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## International Production And Welfare Distribution Under Different Union Wage Settings

Domenico Buccella

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### Abstract

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A key aspect of economic integration is the internationalization of productive activities, conducted mainly by Multinational Enterprises, which often occurs in countries with unionized labor markets that belong to an already integrated area like the EU. Solving a two-stage game by backward induction both in a static and in a repeated framework, this paper investigates, within a symmetric two-country model of oligopoly with a homogeneous product, the effects on welfare distribution of different union wage settings, examining both separate and coordinated wage settings by national labor unions. Some policy indications are derived.

*JEL classification:* F21, F23, J50, J51 ;

*Keywords:* international production, union competition, union collusion, welfare distribution;

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### The author/s

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**Domenico Buccella** is PhD Student at the Dipartimento di Economia Politica, Università di Siena and visiting scholar at the Institut für Volkswirtschaftslehre, Universität Graz.

E-Mail: [buccella@unisi.it](mailto:buccella@unisi.it)



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## 1 Introduction

Closer economic integration within regional and international spheres has been the course of action characterizing the last decades of contemporary history. International trade, as a result of increasing removal of trade restrictions, and foreign direct investments (FDI), due to the deregulation of international capital markets, have been among the fastest expanding economic activities around the world. Nowadays, FDI lead the process of internationalization of productive activities, whose principal actors are Multinational Enterprises (MNEs). While undertaking direct investments in different countries which often belong to an already economic integrated area like the EU or the NAFTA,<sup>1</sup> MNEs frequently own plants in several locations, organizing their business internationally. As a consequence, MNEs can reallocate part of their production between different plants whenever is possible to capture comparative advantages from lower input costs (i.e. lower wages).

Within this context, a major concern for organized labor is that, by relocating production (or simply threatening to do it), MNEs are able to obtain concessions from unions which are frequently asked to take care of national interest, preserving existing jobs and economic activities and trying to generate further domestic employment.

In Europe the debate on this phenomenon started since the early 90's: in 1993, the American multinational Hoover decided to relocate production activities from France to Scotland, because of the lower levels of non-wage labor costs as well as due to the higher flexibility assured by Scottish workers in terms of pay and working time (EIRR, 1993). But this phenomenon is still current in Western European countries: at the end of 2004, Danish Crown announced that it would close its Tulip meat factory at Ringsted in Denmark and relocate production to Germany, if a new local collective agreement failed to introduce a cost reduction equivalent to a wage cut of 15%.<sup>2</sup>

As a consequence, an increasing number of European trade unions have shown interest in coordinating their activities across boundaries, transnationalizing cooperation: recently, the exchange of information on wage

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<sup>1</sup> For example, of all the flows of FDI into countries of the European Union, the bulk is originated within the EU itself: as of 2000, 79 per cent of inward FDI flows were intra-EU (see *Bulletin EU* 7/8, 2001).

<sup>2</sup> A survey of cases concerning the relocation of production processes by MNEs in the last years in Europe is treated in Eurofound (2006).

levels, working conditions and employment policies in different countries, as well as some shared rules in collective bargaining, have been introduced at least at the intersectoral level - e.g. as in the case of the "guideline for collective bargaining at the European level" by the European Trade Union Confederation (ETUC) in 1998.<sup>3</sup> Moreover, a gradually increasing number of trans-national agreements between trade unions have been signed in the last years: from 92 in 2005 to 147 in 2007, two thirds of which related to European MNEs activities within the EU itself (ETUC, 2007).

The analysis of incentives and scopes for wage coordination among trade unions within a context of economic integration is somehow recent, although the subject is of great relevance in the study of the impact of globalization and "Europeanization" on labor markets and their institutions. Precisely, the latter is the subject of this paper.

This work relates to a consistent body of literature that analyzes, within different contexts, how economic integration affects the unions' strategic behavior. A first strand, represented by Huizinga (1993), Driffil and van der Ploeg (1993, 1995), Sørensen, (1993), Danthine and Hunt (1994), Naylor (1998, 1999), Borghijs and Du Caju (1999), Munch and Skaksen (2002), Straume (2002), Dube and Reddy (2006) and Strozzi (2007), examines how international integration affects wage bargaining in unionized countries taking in consideration the strategic interaction between unions. In particular, Huizinga (1993) considers the integration of two single union-firm bargaining units into a unified market with two bargaining units; the effects of wage harmonization in the two countries are briefly sketched. Incentives for labor union cooperation at trans-national level instead are explored in Borghijs and Du Caju (1999), Straume (2002), and Strozzi (2007). Borghijs and Du Caju (1999) analyze the possibility for labor union cooperation in a context of international production with a fully integrated product market. Starting from a very basic set up, with a firm having two plants in different countries and characterized by decreasing returns to scale in the only factor of production, labor, these authors find that if one labor union demands a wage rate too high, production is relocated to the other plant. The main results are that, in presence of trans-national coordination costs in wage bargaining, labor unions act as competitors in the labor market and

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<sup>3</sup> For a review on cross-border coordination activities concerning collective bargaining, see European Commission (2002).

consequently moderate their wage demands. But below a certain threshold value, to cooperate turns out to be increasingly an attractive option, which translates in a raise in wages. A further decrease in coordination costs reduces wage rates, but the collusive wage remains higher than the competitive wage.

Conversely, the works of Straume (2002) and Strozzi (2007) analyze the scope for unions to adopt a collusive behavior within a context of an international duopoly game under which firms can either to undertake an export strategy or to remain in a monopoly regime, examining if collusion could be supported as equilibrium of an infinitely repeated game. While the analysis of Straume (2002) and Strozzi (2007) is addressed to the case of intra-industry international trade, the model presented here instead analyzes if coordination in wage demands could be maintained in a repeated game within a context of international production. In doing so, a framework similar to Borghijs and Du Caju (1999) is used, further extending the study of these authors with a comparison of the effects of different wage settings on welfare distribution. The analysis related to the sustainability of cooperative behavior by labor unions (which is lacking in Borghijs and Du Caju (1999)) in the present paper is developed according to classical game theory, with collusion depending on unions' discount factors.

A second strand of the literature analyzes the interrelationship between unionized labor markets and firms' international production activities related to FDI. Mezzetti and Dinopoulos (1991) and Bughin and Vannini (1995) investigate the interaction between unionism and a firm's choice between serving a foreign market through exports or by investing overseas. Using an efficient bargaining approach, Zhao (1995, 1998) considers the impact of intra-industry reciprocal FDI on wages and employment determination in a unionized international oligopoly. In a different set-up, the subject is also treated by Naylor and Santoni (2003). Nevertheless, none of these papers consider the possibility of transnational union cooperation which represents one of the central issues in this work.

The rest of the paper is organized in the following way: Section 2 presents the formal model of international production in presence of unionized labor markets. Section 3 is devoted to analyze the sustainability of a trans-national coordinated wage demand. Section 4 examines the comparative static analysis and the welfare effects of the

different wage bargaining. Section 5 concludes with some policy implications and further extensions.

## **2 A model of international production in unionized countries**

This section develops a partial equilibrium model of international production in unionized countries within a two-stage game framework in which unions and firms interact strategically. The model builds on Borghijs and Du Caju (1999), adding one firm in the product market which better reflects the reality of product market integration within the EU, where firms of different state members have plants in diverse countries. There are two symmetric countries, A and B, that belong to the same economic integrated bloc, and in each country two firms, 1 (which headquarter is in A) and 2 (with headquarter in B), locate a plant. Firms produce a homogeneous good, denoted X when it is produced in A and Y when it is manufactured in B, using only one factor of production, labor, with decreasing returns to scale. In each country there is a national union and it is assumed that workers are fully unionized. The demand function is assumed for simplicity to be linear. There may be trade between the two countries but, since markets are not segmented, there is no intra-industry trade. There are zero transportation costs. Consequently, if one union national demands excessive wage rates, production is shifted toward the plants in the other country and eventually imported without extra costs.

It is also assumed that firms always act as Cournot competitors: even if this is a strong assumption when a repeated framework is considered, it is retained in order to isolate and investigate union behavior. The model is solved by backward induction: in the second stage, each firm chooses its output in the product market taking as given the output decision of the rival firm; in the first stage, monopoly unions (see Oswald, 1985) have complete power to set wages, maximizing rents. Two different union wage settings are compared: 1) a separate bargaining, where unions bargain separately at national<sup>4</sup> level with firms operating within the

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<sup>4</sup> Given the assumptions of this model, national and industry level bargaining are identical. Nonetheless, as remarked in the introduction, the greatest part of the trans-national union agreements occurs at industry level.

country; 2) a collusive agreement on wage demands by national trade unions.

The production functions for firms are represented by  $x_{iA} = \sqrt{n_{iA}}$  and  $y_{iB} = \sqrt{n_{iB}}$ , while the product demand is given by the following expression:

$$p = a - (X + Y) \quad (1)$$

where  $X = x_{1A} + x_{2A}$  is total production in A,  $Y = y_{1B} + y_{2B}$  is total production in B and  $a$  represents the positive intercept of the demand curve.<sup>5</sup> Firms' profits are given by:

$$\Pi_i = [a - (X + Y)](x_{iA} + y_{iB}) - w_A x_{iA}^2 - w_B y_{iB}^2 \quad \text{for } i = 1, 2 \quad (2)$$

where  $x_{iA}$  is the output produced by firm  $i$  in country A,  $y_{iB}$  is the production of the good by firm  $i$  in country B,  $w_A$  is the wage rate paid in A and  $w_B$  is the wage rate paid B, respectively. Union utilities are given by:

$$U_A = (w_A - \bar{w}) (x_{1A}^2 + x_{2A}^2) \quad (3)$$

for union in country A and

$$U_B = (w_B - \bar{w}) (y_{1B}^2 + y_{2B}^2) \quad (4)$$

for union in country B, where  $\bar{w}$ , assumed to be equal between the two countries, could be interpreted as the minimum wage fixed by law and hence exogenously given for unions.

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<sup>5</sup> Just for simplicity it was assumed that the slope of the linear demand is equal to  $b = 1$ , but it is straightforward to generalize for the case in which  $b \neq 1$ .



## 2.1 Stage 2: Cournot competition between firms

In the second stage of the game, firms are engaged in a Cournot competition in the product market. The profit maximization problem that each firm faces is then the following:

$$\max_{x_{iA}, Y_{iB}} \Pi_i = \max_{x_{iA}, Y_{iB}} [a - (X + Y)](x_{iA} + Y_{iB}) - w_A x_{iA}^2 - w_B Y_{iB}^2 \quad (5)$$

for  $i = 1, 2$  from which first order conditions yield the following reaction functions

$$x_{1A} = \frac{1}{2w_A} [a - 2z_1 - z_2]$$

$$Y_{1B} = \frac{1}{2w_B} [a - 2z_1 - z_2]$$

for firm 1 and

$$x_{2A} = \frac{1}{2w_A} [a - z_1 - 2z_2]$$

$$Y_{2B} = \frac{1}{2w_B} [a - z_1 - 2z_2]$$

for firm 2, where  $z_1 = x_{1A} + Y_{1B}$  and  $z_2 = x_{2A} + Y_{2B}$ . Notice that optimal quantities do not depend exclusively on the quantities produced by the rival firm, but also on the output produced by the affiliated in the other country. The following demand equations in terms of the two countries' wages are hence obtained

$$x_{iA}^*(w_A, w_B) = \frac{a}{w_A} \left[ \frac{1 - \Psi}{2 + \Psi} \right] \quad (6)$$

$$Y_{iB}^*(w_A, w_B) = \frac{a}{w_B} \left[ \frac{1 - \Psi}{2 + \Psi} \right] \quad (7)$$

where  $\Psi = \frac{w_A + w_B}{w_A w_B + w_A + w_B}$  and with

$$\partial x_{iA} / \partial w_A < 0, \quad \partial x_{iA} / \partial w_B > 0, \quad \partial Y_{iB} / \partial w_A > 0, \quad \partial Y_{iB} / \partial w_B < 0.$$

The output of each plant depends negatively on the wage level of the country where the plant is located and it is positively related to the wage rate of the other country. Additionally, it should be noted that, when wage rates are different between the two countries, labor demand in the country with higher wages is not equal to zero: in fact, firms' total revenues depends on their total production and not on how total production is shared between the two countries.

## 2.2 Stage 1, Case 1: Separate bargaining

In stage 1, each union will choose a wage which maximizes its rents, taking as given the labor demand functions by firms. First, it is considered the case of separate bargaining: each national union selects a wage for its industry, taking as given the wage set in the other country. It is considered, i.e., the problem faced by union in country A. Union in A will choose  $w_A$  such that

$$w_A = \arg \max_{w_A} \left\{ U_A = (w_A - \bar{w}) (x_{1A}^2 + x_{2A}^2) \right\}. \quad (8)$$

Substituting equations (6) into (8) it is obtained

$$w_A = \arg \max_{w_A} \left\{ U_A = 2(w_A - \bar{w}) \left( \frac{a \bar{w}_B}{2w_A \bar{w}_B + 3w_A + 3\bar{w}_B} \right)^2 \right\} \quad (9)$$

where  $\bar{w}_B$  is the wage set in country B and which Union A takes as given. Such maximization leads to the following expression

$$w_A = 2 \bar{w} + \frac{3 \bar{w}_B}{2 \bar{w}_B + 3} .$$

A similar expression holds for Union B. In the symmetric case, the equilibrium wage level under separate bargaining is given by

$$w^{SB} = w_A = w_B = \bar{w} + (\sqrt{\bar{w}} \sqrt{\bar{w} + 3}) = \bar{w} + \varphi$$

where  $\varphi$  represents the rent over the minimum wage level and with  $\partial w^{SB} / \partial \bar{w} > 0$ : an increase in the minimum wage level implies an increase in the resulting wage rate. Substituting the wage rate into the demand functions and rearranging terms, the following production levels are derived

$$x_{iA}^{SB} = y_{iB}^{SB} = \frac{a}{\varphi + \gamma}$$

for  $i = 1, 2$  where  $\gamma = \bar{w} + 3$  and upper script indicates "Separate Bargaining". Now it is also possible to provide an expression for total consumers' surplus, given by

$$CS = \int_0^Q (a - Q) dQ - p(Q)$$

where  $Q = X + Y$ , and for national welfare, defined for country A as

$$W_A = \Pi_1 + U_A + CS_A$$

whit  $\Pi_1 = \Pi_{1A} + \Pi_{1B}$ , that is, profits generated abroad by firm 1 are repatriated. A similar expression holds for country B. Further substitutions of wage rates and quantities into union utilities, price, firms' profits and consumer's surplus expressions give the equilibrium values of these variables under union separate bargaining. All findings are summarized in Table 1.

Table 1: *Summary of the relevant findings under different union bargaining*

	Wage	Production	Employment	Price	Union utility	National Profits	Consumer surplus	National welfare
Separate Bargaining	$\bar{w} + \varphi$	$\frac{a}{\varphi + \gamma}$	$\left(\frac{a}{\varphi + \gamma}\right)^2$	$\frac{a(\varphi + 1)}{\varphi + \gamma}$	$\frac{a^2 \varphi}{2(\varphi + \gamma)^2}$	$\frac{a^2(\varphi + 2)}{2(\varphi + \gamma)^2}$	$\left(\frac{a}{\varphi + \gamma}\right)^2$	$\frac{a^2(2\varphi + \gamma + 1)}{2(\varphi + \gamma)^2}$
Coordinated Bargaining	$\bar{w} + \gamma$	$\frac{a}{2\gamma}$	$\left(\frac{a}{2\gamma}\right)^2$	$\frac{a(\gamma - 1)}{\gamma}$	$\frac{a^2}{8\gamma}$	$\frac{a^2(2\gamma - 1)}{8\gamma^2}$	$\left(\frac{a}{2\gamma}\right)^2$	$\frac{a^2(3\gamma + 1)}{8\gamma^2}$

## 2.2 Stage 1, Case 2: Collusive wage setting between national unions

In this second case it is considered the collusive behavior between unions. In this model collusion stands for labor unions to achieve an agreement to fix a common wage that maximizes their joint utility, namely the sum of their utilities (*efficient union collusion*). This agreement determines a wage level which is higher than that obtained under separate bargaining.

Unions now are supposed to maximize the following function

$$w = \arg \max_w \{U_A + U_B\} \quad (10)$$

where  $U_A$  and  $U_B$  are given by the expression in (3) and (4). The solution of the maximization problem in (10) is given by

$$w^c = w_A = w_B = \bar{w} + (\bar{w} + 3)\gamma = \bar{w} + \gamma$$

where  $\gamma$  is the rent over the minimum wage level obtained with the collusive agreement (upper script indicates Collusion) and with  $\partial w^c / \partial \bar{w} > 0$ . Substituting the collusive wage rate into firms' demand functions and rearranging terms, the following production levels under collusion are obtained

$$x_{iA}^c = y_{iB}^c = \frac{a}{2\gamma}$$

for  $i = 1, 2$ . As in the previous subsection, further substitutions into expressions for union utilities, price and firms' profits give the equilibrium values of these variables and, subsequently, the values of consumers' surplus and welfare. These findings are reported in Table 1.

### 3 The sustainability of trans-national union cooperation

Which are unions' positions? As it was seen above, within this model each union can choose between two different wage bargaining, namely either to have a separate bargaining with firms operating within the country (SB), or to coordinate wage levels collusively (C). Depending on the selected type of bargaining, the relative unions' utilities are obviously different. Transnational coordination is profitable if  $U^C > U^{SB}$ . Payoffs' comparison leads to the following proposition.

**Proposition 1:** *The separate bargaining is Pareto-dominated by the collusive outcome  $\forall \bar{w} \in [0, \infty)$ .*

Proof: The difference between the two union payoffs'

$$U^C - U^{SB} = \frac{(\bar{w} + \gamma - 2\varphi)}{8(\gamma + \varphi)^2} > 0$$

is always verified in the economic relevant range  $\bar{w} \in [0, \infty)$ .  $\square$

Hence, for every economic relevant value of the minimum wage level, unions have strong incentives to form a collusive agreement. Collusion could be implemented in an infinitely repeated two-stage game. With four players, the set of possible strategy combinations is clearly very huge. It follows that a very simplifying assumptions is needed: for the purposes of this paper, it is assumed that firms have not the possibility to collude, namely firms always act as Cournot competitors. Although in a repeated game framework this is a very strong assumption (due to the fact that also firms have strong incentives to collude), it is retained in order to isolate exclusively the effects of unions' coordinated wage

demands; but this hypothesis could be also seen as if there is a sufficiently effective Antitrust Authority able to avoid collusion in the product market.

Starting from a situation where a coordinated wage demand is presented, each union will capture an immediate utility gain by unilaterally deviating from the collusive agreement. Deviation implies a reduction in the wage level which will induce the firms to relocate part of their productive activities within the country which union makes concessions. It is supposed that when one union breaks the collusive agreement, in the subsequent period both unions come back to a national separate bargaining. Such a situation is identical to the case where unions are adopting a trigger strategy: collusion can be sustained only if it is backed by some realistic threats, such that the one-period gain from cheating will be lower than the discounted expected value from punishment, which in this model means reversion to a separate bargaining. It is also assumed that the discounted factor is identical for both unions.

Collusion is sustainable in a repeated framework if

$$\delta \geq \frac{U^D - U^C}{U^D - U^{SB}} \quad (11)$$

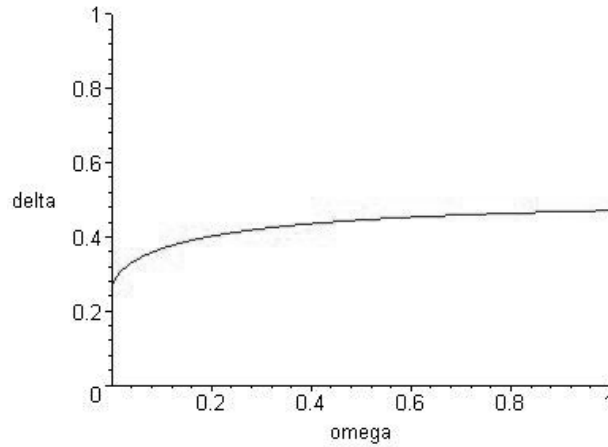
where  $U^C$  is the utility level obtained with collusion,  $U^D$  is the utility level deriving from the one-period defection<sup>6</sup> and  $U^{SB}$  the utility derived from punishment. The right-hand side of (11) represents the discount factor threshold: unions will implicitly collude at international level as long as they do not discount too much future and the instantaneous gains from unilaterally deviating the coordinated wage demand are low.

Inserting the relevant payoff functions into (11) yields the following critical discount factor:

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<sup>6</sup> If, for example, the cheating union is Union in country A, the union utility from deviation  $U_A^D$  is obtained from the following maximization problem  $w_A = \arg \max_{w_A} \{U_A(w_A, w_B^C)\}$ .

Figure 1: Relationship between the discount factor and the minimum wage level

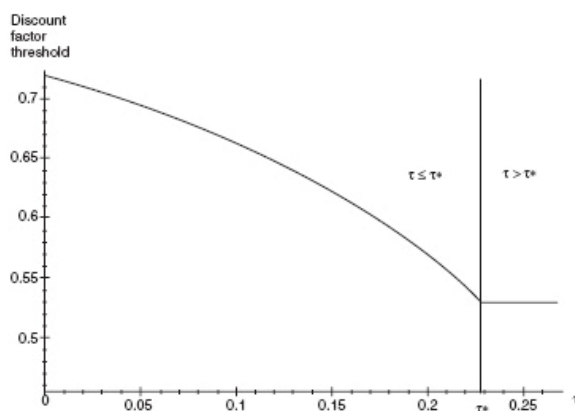


$$\delta(\bar{w}) = \frac{9}{4} \frac{(\bar{w} + \gamma + 2\varphi)}{(\bar{w} + \gamma)^3 - (8\bar{w}\gamma + 9)\varphi} \quad (12)$$

Closer analytical examination of (12) yields  $d\delta / d\bar{w} > 0$ : a reduction in the minimum wage level makes collusion easier to be sustained. In fact, as long as the minimum wage decreases, the threshold value for the discount factor also decreases and the punishment becomes harsher. Further inspection reveals also that in the economic relevant range  $\bar{w} \in [0, \infty)$  the value of the discount factor varies between  $\delta \in [1/4, 1/2)$ , approaching its upper limit if the minimum wage tends to infinity (Figure 1).

These results to some extent complement those obtained in the intra-industry trade literature. Straume (2002) and Strozzi (2007) find that under the assumption of segmented markets, the sustainability of transnational implicit collusion among labor unions depends both on the trade cost levels ( $\tau$ ), and on the degree of substitutability among traded goods. When trade costs are relatively low, a reduction in trade barriers makes deviation an increasingly attractive option for unions. While implicit collusion is more difficult the less similar are traded goods, for perfect substitute goods to deviate is comparatively more profitable from the unions' perspective: in such a case, the discount factor threshold is independent of trade barriers for relatively high values of

Figure 2: *Relationship between discount factor and trade cost levels for perfect substitute goods (Strozzi 2007)*



these costs, while for relatively low values, it increases as long as trade barriers decrease, that is,  $d\delta/d\tau < 0$ . Hence, a reduction of trade costs makes collusion increasingly difficult to be sustained.

Moreover, for  $\tau \in [0,1)$ , it is found that  $\delta > 1/2$  (Figure 2). Comparison of these findings with the results derived from equation (11) and Figure 1 allows establishing the following proposition.

**Proposition 2:** *In a context of international production within a fully integrated product market, collusion in wage levels is relatively easier to be supported by labor unions.*

This could represent a reasonable explanation of the fact that the transnational agreements between labor unions related to MNE activities within the EU are progressively increasing in the last years. To sign these agreements manifests the belief by unions that wage coordination at European level will improve workers' bargaining position, preventing a kind of international rivalry in labor markets that will lead national unions to act separately and hence to be engaged in future downward competition in wages, making concession in wage bargaining. Within the context analyzed in the present work, this seems to be a viable opportunity.



Table 4: *Variables' values under different wage setting*

Price level	$p^C >$	$p^{SB}$
World profits	$\Pi^{SB} >$	$\Pi^C$
World consumer surplus	$CS^{SB} >$	$CS^C$
World welfare	$W^{SB} >$	$W^{NB}$

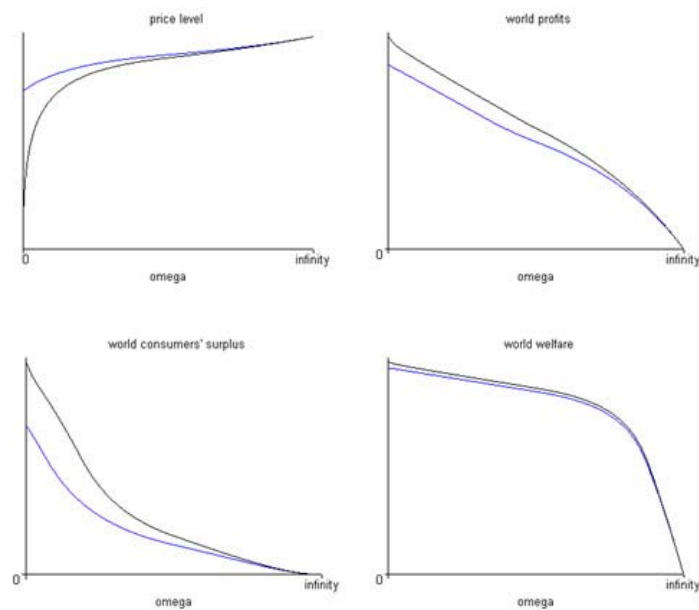
#### 4 Analysis of welfare distribution

With the results previously reported in Table 1 it is possible to construct Table 4 that ranks the values of the relevant variables under the two wage bargaining. Firstly, it could be observed that world's values related to single components of welfare and world welfare itself are in general higher in the separate bargaining scenario than with respect to the collusive case. Exceptions are the price level, because of the pass through effect of higher wage levels in case of coordinated bargaining, and union utilities, treated in the previous paragraph.

Since all relevant variables are function of the minimum wage level fixed by governments, some additional observations could be addressed. As it is possible to note from Figure 3, as long as the value of  $\bar{w}$  increases and tends to infinity, the corresponding values for all variables are convergent, the distinctions between the two different cases tend to disappears and, as previously seen, incentives for unions to deviate from a coordinated wage demand become smaller and smaller. The share of national welfare detained by unions is obviously greater in collusion with respect to the separate wage setting. Moreover, a transnational agreement between unions improves workers' conditions but, on the other hand, the welfare level under union collusion is lower with respect to the competitive case. However, as long as the minimum wage level rises, unions' shares turn out to be asymptotically equal. This asymptotic behavior holds for each national welfare component.

Nevertheless, total national welfare decreases, due to the pass-through effect on price of an increase in the minimum wage rate. Intuitions behind Table 4 and Figure 3 can be formally stated in the following proposition.

Figure 3: *Variables' behavior in the model: blue lines refer to coordinated bargaining*



**Proposition 3:** *A coordinated increase in the minimum wage level set by governments' leads to:*

- 1) a reduction in welfare differences;*
- 2) the same welfare distribution;*
- 3) a decrease in world welfare irrespective of union wage bargaining.*

Proof: See the Appendix.

Proposition 3 states that, whenever the minimum wage level is used as an instrument to implement redistributive policies, governments face a clear trade-off: an increase in  $\bar{w}$  reduces inequalities in welfare distribution and makes union collusion less likely, but on the other hand this is done at the expenses of a lower national welfare level. An increase in the minimum wage level translates in higher prices and consequently in a drastically fall in consumer surplus. These results should be taken into account when policy makers have to select the appropriate redistributive policy mix.

## 5 Conclusions: policy implications and further extensions

This work represents an attempt to study the prospect of unions' wage coordination at trans-national level within a context of international production in an integrated economy, and the consequences on welfare distribution deriving from this behavior, complementing a framework which was not fully investigated in the earlier literature. A simple model of international duopoly in unionized countries was presented: using a two-stage game, effects on world welfare distribution under different union wage bargaining were analyzed, considering both the separate and the coordinated behavior in wage demands by national unions. Comparing payoffs under separate and coordinated wage bargaining, it was shown that unions face a Prisoner's Dilemma situation because separate bargaining is Pareto-dominated by the collusive outcome. Hence, there are strong incentives for national unions to coordinate wage demands. When a repeated framework is considered, it was shown that in the analyzed framework, collusion in wage levels seems to be easier to be supported by labor unions relatively to sectors where international business is characterized by intra-industry trade. This could represent a reasonable explanation of the fact that the transnational agreements between labor unions related to MNE activities within the EU are progressively increasing in the last years.

From these results, some policy insights follow: a transnational agreement between unions could be a possible way to improve workers' conditions; colluding, unions are able to capture a greater share of welfare. The shortcut is that welfare level in this case is lower with respect to separate bargaining.<sup>7</sup> A possible alternative could be an international agreement (e.g. a set of rule generally shared) between governments to coordinate a raise in minimum wages, but this policy presents at least one problem: as long as the minimum wage level is higher, the welfare level decreases. An alternative policy could be to

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<sup>7</sup> Moreover, there are other aspects that are not explicitly modeled. The coordination between unions does not pass only through an agreement over wage level; there are many other aspects concerning the labor discipline not treated here; it is not easy to sign binding agreements and organize activities in order to achieve some common result without considering collateral problems like cultural, traditional and customary diversities in different countries, leadership position and the pursuit of particular interests. In addition, this is a very simple model with only two national unions, but as long as the number of countries (and hence of unions) increases, the cooperative equilibrium is more difficult to reach.

leave unions set their wage separately at national level and subsequently to have national government interventions in redistributing welfare through the appropriate instruments.

All findings in this work are obtained under the hypothesis of a convex cost function, fully symmetric countries and perfect symmetry in unions' preferences. Asymmetries in market structures as well as differences both in preferences over wages and employment and, in a context of transnational agreement, in beliefs concerning the likelihood of breakdown between national unions, represents further extensions of the model that could change significantly these results. Moreover, a deeper analysis is needed to establish the appropriate public policy instruments in redistributing national welfare, requiring future research.

## Appendix

### Proof of proposition 3

To show that an increase in the minimum wage rate leads to a reduction in differences in welfare level independently of the union wage bargaining, it needs simply to evaluate the limit of national welfare expressions and verify that are convergent. It follows that

$$\lim_{\bar{w} \rightarrow \infty} NW^C = \lim_{\bar{w} \rightarrow \infty} \frac{3\bar{w} + 10}{8(\bar{w} + 3)^2} = 0 \quad (\text{A.1})$$

$$\lim_{\bar{w} \rightarrow \infty} NW^{SB} = \lim_{\bar{w} \rightarrow \infty} \frac{(\bar{w} + 2\sqrt{\bar{w}}\sqrt{\bar{w} + 3} + 4)}{2(\bar{w} + \sqrt{\bar{w}}\sqrt{\bar{w} + 3} + 3)^2} = 0 \quad (\text{A.2})$$

Since the two functions are defined on the same set and have the same accumulation point, the limits of their differences are equal to the differences of their limits, and all tends to zero. This proves sentence 1.

To show that a coordinated increase in minimum wage level leads to the same welfare distribution irrespective of the union wage bargaining, it needs to analyze if the components of national welfare converge to the

same shares as long as the minimum wage rate increases. It is obtained that union share of national welfare converges to

$$\lim_{\bar{w} \rightarrow \infty} \frac{U^{BC}}{NW^{BC}} = \lim_{\bar{w} \rightarrow \infty} \frac{(\sqrt{\bar{w}} \sqrt{\bar{w}+3})}{2(\sqrt{\bar{w}} \sqrt{\bar{w}+3}) + \bar{w} + 4} = \frac{1}{2 + \lim_{\bar{w} \rightarrow \infty} \frac{\bar{w} + 4}{(\sqrt{\bar{w}} \sqrt{\bar{w}+3})}} = \frac{1}{3} \quad (\text{A.3})$$

$$\lim_{\bar{w} \rightarrow \infty} \frac{U^{NB}}{NW^{NB}} = \lim_{\bar{w} \rightarrow \infty} \frac{\bar{w} + 3}{3\bar{w} + 10} = \frac{1 + (3/\bar{w})}{3 + (10/\bar{w})} = \frac{1}{3} \quad (\text{A.4})$$

Similarly it is obtained that the share of consumer surplus converges to

$$\lim_{\bar{w} \rightarrow \infty} \frac{CS^{BC}}{NW^{BC}} = \lim_{\bar{w} \rightarrow \infty} \frac{2}{2(\sqrt{\bar{w}} \sqrt{\bar{w}+3}) + \bar{w} + 4} = 0 \quad (\text{A.5})$$

$$\lim_{\bar{w} \rightarrow \infty} \frac{CS^{NB}}{NW^{NB}} = \lim_{\bar{w} \rightarrow \infty} \frac{2}{3\bar{w} + 10} = 0 \quad (\text{A.6})$$

From conditions (A.1) to (A.6) directly follow that

$$\lim_{\bar{w} \rightarrow \infty} \frac{\Pi^{BC}}{NW^{BC}} = \lim_{\bar{w} \rightarrow \infty} \frac{\Pi^{NB}}{NW^{NB}} = \frac{2}{3} \quad (\text{A.7})$$

Independently of the union wage bargaining, an increase in the minimum wage rate leads, in the limit, to the same welfare shares. This proves sentence 2.

To prove sentence 3, that a coordinated increase in minimum wage level leads to a reduction in world welfare irrespective of the union wage bargaining, it needs to take the derivatives of the world welfare expressions. It is obtained that

$$\begin{aligned} \frac{\partial WW^{BC}}{\partial \bar{w}} &= \frac{\partial \left( (2\sqrt{\bar{w}}\sqrt{\bar{w}+3} + \bar{w} + 4) / (\bar{w} + \sqrt{\bar{w}}\sqrt{\bar{w}+3} + 3) \right)}{\partial \bar{w}} = \\ &= - \frac{3\bar{w}\sqrt{\bar{w}}\sqrt{\bar{w}+3} + 8\sqrt{\bar{w}}\sqrt{\bar{w}+3} + 11\bar{w} + 3 + 3\bar{w}^2}{(\bar{w} + \sqrt{\bar{w}}\sqrt{\bar{w}+3} + 3)^3(\sqrt{\bar{w}}\sqrt{\bar{w}+3})} < 0 \end{aligned} \quad (A.8)$$

$$\frac{\partial WW^{NB}}{\partial \bar{w}} = \frac{\partial \left( (3\bar{w} + 10) / 4(\bar{w} + 3)^2 \right)}{\partial \bar{w}} = \frac{3}{4(\bar{w} + 3)^2} - \frac{(3\bar{w} + 10)}{2(\bar{w} + 3)^2} < 0 \quad (A.9)$$

in the economic relevant range  $\bar{w} \in [0, \infty)$ .  $\square$

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