holds if countries are sufficiently symmetric in terms of labour productivity and market size. For asymmetric countries a larger market size or the existence of a comparative advantage can induce all firms to agglomerate in a single country. With full agglomeration profits are no longer equalised internationally and the resulting agglomeration rents are appropriated by the union in the form of higher wages. As agglomeration rents are a hump-shaped function of trade freeness in the larger country, so are wages. But even when both countries contain firms, union wage demands may increase after trade liberalisation. This might help explain why some studies find proof of wage divergence between large EU member states after the major trade reforms of 1992, rather than convergence (see Webber, 2002; Webber and White, 2003).

Another counter-intuitive result of our model is that an exogenous decrease in the level of foreign wages does not necessarily lead to lower local union wage demands. Union wages thus do not act as strategic complements in an international context. This is surprising, as the manufacturing varieties produced by the unionised firms in both countries are substitutes in the model. The reason is that, although lower foreign wages cause some firms to relocate as long as both countries contain firms (and this runs counter to union interests), the marginal propensity of firms to relocate may actually decrease after the foreign wage decrease, leading to higher optimal union wage demands in the remaining local firms.

Moreover, it turns out that, at least for small changes around the symmetric case, larger, more closed countries are *more* sensitive to the foreign wage level. The reason is that, although the 'direct' effect of a larger market size is to make union wages less sensible to foreign wage changes, these changes also induce unions to increase their wage demands. As higher wages are more sensitive to foreign wage changes, it turns out that the total effect is that union wages become more sensitive to changes in the foreign wage level.

This paper consists of three sections after the introduction. Section 2 introduces a simple NEG model where wages are taken as given. We consider the effect of exogenous wage

changes on firm profits and the equilibrium international distribution of firms. In section 3 wages are set by a monopoly union which fully takes into account the results on firm behaviour. We determine how union wage demands react to changes in transport costs, foreign wages, and market size; and how the sensitivity of union wage demands with respect to foreign wage changes is affected by the market size of a country and the level of trade costs. A final section concludes.

2. A simple two-country NEG model

In this section we adapt the two-country footloose-capital model of Martin and Rogers (1995), allowing for international differences in wages and labour productivity. We establish how 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 result if this occurs. Throughout this section we take wages in both countries as given.

2.1. Model Setup

There are two countries, H and F. As in Pflüger (2004) the utility function of the representative consumer in both countries is quasi-linear in a homogeneous good C_A and a CES-composite of manufacturing varieties C_M.

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

Constrained utility maximisation gives rise to a simple demand function for the CES-composite $C_M = \mu P_k^{-1}$, 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. Demand for the homogeneous good is the residual of the individual income after subtracting expenditures on manufacturing goods, or $C_A = Y - \mu$. The demand function of a typical consumer in country k for a manufacturing variety q_{jk} produced in country j and sold in country k at price p_{jk} then is simply

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

Because of the quasi-linear utility specification, the demand for manufacturing goods of the typical consumer does not depend on her income. Total demand in k is simply the demand of the typical consumer times the exogenously given mass of consumers M_k in the country.

The homogeneous good A-sector is kept as simple as possible. We assume A-sector firms use a constant returns to scale technology with labour as the sole input. Countries may have different labour productivities. We write $1/\alpha_j$ for the quantity of labour required in country j to obtain one productivity-equivalent unit of labour and w_j^A for the reward to labour. Perfect competition in the A-sector leads to marginal cost pricing. Assuming costless trade implies prices, and therefore marginal costs, are equalised internationally. Choosing the A-sector good as the numéraire implies $p^A = 1$. The result is productivity-adjusted international wage equalisation for labour employed in the A-sector:

$$\frac{w_H^A}{\alpha_H} = \frac{w_F^A}{\alpha_F} = p^A = 1 \qquad \text{or} \qquad w_H^A = \alpha_H \quad \text{and} \quad w_F^A = \alpha_F.$$

Unlike the A-sector firms, 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 $1/\alpha_j$ units of labour are required per unit of output. The representative country j manufacturing firm's cost for producing x units of output is

$$C_j(x) = r_j + \frac{w_j}{\alpha_j} x.$$

w_j/α_j measures the labour cost of producing one extra unit of manufacturing output, the manufacturing unit labour cost in country j. Throughout, we assume $w_H \geq w_H^A$ (and in the next section the union will be shown to optimally set wages such that this holds). There is perfect labour mobility between the CRS and manufacturing sector, with the CRS sector absorbing all labour which is not hired by the manufacturing firms.

Manufacturing firms operate under monopolistic competition. Profit maximisation implies firms set consumer prices at a constant markup over marginal costs. The consumer price charged by a manufacturing firm located in country j for sales in country k is

$$\begin{aligned} p_{jj} &= \eta w_j/\alpha_j && j \quad \in \{H, F\} && \text{(local sales)} \\ p_{jk} &= \tau\eta w_j/\alpha_j = \tau p_{jj} && j, k \in \{H, F\}, \quad j \neq k && \text{(exports)} \end{aligned} \tag{2}$$

where we introduce $\eta = \frac{\sigma}{\sigma-1}$ to denote the fixed markup of price over marginal costs. 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 consumer price.

We assume the amount of capital in the world is fixed and normalise it to one. Using the

above pricing rules the manufacturing price indices in both countries can then be written as

$$\begin{aligned} P_H &= \left[\int_0^n p_{HH}^{1-\sigma}\, ds + \int_n^1 p_{FH}^{1-\sigma}\, ds\right]^{\frac{1}{1-\sigma}} \\ &= \left[n(\eta w_H/\alpha_H)^{1-\sigma} + (1-n)(\tau\eta w_F/\alpha_F)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \\ &= \eta\frac{w_H}{\alpha_H}\left[n + c\phi(1-n)\right]^{\frac{1}{1-\sigma}}, \\ P_F &= \eta\frac{w_H}{\alpha_H}\left[\phi n + c(1-n)\right]^{\frac{1}{1-\sigma}}. \end{aligned}$$

The indices are composed of a term stemming from sales of domestic firms and a terms stemming from imports. These are weighted by the number (or share) of firms in each country (there are n firms in H and $1-n$ firms in F), a parameter measuring trade freeness $\phi \equiv \tau^{1-\sigma}$ for imports, and a measure of the relative unit labour costs of country H, $c \equiv \left[\frac{w_H}{\alpha_H}/\frac{w_F}{\alpha_F}\right]^{\sigma-1}$. A higher ϕ means freer trade and a higher c corresponds to higher relative unit labour costs in country H.

Given the above pricing rules and taking into account that due to iceberg transport costs τx units of output have to be produced to sell x units abroad, operating profits are proportional to sales:

$$\pi = p_{jj}x_{jj} + \tau p_{jj}x_{jk} - \frac{w_j}{\alpha_j}(x_{jj} + \tau x_{jk}) = \frac{p_{jj}(x_{jj} + \tau x_{jk})}{\sigma}.$$

Given the fixed supply of capital its reward is bid up to the point where all these operating profits accrue to capital. Substituting the optimal pricing rules from equation (2) and consumer demand from equation (1) we obtain following expressions for the return to capital in both countries:

$$\begin{aligned} r_H &= \frac{\mu}{\sigma}\left[\frac{m}{\Delta_H} + \phi\frac{1-m}{\Delta_F}\right] \qquad & \Delta_H &= n + \phi c(1-n) \\ r_F &= \frac{\mu}{\sigma}\, c\left[\phi\frac{m}{\Delta_H} + \frac{1-m}{\Delta_F}\right] \qquad & \Delta_F &= \phi n + c(1-n). \end{aligned} \tag{3}$$

Here we write m for the share of world expenditure on manufactures in country H. Because per capita expenditure on manufacturing is fixed by the quasi-linear utility specification, the expenditure share of H is simply the share of consumers M_H/M_W located in the country. Moreover, as in the footloose-capital model of Martin and Rogers (1995) we assume capital to be mobile but the capital owners and consumers to be immobile. The share of manufacturing

expenditures in a country then is exogenous. Normalising the world mass of consumers $M_W = 1$, the market share of H is $0 < m < 1$ and $1 - m$ for country F.

The expressions for the reward to capital in both countries closely resemble these for firm sales in the classic core periphery model of Krugman (1991), as shown, for example, in equation (2.12) of Baldwin et al. (2003).[1] Our model is rather different in essence, however, as we assume capital rather than workers relocate and in our model expenditures on manufacturing in a country are exogenous due to the linear utility specification and the immobility of capital owners and consumers.

2.2. Interior equilibrium

Capital is mobile and is relocated to the country with the highest reward until profits are equalised (defining the long-run interior equilibrium), or until all capital is located in a single country (defining a corner solution). The capital owners are assumed to be immobile and therefore seek to maximise *nominal* returns. Equating the expressions for the return to capital from equation (3) and solving for n we obtain following expression for the unique interior long-run equilibrium share of capital in country H:

$$n = c\frac{(1-\phi^2)m - \phi(c-\phi)}{(c-\phi)(1-c\phi)} \qquad \text{if} \quad 0 < n < 1. \tag{4}$$

Following properties can be easily shown to hold.

Proposition 1. *For interior solutions, with exogenous wages, the share of manufacturing firms in a country is decreasing in its relative labour cost and increasing in its market size. A home-market effect holds as* $\partial n / \partial m > 1$.

Figure 1 illustrates how n depends on the market size m (left panel) and wages w_H (right panel). The home-market effect is at work in our model as $\partial n / \partial m > 1$: an increase in the expenditure share leads to a more than proportional increase in a country's share of manufacturing. Note that in the right panel, starting from the symmetric equilibrium, subsequent changes in wages have an increasing effect on the interior equilibrium distribution of firms: the curve n becomes steeper for extreme values of w_H. This will play an important role for the optimal union wage determination in section 3.

The effect of the trade freeness parameter ϕ on the interior distribution of capital n depends on the direction of production cost and market size asymmetries. Differentiating

[1] Divide by σ to obtain operating profits, divide numerator and denominator by the foreign wage level, take into account our normalisation of the world supply of both capital and total expenditures to one and apply our definition of c and m.

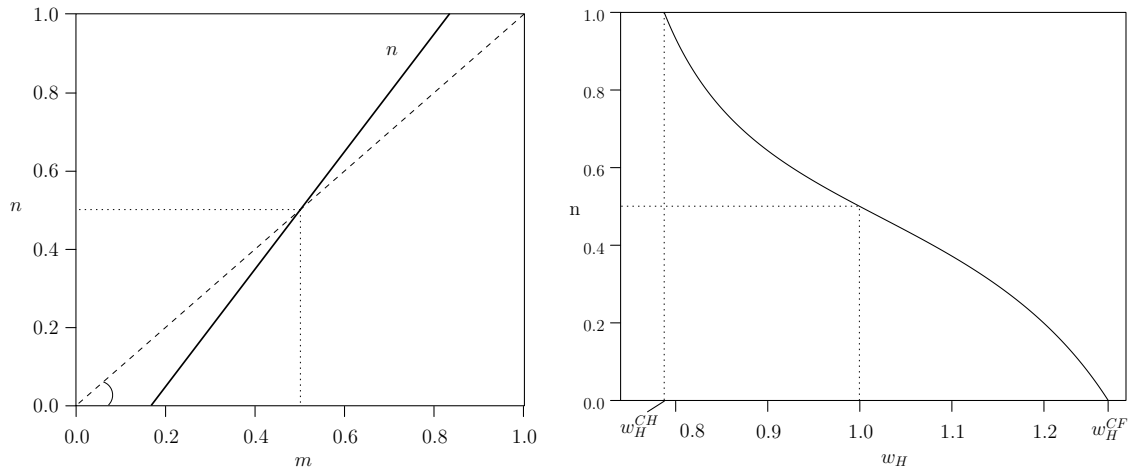

Figure 1: The effect of the relative market size (left panel) and production costs (right panel) on a country's share of manufacturing firms.

n with respect to ϕ shows that if wages are lower in the larger country, say H, freer trade (increasing ϕ) always leads to an increase in n. If wages are higher in H, but its size advantage is large enough with respect to the wage handicap in that $m > c^2/(1+c^2)$, firms initially increasingly locate in H for higher ϕ. For sufficiently high ϕ, however, firms eventually relocate toward the low wage country. For perfectly free trade only the production cost differential matters to firm profits: firms costlessly transport goods from the low wage country to where consumers are located. The following proposition therefore holds:

Proposition 2. *For interior solutions and exogenous wages,*

The share of firms in a large, low wage country always increases with freer trade. The share of firms in a small, high wage country always decreases with freer trade.

There exists a range of trade freeness where a large high-wage country attracts an increasing share of firms when trade becomes freer, provided its market is sufficiently large compared to its wage handicap. The condition is $m > c^2/(1+c^2)$ for country H.

There exists a level of $\phi < 1$ above which firms increasingly locate toward the low-wage country irrespective of any market size asymmetry.

2.3. Corner solutions

Propositions 1 and 2 describe how changes in c, m and ϕ affect the interior equilibrium distribution of firms as defined by equation (4). As H's share of firms is strictly decreasing in its labour costs and the world supply of capital (and thus firms) is fixed, there exists a critical level c^{CH} of labour costs c below which all firms find it optimal to locate in H. The

condition for $n = 1$ is[2]

$$c < c^{CH} \equiv \frac{\phi}{1 - m(1 - \phi^2)}.$$

In terms of ϕ the condition for full agglomeration in H is $\phi \in [\phi^{CH1}, \phi^{CH2}]$ with

$$\phi^{CH1} \equiv \frac{1 - \sqrt{1 - 4c^2 m(1-m)}}{2cm} \quad < \quad \phi^{CH2} \equiv \frac{1 + \sqrt{1 - 4c^2 m(1-m)}}{2cm}.$$

If $c < 1$ and $m > 1/2$, the upper critical value ϕ^{CH2} is irrelevant (as it is larger than one): all firms remain in H for all $\phi > \phi^{CH1}$ (see proposition 2). If $c > 1$ and $m < 1/2$, both critical values are irrelevant, as the combined market size and cost advantage of F make it impossible for H to attract the industrial core for any level of trade freeness. The isomorphic critical value for full agglomeration in F ($n = 0$) is

$$c > c^{CF} \equiv \frac{\phi^2 + m(1 - \phi^2)}{\phi}.$$

All equations and propositions relating to interior solutions are valid only if both countries contain firms, or $c^{CH} < c < c^{CF}$. It can be easily verified that $c > c^{CH}$ implies $1 - c\phi > 0$ and $c < c^{CF}$ implies $c - \phi > 0$. These conditions are weaker but often turn out to be sufficiently strong to sign equations. Following proposition summarises these results on the critical values for full agglomeration.

Proposition 3. *If asymmetries are sufficiently large compared to transportation costs, full agglomeration occurs. With* $c < c^{CH} \equiv \frac{\phi}{1-m(1-\phi^2)}$ *all firms agglomerate in* H*. If* $c > c^{CF} \equiv \frac{\phi^2+m(1-\phi^2)}{\phi}$ *all firms agglomerate in* F*.*

We will frequently use critical values in terms of absolute levels of wages rather then relative unit labour costs. Writing w_H^{CH} for the level of w_H for which all firms agglomerate in country H and using the definition of $c \equiv (\alpha_F w_H / \alpha_H w_F)^{\sigma-1}$ we have $c < c^{CH}$ if $w_H < w_H^{CH} \equiv \frac{\alpha_H w_F}{\alpha_F}(c^{CH})^{1/(\sigma-1)}$.

2.4. The wage elasticity of the international firm distribution

We saw that for interior equilibria increasing wages decrease a country's share of firms. It is convenient to express how fast small changes in wages cause international relocation of

[2]We use the superscript Cj to denote a critical level of a parameter or variable at which country j is able to attract the industrial core.

firms in terms of an elasticity. For the share of firms in H we define

$$\epsilon^{H}_{\text{reloc}} \equiv \frac{\partial n}{\partial w_{H}} \frac{w_{H}}{n} = (1-\sigma) \frac{m(1-\phi^2)(1-c^2) + (c-\phi)^2}{(c-\phi)(1-c\phi)(c^{CF}-c)} < 0, \quad \text{if} \quad 0 < n < 1. \tag{5}$$

When wages in H are increased up to the point where c approaches the level c^{CF} at which all firms relocate to country F, $\epsilon^{H}_{\text{reloc}}$ tends to minus infinity as the elasticity expresses $\partial n / \partial w_{H} < 0$ relative to an ever smaller base of remaining firms n. From now on we refer to the positive number $|\epsilon^{H}_{\text{reloc}}|$ as the elasticity of relocation. A similar expression can be written for changes in w_{F} from the point of view of the foreign country.

The elasticity of relocation will be key to the wage setting decision of the union in section 3.

2.5. Agglomeration rents

When all firms locate in a single country this prevents relocation to act as corrective arbitrage and (potential) profits may differ between countries. The resulting international profit gap or agglomeration rents play an important role for the union when determining the optimal wage demand. Taking the ratio of capital rents in both countries from equation (3), we can conveniently express the agglomeration rents for a firm located in country H as

$$\begin{aligned} z_{H} \equiv r_{H}/r_{F} &= \tfrac{c\phi}{(1-m+\phi^2 m)} = c^{CH}/c \qquad && \text{if} \quad n = 1 \\ z_{H} \equiv r_{H}/r_{F} &= 1 && \text{if} \quad 0 < n < 1. \end{aligned}$$

The agglomeration rents in H are higher the lower relative unit labour costs c are relative to the critical level where all firms agglomerate in H, c^{CH}. In the knife-edge case $c = c^{CH}$ and for interior equilibria firms earn equal profits in both countries, firms are indifferent between locations and there are no agglomeration rents, or $z_{H} = 1$. Some comparative statics of the agglomeration rents in the core-periphery configuration $n = 1$ will prove useful in the next section on the union wage demands:

$$\frac{\partial z_{H}}{\partial c} < 0 \qquad \frac{\partial z_{H}}{\partial m} > 0 \qquad \frac{\partial z_{H}}{\partial \phi} = \frac{1 - m(1+\phi^2)}{c[1-m(1-\phi^2)]^2}.$$

The first two results are not surprising: as firms are attracted by low production costs and large markets the agglomeration rents in H are decreasing in c and increasing in m. z_{H} is monotonically increasing in ϕ if $m \leq 1/2$, but is hump-shaped with a top at $\phi^{*} = \sqrt{\frac{1-m}{m}}$ if $m > 1/2$. Note that a smaller country can only attract the core if it has sufficiently low wages.

Following proposition summarises the results on the effect of trade freeness on agglomeration rents:

Proposition 4. *If a relatively small or equally sized country attracts all firms, agglomeration rents are monotonically increasing in the freeness of trade. If the larger country contains the core, agglomeration rents are a hump-shaped function of ϕ.*

2.6. Illustration

The effect of economic integration on the equilibrium distribution of firms n and the effect on the footlooseness of firms as expressed by $|\epsilon_{\text{reloc}}|$ is illustrated in figure 2. In both

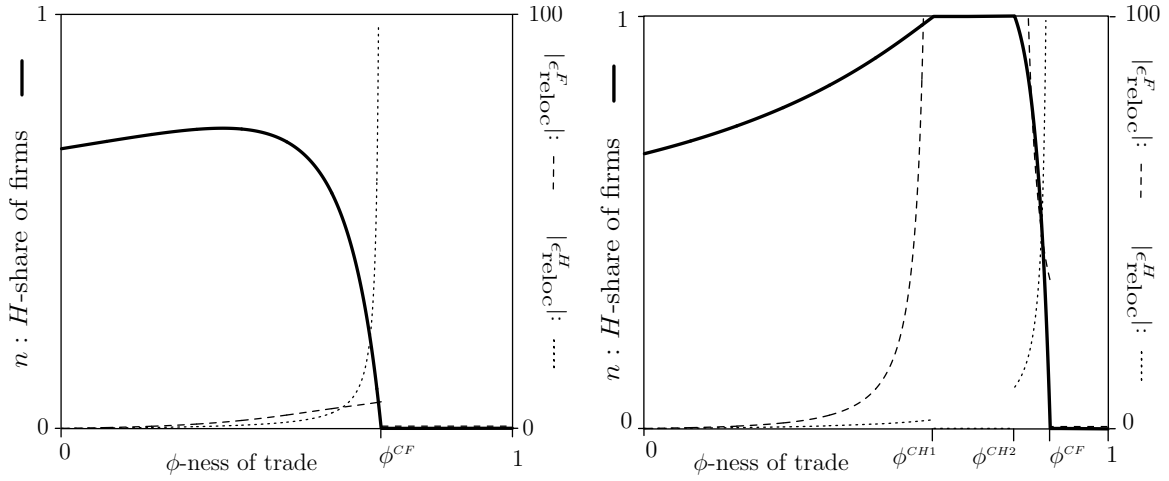

Figure 2: The share of manufacturing firms in country H (solid line, left scale) and the sensitivity of this share to changes in productions costs $|\epsilon^H_{\text{reloc}}|$ (dotted line, right scale), both as a function of trade freeness. The left panel shows the case of a large wage handicap in country H ($c = 1.18$) with $m = 2/3$. The right panel shows the case of a more moderate wage handicap $c = 1.04$.

panels $m > c^2/(1 + c^2)$, so initially H attracts more firms as trade costs decline. In the left panel there does not exist an intermediate interval of trade freeness where H can attract the core: its wage handicap is too large compared to its market size[3]. Both $|\epsilon^H_{\text{reloc}}|$ (dotted line) and $|\epsilon^F_{\text{reloc}}|$ (dashed line) which are a measure for the footlooseness of firms initially are monotonically increasing in ϕ as long as both countries contain some firms. When ϕ approaches ϕ^{CF}, the level where all firms leave H the sensitivity $\frac{\partial n}{\partial w_H}$ is expressed with respect to an ever decreasing remaining share of firms n and $|\epsilon^H_{\text{reloc}}|$ becomes infinitely large. For $\phi \geq \phi^{CF}$, $|\epsilon^F_{\text{reloc}}|$ is *locally* zero: firms in F do not relocate in response (small) changes in the F's wages when there exist agglomeration rents from locating in F. In the right panel the

[3]Such an interval exists if and only if $c < 1/2\sqrt{(1-m)m}$.

production cost handicap of H is relatively moderate and it attracts the industrial core for some intermediate interval of ϕ due to its larger market size. Note that in the right panel $|\epsilon^F_{\text{reloc}}|$ (dashed line) first becomes infinitely large as ϕ approaches ϕ^{CH1} and all firms locate in H. When trade becomes more free firms move back to F for ϕ between ϕ^{CH2} and ϕ^{CF} and $|\epsilon^F_{\text{reloc}}|$ declines over this interval.

3. Sector level union wage demands when firms are internationally mobile

So far we focused on the international distribution of firms, taking wages in both countries as given. Now let the wage in H be set by a monopoly union operating at the sectoral level. When determining the optimal wage, the union takes into account the aspects of firm behaviour established in the previous section. When both countries contain firms the union rationally anticipates that not all firms relocate for a small wage increase as tighter competition abroad and softer domestic competition tend to equalise profits in both countries before all firms relocated. In the case of full agglomeration, however, the existence of agglomeration rents in a country allows wages to be increased up to some point without causing any relocation. The union will exploit this property to appropriate all agglomeration rents in the form of higher wages.

We first determine the optimal union wage demand and derive its properties both for interior equilibria and corner solutions. It is shown that (1) union wages are a non-monotonic function of trade freeness if there exist asymmetries between countries and trade is sufficiently free, (2) local union wage demands are not always increasing in the foreign wage level, (3) freer trade or a smaller home-market do not necessarily make countries more sensitive to the foreign wage level.

3.1. The optimal union wage demand

Assume a monopoly union acting on the level of the manufacturing sector under consideration seeks to maximise

$$U = nl(w_H - w_H^A). \tag{6}$$

Union utility U equals the product of aggregate employment nl and the difference between the manufacturing wage w_H and the A-sector wage w_H^A, which serves as a benchmark against which union wages are gauged. It it assumed that the sector in which the union operates is sufficiently small compared to the overall economy such that the union ignores the effect its wage demands have on the economy-wide price level (the union does take into account how wages affect manufacturing prices and thus the location choice of firms). This seems a

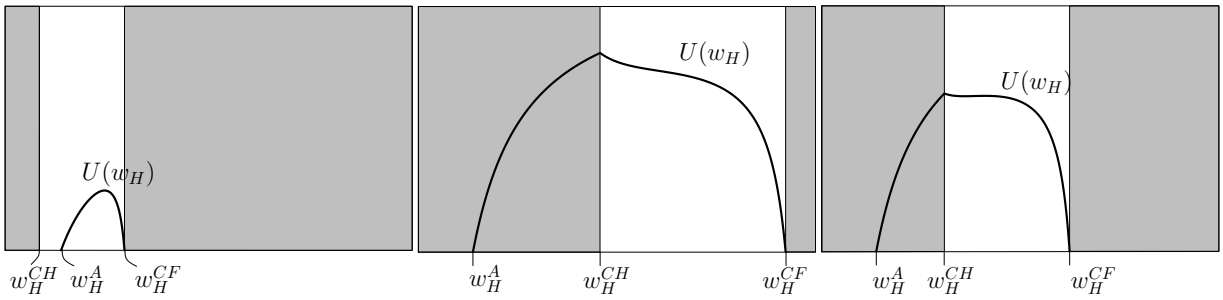

Figure 3: If $w_H^{CH} < w_H^A$ the optimal union wage implies an interior equilibrium (left panel). If w_H^{CH} is sufficiently large compared to w_H^A, U is downward sloping over the interval $]w_H^{CH}, w_H^{CF}[$ and the union sets wages at w_H^{CH}, attracting all firms (middle panel). If w_H^{CH} is only moderately higher than w_H^A the level of U at the unique interior maximum of U has to be compared numerically with the level of U at the corner solution w_H^{CH} (right panel).

reasonable assumption given the fact intermediate sector-level bargaining is widely observed in practice[4]. Unions explicitly take into account that wage increases *may* cause some firms to relocate and that individual firms will employ fewer workers, e.g. that n and l are functions of w_H. Under the given assumptions firm level labour demand is a simple function of wages with $l = (\sigma - 1)/w_H$. The dependency of n on w_H was described in sections 2.2 and 2.3.

Union utility equals 0 at both endpoints of the interval $[w_H^A, w_H^{CF}]$ and is strictly positive $\forall\ w_H \in]w_H^A, w_H^{CF}[$ and therefore *necessarily* reaches a maximum in this interval.[5] Three cases can be distinguished depending on the level of w_H^A relative to w_H^{CH}. These different cases are illustrated in figure 3. The first case is when w_H^{CH} is relatively small such that $w_H^{CH} < w_H^A$. The union then sets its wage demand w_H in the interval $]w_H^A, w_H^{CF}[$ and both countries contain firms. The second case occurs when w_H^{CH} is sufficiently large relative to w_H^A. In this case the union will set the wage at w_H^{CH} such that country H contains all firms. In the third case, where w_H^{CH} is not much larger than w_H^A, the chosen wage depends on the shape of U over the interval $]w_H^{CH}, w_H^{CF}[$. We now discuss the optimal union wage determination more in detail in each of these cases.

Case 1 If $w_H^{CH} < w_H^A$ it holds $\forall\ w_H \in]w_H^A, w_H^{CF}[$ that $w_H^{CH} < w_H < w_H^{CF}$ such that at any wage the union chooses in this interval $0 < n < 1$ holds and equation (4) is relevant. The

[4]For example the union IG metal in Germany is likely to take into consideration the effects of its actions on the international competitiveness of the sector, but even the actions of such a large union, when considered in isolation, would have only a small effect on the overall German price level.

[5]It is assumed that $w_H^A < w_H^{CF}$ as otherwise all firms would prefer to locate in country F, even with manufacturing wages in H lowered to the A-sector level w_H^A.

maximum of U is a solution of $\partial U/\partial w_H = 0$, which can be written as

$$\boxed{w_H = w_H^A + w_H^A \frac{1}{|\epsilon_{\text{reloc}}(w_H, w_F, \phi)|} \qquad \text{if } 0 < n < 1.} \tag{7}$$

where ϵ_{reloc} is given by

$$\epsilon_{\text{reloc}}(w_H, w_F, \phi) \equiv \frac{\partial n}{\partial w_H}\frac{w_H}{n} = (1-\sigma)\frac{m(1-\phi^2)(1-c^2)+(c-\phi)^2}{(c-\phi)(1-c\phi)(c^{CF}-c)} < 0.$$

As ϵ_{reloc} contains w_H with non-integer exponents through $c = (\alpha_F w_H/\alpha_H w_F)^{\sigma-1}$ the union wage can not generally be written as an explicit function of the model parameters for interior equilibria. Despite this fact the exact properties of the optimal union wage can be determined using the implicit function theorem.

Case 2 If $w_H^A < w_H^{CH}$, country H attracts all firms ($n = 1$) for wages $w_H \in [w_H^A, w_H^{CH}]$. As firm level labour demand is given by $(\sigma-1)/w_H$ union utility is proportional to $(w_H - w_H^A)/w_H$ in this interval and therefore strictly increasing. A union wage $w_H < w_H^{CH}$ can therefore never be optimal, and the shape of U over the interval $]w_H^{CH}, w_H^{CF}[$ determines whether utility reaches a maximum at w_H^{CH} (a corner solution) or in $]w_H^{CH}, w_H^{CF}[$ (interior solution). The slope of U in $]w_H^{CH}, w_H^{CF}[$ is negative if $\forall\ w_H \in]w_H^{CH}, w_F^{CF}[$

$$\begin{aligned} 0 &> \frac{\partial U}{\partial w_H} \\ 0 &> \frac{\partial n}{\partial w_H} l(w_H - w_H^A) + n[\frac{\partial l}{\partial w_H}(w_H - w_H^A) + l] \\ \frac{w_H - w_H^A}{w_H} &> \frac{1}{-\epsilon_{l,w} - \epsilon_{\text{reloc}}^H} = \frac{1}{1-\epsilon_{\text{reloc}}^H} \end{aligned} \tag{8}$$

where the last inequality is obtained by multiplying by w_H/n, using the fact that $\epsilon_{l,w} = \frac{\partial l}{\partial w_H}\frac{w_H}{l} = -1$ and rearranging. Condition (8) holds if w^A is sufficiently smaller than w_H^{CH},[6] and when $-\epsilon_{\text{reloc}}^H$ is large ($n(w_H)$ is steep), which is the case if trade costs are low.

If condition (8) holds, union utility is decreasing over $[w_H^{CH}, w_H^{CF}]$ and this is a sufficient condition for unions to set $w_H = w_H^{CH}$, the wage level at which H attracts all firms firms, or

$$\boxed{w_H = w_H^{CH} = \frac{\alpha_H w_F}{\alpha_F}\left(c^{CH}\right)^{\frac{1}{\sigma-1}} \qquad \text{if } n = 1.} \tag{9}$$

[6] w_H^{CH} is large if H has a large market size and ϕ is intermediate, or if H has a production cost advantage and ϕ is large (see the definition below proposition 3). In this case $(w_H - w_H^A)/w_H \approx 1$ and the slope of U will be determined by n, which is strictly decreasing in w_H in this interval.

Here w_F is the wage which a firm would pay in country F, which is more of a virtual wage as country F does not contain any firms. The optimal union wage demand for full agglomeration is $w_H = w_H^{CH}$, which implies zero agglomeration rents. Manufacturing workers therefore appropriate all the agglomeration rents which firms would earn in the absence of unions in the form of higher wages.

Case 3 If condition (8) does not hold U is increasing over a section of $[w_H^{CH}, w_H^{CF}]$. If $\sigma \leq 2$, U is concave and therefore union wages are set at $\partial U / \partial w_H = 0$ where $0 < n < 1$. If $\sigma > 2$ the maximum in $[w_H^{CH}, w_H^{CF}]$ may be local and the corner solution $w_H = w_H^{CH}$ might still be preferred by the union. As $\partial U / \partial w_H = 0$ can not generally be solved for w_H, the utility level at different points in the interval $[w_H^{CH}, w_H^{CF}]$ where $\partial U / \partial w_H = 0$ and the utility level at the corner solution w_H^{CH} must then be compared numerically.

Summarising, for low values of w_H^{CH} relative to w_H^A, the union optimally sets wages such that both countries contain firms, according to equation (7). If $w_H^{CH} < w_H^A$ this is always the case. If w_H^{CH}, in contrast, is sufficiently high relative to w_H^A the optimal union wages equals w_H^{CH}, the corner solution at which country H attracts all firms and firms are indifferent between locations. Wages are set according to equation (9). For intermediate levels of w_H^A and w_H^{CH}, union utility at the interior equilibrium and the corner solution must be compared numerically. The comparative static properties of the optimal union wage demand both in the case of an interior solution and a corner solution can be determined analytically and we turn to deriving these properties for both cases in the remainder of this paper.

3.2. Foreign wage changes and union wage demands

If union wages are set such that the country is able to attract all firms, union wages move in line with the agglomeration rents. The agglomeration rents in a country are defined as the ratio of profits in this country to the (potential) foreign profits. As is clear from equation (9) a foreign potential wage increase (say an increase in the foreign alternative wage) makes the foreign country less attractive, increasing the home country's agglomeration rents, leading to a higher union wage demand.

Proposition 5. *Under full agglomeration a foreign -potential- manufacturing wage increase (decrease) leads to a local union wage increase (decrease).*

The effect of a foreign wage change for interior solutions is derived in appendix A. Consider first the effect of a small deviation of w_F around the symmetric case $c = 1,\ m = 1/2$

$$\left.\frac{\partial w_H}{\partial w_F}\right|_{c=1,m=\frac{1}{2}} = -\left.\frac{\partial^2 U}{\partial w_H \partial w_F} \middle/ \frac{\partial^2 U}{\partial {w_H}^2}\right|_{c=1,m=\frac{1}{2}} = \frac{2\phi(\sigma-1)}{((1-\phi)^2+4(\sigma-1))} > 0. \qquad (10)$$

As might be expected, a small increase in the foreign wage around the symmetric case implies higher local union wage demands.

In the general asymmetric case an interesting relationship between local and foreign wages emerges: under the quite weak (necessary and sufficient) conditions $\phi < 1/\sqrt{2}$ and $m < (1-2\phi^2)/(1-\phi^4)$ there exists a level of w_F where w_H reaches a maximum in function of w_F and further increases in w_F lead to lower local wages. If these conditions are not met w_H is always increasing in w_F.[7] Following proposition therefore holds:

Proposition 6. *For symmetric countries, a small increase in the foreign wage always leads to an increase of the local union wage demands. For asymmetric cases with interior solutions this does not hold: under weak conditions there exist a level of w_F above which increases of the foreign wage imply lower wages.*

The left panel of figure 4 shows how the number of firms located in H, n (solid line), changes in function of the foreign wage level for the general asymmetric case. The dotted line shows the sensitivity of firm relocation to changes in w_F as an elasticity, which is identical to $|\epsilon^H_{\text{reloc}}|$.[8] The right panel shows the corresponding union wage. In the left panel we see the share of firms n is more sensitive to changes in the foreign wage at extreme levels, close to w_F^{CF} or w_F^{CH}. At moderate levels of w_F, changes in the foreign wage do not greatly affect the international distribution of firms (the n-curve is relatively flat, the elasticity of relocation is low), which is why unions make the largest wage demands at these intermediate levels of foreign wages.

Discussion. It might be surprising that a foreign wage increase may lead to lower local union wage demands, making wages act as strategic substitutes although the manufacturing goods produced in both countries are substitutes.[9] This property makes sense, however, as in our model wages are rationally set in function of the *marginal* effect of wages on the international firm distribution as expressed by $|\epsilon_{\text{reloc}}|$. A decrease in the level of foreign wages always leads to a decrease of the local number of firms and runs counter to union interests. This may simultaneously imply a decrease in the marginal effect of further wage changes

[7] Only if trade costs are very low or the country is quite large compared to the freeness of trade, local union wage demands are always increasing with higher foreign wages. For empirically relevant values such as $\phi = 0.2$ the stated conditions imply the market share m of country H must exceed 0.92 for $\partial w_H / \partial w_F > 0$ to hold.

[8] $|\epsilon^H_{\text{reloc}}|$ is directly related to the slope of n in function of w_F, as $\frac{\partial n}{\partial w_F}\frac{w_F}{n} = -\frac{\partial n}{\partial w_H}\frac{w_H}{n} = -\epsilon_{\text{reloc}} = |\epsilon_{\text{reloc}}|$.

[9] See Gürtzgen (2002) for a discussion of the strategic properties of union wages and an example where the strategic properties of wages depends directly on the properties of the good market. See Corneo (1995), Naylor (1998, 1999) for early examples of models where the reaction to the foreign wage level plays a key role in the derivation of an international Nash equilibrium in wages.

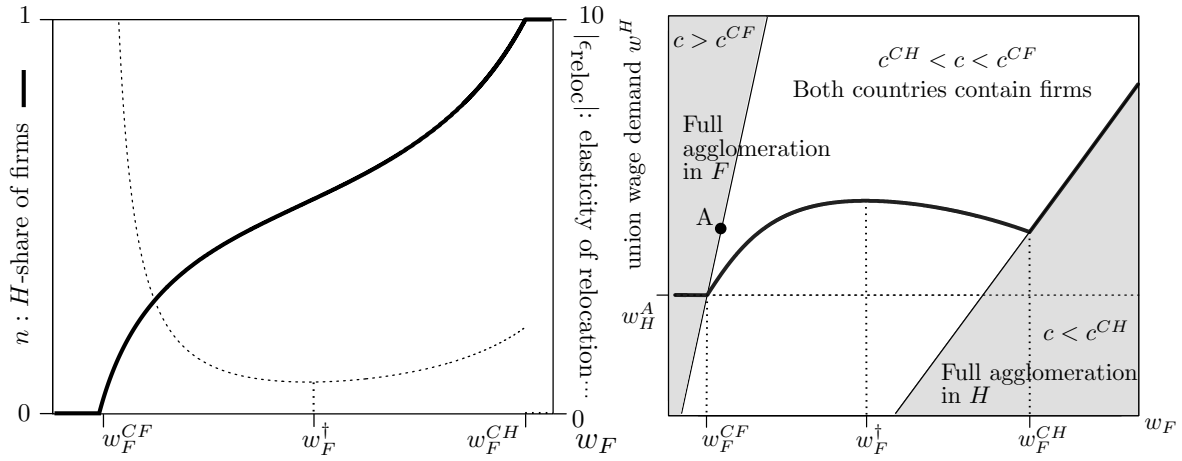

Figure 4: The international distribution of firms and the relocation elasticity (left panel) and the wage bargaining solution in country H (right panel), as a function of the foreign wage w_F.

on the distribution of firms, however, leading to higher optimal union wage demands in the remaining firms. The fact wages are neither strict strategic complements or substitutes would considerably complicate the analysis of a non-cooperative Nash equilibrium where unions are setting wages simultaneously in both countries.

Note that when foreign wages w_F are lowered to the level w_F^{CF} (where c approaches c^{CF}) and all firms start leaving H, the elasticity of relocation $|\epsilon_{\text{reloc}}^H|$ in H approaches infinity (see equation (5)). The union wage demand then converges to the outside-option A-sector wage w_H^A. It is intuitive that unions are willing to make ever larger wage concessions in such a situation, in an attempt to retain some employment and obtain positive utility.

Models with fixed union wage demands or wage bargaining outcomes (for example Picard and Toulemonde, 2006) or models where wages are proportional to firm profits (for example Head and Mayer, 2006) do not share this property, although firms are equally assumed to be perfectly mobile in these models. This leads to inconsistencies, however, as one can imagine cases where no firm is willing to locate in a country at this wage (resulting in 0 utility for the local union), whereas lowering wages to some level between the reservation wage w^A and the fixed wage could attract a positive number of firms (resulting in positive utility for the union). Point A in figure 4 is an example of such a point where a rational union would want to lower its wage demands. The reason for the inconsistency is that although firms are assumed to be perfectly mobile in the economic geography sections of these models, the possibility of firm relocation is not subsequently taken into account by unions in the wage bargaining stage.[10]

[10]For the case of firm level bargaining, which is more popular in the literature, the combined assumption

3.3. The effect of freer trade

A decrease in trade costs has an ambiguous effect on union wage demands.

Consider first the case of full agglomeration, where the wage moves in line with the agglomeration rents. Following proposition follows directly from the properties of agglomeration rents as described in section 2.5.

Proposition 7. *If the larger country attracts all firms, its wages are a hump-shaped function of trade freeness. If the smaller country attracts all firms its wages are strictly increasing with trade freeness.*

But even when both countries contain firms an increasing freeness of trade may imply higher wage demands, albeit in a rather specific configuration. Consider the case where country F is sufficiently large to attract the industrial core for some intermediate levels of trade freeness, even with the union wage in H (which is more a virtual wage, as there are no firms in H) set equal to the level of the local alternative wage w_H^A. If the alternative wage (and thus the minimal potential manufacturing wage) in H, w_H^A is lower than the alternative wage in F, w_F^A, however, there exists a level of trade freeness ϕ above which unions in H are able to set a wage which is both above w_H^A (and thus w_H increased after trade liberalisation) and below the level where firms start relocating to H [11]. Summarising, we have that

Proposition 8. *For interior solutions, increasing trade freeness generally leads to lower wages. An exception exists for the case of a small country with a production cost advantage (a lower alternative wage w^A), but only if size asymmetries are sufficiently large and trade is sufficiently free such that $\phi > 2m$. (proof see appendix B)*

Figure 5 illustrates our results on the effect of ϕ on union wages. The figure corresponds to a situation depicted in the right panel of figure 2 where country H is able to attract all firms between $[\phi^{CH1}, \phi^{CH2}]$. The left panel shows the case where the larger country H is the unionised country under consideration. Foreign wages are assumed to be fixed. Union wages in H then are monotonically decreasing with freer trade as long as both countries contain firms. Full agglomeration in H occurs between ϕ^{CH1} and ϕ^{CH2}. Wages are a bell-shaped

of costless firm relocation and international profit equalisation in interior equilibria should give firms a perfect outside option (relocation) during wage negotiations. Wages then should equal the alternative wage except in the case of full agglomeration where international profit differences may persist, creating a gap between current profits and the outside option (foreign profits) for the individual firm bargaining with a union.

[11] In the limit, for $\phi = 1$, the country with the lowest unit labour costs is able to attract all firms, as is obvious from $c^{CH}|_{\phi=1} = c^{CF}|_{\phi=1} = 1$. The country with the highest labour productivity, say H, is able to attract all firms setting wages such that unit labour costs are marginally below the foreign level. This can be seen from filling in $c^{CH}|_{\phi=1} = 1$ in equation (9).

function of ϕ as the union appropriates the agglomeration rents over this interval. If the smaller country F is unionised (right panel), wages decline with increasing freeness of trade up to the level where all firms leave the country and $w_{F} = w_{F}^{A}$. Wages are increasing for the interior equilibria between ϕ^{CH2} and ϕ^{CF} where firms relocate toward F (the exception described in proposition 8) and continue to increase with full agglomeration in F beyond ϕ^{CF}, where the union appropriates the increasing agglomeration rents.

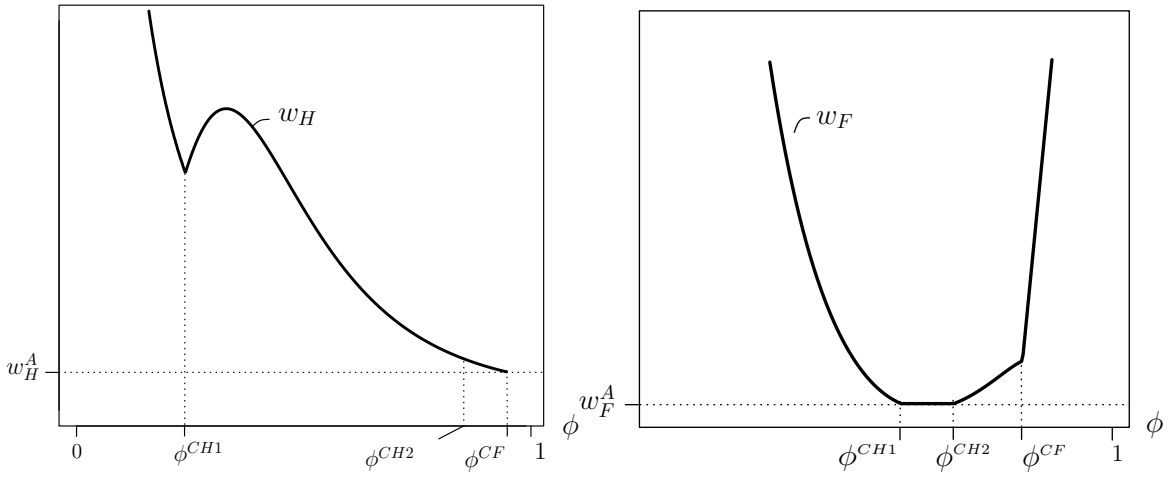

Figure 5: Agglomeration rents and wages in the larger country (left panel) and the smaller country (right panel) for large asymmetries.

Another interesting property of the model is the effect of freer trade on the sensitivity of local union wage demands to the foreign wage level. With

$$\frac{\partial w_{H}}{\partial w_{F}} = -\frac{\partial^2 U}{\partial w_{H} \partial w_{F}} \Big/ \frac{\partial^2 U}{\partial {w_{H}}^2} = T(w_{H}(w_{F}, \phi), w_{F}, \phi), \tag{11}$$

it holds that

$$\frac{\partial^2 w_{H}}{\partial w_{F} \partial \phi} = \frac{\partial T}{\partial w_{H}} \frac{\partial w_{H}}{\partial \phi} + \frac{\partial T}{\partial \phi}. \tag{12}$$

Unfortunately, the expressions for the general asymmetric case are rather complex, but even for the the cases of small deviations around the symmetric case $c = 1$ and $m = 1/2$ it can be shown that $\frac{\partial^2 w_H}{\partial w_F \partial \phi} < 0$. For $\sigma = 2$ the expression simplifies to $\frac{\partial^2 w_H}{\partial w_F \partial \phi} = -(1-\phi)/\left(\phi(1+\phi)\right)$.

The reason why freer trade can make the union less sensitive to the foreign wage level is that, while freer trade does increase the slope of $w_{H}(w_{F})$ as derived in equation (10) for the symmetric case, this reflects the effect on the slope keeping the *level* of union wages fixed. This 'primary effect' of a change in ϕ on the slope $\partial w_{H} / \partial w_{F}$ is given by the term $\frac{\partial T}{\partial \phi}$ in equation (12). To measure the full effect, it has to be taken into account that changes in

trade costs will also affect the level of union wage demands. Lower trade costs always lead to lower optimal union wage demands in the symmetric case. Lower union wages are less sensitive to foreign wages. The term $\frac{\partial T}{\partial w_H}\frac{\partial w_H}{\partial \phi}$ reflects this 'secondary effect' and as it turns out, it dominates the primary effect for the symmetric case, causing freer trade to decrease the sensitivity to foreign wages. For the more general asymmetric case this does not always hold.[12]

Discussion. The result that decreasing trade costs may lead to higher union wage demands is not unique to our model. In the two-country Cournot duopoly setting of Naylor (1999), for example, labour demand increases with lower trade costs because the effect of additional access to the foreign market exceeds the negative impact of increased domestic competition, inducing unions to make higher wage demands. A very different mechanism is at work in our model. The results for the effect of freer trade on wages under full agglomeration are derived directly from the properties of agglomeration rents. For interior equilibria, the fact increasing trade freeness may induce unions to increase wage demands stems, firstly, from the fact that unions first rationally lower their wage demands to the absolute minimum w^A when all firms leave their country, and secondly, that trade liberalisation makes a large high-wage country attractive only for intermediate levels of trade liberalisation. When trade costs become very low the market size asymmetries become less important, and the country with the lowest production costs will again be able to attract some firms. When this happens unions in the smaller country optimally make some wage demand strictly exceeding w^A, and this wage demand increases with freer trade.

3.4. Market size and union wage demands

A larger market size leads to higher union wage demands.

For the case of full agglomeration, this follows directly from the properties of the agglomeration rents. With a larger home market H can afford higher wages while keeping firms indifferent between locations.

[12]This effect also depends on union preferences: in our case the union tends to increase wage demands to very high levels if the economy is rather closed. Subsequently, trade liberalisation has a strong disciplinary effect. As lower wages are less sensitive to foreign wages this makes union wages less sensitive to foreign wages after trade liberalisation. If $U = nl(w_H - w_H^A)^\gamma$ with $0 < \gamma$ the relative preference for wages compared to employment, and γ is sufficiently low, then union wage demands are less exorbitant in a closed economy. The wage decrease is less pronounced after trade liberalisation and in this case union wages unambiguously become more sensitive to after trade liberalisation.

For interior solutions the effect of market size on union wage demands also is unambiguously positive. For the symmetric case the effect is

$$\left.\frac{\partial w_H}{\partial m}\right|_{c=1,m=\frac{1}{2}} = \frac{2(1-\phi^2)}{(1-\phi)^2+4\phi(\sigma-1)} > 0.$$

Following the same approach as in appendices A and B it can be shown the effect of market size on wages is positive in the general case with asymmetric countries. We therefore conclude

Proposition 9. *A larger home market size leads to higher union wage demands.*

A more surprising result is the ambiguous effect of market size on the sensitivity of the wage bargaining outcome with respect to the foreign wage level. Unfortunately, the expressions involved are rather complex and hard to sign for the general asymmetric case. But even for the symmetric case and $\sigma \geq 2$ it can be shown that, counter to intuition,

$$\left.\frac{\partial^2 w_H}{\partial w_F \partial m}\right|_{m=1/2,c=1} > 0.$$

For $\sigma = 2$ the expression simplifies to $4(1-\phi)\phi/(1+\phi)^3$. Numerical analysis shows that for a large set of parameters an increase in a country's market size implies an increased sensitivity to foreign wages. The reason is that, as with the effect of freer trade, a higher market size always decreases the sensitivity to the foreign wage level *when keeping wage demands constant*, but a larger market size simultaneously leads to higher union wage demands which are more sensitive to foreign wage changes.

As can be seen in equation (9) a larger market always implies more sensitive wages in the case of full agglomeration.

This counter-intuitive result runs contrary to the findings of the literature on tax competition between asymmetric countries. For example Gaigné and Riou (2007) predicts higher taxes and a lower sensitivity to the foreign tax level in larger countries. In models of tax competition which consider full agglomeration (see for example Baldwin and Krugman, 2004) higher foreign taxes lead to a higher local tax *level*. In most of these models, however, the market size does not affect how the optimal local tax depends on the foreign tax level. This is due to the fact taxes are a simply subtracted from firm profits whereas in our model wage changes alter firms' production costs.

3.5. The effect of unions on the equilibrium distribution of firms

The focus of this paper was on how international firm mobility affects union wage demands. This section briefly considers the reverse question, on how union activity affects the equilibrium distribution of firms. This issue has received more attention in the literature, for example in the work of Picard and Toulemonde (2006). In their model, as in ours, all labour shed by the manufacturing sector due to union wage demands is fully absorbed by the CRS A-sector without affecting wages in that sector. Higher manufacturing wage demands therefore may increase aggregate nominal income. In the model of Picard and Toulemonde (2006) higher income implies more demand for manufacturing goods in a region and thus union activity increases the attractiveness of a country. Our model is quite different in that all income effects are absorbed by the demand for A-sector output. Higher wages in the manufacturing sector then do not alter demand for manufacturing goods in a country, causing wage increases to have an unambiguously negative effect on the profitability of firms and on the attractiveness of a location.

Consider the home market effect with unions setting wages in country H, with fixed foreign wages. It holds that

$$\frac{\mathrm{d}n}{\mathrm{d}m} = \frac{\partial n}{\partial m} + \frac{\partial n}{\partial w_H}\frac{\partial w_H}{\partial m} \tag{13}$$

and as $\partial n / \partial w_H > 0$ (proposition 1) and $\partial w_H / \partial m < 0$ (proposition 9) union activity reduces the number of firms in the unionised country and attenuates the home market effect compared to the case with competitive labour markets.

4. Conclusion

This paper analysed the optimal wage demand of a monopoly union acting on the sector level in face of internationally mobile firms. Using a simple two-country new economic geography model it was established how firms locate in function of trade costs and international differences in market access, labour productivity and wages. Unions fully take the results on firm behaviour into account when making wage demands. It was shown that when both countries contain firms (interior equilibria) the union wage demand is inversely related to the amount of firm relocation in response to wage changes. When the country under consideration attracts all firms, the union sets wages as to keep firms indifferent between locations and the union appropriates all agglomeration rents in the form of higher wages.

Under full agglomeration union wage demands are proportional to agglomeration rents and therefore are a hump-shaped function of trade freeness in the larger country, and are strictly

increasing after trade liberalisation in the smaller country if it is able to attract all firms. But even when both countries contain firms wages may increase after trade liberalisation, albeit in a specific configuration, where asymmetries are large and firms start to leave the country with a larger market size and relocate to a smaller more productive country when trade becomes sufficiently free.

Union wages are not pure complements or substitutes in an international context. Under mild conditions, there exists a level of foreign wages above which a further increase in foreign wages induces lower union wage demands. Although a foreign wage decrease hurts union interests and reduces the number of firms in a country, the marginal propensity of firms to relocate in function of union wage demands may simultaneously decline in the remaining firms, leading to higher union wage demands in function of a foreign wage decrease.

When all firms are leaving the country (for example because foreign wages are set ever lower), unions rationally lower wages to their outside-option, the wage level in an alternative sector of employment which is assumed to exist. This intuitive property is lacking from several well-known models of union wage demands with perfectly mobile firms.

For small deviations around the symmetric case, lower trade costs or a smaller market size always lead to lower union wage demands, as might be expected. A counter-intuitive finding is that, even when considering small deviations around the symmetric case, the lower level of union wage demands in smaller and more open economies make the union wages demands in these countries less sensitive to the foreign wage level.

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A. The effect of foreign wages

In an interior equilibrium the optimal union wage demand satisfies the first order condition

$$\frac{\partial U}{\partial w_H} = \frac{\partial n}{\partial w_H}\left[(w_H - w_H^A)l\right] + n\left[l + (w_H - w_H^A)\frac{\partial l}{\partial w_H}\right] = 0.$$

By the implicit function theorem the effect of a change in w_F on the wage bargaining outcome is given by

$$\frac{\partial w_H}{\partial w_F} = -\frac{\partial^2 U}{\partial w_H \partial w_F} \Big/ \frac{\partial^2 U}{\partial {w_H}^2}$$

The denominator is negative at points where U reaches a maximum (and we know at least one such point must exist if U is increasing over a part of $[w_H^{CH}, w_H^{CF}]$, see condition 8), as it represents the second order condition for a maximum. The sign of $\frac{\mathrm{d}w_H}{\mathrm{d}w_F}$ therefore equals the sign of $\frac{\partial^2 U}{\partial w_H \partial w_F}$.

$$\frac{\partial^2 n}{\partial w_H \partial w_F} w_H - \frac{\partial n}{\partial w_F}\frac{\partial n}{\partial w_H}\frac{w_H}{n} \tag{14}$$

After dividing by n (which does not affect the sign) this equals

$$\frac{\partial^2 n}{\partial w_H \partial w_F}\frac{w_H}{n} - \frac{\partial n}{\partial w_F}\frac{\partial n}{\partial w_H}\frac{w_H}{n^2} = \frac{\partial \epsilon_{\text{reloc}}}{\partial w_F}.$$

The reaction function therefore has a turning point at the level where $\frac{\partial \epsilon_{\text{reloc}}}{\partial w_F}$ switches sign, where ϵ_{reloc} reaches a minimum as a function of w_F as depicted in the left panel of figure 4. Although readily interpretable, the exact expression in function of the model parameters is rather complicated for the general asymmetric case and we omit it here.

When does such a turning point exist, where the bargaining function in function of the foreign wage reaches a maximum? Note that the derivative of the bargaining outcome with respect to the foreign wage, evaluated at the lowest level of the foreign wage for which the home country contains some firms, equals

$$\left.\frac{\partial w_H}{\partial w_F}\right|_{c=c^{CH}} = -\frac{\partial^2 U_H}{\partial w_H \partial w_F} \Bigg/ \left.\frac{\partial^2 U_H}{\partial {w_H}^2}\right|_{c=c^{CH}} = \frac{1}{3}\frac{w_H}{w_F}$$

In other words: the sensitivity of the wage bargaining outcome with respect to the foreign wage expressed as an elasticity $\frac{\mathrm{d}w_H}{\mathrm{d}w_F}\frac{w_F}{w_H}$ equals $\frac{1}{3}$ when evaluated at w_F^{CF}. The slope of the reaction function at w_F^{CF} is always positive (as depicted in the right panel of figure 4).

Evaluated at the other extreme, w_F^{CH}, where the high foreign wage induces all firms to locate in H, and assuming $\sigma = 2$ to assure concavity of the objective function and thus the existence of a range of wages for which both countries contain firms, the slope of the reaction function for the case can be shown to equal

$$\begin{aligned}\left.\frac{\partial w_H}{\partial w_F}\right|_{c=c^{CH}} &= -\frac{\partial^2 U_H}{\partial w_H \partial w_F} \Bigg/ \left.\frac{\partial^2 U_H}{\partial {w_H}^2}\right|_{c=c^{CF}} \\ &= \frac{w_H}{w_F}\frac{-\phi^4 m + m + 2\phi^2 - 1}{\phi^4 m^2 - 2\phi^2 m^2 + m^2 + 2\phi^2 m - 2m + 2\phi^2 + 1}\end{aligned}$$

As the denominator can be shown to be positive, the sign of $\mathrm{d}w_H/\mathrm{d}w_F|_{c=c^{CH}}$ equals the sign of $-\phi^4 m + m + 2\phi^2 - 1$ and by solving for ϕ and m we conclude the slope of the reaction

function is negative at w_F^{CH} if $\phi < 1/\sqrt{2}$ and $m < \frac{1-2\phi^2}{1-\phi^4}$. This is the case for common levels of ϕ and m. Under these conditions the reaction curve goes from positively sloped at w_F^{CF} to negatively sloped at w_F^{CH} and reaches a maximum between w_F^{CF} and w_F^{CH} at the point where $|\epsilon_{\text{reloc}}|$ as a function of w_F is minimal.

B. The effect of trade freeness

Proceeding as in appendix A the effect of a change in ϕ on the bargaining outcome, $\mathrm{d}w_H/\mathrm{d}\phi$ has the same sign as

$$\begin{aligned}\frac{\partial^2 U}{\partial w_H \partial \phi} = &\frac{\partial^2 n}{\partial w_H \partial \phi}\left[(w_H - w^A)l\right] \\ &+ \frac{\partial n}{\partial \phi}\left[l + (w_H - w^A)\frac{\partial l}{\partial w_H}\right]\end{aligned}$$

Dividing by $[(w_H - w^A)l]/w_H > 0$ does not affect the sign. Substituting the first order condition $(w - w^A)/w^A = 1/|\epsilon_{\text{reloc}}| = -1/\left(\frac{\partial n}{\partial w_H}\frac{w_H}{n}\right)$ and using $\epsilon_{l,w} = \frac{\partial l}{\partial w}\frac{w}{l} = -1$ then gives

$$\frac{\partial^2 n}{\partial w_H \partial \phi} w_H - \frac{\partial n}{\partial \phi}\frac{\partial n}{\partial w_H}\frac{w_H}{n} \tag{15}$$

This expression can be straightforwardly calculated from the long-run equilibrium definition of n from equation (4) yielding a complex expression we omit here. From the point of view of country H the expression (and therefore the effect of ϕ on w_H) can be shown to be negative unless it holds combined that $c < 1$, $m < 1/2$ and $\phi > 2m$ (the country under consideration has a cost advantage, is small, and trade is sufficiently free) in which case it the effect of freer trade on the union wage demand can be positive. These are necessary but not sufficient conditions, however.