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**The Characteristics of International Trade Union Competition**

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# The Characteristics of International Trade Union Competition

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## 1. Introduction*

This note investigates the behaviour of national trade unions facing international mobile capital. It is now widely recognized, that the world of today is characterized by high international capital mobility and integrated production across national borders. Thus, suppliers of more or less immobile factors have to be conscious about this restraint on their behaviour. They have to compete for mobile capital just like suppliers of private goods have to compete for customers. A widely disseminated model of trade union behaviour is that of a monopoly trade union, with a large and powerful union fixing the wage rate and firms, which subsequently determine labour demand by adjusting their employment.[1] Under capital mobility, this model has to be replaced by that of an oligopoly trade union, with a countable number of trade unions fixing the wage rate noncooperatively. Oligopolistic trade union behaviour has already been treated by some authors in a national context. At first glance, their results seem to be transferable to an international context.[2] However, this paper, which derives labour demand explicitly from a model of international production, obtains results very different from these oligopoly trade union models.

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* I would like to thank Henning Klodt, Rainer Maurer and Karl-Heinz Paqué for helpful comments.

[1]See for instance Oswald (1985).

[2]See Oswald(1979), Gylfason/Lindbeck (1984) for noncooperative wage setting and Davidson (1988) for cooperative wage setting.

## 2. The Bertrand-Edgeworth Character of Noncooperative Wage Setting

Oligopoly theory divides competition up into Cournot competition, where the instrument variables are output quantities, and Bertrand-competition, where the instrument variables are output prices. Theoretically, both kinds of behaviour seem possible in wage setting games. However, quantitiy competition has never been observed in labour markets, so that international trade union competition should be modelled as price and therefore wage competition. The players of this game are facing a capacity constraint: the quantity of labour, which unions are able to offer, is restricted to the number of its members. Therefore, the situation of national trade unions is very similar to the capacity constrained version of the Bertrand-model, which is known as the Bertrand-Edgeworth-model of oligopoly theory.[3]

### 2.1 Description of the Game

The following model tries to capture the main features of international trade union competition in a symmetric 2·2·2 (two countries, two factors, two unions) model.[4] The two factors of production are perfectly mobile capital (K) and perfectly immobile labour (L). The world capital stock $\overline{K}$ is equally divided between 2n capital owners, n in each country. In each country, capital owners can produce the consumption good x with the production function x=F(K,L). The technology F(K,L) is homogenous of degree 1 in capital and labour. Thus, with $F(K,L)\equiv L\cdot f(K/L)$, the partial derivatives read as follows:

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[3]For a description of the Betrand-Edgeworth-model of price competition, see for instance Tirole (1988, pp. 214 ) or Wolfstetter (1990, pp. 49).

[4]It thus differs from the 2·2·2·2 (two countries, two factors, two unions, two goods) model of Kemp et al. (1992), who were introducing trade unions in the textbook models of international trade.

$$F_K(K,L) = f'(K/L), \tag{1}$$

$$F_L(K,L) = f(K/L) - K/L \cdot f'(K/L). \tag{2}$$

In both countries, labour capacity is constrained to $\bar{L}$. For simplicity, I assume that $\bar{L} = 1$. Therefore it is possible, that the capital owners are rationed in their labour usage: at comparably low wage rates they may want to employ more workers than offered by the unions. In the following I assume, that labour in this case is rationed proportionally between capital owners. If the labour constraint is binding, then every capital owner obtains the same amount of labour, namely *1/2n*. Given this rationing rule and the wage rates $w_1$ and $w_2$, the representative capital owner adjusts his capital allocation and labour demand to solve the following programme:[5]

$$\max_{K_1,K_2,L_1,L_2} F(K_1,L_1) + F(K_2,L_2) - w_1 L_1 - w_2 L_2, \tag{3}$$

s.t. $\quad K_1 + K_2 \leq \dfrac{\bar{K}}{2n},$ (4a)-(4g)

$$L_1 \leq \frac{1}{2n}, L_2 \leq \frac{1}{2n},$$

$$K_1, K_2, L_1, L_2 \geq 0.$$

The factor labour is uniformly unionized in each country. There is no competition between labour suppliers within a country. This is, of course, a rather simplistic assumption. In most countries there exist several trade unions, usually organized sector- or regionwide. Furthermore, it neglects competition between organized workers and those workers who are not members of a trade union. Therefore, this model should not be seen as a one-to-one description of reality, but as a reference point: as the following analysis will show, international trade union competition will lead to competitive behaviour - even from this most non-competitive starting point.

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[5]$K_i$ resp. $L_i$ denotes capital resp. labour usage in country i.

The whole wage setting game can be described as follows: First, the unions of country 1 and 2 simultanously set the wage rate. Then, the capital owners decide about labour demand and the allocation of the capital stock (see Figure 1).[6]

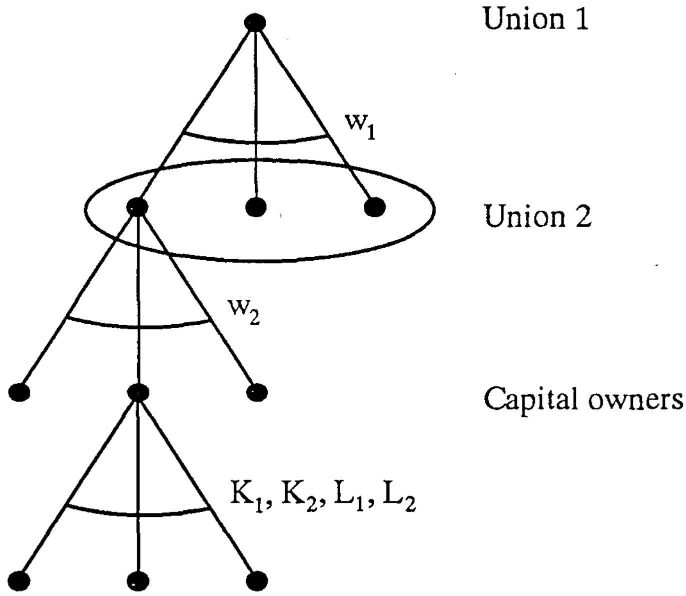


**Figure 1:** The Wage-Setting-Game

The solution to the second stage of the game is described by the Kuhn Tucker conditions to the program (3) and (4).[7] With

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[6]This game structure describes the situation where capital and labour can be allocated freely during the production period. Then capital owners can not credibly commit themselves to a certain capital or labour stock.

[7]See Appendix.

$g(K/L) \equiv f(K/L) - K/L \cdot f'(K/L)$, they implicitly define the following aggregate labour demand functions for both countries:[8]

$$L_i^a = \begin{cases} 1 & \text{for} \quad w_i < w_j \\ \max\left(0, \dfrac{\overline{K}}{2 \cdot g^{-1}(w_i)}\right) & \text{for} \quad w_i = w_j \\ \max\left(0, \dfrac{\overline{K} - g^{-1}(w_i)}{g^{-1}(w_i)}\right) & \text{for} \quad w_i > w_j \end{cases} \tag{5}$$

For $w_1 = g(\overline{K}/2)$ and $w_2 = g(\overline{K}/2)$ labour in both countries is fully employed.

For $w_i \neq g(\overline{K}/2)$, the labour demand function posesses a discontinuity at $w_1 = w_2$.

Now I turn to the decision problem of the trade unions. Given the result of the labour demand subgame, their objective is to find the wage rate $w_i$ that maximizes their payoff function, which contains the wage rate of its members and the resulting aggregate labour demand as arguments. For a more detailed specification I assume, that the trade unions maximize the expected utility of their representative member. Then their payoff function is given by the following equation:

$$V_i(w_i, w_j) \equiv E(U(w_i)) = L_i^a(w_i, w_j) \cdot (U(w_i) - U(w_0)) + U(w_0), \tag{6}$$

$$i, j = 1, 2, \; i \neq j.$$

[8]For illustrative reasons, it is assumed, that for $w_1 = w_2$ capital is always allocated symetrically between the two countries. This need not to be the case for both wages equal and higher than the full employment wage. However, this assumption has no influence on the results of this paper, because it will be dropped for the determination of the wage equilibria.

$U(w_i)$ represents the von-Neumann-Morgenstern (vNM) utility if the worker is employed, and $U(w_0)$ represents the vNM utility if he is not employed and has to be contended with an unemployment benefit of $w_0$. It is assumed, that this unemployment benefit is always smaller than $w_i$. Because of the underlying discontinous labour demand, the payoff function is discontinous at $w_i=w_j$.

## 2.2 Solution of the Game

This section evaluates conditions that allow pure strategy equilibria to solve the trade union game.[9] It shows, that these equilibria imply full employment for both countries.

Lemma 1 reduces the set of possible strategy combinations to the set of full employment wages. The succeeding Lemma 2 points to an important relationship between the strategy combinations.

***Lemma 1:** Let $w_i^*$ be the set of all symmetric pure equilibrium strategies for player i. Then $w_i^* \subset \left[w_0, g\left(\overline{K}/2\right)\right]$.*

***Proof:*** Lemma 1 results from the discontinuity of the labur demand. Let $w_1 = w_2 > g\left(\overline{K}/2\right)$. Then the members of at least one union are not fully employed. Their union could achieve full employment by marginally underbidding its opponent with the amount $\Delta w$. The costs of such a policy were $\frac{\partial U}{\partial w} \cdot \Delta w \cdot L^a$, whereas the benefits would be given by $\left(U(w-\Delta w) - U(w_0)\right)\left(1-L^a\right)$. For $\Delta w \to 0$ the net benefit would be positive. Thus, a symmetric Nash-equilibrium can only exist at $w_1 = w_2 \leq g\left(\overline{K}/2\right)$.

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[9]For the existence of mixed strategy equilibria in discontinous games like this one, see Dasgupta/Maskin (1986), lemma 7.

*Lemma 2: The strategy combination* $\{g(\overline{K}/2), g(\overline{K}/2)\}$ *is pareto superior to all other* $W^* = w_1^* \times w_2^*$.

***Proof:*** For all $W^*$, labour in both countries is fully employed. Therefore, the payoff function for the unions equals the utility function of the representative member. Then, because of the increasing utility function of the union members, an equilibrium with both wages lower than $g(\overline{K}/2)$ is pareto inferior to $W^*$.

Lemma 2 has two implications: First, if more than one equilibrium exist, and if one accepts the conjecture that pareto superior Nash equilibria are more likely to be played, then the strategy combination $\{g(\overline{K}/2), g(\overline{K}/2)\}$ is the focal point of the game. Second, if there is only one equilibrium, then it will be the strategy combination $\{g(\overline{K}/2), g(\overline{K}/2)\}$.

With the help of these two lemmas and with the following assumption and two definitions, I am able two derive Proposition 1, which characterizes the pure strategy Nash-equilibria of the trade union game.

Define

$$H(\overline{K}, w_1) \equiv \frac{\overline{K} - g^{-1}(w_1)}{g^{-1}(w_1)} \cdot \left(U(w_1) - U(w_0)\right) \tag{7}$$

and

$$I(\overline{K}) \equiv \left.\frac{\partial H(\overline{K}, w_1)}{\partial w_1}\right|_{w_1 = g(\overline{K}/2)} = U'\left(g(\overline{K}/2)\right) - \frac{4 \cdot \left(U\left(g(\overline{K}/2)\right) - U(w_0)\right)}{\overline{K} \cdot g'\left(\overline{K}/2\right)}. \tag{8}$$

Assume, that $\frac{\partial^2 H(\overline{K}, w_1)}{\partial w_1^2} < 0$.[10]

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[10]This assumption is equivalent to the assumption, that the second order conditon of expected utility maximization of a monopoly trade union is satisfied. This is usually done in the literature.

*Proposition 1: Suppose* $I(\overline{K}) \leq 0$. *Then there exists at least one equilibrium in pure strategies,* $W^* = w_1^* \times w_2^*$, *with* $w_i^* \subset [0, g(\overline{K}/2)]$, *i=1,2. Iff* $I(\overline{K}) > 0$, *then no pure strategy equilibrium exists.*

***Proof:*** Lemma 2 implies, that the necessary conditions for the existence of the equilibrium $\{g(\overline{K}/2), g(\overline{K}/2)\}$ are necessary for the existence of all other possible symmetric equilibria. Thus, nonexistence of any symmetric equilibrium occurs, iff, for a given $w_2 = g(\overline{K}/2)$, union 1 could play $w_1 = g(\overline{K}/2) + \varepsilon$, with $\varepsilon \neq 0$ and obtain $V(g(K/2)+\varepsilon) > V(g(\overline{K}/2))$. For $w_2 = g(\overline{K}/2)$, aggregate labour demand in country 1 is given by:

$$L_1^a = \begin{cases} 1 & for \quad w_1 < g(\overline{K}/2) \\ \dfrac{\overline{K} - g^{-1}(w_1)}{g^{-1}(w_1)} & for \quad g(\overline{K}/2) \leq w_1 < g(\overline{K}). \\ 0 & for \quad w_1 \geq g(\overline{K}) \end{cases} \tag{9}$$

Note, that $V(g(\overline{K}/2)) = U(g(\overline{K}/2)) - U(w_0)$.

Let $\varepsilon < 0$. Then $V(g(\overline{K}/2)+\varepsilon) = U(g(\overline{K}/2)+\varepsilon) - U(w_0)$. From $\partial U(w_i)/\partial w_i > 0$ follows $V(g(\overline{K}/2)+\varepsilon) < V(g(\overline{K}/2))$. Thus, underbidding of $w_1 = g(\overline{K}/2)$ does not pay.

Let $\varepsilon > 0$. Then $V(g(\overline{K}/2)+\varepsilon) = H(\overline{K}, g(\overline{K}/2)+\varepsilon)$. If $I(\overline{K}) \leq 0$, then, because of $\dfrac{\partial^2 H(\overline{K}, w_1)}{\partial w_1^2} < 0$, $H(\overline{K}, g(\overline{K}/2)+\varepsilon) < H(\overline{K}, g(\overline{K}/2))$. From equations (7) and (8) follows $H(\overline{K}, g(\overline{K}/2)) = V(g(\overline{K}/2))$. Thus $V(g(\overline{K}/2)+\varepsilon) < V(g(\overline{K}/2))$. Deviation from $w_1 = g(\overline{K}/2)$ does not pay.

If, however, $I(\overline{K}) > 0$, then for $\varepsilon^* \equiv \arg\max_{\varepsilon} H(\overline{K}, g(\overline{K}/2)+\varepsilon)$ $V(g(\overline{K}/2)+\varepsilon^*) > V(g(\overline{K}/2))$. Deviation does pay, $w_1 = g(\overline{K}/2)$ is not optimal, $\{g(\overline{K}/2), g(\overline{K}/2)\}$ is no Nash equilibrium and, because of Lemma 2, no other symmetric pure strategy equilibrium will be found.

Finally, there is to show, that no assymetric pure strategy equilibrium exists in this game. Suppose, $w_1 > w_2$. Then $V(w_2) = U(w_2) - U(w_0)$. Because $\frac{\partial U(w_2)}{\partial w_2} > 0$, no optimal $w_2$ can be found and therefore no assymetric equilibrium exists. q.e.d.

Proposition 1 shows that the Bertrand-paradox also appears in our model of international trade union competition. Even with only two unions, the equilibrium wage - if it exists in pure strategies - settles at a full employment level. This is of course due to the discontinuity of the labour demand function. Because the producers can costlessy reallocate capital between the two countries, and because of constant returns to scale, they first demand the whole amount of cheap labour before falling back upon the labour in the high wage country - just like buyers of a homogenous good in the Bertrand-Edgeworth model. But in the Bertrand-Edgeworth-model, the condition for the existence of a competitive pure strategy equilibrium differs from the existence condition in this model. In the Bertrand-Edgeworth-model, a competitive pure strategy equilibrium exists only if the capacities of the producers are high enough to satisfy consumer demand at the competitive price. Then the capacity constraint is no longer binding. In the present model of trade union competition, the capacity constraint is always binding, because it is assumed that $w_0$ - the ´competitive´ wage - is smaller than the full employment wage. Nevertheless, there may also exist equilibria in pure strategies, namely when the costs of a wage increase - due to unemployment - are higher than the gains for the employed - due to the wage increase. Then $H(\bar{K}, w_1)$ has its maximum left of $G(\bar{K}/2)$ (see Figure 2).[11]

[11]For illustrative reasons, it is assumed, that the unions are risk neutral, so that the full employment sections of the payoff function become linear.

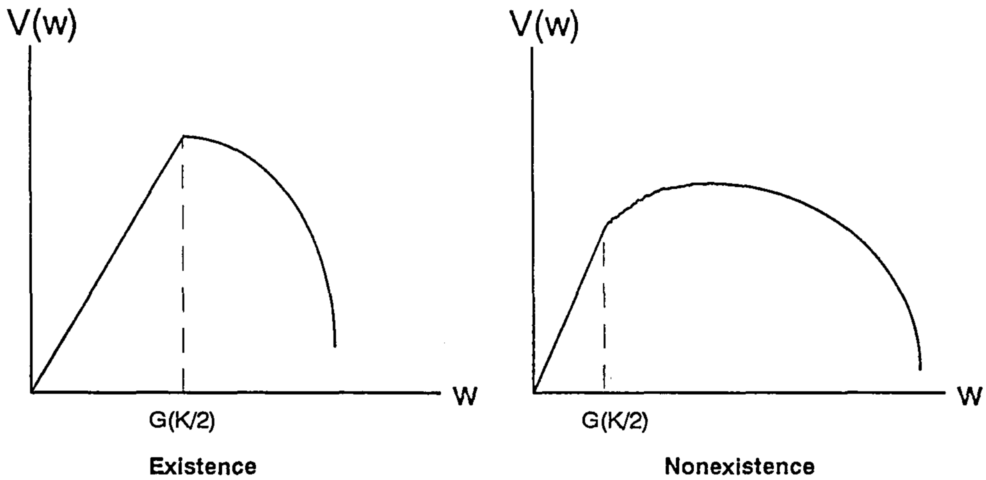


**Figure 2:** Condition for the Existence of Pure Strategy Equilibria

This condition can be interpreted in elasticity terms. Because of the discontinuity of the payoff function in this model, elasiticities can only be evaluated for $w_1 > G(\overline{K}/2)$. An equilibrium in pure strategies exists, iff for any $w_1 > G(\overline{K}/2)$ the wage elasticity of the utility fuction is smaller than the absolute value of the wage elasticity of the labour demand. At a point sufficiently close to the equilibrium point, both elasticities are directly determined by the world capital-labour ratio, as equation (7) shows. But unfortunately a clear relationship between these elasticities and the capital-labour ratios cannot be established. Depending on the shape of the vNM utility function and the production function, these elasticities may increase or decrease with a rising capital-labour ratio.

## 2.3 Comparison to the Monopoly Union Model

The preceeding section derived full employment equilibria for $I(\overline{K}) \geq 0$. This result has to be compared to the reference point, the case of no capital mobility. With immobile capital, aggregate labour demand in country i is given by:

$$L_i^a = \frac{\overline{K}_i}{g^{-1}(w_i)}. \tag{9}$$

Then, with $\overline{K}_i = \overline{K}/2$, Proposition 2 follows immediately from the first order condition of the expected utility maximizing trade union and another definition:

$$L_i^a(w_i) \cdot U'(w_i) - \frac{\left(U(w_i) - U(w_0)\right) \cdot g^{-1}(w_i)'}{\left(g^{-1}(w_i)\right)^2} \overset{!}{=} 0. \tag{10}$$

Define $J(\overline{K}) \equiv U'\left(g(\overline{K}/2)\right) - \dfrac{2 \cdot \left(U\left(g(\overline{K}/2)\right) - U(w_0)\right)}{\overline{K} \cdot g'(\overline{K}/2)}$.

***Proposition 2:*** *Suppose, capital is internationally immobile. Then the equilibrium wage equals the full employment wage* $w_i = g(\overline{K}/2)$ *iff* $J(\overline{K}) \leq 0$.

**Proof:** If $J(\overline{K}) \leq 0$, then $EU(w_i + \varepsilon) < EU(w_i) \forall \varepsilon \neq 0$, because the assumption $\partial^2 H / \partial w_i^2 < 0$ assures that the payoff function of the union is strictly concave in $w_i$. Therefore $w_i^* = g(\overline{K}/2)$. q.e.d.

Note that $J(\overline{K}) > I(\overline{K}) \forall \overline{K}$. Therefore, the set of $\overline{K}$ which implies full employment equilibria in the monopoly union case is a subset of the set of $\overline{K}$, which implies full employment equilibria in the duopoly union case. Thus, if there exist values of $\overline{K}$ for which a monopoly union sets the full employment wage, then there exist values of $\overline{K}$, which imply pure strategy equilibria in the duopoly union case, but the opposite is not true.

## 2.4 An Illustrative Example

In general, the existence conditions for a full employment equilibrium $J(\overline{K})\leq 0$ and $I(\overline{K})\leq 0$ vary with the world capital-labour ratio. As mentioned above, no simple relationship between these conditions and the capital-labour ratio can be determined, because both the underlying labour demand elasticities and the vNM utility elasiticities are affected by changes in the capital labour ratio.[12] However, if the vNM utility functions exhibits constant relative risk aversion, then the utility elasticity is also a constant and the existence conditions can be interpreted easily. The vNM utility function for constant relative risk aversion is given by:

$$U(w_i)=\frac{1}{\Theta}w_i^{\Theta} \qquad \text{for } \Theta\leq 1, \Theta\neq 0, \tag{11}$$

$$U(w_i)=\ln(w_i) \qquad \text{for } \Theta=0.$$

a≡1-Θ is defined as the Arrow-Pratt measure of relative risk aversion.

Without loss of generality, the unemployment benefit $w_0$ can be written as a constant fraction of the full employment wage.

$$w_0\equiv u\cdot g(\overline{K}/2), \qquad 0\leq u\leq 1. \tag{12}$$

Then $I(\overline{K})$ and $J(\overline{K})$ can be rewritten as

$$I(\overline{K})=\begin{cases}\dfrac{\left(g(\overline{K}/2)\right)^{\Theta-1}}{\beta}\cdot\left(\beta-\dfrac{2\cdot(1-u^{\Theta})}{\Theta}\right) & for \quad \Theta\neq 0\\[2ex] \dfrac{g(\overline{K}/2)^{-1}}{\beta}\cdot(\beta+2\cdot\ln u) & for \quad \Theta=0\end{cases}, \tag{13}$$

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[12]Cf. Oswald (1982).

$$J(\overline{K})=\begin{cases}\dfrac{\left(g(\overline{K}/2)\right)^{\Theta-1}}{\beta}\cdot\left(\beta-\dfrac{\left(1-u^{\Theta}\right)}{\Theta}\right) & for \quad \Theta\neq 0\\ \dfrac{g(\overline{K}/2)^{-1}}{\beta}\cdot(\beta+\ln u) & for \quad \Theta=0\end{cases}. \tag{14}$$

$\beta\equiv\dfrac{g'(\overline{K}/2)\cdot\overline{K}/2}{g(\overline{K}/2)}$ is the elasticity of the full employment wage with respect to the world capital intensitiy. (13) and (14) show that a full employment equilibrium is the more likely the higher the risk aversion, the lower the unemployment benefit and the lower the wage elasticity ß. (Figure 3 ).

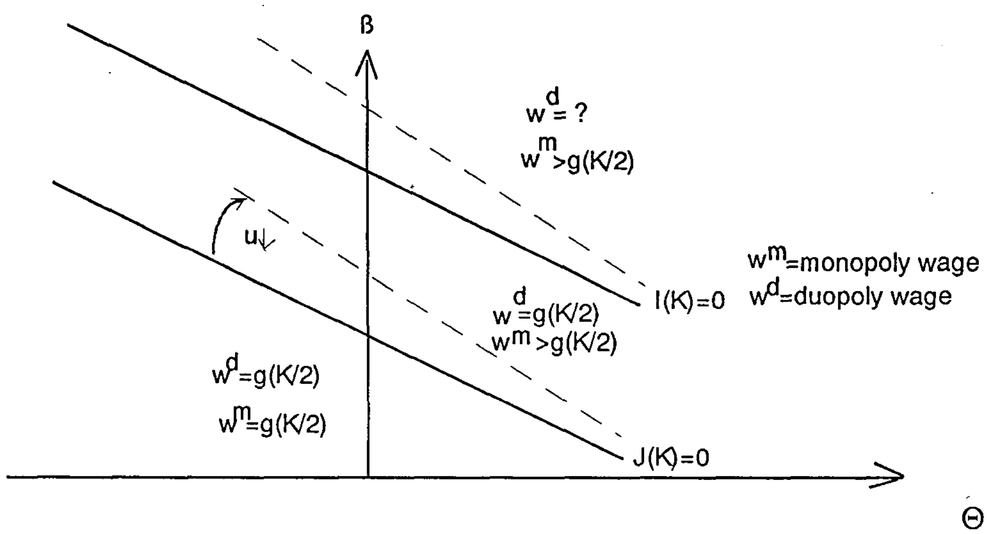


**Figure 3:** Existence Conditions for Full Employment Equilibria

## 3. Conclusion

Noncooperative wage setting by national trade unions which face international mobile capital is comparable to price setting of Bertrand-Edgeworth-oligopolists. Not only the rules of the game, but also its outcome resemble those of the Bertrand-Edgeworth-model. Therefore, both the Bertrand-Paradox and the possibility of nonexisting pure strategy equilibria also appear in this context. In the Bertrand-Edgeworth-model of oligopoly theory, the competitive price is an equilibrium in pure strategies if the production capacities are sufficiently large, so that the capacity constraint actually does not bind. However, in the model of trade union competition, the condition for existence is somewhat different. Pure strategy equilibria exist, if the world capital-labour ratio determines a full employment wage and labour demand function, which discourages wage increases, because resulting unemployment is not fully offset by the utility gains for the employed.

The results of this paper - full employment wages for a certain capital-labour ratio and nonexistence of pure strategy equilibria in all other cases, differ from other investigations of oligopolistic trade union behaviour, which are mentioned in the introduction. Those models obtained interior pure strategy equilibria somewhere in between the monopoly and the full employment wage. This is because they either assumed ad-hoc a well behaved labour demand function $L_i(w_i, w_j)$ with $\partial L_i / \partial w_j > 0$ (Oswald, 1979), or derive the labour demand function from a one-factor production function with diminishing returns (Davidson, 1988). Furthermore they did not consider the capacity constraint by the trade unions.

**Appendix**

The Kuhn-Tucker conditions to the program (3) and (4)

$$K_1\left(F_K(K_1,L_1)-y_1\right)=0, \qquad \text{(A1a)-(A1u)}$$

$$K_2\left(F_K(K_2,L_2)-y_1\right)=0,$$

$$L_1\left(F_L(K_1,L_1)-w_1-y_2\right)=0,$$

$$L_2\left(F_L(K_2,L_2)-w_2-y_3\right)=0,$$

$$y_1\left(\frac{\overline{K}}{2n}-K_1-K_2\right)=0,$$

$$y_2\left(\frac{1}{2n}-L_1\right)=0,$$

$$y_3\left(\frac{1}{2n}-L_2\right)=0,$$

$$F_K(K_1,L_1)-y_1\leq 0,\ F_K(K_2,L_2)-y_1\leq 0,$$

$$F_L(K_1,L_1)-w_1-y_2\leq 0,\ F_L(K_2,L_2)-w_2-y_3\leq 0,$$

$$\overline{K}/2n-K_1-K_2\geq 0,\ 1/2n-L_1\geq 0,\ 1/2n-L_2\geq 0,$$

$$K_1,K_2,L_1,L_2,y_1,y_2,y_3\geq 0.$$

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