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**The Sustainability of Transnational
Collective Bargaining Policies**

by

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Abstract

The paper investigates whether and under what conditions unions set common guidelines for collective bargaining policy across borders without signing legally binding agreements. Our findings indicate that the presence or absence of implicit collusive agreements among unions across borders depends both on the degree of product market integration and on the degree of substitutability among traded goods. In particular, if international product markets are not sufficiently well integrated, trade liberalisation can diminish the incentives for union collusion. The sustainability of transnational collective bargaining policies.

1 Introduction

The completion of the Single Market has recently been coupled with a prominent change in collective bargaining practices throughout Europe: an increasing number of trade unions have shown interest in coordinating their wage policies across borders. This process is otherwise called the "Europeanisation" of collective bargaining and is identified as the practice by social partners' representatives at European level to set common positions and common guidelines for collective bargaining negotiations across European borders.¹

The main characteristic of this type of agreements is that they have essentially a "voluntaristic" nature. In other words, they are basically founded on the voluntary self-obligation by unions to comply with certain jointly formulated positions, being absent any legal or political enforcement related to them. This means that, where unions coming from different countries collude over a jointly agreed collective bargaining policy, this practice necessarily takes the form of *implicit* collusion.²

¹A very recent report about the initiatives by European unions towards the coordination of collective bargaining can be found in Dufresne and Mermet (2002).

²Note that, although the practice by European unions to coordinate their collective bargaining policies can be identified as a form of implicit collusion, this practice can be *implicit* as well as *explicit*. In particular, while implicit coordination identifies the practice of taking the collective bargaining outcomes in other countries as

The relationship between the process of international product market integration and the conditions which guarantee the possibility that unions implicitly collude over guidelines for collective bargaining across the European borders have not been sufficiently investigated so far, although their relevant potential consequences for the future evolution of labour market institutions in Europe.

The aim of this paper is to concentrate on these issues. In particular, the focus is on the role of the degree of international product market integration and of the degree of product differentiation among traded goods on the sustainability of implicit transnational collusion from the unions' point of view.

To explain the presence or absence of implicit collusive agreements among unions we adopt the supergame approach.³ In such a framework, we analyse the case where rent-maximising unions interact repeatedly, the repetition of the bargaining process providing itself a vehicle for cooperation independently of the existence of legally binding commitments.

Our results evidence that the sustainability of implicit collusion depends both on the degree of product market integration and on the degree of substitutability among traded goods, although in different ways according to the stringency of trade barriers. In particular, where traded products are sufficiently similar and transportation costs are relatively low, implicit collusion among unions does not depend on the degree of international product market integration, being relatively more difficult the more products are similar. Where instead transportation costs are relatively high, product market integration has pro-competitive effects, by rendering implicit transnational collusion among unions relatively more difficult.

The remainder of this paper is organised as follows. Section 2 reviews the theoretical literature related to the issue of the sustainability of implicit collusion. Section 3 sketches the main features of our reference theoretical framework. Section 4 describes the main feature of the repeated game we focus on. Section 5 analyses in details the conditions which guarantee implicit collusion among unions. Finally, section 6 concludes and gives directions for further research.

2 Literature overview

Most of the literature which focusses on implicit collusion has so far addressed this issue mainly from the point of view of firms. Within this branch of literature, the contributions which are the closest to the present paper are those which analyse the sustainability of implicit collusion

a reference for internal negotiations, explicit coordination identifies the practice of linking certain bargaining outcomes to developments in other European countries (see EIROOnline (1999)).

³Indeed, one of the key results of supergame theory is that players might reach a collusive outcome through purely non-cooperative behaviour, provided that threats related to opting out from the collusive agreement are credible (Friedman (1971)). For a general discussion of the supergame approach to the study of collusion, see Tirole (1989).

by explicitly considering the role of degree of substitutability among products and the role of the degree of product market integration.⁴

Among the studies which concentrate on the effects of the degree of product differentiation different results have been obtained according to whether firms compete in prices or in quantities.

In a duopolistic framework with differentiated products, Deneckere (1983, 1984) finds that when goods are very close substitutes, implicit collusion is more stable under Bertrand agreements than under Cournot agreements, the reverse being true when products are moderate or poor substitutes. In a more general oligopolistic framework, Majerus (1988) shows instead that implicit collusion is always easier to sustain under quantity competition than under price competition, for any degree of substitutability among products.⁵

Both Deneckere and Majerus, moreover, find that when firms compete in prices there exist a non-monotonic relationship between the degree of product differentiation and the sustainability of implicit collusion. In particular, the critical discount factor threshold which guarantees the sustainability of implicit collusion is shown to be different according to whether the constraint that a deviating firm fixes a price which leads to the exit of the rival firm from the market is binding or not.⁶ Similarly, Ross (1992) shows that in the presence of price competition the critical discount factor threshold which makes implicit collusion sustainable is characterised by non-monotonicity. His main result is that, provided that the degree of substitutability between products is below the threshold which induces the foreign firm to stop production, the incentives for implicit collusion among firms increase as long as products become more differentiated. The opposite holds where the degree of differentiation among products is above that threshold.

In line with the previous results, even if within a framework which is slightly different from those adopted in most of the above mentioned contributions, Motta (1998) shows that when competition is *à la* Bertrand there is a discontinuity in the relationship between the critical discount factor threshold which guarantees implicit collusion and the degree of substitutability among goods.⁷ Differently from the rest of the authors, instead, Rotschild (1992) finds that

⁴Related to this, note that, even if the above mentioned theoretical contributions model both product differentiation and product market integration in many different ways, in the our literature review we only refer to the studies where product differentiation is exogenous and product market integration is modelled as a decrease in trade barriers. This is due to the fact that these are also the key features of our reference theoretical framework (see Section 3).

⁵Related to this, Majerus points out that the apparent contradiction between his result and that of Deneckere is due to the fact that the Deneckere's outcome is very much particular to the duopoly case.

⁶Note that this constraint is not relevant in the case of Cournot competition. As a consequence, it arises that the critical discount factor threshold which guarantees implicit collusion is a monotonic function of the degree of product differentiation (see Deneckere (1983) and Majerus (1988)).

⁷The difference between the approach of Motta (1998) and that of the previously mentioned contributions is that while the former models product differentiation as in Shubik and Leviatan (1980), the latter adopt the framework of Dixit (1979) and Singh and Vives (1984).

the discount factor threshold which is relevant for implicit collusion is monotonic with respect to the degree of product differentiation.⁸

One of the first contributions which analyses the implications of the process of trade liberalisation in terms of the issue of the sustainability of implicit collusion among firms is instead that of Davidson (1984). The author shows that in a framework where home and foreign firms compete only in the home market small tariff rates lead to an industry structure more conducive to collusive behaviour.⁹ Later, in a context of a reciprocal dumping model of international trade, Pinto (1986) finds instead that when firms compete *à la* Cournot implicit collusion is less likely when trade barriers are relatively low. Lommerud and Sorgard (2001), then, confirm the result by Pinto, by also showing that where firms compete in prices the influence of a decrease in trade barriers on the sustainability of implicit collusion is opposite to the case where firms compete in quantities: if competition is *à la* Bertrand, an increase in product market integration makes implicit collusion less difficult to sustain.

A key feature of the present framework with respect to the above mentioned literature is that it considers the issue of the sustainability of implicit collusion from the point of view of unions (instead of from the point of view of firms). For this reason, the contribution which is perhaps the closest to ours is that of Straume (2002), who analyses the effect of trade liberalisation on the sustainability of implicit collusion among unions belonging to different countries in an international duopolistic supergame framework. Differently from Straume, however, in the present framework we explicitly take into account that union behaviour can induce a modification in the trade regime that will arise under deviation, by thus being able to fully characterise the effects of the process of product market integration on the behaviour of the critical discount factor threshold that makes implicit collusion among unions sustainable.¹⁰ In addition, still differently from Straume, we analyse the sustainability of union collusion by focussing not only on the role of the process of trade liberalisation but also on the role of the degree of differentiation among traded products. Related to this, it is worth pointing out that such a comprehensive framework has not so far been adopted even in the most widespread literature about the sustainability of implicit collusion among firms.

⁸This result is only apparently at odds with the previous results: indeed, as it is shown in Albaek and Lambertini (1998), the Rothschild's results are the same as those of Deneckere (1983,1984) and Ross (1992), once the constraint that a deviating behaviour can induce the exit of the rival firm from the market is taken into account.

⁹Similar frameworks are also in Rotemberg and Saloner (1989) and Fung (1991).

¹⁰Straume (2002) does not consider in particular the possibility that in the presence of two-way trade across countries a union which deviates from collusive behaviour could find it profitable to fix a wage that is so low that it induces the exit of the foreign firm from the domestic market.

3 The reference framework

The reference theoretical framework is a two-country partial equilibrium model with differentiated products and reciprocal dumping across countries. The model is specified as follows.

In each country there is one firm producing the differentiated good: the firm in country 1 produces good x while the firm in country 2 produces good y . Competition across countries, when it occurs, is characterised as Cournot. To sell their products in the foreign country, firms have to pay some transportation costs τ per unit of the commodity exported. Reciprocal dumping arises because the presence of transportation costs allows firms to price discriminate across countries, by selling their products into each others' market for prices below what each charges at home.¹¹ Production is linear in labour and the marginal productivity of labour is equal to one.

The firm maximisation problems in countries 1 and 2 are characterised as follows:

$$\begin{aligned} \max_{x_1, x_2} \Pi_1 &= p_{1x}x_1 + (p_{2x} - \tau)x_2 - w_1(x_1 + x_2), \\ \max_{y_1, y_2} \Pi_2 &= p_{2y}y_2 + (p_{1y} - \tau)y_1 - w_2(y_1 + y_2), \end{aligned} \quad (1)$$

where x_1 is the production of good x for consumption in country 1, x_2 is the production of good x for consumption in country 2, y_2 is the production of good y for consumption in country 2 and y_1 is the production of good y for consumption in country 1. Moreover, p_{ix} and p_{iy} are the inverse demands for goods x and y in country i , which are given by:¹²

$$\begin{aligned} p_{1x} &= (a - x_1 - \gamma y_1); & p_{2x} &= (a - x_2 - \gamma y_2); \\ p_{1y} &= (a - y_1 - \gamma x_1); & p_{2y} &= (a - y_2 - \gamma x_2). \end{aligned}$$

where a is a shift parameter loosely representing the market size (which is the same across countries because of the assumption of perfect symmetry) and γ is a parameter which captures the degree of differentiation among products. Under the assumption that countries produce substitute products, γ is positive and belongs to the interval $(0, 1]$.¹³

¹¹The concept of reciprocal dumping was first introduced by Brander (1981) and then elaborated by Brander and Krugman (1983). Later, Brander and Spencer (1988) adopted the same concept in a unionised oligopoly model with international trade. Recently, Bernhofen (2001) integrated the Brander's intra-industry trade model in identical commodities with the Krugman's intra-industry trade model with monopolistic competition and taste for varieties in a single analytical framework.

¹²The inverse demand functions are derived by assuming that consumers maximise a quasi-linear utility function defined over goods x , y , z , where goods x and y are the two differentiated goods (associated with a quadratic sub-utility function) and good z is the *numéraire* (associated with a linear sub-utility function). For a similar framework, see Singh and Vives (1984).

¹³It is worth pointing out that the assumption that trade across countries occurs in substitutes allows us to capture two important features of the process of trade liberalisation in Europe. On the one hand, the fact that trade across European countries is increasingly characterised by a large share of intra-industry trade. On the other hand, the fact that the cross-border coordination of collective bargaining policies seems to have the best possibilities of development at the sectoral level (see Pochet (1999)).

Concerning the labour market side, labour supply is rigid and wages are determined by monopolistic unions which maximise their rents.¹⁴ In addition, we assume the absence of labour mobility across countries.

The reference framework can hence be characterised as a two-stage game where at the first stage unions set their rent-maximising (Bertrand) wage taking into account the labour demands expressed by firms, while at the second stage firms set their (Cournot) output levels taking as given the wages set by the unions.

Note that in such a framework the trade regime will be endogenously determined by union behaviour. This occurs because in the two-stage game we consider unions are monopolistic and are at the same time the first movers. Indeed, at the first stage unions fix their wages independently of firms, then firms determine their optimal employment levels taking into account the wages expressed by unions. Then, after evaluating the relative magnitude of production costs and transportation costs (exogenously given), firms decide whether to export or not.¹⁵

When unions set separately their wages in each country, the Bertrand-Nash optimal wages arises as a solutions to the following system:¹⁶

$$\begin{aligned}\max_{w_1} \Omega_1 &= (w_1 - B) L_1, \\ \max_{w_2} \Omega_2 &= (w_2 - B) L_2.\end{aligned}\tag{2}$$

where B are the unemployment benefits (which we assume symmetric across countries) and L_1 and L_2 are the labour demands expressed by firms.

Where instead unions collude across countries over a common wage policy, the optimal collusive wage arises as a solution to the following maximisation problem:

$$\max_{w_1, w_2} \Omega = \Omega_1 + \Omega_2 = (w_1 - B) L_1 + (w_2 - B) L_2.\tag{3}$$

We further assume that in each country the sector of the differentiated good is small relative to the rest of the economy. This implies that price changes in this sector do not lead to a significant change in the consumer price index. As a consequence, both the profit maximisation problem in (1) and the union welfare maximisation problems in (2) and in (3) can be considered a good approximation of the reality.

¹⁴The *monopoly union* model is a particular case of the more general class of *right-to-manage* models of union behaviour. For a description of the main features of this kind of models see e.g. Booth (1995).

¹⁵On the issue of the endogeneity of trade regime in a similar reciprocal dumping framework with monopolistic unions, see Naylor (1999, 2000).

¹⁶Note that in the present framework union rents are defined in excess of the unemployment benefits. This derives from our assumption of labour immobility across countries. More properly, union rents are defined by what workers can get in excess of what they would receive if they were not to find a job. Indeed, in a more general model with rent-maximising unions the alternative wage is in general expressed as a weighted average between the wage workers can get outside the firm and the unemployment benefits (see e.g. Layard and Nickell (1991)).

4 The repeated game

We now consider a repeated game where each union interacts an infinite number of times with the union belonging to the other country.¹⁷ The purpose is to investigate the conditions which guarantee that the collusive outcome arises as a solution to the repeated game. Our aim is hence to assess whether and under what conditions a transnational non-cooperative collusive wage agreement is sustainable.¹⁸

The game is specified as follows. In period $t = 0$ union i chooses to act cooperatively, i.e. plays the collusive wage that maximises the sum of the union welfare levels in the two countries (which arises as a solution to (2)). Then, in each period $t > 0$, union i chooses the collusive wage if in every previous period both unions have chosen the collusive wage; otherwise, union i chooses to act non cooperatively and plays the Bertrand-Nash wage resulting from separate wage setting (which arises as a solution to (3)). The strategy of the firms is simply to choose their Cournot quantities in each market for each period of the repeated game.

In this context, the union wage strategies at time t as a function of the history of the game (H_{t-1}) are the following:

$$\begin{aligned} w_{it}(H_{t-1}) &= w_i^C && \text{if all elements of } H_{t-1} \text{ equal } (w_i^C, w_j^C) \text{ or } t = 0 \\ w_{it}(H_{t-1}) &= w_i^N && \text{otherwise} \end{aligned} \quad (4)$$

where w_i^C is the optimal wage in country i when unions maximise jointly their labour rents (which is found by solving (3)), while w_i^N is the optimal wage in country i when unions maximise separately their labour rents (which is found by solving (2)).

According to the specification in (4), unions play a *trigger strategy*, implying a permanent reversion to separate wage setting after any deviation from collusive behaviour.¹⁹ Consider the following expressions:

1. Ω_i^C : One-period union i 's welfare when unions act collusively.
2. Ω_i^N : One-period union i 's welfare when unions play the Nash strategies (corresponding to union utility during the punishment phase of the game).
3. Ω_i^D : One-period union i 's welfare when union i deviates from the collusive agreement while union j plays the collusive wage.

¹⁷This framework can be justified by the idea that any wage agreement which involves a great number of workers coming from different countries must entail highly complex transaction costs, thus making it potentially preferable for unions to set multiperiodal agreements.

¹⁸The incentives for collusion are analysed in details in appendix (see section A.3).

¹⁹Note that even if the trigger strategy is surely the simplest and most commonly assumed punishment strategy, it does not constitute necessarily the optimal punishment (see Abreu (1988)).

If unions are rent maximisers and union members are risk neutral, the above expressions are to be written as follows:

$$\begin{aligned}\Omega_i^C &= (w_i^C - B) L_i(w_i^C, w_j^C) \\ \Omega_i^N &= (w_i^N - B) L_i(w_i^N, w_j^N) \\ \Omega_i^D &= (w_i^D - B) L_i(w_i^D, w_j^C)\end{aligned}$$

where w_i^D is the optimal wage set by the deviating union, B_i are the unemployment benefits in country i and L_i is the labour demand in country i .

4.1 Sustainability

We now consider under what conditions the strategies described in (4) constitute a subgame perfect equilibrium of the repeated game between unions. To find these conditions, it is necessary to define “what unions have to compare” when they choose to deviate from the collusive behaviour. The one-period current gain from deviation from the collusive wage agreement is:

$$(\Omega_i^D - \Omega_i^C). \quad (5)$$

After deviation, unions act independently losing the gains they can obtain from collusion. If the game is repeated an infinite number of times and union i discounts future welfare at a factor δ_i , the future expected loss from deviation is:

$$\delta_i (1 + \delta_i + \delta_i^2 + \delta_i^3 + \dots) (\Omega_i^C - \Omega_i^N). \quad (6)$$

Collusive behaviour is sustainable if and only if the present value of the future losses in (6) is large enough relative to the possible current gain from deviation in (5). This happens if and only if:

$$\delta_i \geq \bar{\delta}_i = \frac{\Omega_i^D - \Omega_i^C}{\Omega_i^C - \Omega_i^N}. \quad (7)$$

where $\bar{\delta}_i$ is the discount factor threshold which guarantees the sustainability of non-cooperative collusion from the point of view of the union belonging to country i . Note that, since in the present framework we assume that countries are perfectly symmetric and that unions have the same bargaining power in both countries, the relevant discount factor threshold will be equal for both unions ($\bar{\delta}$).²⁰

²⁰Note that, because in our framework countries are perfectly symmetric (in both product and labour markets), both the profit maximisation problems and the union maximisation problems will lead to symmetric solutions in each country. As a consequence, the subscript i is redundant in this context.

4.2 Relevant payoffs

In the present framework the relevant payoffs that are necessary to evaluate the sustainability of non-cooperative collusion among unions will differ according to the trade regime that will prevail in each phase of the game. As we specified above (see section 3), each trade regime will in turn depend on the wage strategies that will be adopted by unions. Since our dynamic game is specified in such a way that at time $t = 0$ unions collude, at the beginning of the game the trade regime will be endogenously determined by union behaviour under collusion.

To study the implications of repeated interactions among unions in terms of the sustainability of implicit collusion among them, hence, it is necessary first to identify which wage strategy will be chosen by unions in case they collude. As Naylor (1999) points out, in such a context unions can adopt in principle one of the two following wage strategies: a *low wage strategy* or a *high wage strategy*. If countries are perfectly symmetric (as in our framework), in the former case unions fix a wage such that two-way trade is always possible (which is the case we consider here), while in the latter case the wage arising from the union maximisation problem is such that at equilibrium there is no trade.²¹

Hence, we define the wage strategies which are available to collusive unions in this way:

- The low wage strategy is such that at equilibrium two-way trade is possible:

$x_1, x_2, y_1, y_2 > 0$ (i.e. both production for the domestic country and production for the foreign country are positive)

- The high wage strategy is such that autarchy arises at equilibrium:

$x_1, y_2 > 0, x_2 = y_1 = 0$ (i.e. production for the domestic country is positive while production for the foreign country is zero).²²

5 Is implicit union collusion sustainable?

Collusive unions can adopt in principle either the low wage strategy (which allows exports) or the high wage strategy (which does not allow exports). In appendix we show in details which are the relevant union optimal strategies in case of collusion (section A.2.2). As it emerges from there, the relevant union welfare levels in case of collusion (see (A.21) and (A.23)):

$$\begin{aligned} \text{Two-way trade : } \Omega_L^C &= \frac{1}{8} \frac{(2a-2B-\tau)^2}{2+\gamma} \\ \text{Autarchy : } \Omega_H^C &= \frac{1}{8} (a-B)^2 \end{aligned}$$

²¹As shown in details in appendix (see section A.2), the selection of the union optimal wage strategies both in case of collusion and in case of separate wage setting depends on the level of transportation costs as well as on the degree of product differentiation.

²²The production levels which satisfy the firm maximisation problems in case of two-way trade and in case of autarchy are derived in appendix (see section A.1).

Collusive unions will choose the low wage strategy instead of the high wage strategy as long as $\Omega_L^C > \Omega_H^C$, that is as long as (see (A.25a) in appendix):

$$\tau < \tau_A^C = \left(2 - \sqrt{(2 + \gamma)}\right) (a - B). \quad (8)$$

In other words, when transportation costs are below a certain threshold (i.e. below τ_A^C), collusive unions will adopt the low wage strategy instead of the high wage strategy. This means that when transportation costs are relatively low (i.e. below τ_A^C) the trade regime that will be endogenously determined by union behaviour is a two-way trade regime. A no trade regime will emerge instead where transportation costs are relatively high (i.e. above τ_A^C).

We now investigate in greater detail the implications of each of the available wage strategies in terms of the issue of the sustainability of implicit collusion among unions. Before proceeding, however, it is useful to make some clarifications as far as the relevant payoffs functions are concerned.

First of all, it is necessary to point out that in the present supergame framework the utility from punishment will always be defined as the Bertrand-Nash equilibrium union welfare derived in the presence of two-way trade. This means that in the present context we will simply consider the case where separately maximising unions fix a wage that is so low as to guarantee the presence of positive exports from both countries. As it emerges from condition (A.17) in appendix, this implies that we will only focus on the interval of transportation costs which is such that $0 \leq \tau < \tau_{1A}^N$, by thus taking into account that the utility from punishment will be always given by Ω_L^N in (A.13).

The fact that we analyse our repeated game framework only with reference to the values of transportation costs which are such that $0 \leq \tau < \tau_{1A}^N$ is due to the fact that for transportation costs which are greater than τ_{1A}^N the results of supergame theory cannot apply. As it arises from the derivations in appendix, in fact, while for any value of transportation costs which belongs to the interval $(\tau_{1A}^N, \tau_{2A}^N)$ there is no symmetric Bertrand-Nash equilibrium in pure strategies (see section A.2.1), for the values of transportation costs which are greater than τ_{2A}^N both the Bertrand-Nash strategy and the collusive strategy correspond to the autarchy equilibrium and lead to the same union welfare (see (A.15) and (A.23)). This leads to the result that, while in case $\tau_{1A}^N \leq \tau < \tau_{2A}^N$ the supergame is not defined, in case $\tau \geq \tau_{2A}^N$ the supergame simply does not exist (since there is no Prisoner's dilemma).²³

In terms of the relevant payoffs that must be considered for the analysis of the supergame, the general conclusion that is possible to trace out from the above discussion is hence that we anticipated before: the utility from punishment will always coincide with the utility that separately maximising unions get when two-way trade across countries is possible, whatever is the level of transportation costs.

²³Note that for if products are substitute (i.e. $\gamma > 0$), the following chain of relationships holds: $0 < \tau_A^C < \tau_{1A}^N < \tau_{2A}^N$ (see appendix, section A.2.1).

Note however that in the present framework the utility from collusion and the utility from deviation will be defined in different ways according to the interval of transportation costs which will in turn be considered, that is according to the wage strategy that will be in turn adopted by collusive unions. The relevant definitions are illustrated in greater details in the next paragraphs (see sections 5.1 and 5.2).

5.1 Low wage strategy under collusion

As we specified above, collusive unions adopt the low wage strategy as long as transportation costs are such that $\tau < \tau_A^C$. In this case, the utility from collusion (Ω_L^C) and the utility from punishment (Ω_L^N) are respectively given by (see appendix, (A.21) and (A.13)):

$$\Omega_L^C = \frac{1}{8} \frac{(2a - 2B - \tau)^2}{2 + \gamma} \quad (9)$$

$$\Omega_L^N = \frac{(2 - \gamma)(2a - 2B - \tau)^2}{(\gamma + 2)(4 - \gamma)^2} \quad (10)$$

It is worth pointing out that in such a context the optimal union welfare under deviation will be defined in a different way according to the fact that two-way trade is possible or not possible under deviation.

A union which deviates from a transnational collusive wage agreement can either fix a wage such that two-way trade across countries is still possible after deviation or fix a wage that is so low as to induce the exit of the foreign firm from the domestic market (while still allowing the foreign firm to supply the domestic market).²⁴ We define the former case as the case of *constrained cheating* behaviour and the latter case as the case of *unconstrained cheating* behaviour. These definitions derive from the fact that while in the former case the optimal deviation wage is “constrained” to be sufficiently high to allow exports from both countries, in the latter case the optimal wage can reach a level such that the exports of the foreign country are reduced to zero.

We now analyse each of the two possible behaviours under deviation, by highlighting how the choice of the relevant wage strategy depends both on the level of transportation costs and on the degree of differentiation among traded products.

5.1.1 Constrained cheating behaviour

“Constrained cheating” denotes the case where a union which deviates from a transnational collusive agreement induces a trade regime such that under deviation both firms are able to export. In this case the trade regime does not change in the course of the game and two-way trade will be always prevailing (under collusion, punishment and deviation).

²⁴In other words, under the assumption that the cheating union is union 1, while in the former case a deviation is such that $y_1, y_2 > 0$, in the latter case the deviation is such that $y_1 = 0, y_2 > 0$.

To find the optimal deviation wage which arises in such a context it is necessary to maximise union welfare under the constraint that the exports of the firm which belongs to the country of the loyal union are positive.

In case country i 's union is the cheating union, the relevant maximisation problem is the following:

$$\begin{aligned} \max_{\tilde{w}_{Li}^D} \tilde{\Omega}_{Li}^D &= (\tilde{w}_{Li}^D - B) L_{Li}(\tilde{w}_{Li}^D, w_{Lj}), \\ \text{s.t. } w_{Lj} &= w_L^C \end{aligned}$$

where w_L^C is given by (A.20) in appendix and $L_{Li}(\tilde{w}_{Li}^D, w_{Lj})$ is the labour demand in country i defined in (A.2). The solution to the above maximisation problem is:

$$\tilde{w}_L^D = \frac{1}{2}(a + B - \frac{1}{2}\tau) - \frac{1}{8}\gamma(a - B - \frac{1}{2}\tau). \quad (11)$$

Consequently, the utility from deviation is:

$$\tilde{\Omega}_L^D = \frac{1}{64} \frac{((4 - \gamma)(2a - 2B - \tau))^2}{4 - \gamma^2}. \quad (12)$$

Combining (9), (12) and (12), the strategies described under (4) constitute a subgame perfect Nash equilibrium of the infinitely repeated union game if and only if:

$$\delta \geq \tilde{\delta}_L = \frac{\tilde{\Omega}_L^D - \Omega_L^C}{\tilde{\Omega}_L^D - \Omega^N} = \frac{(4 - \gamma)^2}{32 + \gamma^2 - 16\gamma}. \quad (13)$$

Result 1 *Where a deviation from the collusive agreement does not induce the exit of the foreign firm from the domestic market, the sustainability of union collusion does not depend on the level of transportation costs.*

Proof. From (13), $\frac{\partial \tilde{\delta}_L}{\partial \tau} = 0$. ■

From Result 1 we derive that, where a deviating union fixes a wage such that both firms are able to export in both markets, the discount factor threshold which guarantees the sustainability of union collusion in the absence of binding agreements does not depend on the level of transportation costs.²⁵ This means that the sustainability of implicit collusion among unions belonging to different countries is not influenced by the degree of international product market integration.

Related to this, it is worth pointing out that, where transportation costs are such that two-way trade is possible at equilibrium under both separate and joint wage setting, unions'

²⁵It is worth pointing out that this result depends on the linearity of labour demand and of the union welfare function. Indeed, under for example the assumption that unions put a different weight on wage and employment increases (i.e. $\Omega = (w - B)^\theta L^{1-\theta}$, with $\theta \neq 1/2$), the independence of the critical discount factor threshold on the other model parameters (e.g. the level of transportation costs) is not guaranteed.

incentive to coordinate their actions across countries through signing explicit agreements increases as trade barriers decrease.²⁶ Hence, although the process of trade liberalisation rises the incentives for merger from the unions' point of view, it does not influence the possibility that unions implicitly collude across borders in the repeated game model we consider (provided that under deviation both countries export).

Note that the result that the sustainability of implicit collusion is independent of the degree of product market integration is due to fact that a marginal reduction in transportation costs leads to the same proportionate increase in the profitability of deviating from the collusive agreement and in the utility from punishment, thus leaving unaffected the discount factor. The relevant equivalence is given by:

$$\frac{d(\tilde{\Omega}_L^D - \Omega_L^C)/d\tau}{\tilde{\Omega}_L^D - \Omega_L^C} = \frac{d(\Omega^N - \Omega_L^C)/d\tau}{\Omega^N - \Omega_L^C}, \quad (14)$$

where the expression on the LHS indicates the proportionate increase in the profitability of deviating and the expression on the RHS indicates the proportionate increase in the utility from punishment following (see appendix, section A.4).

Result 2 *Where a deviation from the collusive agreement does not induce the exit of the foreign firm from the domestic market, implicit collusion is more stable the more differentiated are traded goods.*

Proof. The derivative of the fraction on the RHS of (13) with respect to γ is:

$$\frac{\partial \tilde{\delta}_L}{\partial \gamma} = \frac{8\gamma(4-\gamma)}{(\gamma^2-16\gamma+32)^2} > 0.$$

Hence, as long as product differentiation decreases (i.e. γ falls), the discount factor threshold δ_0 in (13) becomes smaller. ■

As we can see from Result 2, the sustainability of implicit collusions among unions only depends on the relative magnitude of the degree of product differentiation. Hence, implicit collusion is more difficult the higher is the degree of substitutability among traded goods.²⁷

The intuition for Result 2 is the following: product differentiation reduces the incremental welfare that can be gained by departing from the collusive agreement because product differentiation insulates the market of the rival firm and reduces the extent to which the wage strategy

²⁶This conclusion is due to the fact that, by deriving the difference between union welfare in case of joint and separate wage setting with respect to τ , we find that:

$$\frac{d}{d\tau} (\Omega^C - \Omega^N) = 2(\tau + 2B - 2a) \frac{\gamma^2}{(\gamma+2)(4-\gamma)^2}, \text{ which is always } < 0 \text{ since } \tau < 2(a - B).$$

²⁷In a similar reciprocal dumping framework where firms produce substitute goods and compete *à la* Cournot, Fung (1991) studies the issue of the sustainability of firm collusion by showing that it is not possible to derive any general conclusion about the effects of product differentiation on the critical discount factor threshold which guarantees implicit collusion. This result derives from the fact that the author takes into account that a firm which exports abroad could cheat differently on the domestic and on the foreign market. On the contrary, in our context a deviation by a union will automatically involve both the domestic and the foreign market.

of a single union can allow the firm which is bargaining with to appropriate the rivals' market share. In other words, when products are highly substitutable a defection is tempting because a slight reduction in wages will result in a significant increase in labour demand. It follows that it will be relatively more difficult for unions to depart from a collusive transnational agreement when products are highly differentiated. This result is also in Ross (1992).²⁸

Figure 1 is an illustration of Result 2. As the graph reveals, non-cooperative union collusion is more likely to be stable (i.e. the discount factor threshold which guarantees implicit collusion is comparatively lower) the more the products are differentiated (i.e. the lower is γ).

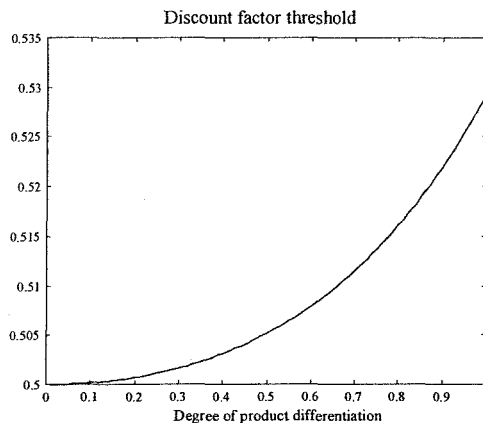


Figure 1: Discount factor threshold in dependence of γ (zero transportation costs)

As pointed out before, in the case of constrained cheating behaviour both firms are able to export under deviation. This means that the optimal deviation wage in (11) is valid only insofar as the firm which belongs to the country of the loyal union still sells a positive amount of goods in the country of the union which deviates.

To check the conditions under which the union welfare under deviation is expressed by (12), let us consider the case where the deviating union is union 1.²⁹ The condition for the firm belonging to country 2 (i.e. the country of the loyal union) to sell in the foreign country after a deviation by the union of country 1 is the following (see appendix, section A.2):

$$y_1 = \frac{2(a - w_2 - \tau) - \gamma(a - w_1)}{4 - \gamma^2} \geq 0. \quad (15)$$

After substituting w_2 with w_L^C as defined in (A.20) in appendix, from condition (15) we derive that for the exports of firm 2 to be positive it is necessary that the wage fixed by the

²⁸Note that the related result by Ross is obtained in a context where firms compete *à la* Bertrand and it is valid insofar the degree of substitutability among products is below the threshold which induces the exit of the foreign firm from the domestic market. See also Martin (2001) for similar conclusions on the relationship between product differentiation and the sustainability of implicit collusion.

²⁹The reasoning is the same in case the deviating union is union 2, being the two countries perfectly symmetric.

cheating union satisfies this condition:

$$\tilde{w}_L^D \geq \frac{1}{2} \frac{3\tau - 2(a(1-\gamma) - B)}{\gamma}. \quad (16)$$

Finally, by replacing \tilde{w}^D with its optimal value as in (11), from (16) we have that, for the deviation not to involve the exit of the foreign firm from the country of the loyal union, the following inequality must be satisfied:

$$\frac{1}{16} \frac{(\gamma^2 - 4\gamma - 24)\tau + (16 - 8\gamma - 2\gamma^2)(a - B)}{\gamma} \geq 0. \quad (17)$$

The above condition can be rewritten as:

$$\tau \leq \tilde{\tau} = 2 \frac{(8 - 4\gamma - \gamma^2)}{24 + 4\gamma - \gamma^2} (a - B). \quad (18)$$

Hence, according to expression (18), the necessary condition for a deviation not to induce the exit of the foreign firm from the domestic market is that transportation costs are relatively low (i.e. lower than or equal to $\tilde{\tau}$).³⁰

In conclusion, for any value of transportation costs which is such that $0 < \tau < \tilde{\tau}$ two-way trade will prevail under deviation and the optimal deviation welfare will be expressed by (12). On the contrary, for the values of transportation costs which are such that $\tilde{\tau} \leq \tau < \tau_A^C$ a deviation could give the firm belonging to the country of the cheating union the whole domestic market.

The comparison between τ_A^C and $\tilde{\tau}$ (see (8) and (18)) reveals that:

$$\tau_A^C \geq \tilde{\tau} \text{ as long as } \gamma \geq \tilde{\gamma} = 6 - 2\sqrt{7} = .7085. \quad (19)$$

Condition (19) tells us that, as long as traded products are sufficiently similar (i.e. $\gamma \geq \tilde{\gamma}$), the level of transportation costs below which there is two-way trade under deviation ($\tilde{\tau}$) is lower than the level of transportation costs below which there is two-way trade under collusion (τ_A^C). By combining conditions (18) and (19), moreover, it is possible to derive that for a deviation to induce the exports of the firm belonging to the country of the loyal union to zero two conditions are necessary:

³⁰Note that condition (17) could also be expressed in terms of γ instead of in terms of τ . Indeed, it is easy to show that (17) is verified for all values of γ which are less or equal than $\tilde{\gamma}$ (we omit the expression of $\tilde{\gamma}$ for brevity). This means that if products are relatively differentiated (i.e. γ is sufficiently low), and provided that there is two-way trade under collusion, a deviation by a union from a transnational collusive agreement would always preserve two-way trade. As we have seen in the introduction to this chapter, this result is very similar to the conclusions of the great majority of contributions which deal with the relationship between the degree of substitutability among products and the critical discount factor threshold which guarantees implicit collusion among firms which compete in prices. Indeed, the relevant literature shows that when firms compete *à la* Bertrand a deviation by a firm from a collusive agreement would not induce the exit of the rival firm from the market where products are sufficiently differentiated.

- (i) that transportation costs are relatively high ($\tau \geq \tilde{\tau}$);
- (ii) that traded products are sufficiently similar ($\gamma \geq \tilde{\gamma}$).

As we will see in the next section, where a deviation induces the exit of the foreign firm from the domestic market the optimal deviation welfare will not coincide any more with expression (12). As a consequence, the critical discount factor threshold which guarantees the sustainability of union collusion will differ from expression (13).

5.1.2 Unconstrained cheating behaviour

“Unconstrained cheating” indicates the case where under deviation the wage fixed by the cheating union is so low as to induce the firm belonging to the country of the loyal union to stop exports. In such a case, a deviation could trigger a phase of one-way trade where the only firm which exports is the one belonging to the country of the cheating union.

For these reasons, under unconstrained cheating behaviour two-way trade will not always prevail during the course of the game. In particular, while there will be two-way trade both under collusion and under punishment, the deviation period will be characterised by a phase of one-way trade.

In such a context, the optimal deviation wage that induces the rival firm to stop exports could be derived from (16) and is given by:

$$\hat{w}_L^D = \frac{1}{2} \frac{3\tau - 2(a(1-\gamma) - B)}{\gamma}, \quad (20)$$

which is exactly the wage that leads the exports of the foreign country to zero (see (16)).

Under the assumption that the cheating union is union 1, in case a deviation induces the rival firm to stop exports the labour demand in country 1 is given by (see (A.4), appendix):

$$L_1 = x_1 + x_2, \text{ where} \quad (21)$$

$$x_1 = \frac{1}{2}a - \frac{1}{2}w_1 \text{ and } x_2 = \frac{1}{4-\gamma^2} (2(a - w_1 - \tau) - \gamma(a - w_2)).$$

By taking into account that the labour demand is given by (21), that $w_1 = \hat{w}_L^D$ as in (20) and that $w_2 = w_L^C$ as in (A.20), country 1's union welfare under deviation is expressed by:

$$\hat{\Omega}_L^D = \frac{1}{4} (\gamma\tau - 2\gamma a + 2\gamma B - 6\tau + 4a - 4B) \frac{3\tau + (2\gamma - 2)(a - B)}{(2 - \gamma)\gamma^2}. \quad (22)$$

The calculation of the discount factor threshold which guarantees tacit collusion among unions can be derived by taking into account that the expressions for the union welfare in the cases of collusion, punishment and deviation are respectively given by expressions (9), (10) and

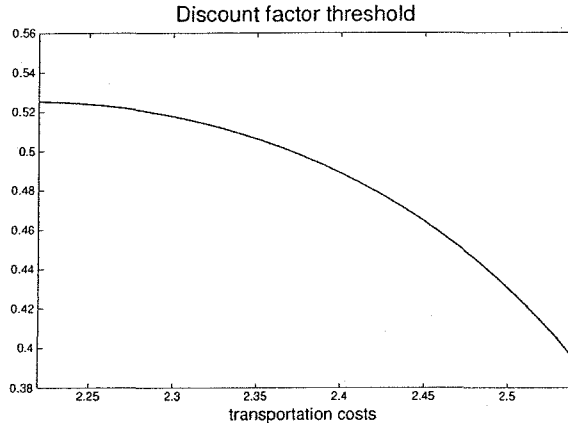


Figure 2: Discount factor threshold in dependence of τ ($0 < \tau \leq \tilde{\tau}$)

(22). By plugging these values in (7), the strategies described under (4) constitute a subgame perfect Nash equilibrium of the infinitely repeated union game if and only if:

$$\delta \geq \hat{\delta}_L = \frac{\hat{\Omega}_L^D - \Omega_L^C}{\hat{\Omega}_L^D - \hat{\Omega}_L^N} = F(a, B, \gamma, \tau). \quad (23)$$

Expression (23) tells us that the critical discount factor threshold which guarantees the sustainability of non-cooperative union collusion is a function of all the model parameters, and in particular of both the level of transportation costs and the degree of product differentiation. This means that, contrary to the case of constrained cheating behaviour, under unconstrained cheating the critical discount factor threshold is not a function of γ only.

Result 3 *Where a deviation induces the exit of the foreign firm from the domestic market, implicit collusion among unions is more difficult the more products markets are integrated.*³¹

Since it is not easy to identify the role played by the different model parameters from the analytical expression of $\hat{\delta}_L$, in Figure 2 we simulate the behaviour of $\hat{\delta}_L$ in dependence of the level of transportation costs for some specific parameter values.³²

As we can see from the graph, the discount factor threshold increases as product markets become more integrated. This occurs because a reduction in transportation costs makes deviation an increasingly attractive option for unions. In other words, reduced trade costs increase

³¹ Note that the fact that product market integration is here modelled as a marginal reduction in trade barriers means that product market integration is modelled as a continuous process. This implies that we are modelling realistically the process towards the completion of the Single Market, which has been a long and gradual one.

³² The parameter values which we used were: $\gamma = 0.9$, $a = 10$ and $B = 1$. The range of transportation costs that we considered was such that to belong to the interval $[\tilde{\tau}, \tau_A^C]$. Within such a interval, the relevant discount factor thresholds were calculated according to expressions (8) and (18): $\tilde{\tau} \cong 2.41$ and $\tau_A^C \cong 2.67$.

the short-run gain from exporting while not making the long-run punishment harsh enough to refrain from deviating. In such a context, given that tacit union collusion is relatively more difficult to sustain as long as trade barriers diminish and, at the same time, product market integration increases the incentives to collude,³³ it may happen that unions find explicit collusion more desirable.

5.1.3 Summing up

From the above analysis we can derive that in case collusive unions adopt the low wage strategy (i.e. for any level of transportation costs which is such that $0 < \tau < \tau_A^C$) the sustainability of implicit collusion among unions coming from different countries depends both on the degree of product market integration and on the degree of substitutability among traded products. In particular, we can distinguish between the following cases:

- Case (i): Traded products are highly substitutable (i.e. $\gamma \geq \tilde{\gamma}$).
 - If transportation costs are relatively low ($0 < \tau < \tilde{\tau}$), a deviation from the collusive agreement does not induce the rival firm to stop exports. In such a case, the discount factor threshold which guarantees the sustainability of union collusion behaves like $\tilde{\delta}_L$: collusion becomes relatively more difficult as long as products become less differentiated.
 - If transportation costs are relatively high ($\tilde{\tau} \leq \tau < \tau_A^C$), a deviation from the collusive agreement induces the rival firm to stop exports. In such a case, the discount factor threshold which guarantees the sustainability of union collusion behaves like $\hat{\delta}_L$: collusion becomes relatively more difficult as long as products become less differentiated and product markets become more integrated.

In Figure 3 we summarise the information of case (i) about the impact of an increase in product market integration on the sustainability of non-cooperative union collusion.³⁴

As we can see from the graph, an increase in product market integration initially leads to an increase in the discount factor threshold which guarantees the sustainability of tacit collusion among unions, then, when transportation costs reach the threshold $\tilde{\tau}$, any further decrease in them does not lead to any changes in the sustainability of implicit collusion among unions.

³³This outcome derives from the fact that a decrease in transportation costs increases the difference between the union welfare in the case of joint and separate wage setting. By using the welfare levels derived in appendix (see (A.21) and (A.13)), the effect of an increase in product market integration on the unions' incentive to collude is measured by the following expression: $\frac{d}{d\tau} (\Omega^C - \Omega^N) = 2(\tau + 2B - 2a) \frac{\gamma^2}{(\gamma+2)(4-\gamma)^2}$, which is always < 0 since $\tau < 2(a - B)$.

³⁴The graph is plotted using $a = 10$, $B = 1$ and $\gamma = 0.95$. The discount factor thresholds are calculated according to expressions (8) and (18).

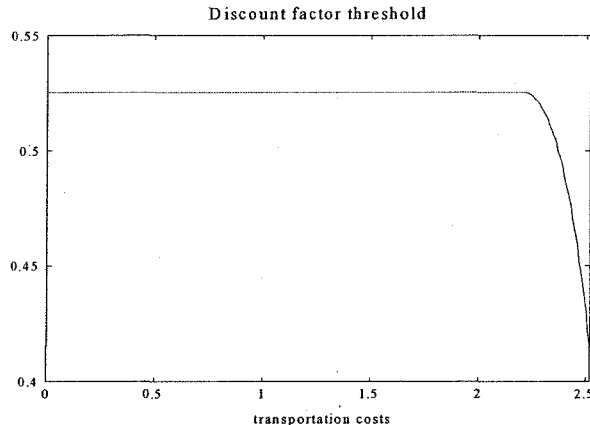


Figure 3: Discount factor threshold in dependence of τ ($0 < \tau < \tau_A^C$)

- Case (ii): Traded products are relatively differentiated ($\gamma < \tilde{\gamma}$).

In this case, a deviation can never induce the rival firm to stop exports. This is due to the fact that when products are sufficiently differentiated, it is not possible for a union which deviates to appropriate the market of the rival firm.³⁵ In this case, the discount factor threshold which guarantees non-cooperative union collusion is given by $\tilde{\delta}_L$ and only depends on the degree of product differentiation.

5.2 High wage strategy under collusion

We now analyse the case where collusive unions choose to adopt the high wage strategy instead of the low wage strategy. As it was highlighted before, collusive unions adopt the high wage strategy as long as transportation costs are such that $\tau \geq \tau_A^C$. In such a context, under collusion trade is not possible and each firm will be a monopolist in its home market (autarchy case).

However, two-way trade is still possible in the punishment phase of the game: as it was outlined before, in fact, the analysis of our repeated game framework is defined only with reference to the values of transportation costs such that separately maximising unions adopt the low wage strategy (by thus allowing two-way trade).³⁶

³⁵It is worth remembering that the case where the degree of product differentiation among traded products is such that $\gamma < \tilde{\gamma}$ corresponds to the case where $\tilde{\tau}$ (the level of transportation costs which guarantees positive exports for the firm belonging to the country of the non-cheating union) is higher than τ_A^C (the threshold which induces collusive unions to adopt a low wage strategy). This means that for any level of transportation costs which is lower or equal than τ_A^C a deviation cannot induce the exit of the rival firm from the domestic market (see section 5.1).

³⁶In terms of the threshold levels of transportation costs that are derived in appendix (section A.2.1), the case we consider is the case where $\tau_A^C \leq \tau < \tau_{1A}^N$ (i.e. no trade is allowed under collusion but two-way trade is allowed under separate wage setting).

Where collusive unions choose the high wage strategy while separately maximising unions choose the low wage strategy, the utility under collusion and under punishment are given by (see (A.23) and (A.13), appendix):

$$\Omega_H^C = \frac{1}{8} (a - B)^2, \quad (24)$$

$$\Omega_L^N = \frac{(2 - \gamma)(2a - 2B - \tau)^2}{(\gamma + 2)(4 - \gamma)^2}. \quad (25)$$

We now consider what happens where a union deviates from the autarchic collusive agreement. In such a context, if a deviation occurs, it will be in the form that the deviating union fixes a wage that allows the domestic firm to enter in the rival's home market. Hence, the potential gain to the cheating union from breaking out of a collusive agreement comes from the fact that, for a short while (i.e. for a period), the firm belonging to its country can capture the rival's home market. In other words, the potential gains from deviation are due to the fact that such a behaviour would trigger a phase of one-way trade.

Under the assumption that the union belonging to country i is the cheating union, the optimal wage in the deviation phase of the game is found by solving the following maximisation problem:

$$\begin{aligned} \max_{w_{Hi}^D} \Omega_{Hi}^D &= (w_{Hi}^D - B) L_i(w_{Hi}^D, w_{Hj}) \\ \text{s.t. } w_{Hj} &= w_H^C \end{aligned}$$

where w_H^C is the optimal wage in case collusive unions play the high wage strategy, w_{Hi}^D is the wage under deviation and $L_i(w_{Hi}^D, w_{Hj})$ is the relevant labour demand of the union belonging to country i .

In case the deviating union is the union which belongs to country 1, the relevant labour demand is expressed by (21), while w_2 will be given by w_H^C as in (A.22) (see appendix). Under these conditions, the optimal deviation wage resulting from the above maximisation problem is the following:

$$w_H^D = \frac{1}{2} \frac{8a - a\gamma^2 - 4\tau - \gamma a + \gamma B + 8B - B\gamma^2}{8 - \gamma^2}, \quad (26)$$

and the utility from deviation is:

$$\Omega_H^D = \frac{1}{8} \frac{((8 - \gamma^2 - \gamma)(a - B) - 4\tau)^2}{(4 - \gamma^2)(8 - \gamma^2)}. \quad (27)$$

In such a context, the discount factor threshold which guarantees the sustainability of union collusion is found by plugging (24), (25) and (27) in (7). This implies that the strategies described under (4) constitute a subgame perfect Nash equilibrium of the infinitely repeated union game if and only if:

$$\delta \geq \delta_H = \frac{\Omega_H^D - \Omega_H^C}{\Omega_H^D - \Omega_L^N} = G(a, B, \gamma, \tau). \quad (28)$$

Result 4 *In case transportation costs across countries are relatively high, collusion is more difficult the more products markets are integrated and the less substitutable are traded products.*

Since it is not easy to identify the role played by the model parameters from the analytical expression of δ_H , in Figure 4 we show some simulations of the behaviour of δ_H in dependence of the level of transportation costs and of the degree of product differentiation.^{37,38}

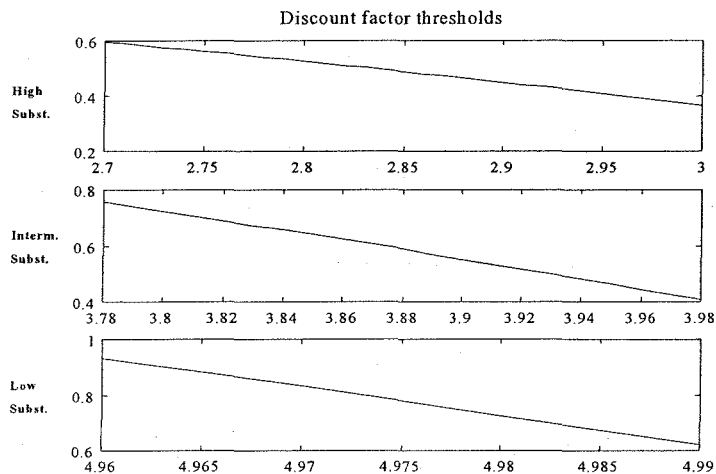


Figure 4: Discount factor threshold in dependence of transportation costs in the case of autarchic union behaviour

The graph shows that implicit collusion becomes relatively more difficult to sustain as long as transportation costs decrease. Hence, where a deviation induces the entry of the domestic firm into the foreign market, product market integration has pro-competitive effects, since implicit collusion among unions is more difficult to sustain as long as products markets become more interdependent and whatever is the degree of differentiation among products, whatever is the degree of substitutability among traded products. In absolute terms, however, non-cooperative union collusion will be relatively more difficult the lower is the degree of substitutability among products.

³⁷We consider the following cases: high substitutes ($\gamma = 0.9$), intermediate substitutes ($\gamma = 0.5$) and low substitutes ($\gamma = 0.1$). In all cases, $a = 10$, $B = 1$ and the relevant interval of transportation costs is $[\tau_A^C, \tau_{1A}^N]$.

³⁸Straume (2002) analyses the sustainability of implicit collusion among unions in a similar context for the case of traded goods which are perfect substitutes and in the absence of unemployment benefits. In terms of our framework, his parametrisation is the following: $a = 1$, $B = 0$, $\gamma = 1$. With these parameter values, in our framework the discount factor threshold which guarantees the sustainability of union collusion is $\delta_H = \frac{9}{4} \frac{15 - 48\tau + 16\tau^2}{25 - 52\tau + 22\tau^2}$, which is the same as that derived by Straume.

6 Conclusions

In this paper we have traced out the conditions which make transnational collusion among unions sustainable in the absence of legally binding agreements. In a two-country partial equilibrium framework with differentiated products and reciprocal dumping, we have shown that if countries are perfectly symmetric in both labour and product markets the discount factor threshold which guarantees the possibility of non-cooperative collusion among unions depends both on the degree of international product market integration and on the degree of substitutability among traded products.

In particular, where traded products are sufficiently similar and transportation costs are relatively low, an increase in the degree of product market integration does not influence the conditions which guarantee the existence of implicit collusion among unions belonging to different countries. Where instead international product markets are not sufficiently well integrated, a decrease in transportation costs makes implicit cross-border collusion among unions relatively more difficult to sustain.

These findings indicate that the intensification of the process of international product market integration does not necessarily lead unions to intensify the initiatives towards the coordination of collective bargaining policies across borders, as the “race to the bottom” argument seems to suggest.³⁹ The results we obtain are naturally dependent on a number of assumptions, some of them more stringent than others. However, they are in line with the conclusions of some of the most recent studies about the developments of industrial relations in Europe, which consider transnational bargaining a not very likely phenomenon in the next future (see Sisson and Marginson (2000)).

The model we outlined in the present paper can be extended in a number of interesting directions. In particular, a promising topic for further research is to analyse the issue of the sustainability of non-cooperative union collusion in the presence of asymmetric business cycle fluctuations across countries. If countries are not perfectly symmetric, in fact, it can happen that a deviation from collusive behaviour becomes particularly profitable for some unions but not for all, thus rendering implicit collusion particularly unstable.⁴⁰ Another interesting extension of the present framework is to consider the possibility that firms can shift

³⁹The intuition which lies behind this argument is that both the EMU and the Single Market are inducing a strong pressure for wage moderation and wage flexibility in Europe, by increasingly exposing the European labour markets to a sort of “regime competition”. In such a context, unions could lose their ability to raise wages where they do not grow as large as the market for goods (Wallerstein (1998)). A great potential challenge that the European integration process is posing to trade unions is hence to coordinate their wage demands across borders in an attempt to protect social standards and to prevent a “race to the bottom”.

⁴⁰By analysing the sustainability of implicit collusion in case product markets switch from being segmented to becoming integrated, Colonescu and Schmitt (1998) find that while trade liberalisation makes implicit collusion relatively easier to sustain when product markets are sufficiently similar, the reverse holds where products markets are relatively different.

production abroad. This possibility could change the union payoffs both under collusion and under punishment, thus modifying the conditions which make implicit collusion among unions sustainable.⁴¹

A Appendix

A.1 Firm maximisation problem

The first order conditions of the maximisation problems lead to the following reaction functions of the country i 's output decisions to country j 's output decisions ($i, j = 1, 2, i \neq j$):

$$\begin{aligned} x_1 &= \frac{1}{2}(a - w_1 - \gamma y_1); & y_1 &= \frac{1}{2}(a - w_2 - \gamma x_1 - \tau); \\ x_2 &= \frac{1}{2}(a - w_1 - \gamma y_2 - \tau); & y_2 &= \frac{1}{2}(a - w_2 - \gamma x_2). \end{aligned} \quad (\text{A.1})$$

We now derive from (A.1) the optimal supplies of x and y in the case of two-way trade, one-way trade and no trade across countries. It is worth remembering that, since in our framework production is linear in labour and the marginal productivity of labour is equal to one, the optimal supplies of goods will coincide with the labour demands.

If two-way trade is possible (i.e. $x_i, y_i > 0$), the optimal supplies of x and y are:

$$\begin{aligned} x_1 &= \frac{1}{4-\gamma^2} (2(a - w_1) - \gamma(a - w_2 - \tau)); & y_1 &= \frac{1}{4-\gamma^2} (2(a - w_2 - \tau) - \gamma(a - w_1)); \\ x_2 &= \frac{1}{4-\gamma^2} (2(a - w_1 - \tau) - \gamma(a - w_2)); & y_2 &= \frac{1}{4-\gamma^2} (2(a - w_2) - \gamma(a - w_1 - \tau)). \end{aligned} \quad (\text{A.2})$$

In case instead only country 2 exports (i.e. $x_1, y_1, y_2 > 0, x_2 = 0$), the optimal supplies are:

$$\begin{aligned} x_1 &= \frac{1}{4-\gamma^2} (2(a - w_1) - \gamma(a - w_2 - \tau)); & y_1 &= \frac{1}{4-\gamma^2} (2(a - w_2 - \tau) - \gamma(a - w_1)); \\ x_2 &= 0; & y_2 &= \frac{1}{2}(a - w_2). \end{aligned} \quad (\text{A.3})$$

Alternatively, where only country 1 exports (i.e. $x_1, x_2, y_2 > 0, y_1 = 0$), the optimal supplies are:

$$\begin{aligned} x_1 &= \frac{1}{2}a - \frac{1}{2}w_1; & y_1 &= 0; \\ x_2 &= \frac{1}{4-\gamma^2} (2(a - w_1 - \tau) - \gamma(a - w_2)); & y_2 &= \frac{1}{4-\gamma^2} (2(a - w_2 - \tau) - \gamma(a - w_1)). \end{aligned} \quad (\text{A.4})$$

Finally, in the autarchy case (i.e. $x_1, y_2 > 0, x_2 = y_1 = 0$), the optimal supplies are given by:

$$\begin{aligned} x_1 &= \frac{1}{2}a - \frac{1}{2}w_1; & y_1 &= 0; \\ x_2 &= 0; & y_2 &= \frac{1}{2}(a - w_2). \end{aligned} \quad (\text{A.5})$$

⁴¹The issue of the possibility to relocate production abroad is strictly related to the topic of strategic trade and location policy, which has been so far mainly considered in a framework of exogenous wages.

A.2 Union optimal strategies

In each country i ($i = 1, 2$) a union can play one of two following strategies: a *low wage strategy*, which allows country i 's firm to export in the foreign market, and a *high wage strategy*, which prevents country i 's firm from selling abroad. In the following we investigate all the possible combinations between the wage strategies played by unions.⁴² We use the subscript L to indicate that country i ' union is adopting the low wage strategy while we use the subscript H to indicate that country i ' union is adopting the high wage strategy.

A.2.1 Separate wage setting

We now consider the optimal union responses to the strategies played by union abroad. We will focus on union 1's response to the strategies played by union 2, taking for granted that when countries are perfectly symmetric the analysis will be exactly the same where the focus is on union 2 instead of on union 1.

Response to a low wage strategy

If union 2 plays the low wage strategy, union 1 can respond in two ways: by selecting the low wage strategy as well or by selecting the high wage strategy. Let us consider each of these strategies in turn.

A) Low wage strategy

In this case the labour demand in country 1 is given by (from (A.2)):

$$x_1 + x_2 = \frac{4a - 2\gamma a - 4w_{1L} + 2\gamma w_{2L} + \gamma\tau - 2\tau}{4 - \gamma^2}.$$

Union 1's welfare is:

$$\tilde{\Omega}_{1L} = (w_{1L} - B)(x_1 + x_2) = (w_{1L} - B) \left(\frac{4a - 2\gamma a - 4w_{1L} + 2\gamma w_{2L} + \gamma\tau - 2\tau}{4 - \gamma^2} \right).$$

The maximisation of $\tilde{\Omega}_{1L}$ with respect to w_{1L} gives the following wage:

$$w_{1L} = \frac{1}{8} (4a - 2\gamma a + 4B + 2\gamma w_{2L} + \gamma\tau - 2\tau).$$

After substituting w_{1L} in $\tilde{\Omega}_{1L}$, union 1's welfare becomes:

$$\tilde{\Omega}_{1L} = \frac{1}{16} \frac{(4a - 2\gamma a + 2\gamma w_{2L} - 4B + \gamma\tau - 2\tau)^2}{4 - \gamma^2}. \quad (\text{A.6})$$

B) High wage strategy

In this case, total labour demand in country 1 is (from (A.3)):

$$x_1 + x_2 = \frac{2a - \gamma a - 2w_{1H} + \gamma w_{2L} + \gamma\tau}{4 - \gamma^2}.$$

Union 1's welfare is:

$$\tilde{\Omega}_{1H} = (w_{1H} - B)(x_1 + x_2) = (w_{1H} - B) \left(\frac{2a - \gamma a - 2w_{1H} + \gamma w_{2L} + \gamma\tau}{4 - \gamma^2} \right).$$

⁴²Naylor (1999) addresses the issue of union strategy selection in a similar two-country oligopolistic framework. Although the frameworks are similar, however, the present description of the union optimal strategies distinguishes from that by Naylor since it takes into account the presence of differentiated products across countries as well as the possibility of transnational union coordination.

The maximisation of $\tilde{\Omega}_{1H}$ with respect to w_{1H} gives the following wage:

$$w_{1H} = \frac{1}{4}(2a - \gamma a + \gamma w_{2L} + 2B + \gamma \tau).$$

After substituting w_{1H} in $\tilde{\Omega}_{1H}$, union 1's welfare becomes:

$$\tilde{\Omega}_{1H} = \frac{1}{8} \frac{(2a - \gamma a + \gamma w_{2L} - 2B + \gamma \tau)^2}{4 - \gamma^2}. \quad (\text{A.7})$$

C) Optimal strategy

The optimal response of union 1 to a low wage strategy by union 2 is to be found by comparing A.6 with A.7. In particular, union 1 will prefer the low wage strategy as long as $\tilde{\Omega}_{1L} > \tilde{\Omega}_{1H}$, that is as long as:

$$\frac{1}{16} \frac{(4a - 2\gamma a + 2\gamma w_{2L} - 4B + \gamma \tau - 2\tau)^2}{4 - \gamma^2} > \frac{1}{8} \frac{(2a - \gamma a + \gamma w_{2L} - 2B + \gamma \tau)^2}{4 - \gamma^2}. \quad (\text{A.8})$$

Response to a high wage strategy

Let us now assume that union 2 selects the high wage strategy. As before, union 1 can respond to it by playing either a low wage strategy or a high wage strategy.

A) Low wage strategy

In this case the labour demand in country 1 is given by (from (A.4)):

$$x_1 + x_2 = \frac{1}{2} \frac{8a - a\gamma^2 - 8w_{1L} + w_{1L}\gamma^2 - 2\gamma a + 2\gamma w_{2H} - 4\tau}{4 - \gamma^2}.$$

Union 1's welfare is:

$$\hat{\Omega}_{1L} = (w_{1L} - B)(x_1 + x_2) = (w_{1L} - B) \left(\frac{1}{2} \frac{8a - a\gamma^2 - 8w_{1L} + w_{1L}\gamma^2 - 2\gamma a + 2\gamma w_{2H} - 4\tau}{4 - \gamma^2} \right).$$

The maximisation of $\hat{\Omega}_{1L}$ with respect to w_{1L} gives the following wage:

$$w_{1L} = \frac{1}{2} \frac{8a - a\gamma^2 - 4\tau + 8B - 2\gamma a + 2\gamma w_{2H} - B\gamma^2}{8 - \gamma^2}.$$

After substituting w_{1L} in $\hat{\Omega}_{1L}$, union 1's welfare becomes:

$$\hat{\Omega}_{1L} = \frac{1}{8} \frac{(8a - a\gamma^2 - 4\tau - 8B - 2\gamma a + 2\gamma w_{2H} + B\gamma^2)^2}{(4 - \gamma^2)(8 - \gamma^2)}. \quad (\text{A.9})$$

B) High wage strategy

In this case the labour demand for union 1 is given by (from (A.5)):

$$x_1 + x_2 = \frac{1}{2}(a - w_{1H}).$$

Union welfare is:

$$\hat{\Omega}_{1H} = (w_{1H} - B)(x_1 + x_2) = \frac{1}{2}(w_{1H} - B)(a - w_{1H}).$$

The maximisation of $\hat{\Omega}_{1H}$ with respect to w_{1H} gives the following wage:

$$w_{1H} = \frac{1}{2}(a + B).$$

After substituting w_{1H} in $\hat{\Omega}_{1H}$, union 1's welfare is expressed by:

$$\hat{\Omega}_{1H} = \frac{1}{8}(a - B)^2. \quad (\text{A.10})$$

Hence, where both countries adopt the high wage strategy union welfare does not depend on wages fixed by unions abroad. This is not surprising, since, should both unions adopt the high wage strategy, there is no trade across countries.

C) Optimal strategy

The optimal response of union 1 to a high wage strategy by union 2 is to be found by comparing A.9 with A.10. In particular, union 1 will prefer the high wage strategy as long as $\widehat{\Omega}_{1H} > \widehat{\Omega}_{1L}$, that is as long as:

$$\frac{1}{8}(a - B)^2 > \frac{1}{8} \frac{(8a - a\gamma^2 - 4\tau - 8B - 2\gamma a + 2\gamma w_{2H} + B\gamma^2)^2}{(4 - \gamma^2)(8 - \gamma^2)}. \quad (\text{A.11})$$

Nash equilibria

Since countries are symmetric, Nash equilibria will be symmetric as well. Note that there are two types of symmetric equilibria: the equilibrium where both unions select a low wage strategy (*LWS*) and the equilibrium where both unions select a high wage strategy (*HWS*).

A) LWS for Union 1, LWS for Union 2

This is the case of two-way trade (i.e. both countries export). In this context, the optimal response of union 1 to the low wage strategy of union 2 is:

$$w_{1L} = \frac{1}{8}(4a - 2\gamma a + 4B + 2\gamma w_{2L} + \gamma\tau - 2\tau),$$

and analogously for union 2:

$$w_{2L} = \frac{1}{8}(4a - 2\gamma a + 4B + 2\gamma w_{1L} + \gamma\tau - 2\tau).$$

Given symmetry, at equilibrium $w_{1L} = w_{2L} = w_L^N$, where

$$w_L^N = \frac{1}{2} \frac{4a - 2\gamma a + 4B + \tau\gamma - 2\tau}{4 - \gamma}. \quad (\text{A.12})$$

Consequently, the union welfare in case both countries adopt the low wage strategy is expressed by (the labour demand being given in (A.2)):

$$\Omega_L^N = \frac{(2 - \gamma)(2a - 2B - \tau)^2}{(\gamma + 2)(4 - \gamma)^2}. \quad (\text{A.13})$$

B) HWS for Union 1, HWS for Union 2

This is the case of no trade. In this case, the optimal response of union 1 to the high wage strategy of union 2 is $w_{1H} = \frac{1}{2}(a + B)$. Analogously, the optimal response of union 2 to a high wage strategy by union 1 is: $w_{2H} = \frac{1}{2}(a + B)$. Hence, at equilibrium $w_{1H} = w_{2H} = w_H^N$, where

$$w_H^N = \frac{1}{2}(a + B). \quad (\text{A.14})$$

Consequently, the union welfare where both countries adopt the high wage strategy is expressed by (the labour demand being given in (A.5)):

$$\Omega_H^N = \frac{1}{8}(a - B)^2. \quad (\text{A.15})$$

Critical thresholds for transportation costs

We now calculate the critical thresholds for transportation costs that make two-way trade possible (i.e. both unions adopt the low wage strategy) or not possible (i.e. both unions adopt the high wage strategy).

Condition A.8 tells us that at equilibrium (i.e. $w_{2L} = w_L^N$) union 1 adopts the low wage strategy as long as:

$$\tau < \tau_{1A}^N, \tau > \tau_{1B}^N,$$

where τ_{1A}^N and τ_{1B}^N are the following switching levels of transportation costs:

$$\tau_{1A}^N = 8 \frac{1 - \sqrt{2}}{\gamma^2 - 6\gamma + 4\sqrt{2}\gamma - 8\sqrt{2}} (2 - \gamma)(a - B), \quad (\text{A.16a})$$

$$\tau_{1B}^N = 8 \frac{1 + \sqrt{2}}{\gamma^2 - 6\gamma - 4\sqrt{2}\gamma + 8\sqrt{2}} (2 - \gamma)(a - B). \quad (\text{A.16b})$$

Note that if both unions adopt a low wage strategy each country will have positive exports in equilibrium. This means that it must be true that (see (A.2)):

$$x_2 > 0 \iff 2(a - w_1 - \tau) - \gamma(a - w_2) > 0,$$

$$y_1 > 0 \iff 2(a - w_2 - \tau) - \gamma(a - w_1) > 0.$$

Since we are in the symmetric case, at the two-way trade equilibrium $w_{1L} = w_{2L} = w_L^N$. As a consequence, the two above conditions simplify as follows:

$$\tau < \frac{4(a-B)(2-\gamma)}{12-\gamma^2}.$$

Moreover, since only threshold τ_{1A}^N satisfies the above condition, we conclude that:

$$\text{Low wage strategy: } 0 < \tau < \tau_{1A}^N. \quad (\text{A.17})$$

Note that in case $a = 1, B = 0, \gamma = 1$, $\tau_{1A}^N \cong 0.31$, which is also the result found by Naylor (1999).

Let us now turn to the interpretation of condition (A.11). This condition tells us that at equilibrium (i.e. $w_{2H} = w_H^N$) union 1 adopts the high wage strategy as long as:

$$\tau_{2A}^N < \tau < \tau_{2B}^N$$

where τ_{2A}^N and τ_{2B}^N are the following switching levels of transportation costs:

$$\tau_{2A}^N = \left(2 - \frac{1}{4}\gamma - \frac{1}{4}\gamma^2 - \frac{1}{4}\sqrt{(32 - 12\gamma^2 + \gamma^4)}\right) (a - B), \quad (\text{A.18a})$$

$$\tau_{2B}^N = \left(2 - \frac{1}{4}\gamma - \frac{1}{4}\gamma^2 + \frac{1}{4}\sqrt{(32 - 12\gamma^2 + \gamma^4)}\right) (a - B). \quad (\text{A.18b})$$

Note that if union 2 adopts the high wage strategy while union 1 adopts a low wage strategy it must be true that (see (A.2)):

$$x_2 > 0 \iff 2(a - w_1 - \tau) - \gamma(a - w_2) > 0,$$

This means that the level of transportation costs must be such that ($w_1 = w_2 = w_H^S$):

$$\tau < \frac{(8 - 4\gamma + \gamma^2)}{(12 - 2\gamma)} (a - B).$$

Hence, since it is easy to show that only thresholds τ_{2A}^N satisfies the above condition, we conclude that:

$$\text{High wage strategy: } \tau > \tau_{2A}^N. \quad 43 \quad (\text{A.19})$$

By taking into account the results of section A.2.1, it is hence possible to conclude that while for any value of transportation costs which is lower than τ_{1A}^N there will be a symmetric Bertrand-Nash equilibrium where both unions adopt the low wage strategy, for any value of transportation costs that is higher than τ_{2A}^N there will be a symmetric Bertrand-Nash equilibrium where both unions adopt the high wage strategy. For transportation costs which belong to the interval $(\tau_{1A}^N, \tau_{2A}^N)$, instead, there will be no a symmetric Bertrand-Nash equilibrium in pure strategies.⁴⁴

A.2.2 Joint wage setting

As under separate wage setting, also in case of collusion unions have the choice to select a low wage strategy or a high wage strategy. Again, while in the former case both countries will be able to export, in the latter case there will be no trade across countries.

A) Low wage strategy

In this case, the total union welfare is expressed by:

$$\Omega_L^I = (w_{1L} - B)(x_1 + x_2) + (w_{2L} - B)(y_1 + y_2),$$

where x_1, x_2, y_1 and y_2 are given in (A.2). The maximisation of Ω_L^I with respect to w_{1L}, w_{2L} gives the following two coinciding solutions:

$$w_L^C = \frac{1}{2}(a + B - \frac{1}{2}\tau). \quad (\text{A.20})$$

⁴⁴On this point, see also Naylor (1999).

This implies that the welfare of union members in country i is given by:

$$\Omega_L^C = \frac{1}{8} \frac{(2a-2B-\tau)^2}{\gamma+2}. \quad (\text{A.21})$$

B) High wage strategy

In this case, the total union welfare is expressed by:

$$\Omega_H^I = (w_{1H} - B)(x_1 + x_2) + (w_{2H} - B)(y_1 + y_2),$$

where x_1, x_2, y_1 and y_2 are given in (A.5). The maximisation of Ω_H^I with respect to w_{1H}, w_{2H} produces the following two coinciding solutions:

$$w_H^C = \frac{1}{2}(a + B). \quad (\text{A.22})$$

This implies that the welfare of union members in country i is given by:

$$\Omega_H^C = \frac{1}{8} (a - B)^2. \quad (\text{A.23})$$

C) Optimal strategy

In case of collusion, unions will select a high (low) wage strategy as long as $\Omega_H^C > (<) \Omega_L^C$. This implies the low wage strategy will be selected as long as:

$$\tau < \tau_A^C, \tau > \tau_B^C$$

where τ_A^C and τ_B^C are the following switching levels of transportation costs:

$$\tau_A^C = \left(2 - \sqrt{\gamma + 2}\right) (a - B), \quad (\text{A.24a})$$

$$\tau_B^C = \left(2 + \sqrt{\gamma + 2}\right) (a - B). \quad (\text{A.24b})$$

In case the low wage strategy emerges at equilibrium both countries must have positive exports. This means that it must be true that (see (A.2)):

$$x_2 > 0 \iff 2(a - w_1 - \tau) - \gamma(a - w_2) > 0;$$

$$y_1 > 0 \iff 2(a - w_2 - \tau) - \gamma(a - w_1) > 0.$$

By substituting w_1 and w_2 with w_L^C , the two above conditions simplify as follows:

$$\tau < \frac{(a-B)(2-\gamma)}{(3+\frac{1}{2}\gamma)}.$$

Finally, since it is possible to show that only threshold τ_A^C satisfies the above condition, we can conclude that the optimal strategies in case of collusive wage setting are:

$$\text{Low wage strategy : } 0 < \tau < \tau_A^C. \quad (\text{A.25a})$$

$$\text{High wage strategy : } \tau > \tau_A^C. \quad (\text{A.25b})$$

Note that in case $a = 1, B = 0, \gamma = 1, \tau_A^C \cong 0.27$, which is also the result found by Straume (2002).

A.3 Incentives for collusion

In the following we investigate whether unions face incentives for collusion. To check if there are incentives for collusion, it is necessary to compare the union welfare under joint wage setting (Ω_i^C) with the union welfare in case of separate wage setting (Ω_i^N). Where the former is greater than the latter, unions would find it profitable to make a collusive agreement with unions abroad. As we will see below, the existence of incentives for collusion strictly depends on the level of transportation costs (whose reference thresholds are derived in section A.2) as well as on the degree of product differentiation. Note that, if products are substitutes (i.e. $\gamma > 0$), the following chain of relationships holds: $0 < \tau_A^C < \tau_{1A}^N < \tau_{2A}^N$.

A.3.1 Case 1: $0 < \tau < \tau_A^C$.

In this interval, unions play the low wage strategy both in case of separate wage setting and in case of joint wage setting (see section (A.2)). The relevant comparison is between:

$$\begin{aligned} \text{Separate wage setting: } \Omega_i^N &= (2a - 2B - \tau) \frac{4a - 2\gamma a - 4B + 2B\gamma + \tau\gamma - 2\tau}{(\gamma+2)(\gamma-4)^2}. \\ \text{Joint wage setting: } \Omega_i^C &= \frac{1}{8} \frac{(2a - 2B - \tau)^2}{\gamma+2}. \end{aligned} \quad (\text{A.26})$$

Incentives for collusion are present if as long as $(\Omega_i^C - \Omega_i^N)$ is > 0 , where:

$$\Omega_i^C - \Omega_i^N = \frac{1}{8} (2a - 2B - \tau)^2 \frac{\gamma^2}{(\gamma+2)(4-\gamma)^2}.$$

As it is easy to verify, $(\Omega_i^C - \Omega_i^N)$ is always positive (since $\gamma \in (0, 1)$ and all the other quantities are positive). Hence, in this interval there will always be incentives for collusion.

A.3.2 Case 2: $\tau_A^C < \tau < \tau_{1A}^N$.

In this interval, under separate wage setting unions will choose the low wage strategy while collusive unions will choose the high wage strategy (see section A.2). The relevant comparison is between:

$$\begin{aligned} \text{Separate wage setting: } \Omega_i^N &= (2a - 2B - \tau) \frac{4a - 2\gamma a - 4B + 2B\gamma + \tau\gamma - 2\tau}{(\gamma+2)(4-\gamma)^2}. \\ \text{Joint wage setting: } \Omega_i^C &= \frac{1}{8} (a - B)^2. \end{aligned} \quad (\text{A.27})$$

To check for the presence of incentives for collusion, it is necessary to verify for what values of τ it occurs that $(\Omega_i^C - \Omega_i^N) > 0$. It is easy to show that this condition is verified for all values of transportation costs such that

$\tilde{\tau}_1 < \tau < \tilde{\tau}_2$, where:

$$\tilde{\tau}_1 = \frac{1}{2(16-8\gamma)} \left(64 - 32\gamma - 4\sqrt{2(4-\gamma^2)(4-\gamma)^2} \right) (a - B),$$

$$\tilde{\tau}_2 = \frac{1}{2(16-8\gamma)} \left(64 - 32\gamma + 4\sqrt{2(4-\gamma^2)(4-\gamma)^2} \right) (a - B).$$

Since $\tilde{\tau}_1$ is lower than τ_A^C while $\tilde{\tau}_2$ is greater than τ_{1A}^S , we can conclude that in the interval $\tau_A^C < \tau < \tau_{1A}^S$ unions always have incentives to collude.

To sum up, for all the values of transportation costs such that $0 < \tau < \tau_{1A}^N$ there is always incentive for collusion.

Note that there is no particular interest in investigating what occurs at the levels of transportation costs which are above τ_{1A}^S . This is due to the fact that in the interval $\tau_{1A}^N < \tau < \tau_{2A}^N$ there are no Nash equilibria in pure strategies (see also Naylor(1999), for the case of perfect substitutes) and above τ_{2A}^N the Nash strategies and the collusive strategies lead to the same outcomes since trade does not occur at equilibrium.

A.4 Independence of the critical discount factor threshold from the level of transportation costs

The expression for the derivative of the discount factor threshold $\tilde{\delta}_L$ with respect to the level of transportation costs τ is:

$$\begin{aligned} \frac{d\tilde{\delta}_L}{d\tau} &= (\tilde{\Omega}_L^D - \bar{\Omega}^N)^{-2} \left(\frac{d(\tilde{\Omega}_L^D - \Omega_L^C)}{d\tau} (\tilde{\Omega}_L^D - \bar{\Omega}^N) - \frac{d(\tilde{\Omega}_L^D - \bar{\Omega}^N)}{d\tau} (\tilde{\Omega}_L^D - \Omega_L^C) \right) = \\ &= (\tilde{\Omega}_L^D - \Omega^N)^{-2} \left(-\frac{d\tilde{\Omega}_L^D}{d\tau} (\Omega^N - \Omega_L^C) - \frac{d\Omega_L^C}{d\tau} (\tilde{\Omega}_L^D - \Omega^N) + \frac{d\bar{\Omega}^N}{d\tau} (\tilde{\Omega}_L^D - \Omega_L^C) \right) = \\ &= (\tilde{\Omega}_L^D - \Omega^N)^{-2} \left(-\frac{d\tilde{\Omega}_L^D}{d\tau} (\Omega^N - \Omega_L^C) - \frac{d\Omega_L^C}{d\tau} (\tilde{\Omega}_L^D - \Omega_L^C + \Omega_L^C - \Omega^N) + \frac{d\bar{\Omega}^N}{d\tau} (\tilde{\Omega}_L^D - \Omega_L^C) \right) = \\ &= (\tilde{\Omega}_L^D - \Omega^N)^{-2} \left(-\left(\frac{d\tilde{\Omega}_L^D}{d\tau} - \frac{d\Omega_L^C}{d\tau}\right) (\Omega^N - \Omega_L^C) + \left(\frac{d\bar{\Omega}^N}{d\tau} - \frac{d\Omega_L^C}{d\tau}\right) (\tilde{\Omega}_L^D - \Omega_L^C) \right). \end{aligned}$$

Since when $\tilde{\Omega}_L^D, \Omega_L^C$ and $\bar{\Omega}^N$ are respectively given by (12), (9) and (10), it verifies that:

$$\frac{d(\tilde{\Omega}_L^D - \Omega_L^C)/d\tau}{\tilde{\Omega}_L^D - \Omega_L^C} = \frac{d(\Omega^N - \Omega_L^C)/d\tau}{\Omega^N - \Omega_L^C} = H \quad (\text{A.28})$$

where H is equal to $\frac{2}{2B-2a+\tau}$ and it is negative if $\tau < 2(a - B)$. Moreover, since $2(a - B)$ is greater than τ_A^C and in the case of constrained cheating we are analysing the region of transportation costs below the threshold τ_A^C , H is always negative.

Hence, when condition (A.28) holds, $d\tilde{\delta}_L/d\tau = 0$. This means that in case there exists two-way trade across countries and a deviation does not induce the exit of the foreign firm from the domestic market, the discount factor threshold which is relevant to sustain union collusion does not depend on the level of transportation costs.

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