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# Trade Liberalisation and Union Wages In a Differentiated Bertrand Duopoly

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# Trade liberalisation and union wages in a differentiated Bertrand duopoly

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**Abstract**

In a framework of a unionised international Bertrand duopoly with differentiated products, this paper analyses national labour market interdependencies and the consequences of trade liberalisation for union wages. The analysis suggests that national wages are likely to be strategic complements (substitutes), if products are ordinary substitutes (complements). Under the assumption of linear demand it is shown that bilateral trade liberalisation always leads to higher union set wages and union utilities, regardless of the nature of product rivalry. Analysing the consequences of unilateral tariff reductions it is shown that foreign tariff reductions always give rise to higher union wages and utilities, whereas the impact of unilateral domestic tariff reductions depends on the nature of product rivalry.

*JEL Classification:* F 12, J 50, L 13

*Keywords:* Trade unions, Oligopoly, Intra-industry trade, Market integration

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## 1. Introduction

The ongoing process of increasing product market integration raises the interesting question as to how collective bargaining outcomes will be affected by the removal of international trade restrictions. This issue is of particular interest as increasing international competition is usually regarded as placing substantial downward pressure on national bargaining systems, thereby suggesting organised labour as a major advocate for protectionist policies.

However, empirical work on the relationship between trade liberalisation and wage formation generally presents mixed evidence on this issue (see e.g. GASTON and TREFLER, 1995, KONINGS and VANDENBUSSCHE, 1995). This mixed empirical evidence is in line with the results derived by the theoretical literature analysing trade liberalisation in the presence of unions in imperfectly competitive product markets. HUIZINGA (1993) and SØRENSEN (1993), who model product market integration as a dichotomous shift from a no-trade to a full trade equilibrium, find that integration lowers union wages due to the additional entry of foreign competitors into the product market. BRANDER and SPENCER (1988) and MEZZETTI and DINOPOULUS (1991) analyse trade policies in a unionised international oligopoly, where firms compete for sales in the domestic market. Modelling product market integration as a reduction in tariffs, both studies generally suggest that wages are positively related to protection. NAYLOR (1998) extends the one-way trade framework of BRANDER and SPENCER (1988) and MEZZETTI and DINOPOULUS (1991) to a model of intra-industry trade in the spirit of BRANDER (1981) and BRANDER and KRUGMAN (1983). He investigates how trade liberalisation affects union wages and employment, when firms export part of their production abroad. In contrast to the former studies, NAYLOR'S (1998) results show that in an intra-industry trade regime bilateral trade liberalisation may lead to higher union set wages: With reciprocal trade, unions suffer from increased foreign competition in the domestic market, but simultaneously benefit from enhanced export possibilities in the foreign market, which may give rise to higher labour demand and thereby higher wages. The contradictory results to HUIZINGA (1993) and SØRENSEN (1993) arise, since NAYLOR (1998) considers tariff reductions starting from a position where trade already takes place. FISHER

and WRIGHT (1999), who take NAYLOR'S analysis further by investigating regional free trade agreements and bargaining outcomes in a three-country model, also find a negative relationship between wages and protection.

A common feature of the literature analysing trade liberalisation in the presence of unions is the assumption of Cournot quantity competition in a homogeneous product market. To date, no attempt has been made in the literature to analyse the impact of tariff removals on union wages with price setting competition in a differentiated product market. The present paper therefore attempts to fill this gap and examines the impact of tariff reduction with Bertrand conjectures and differentiated goods. A related paper is that of BANDYOPADHYAY et al. (2000), who analyse optimal export subsidies in a unionised Bertrand duopoly. While the focus of their analysis is on optimal trade policies, the present paper differs from their analysis in concentrating on the impact of trade liberalisation on union wages. Moreover, we consider import tariffs instead of export subsidies, which gives rise to additional ambiguities when analysing the impact of trade liberalisation on optimal union wages.

In the following analysis, equilibrium prices, quantities and wages are determined in a two-stage game: In the first stage, unions determine their optimal wage, i.e. we adopt the so called monopoly union approach. In the second stage, firms are engaged in Bertrand price-competition, i.e. each firm sets its price so as to maximise its profit, taking the rival's price as given. Profit maximising prices then determine equilibrium quantities. As is usual, the game is solved by backward induction, i.e., the Bertrand price-setting game is analysed first. When analysing the impact of trade liberalisation on bargaining outcomes, the following analysis will be restricted to the so called right-to-manage approach (NICKELL and ANDREWS, 1983), where unions influence wages only, since it seems reasonable to assume that firms retain the discretion to set prices unilaterally[1]. The rest of the paper is organised as follows: In Section 2 we conduct the analysis for general

[1] Alternatively, one could consider the case of wage-employment bargaining (see e.g MCDONALD and SOLOW, 1981), constituting a two-stage game, where wages and employment (or capacity) are bargained over in the first stage and prices are set in the second stage of the game. However, this is beyond the scope of the following analysis, which will be confined to short-run price competition, taking capacity levels as given.

product demand and union preferences in a simple inter-industry (i.e. one-way trade) framework, so as to highlight the general ambiguities that arise when analysing the impact of tariff reductions on union wages with Bertrand conjectures. Section 3 extends the analysis to a reciprocal trade model, but imposes specific functional forms for product demand and union preferences. In contrast to the simple one-way trade framework, the reciprocal trade model allows us to distinguish between unilateral and bilateral tariff reductions, which will give rise to different consequences concerning the attitudes of unions towards product market integration.

## 2. Bertrand competition, union wages and inter-industry trade

### 2.1. Firm objectives

Consider a domestic and a foreign firm, producing a differentiated good and competing for sales in the domestic market. The home and the foreign firm are assumed to face direct demand functions $x = d(P,Q)$ and $y = d^*(P,Q)$, respectively, where $P$ is the price charged by the domestic firm and $Q$ the price charged by the foreign firm. It is assumed that $d_1 < 0$ and $d^*_2 < 0$, where $d_i$ denotes the partial derivative of product demand with respect to its $i$'th argument. If the products are (ordinary) substitutes, we have $d_2 > 0$ and $d^*_1 > 0$, and if the products are (ordinary) complements, we have $d_2 < 0$ and $d^*_1 < 0$. One unit of labour produces one unit of output. Both firms are assumed to maximise profits, which are given by

$$\pi(P,Q,w) = Pd(P,Q) - wd(P,Q) \tag{1}$$

$$\pi^*(P,Q,w^*,t) = Qd^*(P,Q) - (w^*+t)d^*(P,Q), \tag{2}$$

where $w$ and $w^*$ represent domestic and foreign wages, respectively, and $t$ is a specific import tariff imposed by the domestic government. For the time being, the foreign wage, $w^*$, is taken as exogenously given.

**2.2. The Bertrand price setting game**

With Bertrand conjectures, each firm sets its price so as to maximise its profit, taking the rival's price as given. First-order conditions are given by

$$\pi_1 = d + Pd_1 - wd_1 = 0 \tag{3}$$

$$\pi^*_2 = d^* + Qd^*_2 - (w^* + t)d^*_2 = 0\,. \tag{4}$$

The non-cooperative equilibrium is characterised by the simultaneous solution of (3) and (4), yielding prices $P(w, w^*, t)$ and $Q(w, w^*, t)$ as functions of domestic and foreign wages, $w$ and $w^*$, and the import tariff, $t$. Totally differentiating (3) and (4) yields

$$\pi_{11}dP + \pi_{12}dQ = d_1 dw \tag{5}$$

$$\pi^*_{21}\,dP + \pi^*_{22}\,dQ = d^*_2\,(dw^* + dt)\,, \tag{6}$$

yielding the slopes of the domestic and foreign reaction functions

$$\frac{dP}{dQ} = -\frac{\pi_{12}}{\pi_{11}} \text{ and } \frac{dQ}{dP} = -\frac{\pi^*_{21}}{\pi^*_{22}}\,. \tag{7}$$

Second-order conditions require

$$\pi_{11} = 2d_1 + (P - w)d_{11} < 0 \text{ and } \pi^*_{22} = 2d^*_2 + (Q - (w^* + t))d^*_{22} < 0\,. \tag{8}$$

If $\pi_{12}$ and $\pi^*_{21}$ are positive, reaction functions are upward sloping, i.e. products are strategic complements (BULOW et. al., 1985). With the two products being

(ordinary) substitutes[2] (i.e. $d_2 > 0$ and $d^*_1 > 0$), reaction functions are upward sloping, if $d_{12}$ and $d^*_{21}$ are not too negative, since $\pi_{12} = d_2 + (P - w)d_{12}$ and $\pi^*_{21} = d^*_1 + (Q - (w^* + t))d^*_{21}$. Alternatively, if the products are complements, they will be strategic substitutes, provided that $d_{12}$ and $d^*_{21}$ are not too positive. Throughout the following analysis, these conditions are assumed to be fulfilled, so that products being substitutes imply strategic complements, and vice versa.

Comparative static effects of changes in the domestic tariff and the domestic wage may be obtained by application of Cramer's rule. Assuming stability and uniqueness of the equilibrium, i.e. $DET = \pi_{11}\pi^*_{22} - \pi_{12}\pi^*_{21} > 0$, the impact of a change in *t* and *w* on *P* and *Q* is then as follows:

$$\frac{dQ}{dt} = \frac{d^*_2\,\pi_{11}}{DET} > 0 \text{ and } \frac{dP}{dt} = \frac{-d^*_2\,\pi_{12}}{DET} \gtreqless 0, \text{ if } \pi_{12} \gtreqless 0. \qquad (9)$$

and

$$\frac{dP}{dw} = \frac{d_1\pi^*_{22}}{DET} > 0 \text{ and } \frac{dQ}{dw} = \frac{-d_1\pi^*_{21}}{DET} \gtreqless 0, \text{ if } \pi^*_{21} \gtreqless 0. \qquad (10)$$

Eqs. (9) reveal that the imposition of a tariff unambiguously raises the foreign price, *Q*, since a tariff raises the foreign firm's marginal cost. The domestic price response depends on whether the products are strategic complements or substitutes. With the products being strategic complements, the rise of the foreign price induces the domestic firm to charge a higher price, *P*. In contrast, with strategic substitutes, the optimal domestic price response of the home firm is to lower its price, *P*. Analogously, according to eqs. (10), a rise in the domestic wage unambiguously raises the domestic price, while the foreign price response will be positive (negative), if the products are strategic complements (substitutes).

[2] For the sake of expositional brevity, in the following discussion *ordinary substitutes* and *complements* are referred to as *substitutes* and *complements*.

### 2.3. Union objectives

Domestic workers are assumed to be organised by a union, which maximises the following utility function

$$U = x \cdot u(w) + (M - x)u(\overline{w}) \tag{11}$$

where $M$ is membership of the union, $u(\cdot)$ is the workers' utility function over wages, where $u_w(w) > 0$ and $u_{ww}(w) \leq 0$. $\overline{w}$ is the alternative wage which workers may expect to earn elsewhere in the economy. In general, $\overline{w}$ depends positively on the alternative outside wage as well as unemployment benefits and is negatively affected by the unemployment rate. (11) is referred to as an objective function of a utilitarian union which attempts to maximise the sum of its members' utilities (OSWALD, 1982).

### 2.4. Union wage setting

According to the monopoly union approach, the domestic union maximises its utility function, which is given by eq. (11), with respect to the wage, $w$. The union's optimal wage solves

$$U_w = x \cdot u_w(w) + (u(w) - u(\overline{w})) \cdot x_w = 0. \tag{12}$$

Since unions correctly anticipate the impact of wages on product market competition, $x_w$ is given by

$$x_w = d_1 \frac{dP}{dw} + d_2 \frac{dQ}{dw}. \tag{13}$$

Inserting eqs. (10) into (13) yields:

$$x_w = \frac{d_1 \left[ d_1 \pi^*_{22} - d_2 \pi^*_{21} \right]}{DET}, \tag{14}$$

which is negative, provided that $|d_1| > d_2$. When choosing its optimal wage, the union takes into account two effects of a wage rise on domestic employment, *x*, and union utility: First, a higher wage raises the domestic price and reduces demand for the domestic product, which is reflected by the first summand in eq. (13). Second, a rise in the wage affects domestic employment via changes in the foreign price, which is represented by the second term in eq. (13). With products being substitutes $(d_2 > 0)$ and strategic complements, a higher wage raises the foreign price, thereby leading to a rise in demand for the domestic product. With the products being complements $(d_2 < 0)$ and strategic substitutes, a wage increase leads to a reduction in the foreign price, thereby also giving rise to an increase of domestic demand. Stability conditions ensure that the domestic price response to the wage rise dominates the foreign price reaction. Moreover, the own-price effect on domestic demand is assumed to dominate the cross effect, i.e. $|d_1| > d_2$, thereby leading to an overall decrease in domestic employment in response to a higher wage.

### 2.5. Impact of trade liberalisation on the union wage

Comparative static effects of a change in *t* on *w*, may be derived by applying the implicit function theorem, i.e.

$$\frac{dw}{dt} = -\frac{U_{wt}}{U_{ww}}. \tag{15}$$

The sign of *dw/dt* is therefore determined by the sign of $U_{wt}$, which is given by

$$U_{wt} = x_t \cdot u_w(w) + x_{wt}(u(w) - u(\overline{w})). \tag{16}$$

The literature analysing trade policies under Cournot quantity competition has shown that the imposition of a tariff unambiguously shifts the labour demand curve outwards, i.e. $x_t > 0$, if demand is not too convex (e.g. BRANDER and SPENCER, 1985, 1988). The ambiguity with respect to the wage response was shown to result from the tariff's impact on the slope of labour demand, $x_{wt}$. More

specifically, it has been shown that a sufficient condition for the union's optimal wage to increase is that the labour demand curve does not become considerably flatter. In the Bertrand case, however, it will turn out that the adoption of general product demand requires additional restrictions concerning product demand so as to ensure that the labour demand curve shifts outwards, i.e. $x_t > 0$. Since the aim of the present section is to derive this additional condition, the following discussion will be limited to first-order effects, i.e. the direction in which the labour demand curve moves, $x_t$, and it will neglect second-order effects, i.e. a tariff's impact on the slope of labour demand, $x_{wt}$.

The impact of a tariff on domestic employment, $x_t$, may be obtained by totally differentiating $x = d(P,Q)$ and dividing the differential by *dt:*

$$x_t = d_1 \frac{dP}{dt} + d_2 \frac{dQ}{dt}. \tag{17}$$

Inserting (9) into (17) yields:

$$x_t = \frac{d^*_2}{DET}\left[(P-w)(d_{11}d_2 - d_{12}d_1) + d_2 d_1\right]. \tag{18}$$

This may take either sign, since eq. (18) reveals that

$$\operatorname{sgn} x_t = -\operatorname{sgn}\left[(P-w)(d_{11}d_2 - d_{12}d_1) + d_2 d_1\right]. \tag{19}$$

The ambiguity generally arises from two conflicting forces. Consider first the case of products being substitutes (i.e. $d_2 > 0$) and strategic complements: The second term in eq. (17) will then be positive, since an increase in *t* raises the foreign price, *Q*, and therefore demand for the domestic product. The rise in the foreign price, *Q*, in turn, induces the home firm to charge a higher price as well, thereby decreasing demand for the domestic good. I.e., in general, the first term in eq. (17) will be negative. The overall impact on domestic demand depends on which of the two effects will be the dominating one. $x_t$ may, for example, be negative if demand is very convex (i.e. $d_{11} > 0$) and if an increase in the rival's price has a

considerable positive impact on the slope of the demand curve facing the domestic firm (i.e. $d_{12} > 0$). Eq. (19) reveals, that a sufficient condition for *dx/dt* to be positive is that $d_{11}$ and $d_{12}$ be negative. From eq. (9) it can be seen that this condition ensures that the foreign price response turns out to be relatively large compared to the domestic price response[3]. Alternatively spoken, the ambiguity of a tariff change may be explained by the fact that a tariff influences *foreign marginal costs*. While stability conditions ensure that the foreign price response dominates the domestic price response, domestic demand is more sensitive with respect to own-price effects than to foreign price effects, thereby leading to the overall ambiguity.

Finally, consider what would happen with a domestic export subsidy: A domestic export subsidy shifts the labour demand curve ambiguously outwards, since a subsidy basically affects the *domestic firm's marginal cost* (see eq. (14)). This feature essentially distinguishes our analysis from that of BANDYOPADHYAY et al. (2000), who consider export subsidies only. In the Bertrand case, additional requirements concerning product demand are necessary so as to ensure that the labour demand curve shifts outwards in response to a tariff change. Moreover, due to the additional dependence of product demand on foreign prices, the impact of a change in the tariff on the labour demand curve's slope turns out to be ambiguous anyway. This raises considerable difficulties when deriving sufficient conditions for wages to rise in response to a positive tariff change[4].

## 3. Bertrand competition, union wages and intra-industry trade

NAYLOR (1998) has shown that the impact of product market integration on wages critically depends on whether the model is characterised by an inter- or intra-industry trade regime. Thus, a natural extension of the preceding discussion

[3] Analogously, consider the case of products being complements ($d_2 < 0$) and strategic substitutes. A rise in the tariff increase the foreign price, *Q*, which decreases domestic demand, i.e. the second term in eq. (17) is unambiguously negative. Moreover, the rise in the price, *Q*, induces the home firm to charge a lower price, *P*, so that the first term in eq. (17) will generally be positive. Again, the overall effect on domestic demand turns out to be ambiguous.

[4] Note that the results derived above are also valid for domestic demand reactions in response to a change in the foreign wage, *w**. This is because, both the foreign wage, *w**, and a specific domestic import tariff, *t*, constitute the foreign firm's marginal cost. The best response of the domestic union to an increase in the foreign wage is therefore as ambiguous as the response to a rise in the domestic tariff.

involves the consideration of the case of Bertrand competition with reciprocal trade. I.e., in contrast to the preceding section, the following analysis considers two firms competing for sales in the domestic as well as in the foreign markets, with each firm exporting part of its production abroad. The modelling set-up is similar to that of VENABLES (1990), who examines welfare effects of trade liberalisation in a differentiated oligopolistic product market. However, while VENABLES (1990) takes marginal costs as given, the following analysis introduces the presence of unions and considers the impact of tariff reductions on wage formation.

### 3.1. The Bertrand price-setting game

In what follows, we will adopt the assumption of segmented product markets, i.e. each firm regards each country as a separate market and choose for each national market profit maximising prices separately. Let $P$ be the price charged by the domestic firm for sales in the domestic market, $P^*$ the domestic firm's price charged for sales in the foreign market. Similarly, $Q$ represents the foreign firm's price charged for sales in the domestic market and $Q^*$ the foreign firm's price charged for sales in the foreign market. Since in section 2 it has been demonstrated that union wage responses to tariff reductions turn out to be ambiguous with general demand specifications, the following section will consider the particular case of linear demand. Assuming symmetry of the demand systems in the home and foreign countries, inverse demand functions are represented by

$$P(x,y) = 1 - x - by \qquad \text{and} \qquad Q(x,y) = 1 - y - bx\,, \tag{20}$$

$$P^*(x^*,y^*) = 1 - x^* - by^* \quad \text{and} \qquad Q^*(x^*,y^*) = 1 - y^* - bx^*\,, \tag{21}$$

where $x$ represent the domestic firm's sales in the domestic market, $x^*$ are domestic export sales, $y$ are foreign export sales and $y^*$ represent the foreign firm's sales in the foreign market. The parameter $b$ represents the degree of product rivalry and is assumed to lie in the interval $]-1,1[$. Solving eqs. (20) and

(21) for $x$, $y$, $x^*$ and $y^*$, the expressions for home sales, $x$ and $y^*$, and for export sales, $x^*$ and $y$, are given by:

$$x(P,Q) = \frac{1 - P - b(1-Q)}{1-b^2}, \tag{22}$$

$$x^*(P^*,Q^*) = \frac{1 - P^* - b(1-Q^*)}{1-b^2}, \tag{23}$$

$$y(P,Q) = \frac{1 - Q - b(1-P)}{1-b^2}, \tag{24}$$

$$y^*(P^*,Q^*) = \frac{1 - Q^* - b(1-P^*)}{1-b^2}. \tag{25}$$

Differentiating eqs. (22) – (25) with respect to the rival's price, it can be seen that with $b > 0$, the products of the firms are substitutes. As $b$ approaches 1, products become approximately homogeneous substitutes. Conversely, if $b < 0$, products may be thought of as complements.

The domestic and foreign firm's profit functions take the form

$$\pi = (P - w)x + (P^* - w - t^*)x^* \tag{26}$$

and

$$\pi^* = (Q^* - w^*)y^* + (Q - w^* - t)y, \tag{27}$$

where $t$ and $t^*$ are import tariffs levied by the home and foreign countries, respectively. I.e., home sales of the domestic firm earn $P$ per unit, whereas export sales earn $P^* - t^*$ per unit. Following the assumption of Bertrand conjectures in segmented markets, both firms' maximisation problems are given by

$$\max_{P,P^*} \pi \text{ and } \max_{Q,Q^*} \pi^*, \tag{28}$$

taking wages and import tariffs as given. Equilibrium prices then take the form

$$P(w, w^*, t) = \frac{2 \cdot (1 + w) - b \cdot (1 - w^* - t) - b^2}{4 - b^2} \tag{29}$$

and $$P^*(w, w^*, t^*) = \frac{2 \cdot (1 + w + t^*) - b \cdot (1 - w^*) - b^2}{4 - b^2}. \tag{30}$$

Symmetric expressions hold for prices, $Q$ and $Q^*$, charged by the foreign firm. Eq. (29) reveals that the domestic firm's price for sales in the domestic market, $P$, depends positively on its own wage, $w$, and is an increasing (decreasing) function of the rival's marginal costs, $w^* + t$, when products are substitutes (complements), i.e. $b > 0 (b < 0)$. Similarly, according to eq. (30), the domestic firm's export price for sales in the foreign country, $P^*$, depends positively on its own marginal costs, $w + t^*$, and is an increasing (decreasing) function of the rival's marginal costs, $w^*$, when products are substitutes (complements), i.e. $b > 0 (b < 0)$.

Moreover, comparing eqs. (29) and (30) reveals that

$$P^* - P = \frac{2 \cdot t^* - b \cdot t}{4 - b^2}. \tag{31}$$

For symmetric tariff outcomes, expression (31) is positive and increasing in the tariff. With free trade, prices for home and export sales will be equalised. With positive tariffs, each firm charges a higher price for export sales, so as to absorb the higher marginal cost incurred from exporting goods from one country to the other. Moreover, comparing price-cost margins for the home and export market reveals that each firm has a higher mark-up on marginal costs in its home market. Hence, as in the Cournot competition case, the export price net of the tariffs falls short of the domestic price, i.e. each firm dumps its product into the export market (BRANDER and KRUGMAN, 1983).

Inserting equilibrium prices (29) and (30) in eqs. (22) - (25) yields for equilibrium quantities as functions of wages and import tariffs:

$$x(w,w^*,t)=\frac{(2-b^2)(1-w)-b(1-w^*-t)}{(1-b^2)(4-b^2)}, \tag{32}$$

$$x^*(w,w^*,t^*)=\frac{(2-b^2)(1-w-t^*)-b(1-w^*)}{(1-b^2)(4-b^2)}, \tag{33}$$

$$y(w,w^*,t)=\frac{(2-b^2)(1-w^*-t)-b(1-w)}{(1-b^2)(4-b^2)}, \tag{34}$$

$$y^*(w,w^*,t^*)=\frac{(2-b^2)(1-w^*)-b(1-w-t^*)}{(1-b^2)(4-b^2)}. \tag{35}$$

Since output equals employment, $x+x^*$ represents labour demand facing the domestic union, whereas $y+y^*$ represents foreign labour demand. By virtue of eqs. (32) – (35), employment in each firm depends negatively on its own wage and on the tariff imposed by the rival country. Moreover, if products are substitutes $(b>0)$, employment in each firm is positively affected by the rival's wage and the tariff levied by the home country. An increase in the foreign firm's marginal cost therefore shifts the domestic labour demand schedule unambiguously outwards[5]. Similarly, it can be shown, that with linear product demand, labour demand shift inwards, if the products are complements (i.e. $b<0$).

### 3.2. The Bertrand wage-setting game

The present section analyses the Bertrand wage-setting game between national unions. It is assumed that labour markets are symmetric and that unions have the whole bargaining strength. In order to simplify the analysis, unions are assumed to

[5] Recall from section 2 that there are, in general, two effects on home demand associated with a rise in foreign marginal costs: On the one hand, an increase in foreign marginal costs raises the foreign price and therefore demand for the domestic product. On the other hand, with products being strategic complements, the rise in the foreign price induces the domestic firm to charge a higher price as well, thereby decreasing demand for the domestic good. I.e., with linear demand the first effect dominates the second one, thereby increasing demand for the domestic product and shifting the labour demand schedule outwards.

maximise the wage bill, which amounts to risk neutral union members and an alternative wage, $\overline{w}$, set equal to zero. The domestic union therefore maximises

$$U = w(x + x^*), \tag{36}$$

whereas the foreign union maximises

$$U^* = w^*(y + y^*). \tag{37}$$

Since unions correctly anticipate the impact of wages on product market competition, the optimal domestic wage, is given by

$$w = \arg\max_{w}(w(x + x^*)), \tag{38}$$

where labour demand, $x + x^*$, is given by eqs. (31) and (32). Maximising (36) with respect to $w$ yields

$$w(w^*, t, t^*) = \frac{2 \cdot (b+2) \cdot (1-b) - (2-b^2) \cdot t^* + b \cdot t + 2 \cdot b \cdot w^*}{4(2-b^2)}. \tag{39}$$

According to eq. (39), $w$, is an increasing function of foreign marginal costs, $t$ and $w^*$, if products are substitutes $(b > 0)$. Hence with products being substitutes, wages (or, in general, marginal costs) are strategic complements from the union's point of view.

This is due to the fact that a rise in foreign marginal costs shifts labour demand unambiguously outwards (see eqs. (32) and (33)), thereby improving the domestic firm's competitive position and enabling the domestic union to settle for a higher wage[6].

[6] Note that with linear product demand, only the movement of the labour demand curve turns out to be relevant for the union wage response, since the slope of labour demand will be unaffected by a change in foreign marginal costs.

Similarly, $w$ decreases with $t$ and $w^*$, if products are complements $(b<0)$. Hence, marginal costs, i.e. wages and the domestic import tariff, are strategic substitutes from the union's point of view, since a rise in foreign marginal costs unambiguously shifts the labour demand curve inwards, thereby inducing the domestic union to settle for a lower wage. Hence, in contrast to the homogeneous Cournot case, in the present framework, the strategic interaction between national wage outcomes is crucially determined by the nature and degree of product rivalry. The stronger the products are substitutes or complements, i.e. the higher the absolute value of $b$, the more are national wages affected by foreign labour market outcomes.

For the homogeneous Cournot case, the strategic complement property of wages has been derived and discussed by a number of authors (see e.g. DAVIDSON (1988), PADILLA et al. (1996)). Strategic complementarity of national wages has important implications for the impact of international product market integration on national bargaining systems. CORNEO (1995) discusses these implications and examines how institutional changes in national bargaining system affects wage formation in other countries. He shows that country specific shocks affecting institutional factors and therefore national wages influence foreign bargaining outcomes by altering the competitive position of foreign firms. In this context, one of his main findings is that national institutional changes affecting collective bargaining outcomes spill-over to other countries due to the positive externality between national wage levels[7]. Note that in the present analysis, with products being complements and wages strategic substitutes, there may be even negative spill-over effects due to changes in institutional changes affecting national wage outcomes. The analysis therefore suggests, that country specific shocks affecting foreign national wages may even lead to diverging wage movements in the home country, if demand for the domestic product strongly depends on foreign prices for complementary goods.

[7] This transmission mechanism is particularly striking when considering dichotomous shifts from no-trade equilibria characterised by prohibitive tariff outcomes to fully integrated product market equilibria with zero tariffs. By comparing pre-trade wages to wages negotiated in an internationally integrated product market, CORNEO (1995) shows that product market integration mitigates international wage differentials due to country specific labour market institutions.

Describing the outcome of wage determination in the foreign country analogously to eq. (39) and solving simultaneously for the domestic and foreign wage yields:

$$w(t,t^*) = \frac{2\cdot(b+2)\cdot(1-b)\cdot(4+b-2b^2)+b\cdot(2-b^2)\cdot t-(8-9b^2+2b^4)\cdot t^*}{2\cdot(4-b-2b^2)\cdot(4+b-2b^2)} \qquad (40)$$

Similarly, a symmetric expression holds for the foreign wage, $w^*$.

### 3.3. Impact of trade liberalisation on wages, employment and welfare

Due to the reciprocal trade framework it is necessary to distinguish between unilateral and bilateral tariff reductions. Investigating wage and employment effects of unilateral tariff reductions establishes the following proposition:

**Proposition 1:**

*A unilateral domestic tariff reduction (i) reduces (raises) the domestic wage, (ii) reduces (raises) domestic employment, if products are substitutes (complements). A unilateral foreign tariff reduction (iii) raises the domestic wage and (iv) raises domestic employment, regardless of the nature of product rivalry.*

An immediate corollary from Proposition 1 is that while a unilateral *domestic* tariff reduction reduces (raises) domestic union utility, if products are substitutes (complements), a unilateral *foreign* tariff reduction always raises domestic union utility, regardless of the sign of $b$..

**Proof:**

(i) Differentiating eq. (40) with respect to $t$ yields

$$\frac{dw}{dt} = \frac{b(2-b^2)}{2(4-2b^2-b)(4-2b^2+b)} > (<)0, \text{ for } b > (<)0\,. \qquad (41)$$

Differentiating eq. (41) with respect to $b$ it can easily be checked that $d^2w/dtdb>0$, i.e. the sensitivity of $w$ with respect to $t$ is increasing in the degree of product rivalry. This result reflects that the extent to which the domestic firm's competitive position is deteriorated by a domestic tariff reduction will be the larger the closer the products are substitutes.

(ii) See the Appendix

(iii) Differentiating eq. (40) with respect to $t$ yields

$$\frac{dw}{dt*} = \frac{-(8-9b^2+2b^4)}{2(4-b-2b^2)(4+b-2b^2)} < 0, \tag{42}$$

since $(8-9b^2+2b^4)>0$ for $b \in ]-1,1[$.

(iv) See the Appendix.

The result that the sign of *dw/dt* does depend on the sign of $b$ may be explained by the fact that a *domestic tariff* only indirectly affects domestic sales, $x$, through its impact on foreign marginal costs: A domestic tariff reduction lowers the foreign firm's marginal cost and therefore its price for export sales, $Q$. If the products are substitutes, domestic demand for the domestic product, $x$, is decreased, inducing the domestic union to moderate its wage demand. If the products are, in contrast, complements, domestic demand for the domestic product, $x$, rises, thereby enabling the domestic union to charge a higher wage. Moreover, part (iii) of Proposition 1 establishes that in equilibrium, i.e. after taking into account the union's wage reaction, overall domestic employment, $x+x^*$, is reduced (increased), for $b>(<)0$. Hence, the direct negative (positive) effect of a tariff reduction on domestic sales, $x$, more than offsets possible positive (negative) effects on employment arising from the domestic unions' wage responses to the tariff change.

In contrast, the result that the sign of *dw/dt** does not depend on the nature of product rivalry may be explained by the fact that a *foreign tariff* directly affects domestic demand through its impact on domestic marginal costs: According to eq. (30), a reduction of the foreign tariff reduces the domestic firm's marginal cost and therefore the price for export sales, *P**. As a consequence, with linear demand[8], export demand, *x*,* and therefore overall demand, $x + x^*$, for the domestic product is raised (eq. (33)), thereby increasing the domestic union's optimal wage. Part (iv) of Proposition 1 establishes that overall domestic demand is raised in equilibrium, i.e. after taking into account the union's wage reaction. This is because the direct positive effect of a tariff reduction on export sales, *x**; outweighs possible negative effects on employment, $x + x^*$ arising from the unions' wage responses to the tariff change.

Investigating the impact of bilateral reductions and imposing a symmetric tariff outcome $t = t^* = T$ establishes the following proposition:

**Proposition 2:**

*Bilateral trade liberalisation (i) increase the domestic wage, (ii) raises domestic employment, (iii) raises union utility, (iv) reduces (raises) firm profits above (below) some critical level* $T^{\pi}$*, (v) reduces (raises) consumer surplus above (below) some critical level* $T^{CS}$*, (vi) raises domestic welfare, regardless of the sign of b. Symmetric results hold for the foreign country.*

**Proof:**

(i) Imposing a symmetric tariff outcome, eq. (40) reduces to

$$w = \frac{(b+2)\cdot(1-b)(2-T)}{2\cdot(4-b-2b^2)}. \tag{43}$$

so that $dw/dT < 0$, for $b \in ]-1,1[$.

[8] Recall that with linear product demand, the impact of the foreign price change on domestic

(ii-v): See the Appendix.

If $b < 0$, the preceding discussion has shown, that a bilateral tariff reduction raises export sales, $x^*$, as well as home sales, $x$. If, in contrast, $b > 0$, the decrease in home sales, $x$, associated with a tariff reduction is outweighed by the rise in export sales, $x^*$, thereby increasing total employment for the domestic union and leading to a higher wage.

In equilibrium, after taking into account the unions' wage reactions, bilateral tariff reductions raise domestic employment, $x + x^*$, regardless of the sign of $b$. Hence, the direct positive effect on export sales, $x^*$, more than offsets negative effects on employment arising from direct negative effects on domestic sales, $x$, if $b > 0$ and from wage increases in response to the bilateral tariff reduction.

With respect to consumer surplus, Proposition 2 states that below some critical level $T^{CS}$ bilateral tariff reductions give rise to an increase in consumer surplus, whereas for tariff levels above $T^{CS}$ consumer surplus is reduced. The intuition behind this result can be explained by the fact that bilateral tariff reduction may increase the domestic price, $P$, whereas the price for imports, $Q$, is unambiguously reduced. The last effect will more than offset the first one, if tariffs are sufficiently low and import levels sufficiently high. Form eq. (29) it can be seen that the ambiguity of a bilateral tariff reduction with respect to the home price, $P$, arises from two conflicting forces: On the one hand a bilateral tariff reduction raises foreign and domestic wages, which tends to increase $P$. On the other hand, a tariff reduction decreases foreign marginal costs, thereby inducing the domestic firm to charge a lower (higher) price, if products are substitutes (complements). If $b$ is sufficiently large, i.e. if products are very similar, the effects on $P$ via foreign marginal costs dominates the effect arising from higher wages, thereby inducing the home firm to charger a lower price in response to a tariff reduction. The fact that a tariff's impact on export prices, $Q$ and $P^*$, is unambiguously positive may be explained by the fact that a tariff directly affects the export price via its impact on the firms' marginal export costs.

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demand dominates the impact of the domestic price response.

The intuition that domestic profits are a non-monotonic function of tariffs is the following: Whereas a bilateral tariff reduction has an ambiguous impact on the price charged in the home market, $P$, and production for the home market, $x$, it unambiguously raises the wage charged by the domestic union, $w$, lowers the product price for sales in the foreign market, $P^*$, and raises exports, $x^*$. Moreover, marginal costs arising form delivering the foreign market are reduced. The last effects can be shown to dominate negative marginal effects on profits if tariffs are sufficiently low and the trade volume sufficiently large.

## 4. Conclusions

In a framework of a unionised international Bertrand duopoly with differentiated products, the present paper has examined the consequences of trade liberalisation for union wage. The analysis suggests that national wages are likely to be strategic complements (substitutes), if products are ordinary substitutes (complements). The result that wages may me strategic substitutes has important consequences for international labour market interdependencies. More specifically, the results suggest that national wage outcomes may even diverge as a result of product market integration, if demand for the domestic product strongly depends on foreign prices for complementary goods.

Under the assumption of linear demand it has been shown that bilateral trade liberalisation always leads to higher union set wages and union utilities, regardless of the nature of product rivalry. Hence, as in NAYLOR (1998) increased product market competition does not necessarily lead to more competitive outcomes in the labour market. Analysing the consequences of unilateral tariff reductions, it has been shown that foreign tariff reductions always give rise to higher union wages and utilities, whereas the impact of unilateral domestic tariff reductions depends on the nature of product rivalry. The analysis therefore suggests that organised labour's attitudes towards product market integration should critically depend on the question which products are subject to trade liberalisation and on whether tariff removals are undertaken unilaterally or bilaterally.

## Appendix

### Proposition 1

***(ii) and (iv:) Comparative static effects on domestic employment***

Inserting equilibrium wages, eq. (40), into eqs. (32) and (33) yields equilibrium quantities, $x(t,t^*)$ and $x^*(t,t^*)$, denote as eqs. (32') and (33'). It follows that

$$\frac{d(x+x^*)}{dt}(t,\bar{t}^*) =$$

$$\frac{b(2-b^2)^2}{(1-b)(1+b)(2-b)(2+b)(4-b-2b^2)(4+b+2b^2)} \gtreqless 0, \text{ for } b \gtreqless 0. \qquad \text{(A.1)}$$

$$\frac{d(x+x^*)}{dt^*}(\bar{t},t^*) =$$

$$-\frac{(2-b^2)(8-9b^2+2b^4)}{(1-b)(1+b)(2-b)(2+b)(4-b-2b^2)(4+b-2b^2)} < 0 \text{ for } b \in ]-1;1[. \qquad \text{(A.2)}$$

### Proposition 2:

***(ii): Comparative static effects on domestic employment***

Imposing symmetric tariff outcomes $t = t^* = T$ and differentiating (32') + (33') with respect to $T$ gives

$$\frac{d(x+x^*)}{dT} = -\frac{2-b^2}{(2-b)(1+b)(4-b-2b^2)} < 0 \text{ for } b \in ]-1;1[. \qquad \text{(A.3)}$$

***(iv): Comparative static effects on domestic profits***

Inserting equilibrium wages, eq. (40), into eqs. (29) and (30) yields equilibrium prices $P(t,t^*)$ and $Q(t,t^*)$, denoted as eqs. (29') and (30') Substituting eqs. (32'), (33') and (29'), (30') and (40) into the profit equation (26), imposing symmetric tariff outcomes $t = t^* = T$ and differentiating the resulting expression with respect to $T$ gives

$$\frac{d\pi}{dT} = \frac{\Delta}{\Phi}T + \frac{\Gamma}{\Phi}, \text{ where} \tag{A.4}$$

$$\Delta = 80 - 5b^8 - 2b^7 - 42b^6 + 14b^5 + 129b^4 - 28b^3 - 168b^2 + 16b > 0 \text{ for } b \in ]-1;1[$$

$$\Gamma = -2(1-b)^2(2+b)^2(2-b^2)^2 < 0 \text{ for } b \in ]-1;1[$$

$$\Phi = (1-b)(1+b)(2-b)^2(2+b)^2(4-b-2b^2)^2 > 0 \text{ for } b \in ]-1;1[$$

From (A.2) it follows that $\frac{d\pi}{dT} \lessgtr 0$ for $T \lessgtr \frac{-\Gamma}{\Delta} = T^{\pi}$.

***(v): Comparative static effects on consumer surplus***

Imposing $t = t^* = T$ yields $Q = P^*$. Differentiating (29') and (30') with respect to $T$ yields:

$$\frac{dP}{dT} = -\frac{4 - 8b - b^2 + 3b^3}{(2-b)(2+b)(4-b-2b^2)} \lessgtr 0 \text{ for } b \lessgtr 0.519, \tag{A.5}$$

$$\frac{dQ}{dT} = \frac{12 - 4b - 5b^2 + b^3}{(2-b)(2+b)(4-b-2b^2)} > 0 \text{ for } b \in ]-1;1[. \tag{A.6}$$

Consumer surplus is given by $CS = S(x,y) - Px - Qy$, so that

$$\frac{dCS}{dT} = -x\frac{dP}{dT} - y\frac{dQ}{dT} = \frac{A}{B}T + \frac{X}{B}, \text{ where} \qquad \text{(A.7)}$$

$$A = 80 + 3b^7 - 11b^6 - 23b^5 + 69b^4 + 52b^3 - 136b^2 - 32b > 0 \text{ for } b \in ]-1;1[,$$

$$X = -2(1-b)(2+b)^2(2-b^2)^2 < 0 \text{ for } b \in ]-1;1[,$$

$$B = 2(1-b)(2-b)^2(2+b)^2(1+b)(4-b-2b^2)^2 > 0 \text{ for } b \in ]-1;1[,$$

It follows that $\frac{dCS}{dT} \begin{matrix} < \\ = \\ > \end{matrix} 0$ for $T \begin{matrix} < \\ = \\ > \end{matrix} \frac{-X}{A} = T^{CS}$.

***(vi): Comparative static effects on domestic welfare***

Inserting equilibrium wages, eq. (40), equilibrium prices, (29') and (30'), and equilibrium quantities, (32') – (35') into the welfare equation $W = CS + \pi + U + Ty$ and differentiating $W$ with respect to $T$ yields

$$\frac{dW}{dT} = \frac{\Pi}{\Omega}T + \frac{\Psi}{\Omega}, \text{ where} \qquad \text{(A.8)}$$

$$\Pi = 80 + 3b^7 - 11b^6 - 23b^5 + 69b^4 + 52b^3 - 136b^2 - 32b > 0 \text{ for } b \in ]-1;1[,$$

$$\Psi = 4(2-b^2)(3-b^2)(2+b)^2(1-b)^2 > 0 \text{ for } b \in ]-1;1[,$$

$$\Omega = -2(2-b)^2(2+b)^2(1-b)(1+b)(4-b-2b^2)^2 < 0 \text{ for } b \in ]-1;1[.$$

From (A.8) it follow that $dW/dT < 0$ for $T > 0$.

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