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Contents

1 Introduction **1**
References . . . 6

2 Unionization Structures in International Oligopoly **7**
2.1 Introduction . . . 7
2.2 The Model . . . 9
2.3 The Impact of Unionization Structures on Wages and Profits . . . 13
2.3.1 Wages . . . 14
2.3.2 Profits . . . 15
2.4 Equilibrium Wage-Setting Regimes . . . 18
2.5 Conclusion . . . 21
Appendix . . . 23
References . . . 26

3 How to Counter Union Power? Equilibrium Mergers in International Oligopoly **28**
3.1 Introduction . . . 28
3.2 The Model . . . 31
3.3 Merger Incentives . . . 36
3.3.1 Wage and Employment Effects . . . 36
3.4 Equilibrium Industry Structures . . . 41
3.5 Welfare . . . 42
3.6 Concluding Remarks . . . 44
Appendix A . . . 46
Appendix B . . . 60
References . . . 66

4 Union–Firm Wage Bargaining Order and Employers' Associations **68**
4.1 Introduction . . . 68
4.2 Related Literature . . . 71
4.3 The Model . . . 73
4.3.1 Product Market Equilibrium . . . 75
4.3.2 Bargaining Structures . . . 75

4.4 Results 81
4.4.1 Labor Union's Preferences for Bargaining Orders 81
4.4.2 Firms' Preferences for Bargaining Orders 83
4.5 Merger Incentives 85
4.6 Welfare Implications 88
4.7 Conclusion 89
Appendix 91
References 99

5 Concluding Remarks **101**

Chapter 1

Introduction

Traditionally, collective wage bargaining systems are characterized by negotiations between powerful agents on each side. On the employee side, worker interests are usually represented by labor unions. While the term "labor union" is used throughout the world as a description for organizations on the worker side, the the actual organizational forms of these labor unions differ strongly among countries. The spectrum of worker representation reaches from decentralized, firm-level unions, as for example, in the United States and Japan, to highly centralized systems with all-encompassing industry labor unions, as is the case, for example, in the Scandinavian countries, Germany and Austria (Flanagan, 2003).

On the employer side, there are powerful downstream firms interacting in oligopoly settings and thereby earning above-competitive rents. Also among firms, the organization of wage bargaining differs from country to country and also between industries. While in some instances, firms interacting in the same industry join into employers' associations to negotiate with labor unions over a common wage level, other industries are characterized by in-house wage agreements on the firm level. This heterogeneity in the degree of employer organization is documented by Traxler (2000), who finds that peak employers' association density in Europe ranges from 32 percent in Norway to 100 percent in Austria.

Both sides have been subject to substantial structural changes in the past two decades. Looking at the employer side, the process of globalization has initiated a changing market environment. On the one hand new markets have emerged as potential outlets for producers, on the other hand existing market conditions have been irrevocably altered by changing competitive conditions and new competitors from abroad. Concerning production processes and input supplies, globalization has at the same time opened up new possibilities for firms, putting pressure on production costs and thereby on labor as an input (Dreher and Gaston, 2007).

Equivalently, the organization of wage negotiations has changed dramatically, especially in countries where there has been traditionally a strong degree of centralization of wage negotiations. With a decreasing rate of union membership and collective-bargaining coverage (Flanagan, 2003; Visser, 2003), traditionally highly centralized wage bargaining regimes have come under pressure. Foremost, the OECD (2004) itself called for policies to "increase wage flexibility and lower non-wage labour costs", with the aim of allowing firms to pay wage rates suited to their competitive conditions. One major concern – namely that centralized wage bargaining causes a negative macroeconomic performance – should be addressed by this strategy.[1]

While there have been calls for more decentralization from employer and institutional side, there have also been changes initiated by the labor union side. The creation of new so-called craft unions, which represent each one group of complementary workers in a production process, has altered traditional collective bargaining structures and induced new bargaining protocols between unions and employers. In Germany, for example, eight craft unions were founded since 2001 (Bachmann et al., 2012). Although some craft unions existed already beforehand, their conduction of independent bargaining rounds has been a major change to the collective bargaining system in Germany.

The changes on union and firm side have happened in parallel, sometimes a change on one side causing a new development on the other. It is undisputed that changes in the organization of labor market institutions may have a significant impact on market conditions and vice versa. This dissertation addresses this interdependence between labor and product markets and analyzes the interaction between powerful labor unions and powerful firms. Under the hypothesis that changes in the organization of one of the levels has an impact on the structure and outcomes of wage bargaining and therefore also on the other side, different problems concerning unionized oligopolies are examined.

The dissertation can be structured in two parts. Chapters 2 and 3 analyze unionized oligopoly models in international contexts. Building on the fact that increasing market integration also influences wage bargaining structures, the two chapters analyze the interaction between national bargaining systems and international product markets. Both chapters are based on joint research with Christian Wey. In the second part, in Chapter 4, the impact of wage bargaining systems in the national context is examined. As the creation of new craft unions has affected the structure of collective wage bargaining, the effects of different national bargaining orders on the actors' preferences and welfare are analyzed.

More specifically, Chapter 2 examines whether national wage-setting regimes differing in their degree of centralization continue to exist under advancing globalization. Building on previous related literature as e.g. Corneo (1995) and Leahy and Montagna (2000), the chapter analyzes a two-country model, in which firms differ according to the competitive conditions they face in the product market. In each country, there are two firms, one monopolist supplying the domestic market, and one duopolist competing in the international market with the duopolist from the second country. This set-up resembles a common situation where the employer side,

[1] See Flanagan (2003) and OECD (2004) for a discussion of the relationship between wage bargaining institutions and (macro)economic performance.

possibly an employers' association, comprises firms with different production conditions. In the model, different forms of wage-setting are analyzed. Unions can either set uniform or discriminatory wages, where the first type is a form of centralized agreement, and the second type resembles a flexibilization where wages are tailored to firm-specific conditions. To highlight the fact that labor market institutions can be an important strategic variable in international competition, unions choose their regimes sequentially, i.e. they can react to the form of wage-setting regime abroad.

The results indicate that which wage-setting regime will be established by the unions depends on the intensity of competition in the international market. The unions balance their interests to extract high rents from "strong" firms with a strategic effect of "egalitarian" wages, i.e. that uniform wages may dampen competitive pressure in the international market. Under certain parameter constellations a situation can arise in which a collective, centralized wage-setting regime in both countries is in the best interest of all actors involved: unions, firms and consumers on aggregate. But even if one union chooses a discriminatory regime in the first place, it may be optimal for the second union to stick to a uniform regime. That is, flexibilization is not an automatic process which is triggered by discrimination in some countries only. Due to the strategic effect of competition dampening, a union may be willing to set uniform wages, even if flexibilization advances abroad.

The impact of uniform and firm-specific wages in an international setting initiated from the employer side is further analyzed in Chapter 3. Revisiting the models of Lommerud et al. (2005, 2006), Chapter 3 examines firms' merger choices as a strategic device to counter union power. A common view on international merger activity is that firms may use foreign direct investment and production plants located abroad to exert downward pressure on wages in the home country. This threat of re-allocation induces even a monopoly labor union to lower its wage demands. Chapter 3 further develops this point by considering a two-country model in which four firms (two located in each country) compete in an integrated international product market. Firms differ according to their non-labor production costs: in each country, there is one low- and one high-cost firm.

In the first stage of the game, firms can decide to merge or stay independent. The merger decision is modelled as a cooperative game of coalition formation following Horn and Persson (2001a, 2001b). More specifically, firms can decide to merge domestically or cross-border, where a distinction is made between a merger with a firm of the same type (high- or low-cost) or of the other type. In total, eight market structures may arise. In contrast to a cross-border merger, a domestic merger exhibits a so-called wage-unifying effect. That is, once a national merger has occurred, the labor union is required not to discriminate between the workers in the two plants. This detail resembles a widespread aspect of collective wage-setting, namely the "one firm, one wage" policy.

The results indicate that, when firms are sufficiently heterogeneous both in terms of production efficiency and product differentiation, a domestic merger is the best strategy for firms to counter union power. The unifying effect of a domestic merger is strategically induced by the firms to limit the power of the national labor union. When firms become more homogeneous, the cross-border merger equilibrium is reestablished where the threat of reallocation most effectively limits union power. From a welfare perspective, the results indicate that there is no clearly preferable industry structure. Which structure maximizes global welfare depends on cost asymmetry and the degree of product differentiation. In general, we observe a too high merger rate from a welfare perspective. Whereas firms always prefer to achieve the highest possible concentration in the downstream market, social welfare considerations suggest that often structures involving only one merger should be preferred.

The second part of the dissertation analyzes wage bargaining structures in the national context. Based on the observation that the creation of new craft unions and the slow decomposition of the traditional labor union landscape in some countries have caused major changes to collective bargaining structures, Chapter 4 studies the effects of different bargaining orders in a two-firm industry and the preferences of the actors involved. The model is related to previous literature on pattern bargaining (Dobson, 1994; Marshall and Merlo, 2004; Creane and Davidson, 2011) and incorporates the options of employers' associations and mergers in the analysis.

The model compares simultaneous and sequential bargaining between an industry union and two downstream firms to bargaining with an employers' association or a merged entity. Pattern –or sequential – bargaining is a widespread phenomenon. Whereas intra-industry pattern bargaining is quite common in the United States (e.g. in the automobile industry), in the European Union often regional patterns are established, where an industry union approaches firms in a certain region first and then successively opens negotiations in other regions. By modelling the downstream market as a market for differentiated products, we can incorporate both types of sequential bargaining in the analysis (when products become virtually independent, negotiations can be treated as taking place in different regions or markets).

A central result of this chapter is that, in contrast to conventional wisdom, it is the labor union which prefers negotiations with an employers' association, whereas the firms never have an incentive to join into such an agreement. This result confirms observations of discussions between craft unions and employers on industry wide agreements (see for example the case of Deutsche Bahn AG). The firms prefer to stay independent and thereby forego the opportunity to counter the monopoly union by forming a "wage cartel" on the employer side. A result related to Chapter 3 involves the firms incentives to monopolize the downstream market. The merger incentives of the firms crucially depend on the negotiation order in the industry. There are instances where firms never have an incentive to merge to monopoly in the presence of the industry union.

All models suggest that the structure of downstream competition influences the organization of wage bargaining and vice versa. This insight holds true for national as well as international contexts. How unionization structures develop and which form of collective bargaining is preferred by different actors depends on different market parameters. From a labor market policy perspective, this suggests that before labor market reforms, for example towards more flexibilization, are initiated, the market conditions and circumstances should be evaluated.

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Chapter 2

Unionization Structures in International Oligopoly

2.1 Introduction

As globalization and economic integration have increased the competitive pressure in international product markets, the impact of this trend on labor market organization has become increasingly important. While there have been repeated demands for more wage flexibility in response to increasing demand (and supply-) side pressure (see OECD 1996, 2006), empirical evidence on the development of labor market institutions towards more decentralized wage bargaining structures is mixed.[1]

For some countries, such as Denmark and Sweden, there has been a clear tendency towards more decentralization, other countries (e.g., Belgium and Italy) have witnessed a higher degree of centralization in wage bargaining since the 1980s than at any other time in the postwar period (Wallerstein and Western, 2000). In a comparative study of 17 OECD countries, Santoni (2009) shows that market integration has impacted negatively on the level of wage bargaining. Similarly, in West (East) Germany the percentage of employment contracts governed by centralized wage settlements has fallen from 70% (56%) in 1996 to 56% (38%) percent in 2009.[2]

The relation between market integration and trade costs on the one hand, and union power on the other hand has received considerable attention in the literature (e.g., Brander and Spencer, 1988; Mezzetti and Dinopoulos, 1991; Huizinga, 1993; Munch and Skaksen, 2002). However, in most models the degree of wage bargaining centralization is assumed to be exogenously given (Driffill and van der Ploeg, 1993,

[1] We follow Calmfors and Driffill (1988), Moene and Wallerstein (1997), Flanagan (1999), and Wallerstein (1999) to differentiate national unionization structures according to the degree of wage-setting centralization. Under a decentralized structure wages are set between a single employer and the union while the union negotiates a uniform wage for the entire industry under a centralized system.

[2] IAB Betriebspanel: "http://doku.iab.de/aktuell/2010/Tarifbindungsentwicklung_1996-2009.pdf".

1995; Naylor, 1999).[3] In contrast, we endogenize the choice of wage-setting regimes by labor unions. Another critical departure from previous works is that we consider heterogeneous firms which are active in different market environments.

The diversity of wage-setting institutions and their effects in internationally integrated product markets is analyzed in Corneo (1995). That paper examines the impact of different bargaining regimes when product markets are perfectly integrated. Besides other things, it is shown that wages tend to be higher under a centralized bargaining structure when compared with decentralized bargaining. Moreover, this tendency becomes more pronounced when countries' sizes (in terms of national firms) become more asymmetric.

The effects of different labor market structures (varying in the degree of centralization) on product market competition and market performance have been analyzed in many works. One robust finding is that the uniformity rule under a centralized union structure can unfold beneficial effects for firms' incentives to innovate or to set up new production facilities (see Agell and Lommerud, 1993; Leahy and Montagna, 2000; Haucap and Wey, 2004).[4] Centralized wage-setting constrains the unions' ability to extract rents from firms, which can be beneficial for firms and unions alike as it reduces hold-up problems associated with union power.

The main contribution of this chapter is to show that a uniform wage-setting regime unfolds a competition dampening effect which adds to its desirability firstly from a union's perspective and secondly (under particular circumstances) also from an overall social welfare point of view. Precisely, we analyze a two-country model where national firms operate in different markets which give rise to firm-specific labor demands. We analyze the incentives of labor unions to choose uniform or discriminatory wage-setting regimes in the presence of international competition. On the one hand unions might prefer discriminatory wages (which represents the adjustment of unionization structures to firm-specific conditions) in order to extract rents optimally from firms enjoying different degrees of monopoly power. On the other hand a uniform wage regime exhibits a commitment value when there is international competition: if the effect of a uniform wage is to raise the wage above the discriminatory level in the international market, labor unions can benefit from a "competition dampening" effect.[5] Both a fully centralized or a partially centralized outcome can emerge in equilibrium whenever international competition is not too strong. In the parlance of industrial organization a union choosing a uniform wage regime adopts a "fat cat" strategy by committing to raise the wage level of the international firm (Fudenberg and Tirole, 1984). As unions compete indirectly in wages (via the international firms) a uniform wage regime in country 1 induces a higher wage demand of the rival union in country 2 because of strategic comple-

[3] An exception is Petrakis and Vlassis (2004) who analyze endogenous wage institutions at the national level without considering international competition.

[4] See also Mukherjee and Pennings (2011) who qualify that assertion by considering licensing.

[5] A similar effect can occur in final goods markets when a retail chain adopts a uniform pricing policy (see Dobson and Waterson, 2008).

mentarity. The latter reaction is independent of country 2's wage regime so that an asymmetric outcome is possible where one country adopts a centralized regime with uniform wages and the other country a decentralized regime with wage flexibility at the firm level.

Interestingly, a fully decentralized outcome emerges when international competition becomes very intense. In those instances, we identify the possibility of a Pareto improvement through international cooperation of unions' wage regime choices. That is, when international competition is very intense, then each set of agents (i.e., unions, firms and consumers) benefits from a cooperative move towards uniform wage regimes. We, therefore, expect that international coordination of (national) wage-setting regimes should become more likely (and politically feasible) when market integration further deepens.

The remainder of this chapter is organized as follows. In Section 2.2 we present an international oligopoly model with two national and two international firms. We characterize the equilibria under different international unionization structures. Section 2.3 compares wage levels and firm profits under the three possible international unionization structures. Here, we also characterize the possibility of a Pareto improvement through international union cooperation. In Section 2.4 we solve for the equilibrium wage regime and we show that all international unionization structures may emerge depending on the intensity of competition in the international market. Finally, Section 2.5 concludes.

2.2 The Model

We consider a two-country model with two heterogeneous firms in each country. All firms employ the same type of labor, but they are active in different market environments. We suppose that markets differ concerning their competitive intensity. More specifically, there are three separate markets: two national markets and a single international market. The national market in each country, $i = 1, 2$, is served by a firm N_i, with $i = 1, 2$. We suppose that each national market is only served by a single domestic firm; in particular, there is no international competition in the national market.[6] The demand in country i's national market is linear and given by $q_{N_i}(p_{N_i}) = 1 - p_{N_i}$, for $i = 1, 2$, where p_{N_i} is the price charged by N_i.

In the international market two firms I_1 and I_2 produce horizontally differentiated products and compete à la Hotelling. Firm I_i is located in country i.[7] The two

[6] Our results do not depend on our assumption that the national market is served by only a single firm. What is crucial for our results is that the competitive intensity differs in the national and the international market.

[7] In the parlance of international trade theory, we suppose a third-country setting, where firms export their products to the world market. An alternative set-up is the so-called reciprocal dumping model with intra-industry trade. We note that all our results remain valid in the latter setting. In a reciprocal dumping model, however, the intensity of competition depends on tariff-protections.

firms face a unit mass of consumers who are assumed to be uniformly distributed along the unit line segment $[0,1]$. We assume that firms are located at the ends of the Hotelling line. Consumers face transportation cost $t > 0$, which is assumed to be linear in the distance between a consumer's location on the line and the location of a firm. Transportation costs measure the intensity of competition between the firms. The lower t the higher the degree of competition in the international market.

The utility of a consumer located at location x and buying a product at price p_{I_i} from a firm located at x_i is given by $V(x,t,x_i,p_{I_i}) = \vartheta - p_{I_i} - t|x - x_i|$, where x_i is equal to 0 (1) if the consumer buys from international firm I_1 (I_2). The parameter ϑ denotes the constant valuation of a consumer for the purchased product. We assume that ϑ is sufficiently high, so that the market is always covered in equilibrium. It is straightforward to determine the demand faced by firm I_i by identifying the indifferent consumer $\overline{x} = (p_{I_2} - p_{I_1} + t)/(2t)$ from which we get the demand of firm I_1 and the demand of firm I_2 as $q_{I_1} = \overline{x}$ and $q_{I_2} = 1 - \overline{x}$, respectively.

Firms operate under a constant returns to scale technology with respect to labor, which is the only variable input for both national and international firms. Without loss of generality, we assume that $q_{k_i} = l_{k_i}$, for $i = 1, 2$ and $k = N, I$ where q_{k_i} is the output and l_{k_i} employment of firm i in market k.

The workforce in each country is represented by a national labor union, union 1 and union 2, which are responsible for wage-setting in their respective countries. We apply the right-to-manage approach which stipulates that a labor union sets the wage rate by making a take-it or leave-it offer to the firms.[8] For given (and observable) wage rates, firms then determine their employment levels. We assume that each union maximizes its wage bill.

The game proceeds as follows. In stage $1a$, the union located in country 1 chooses its wage regime. It can decide whether it wants to set discriminatory (D) or uniform (U) wages for the two firms in its country. Observing this choice, the union in country 2 determines its wage regime in stage $1b$.[9] In stage 2, the labor unions simultaneously set their wage rates. Finally, in stage 3, firms observe wage rates, and set prices for their products. We solve the game by backward induction to derive subgame perfect Nash equilibria.

Given that there are two rival unions who can determine their wage-setting

[8] Assuming employer bargaining power does not change our results qualitatively under a discriminatory wage-setting regime. Uniform wage regimes typically involve the formation of an employer association which aggregates its members' interests when negotiating with the union. The question of the sources and consequences of bargaining power of an employer association which aggregates conflicting interests of its members is still an open research issue which is beyond the scope of this chapter. We avoid this problem by assuming that the wage-setting power is fully controlled by the union.

[9] A sequential determination of wage-setting regimes mirrors the commitment value associated with a choice of the wage-setting regime. A union cannot change the regime at will any time. For instance, in Germany it took many years until the powerful industry unions (which are organized in the *Deutsche Gewerkschaftsbund*) agreed to more flexible collective agreements which allow for (downward) adjustments at the (individual) firm level.

regimes, we have to consider three possible international unionization structures:

1. *International Discriminatory (DD):* Labor unions in both countries choose discriminatory wage-setting regimes.

2. *International Uniform (UU)*: Labor unions in both countries choose uniform wage-setting regimes.

3. *International Asymmetric* (DU) or (UD): The final international unionization structure is asymmetric. One union chooses a discriminatory wage-setting regime, while the rival union decides to apply a uniform regime.

We solve the model proceeding by backward induction for all three international unionization structures. In the last stage of the game, firms set prices. National firms have local monopoly positions in their markets. The profit function of a national firm is given by

$$\Pi_{N_i} = (1 - p_{N_i})(p_{N_i} - w_{N_i}), \text{ for } i = 1, 2,$$

where w_{N_i} is the wage rate paid by national firm i to each employed worker. Solving the first-order conditions $\partial\Pi_{N_i}/\partial p_{N_i} = 0$ yields the optimal price choices and the associated quantities in stage 3

$$\begin{aligned} \hat{p}_{N_i} &= \frac{1 + w_{N_i}}{2}, \\ \hat{q}_{N_i} &= \frac{1 - w_{N_i}}{2}. \end{aligned} \tag{2.1}$$

Simultaneously, the international firms compete in prices. The profit function of firm I_i is given by

$$\Pi_{I_i} = (p_{I_i} - w_{I_i})\, q_{I_i}, \text{ for } i = 1, 2,$$

where w_{I_i} is the wage rate paid by firm I_i to its employees. Solving the first-order conditions $\partial\Pi_{I_i}/\partial p_{I_i} = 0$ for $i = 1, 2$ yields the optimal prices and quantities

$$\begin{aligned} \hat{p}_{I_i} &= \frac{3t + 2w_{I_i} + w_{I_j}}{3}, \\ \hat{q}_{I_i} &= \frac{3t - w_{I_i} + w_{I_j}}{6t}, \end{aligned} \tag{2.2}$$

with $i \neq j$. In stage 2 unions set wages for the workforce they represent in their respective countries. The objective of each union in country i is to maximize its wage bill given by

$$U_i = (w_{N_i}\hat{l}_{N_i}) + (w_{I_i}\hat{l}_{I_i}), \text{ for } i = 1, 2,$$

where the labor demands $\hat{l}_{N_i}$ and $\hat{l}_{I_i}$ follow from (2.1) and (2.2), respectively. According to the wage-setting regimes unions have determined in the first stage of the game, we have to consider the three international unionization structures DD, UU, and UD/DU separately.

International Discriminatory (DD)**.** Assume that both unions have adopted discriminatory wage regimes. In this case, the optimal wage rates set by each union are given by the solution of

$$\{w_{N_i}^{DD*}, w_{I_i}^{DD*}\} = \arg\max_{w_{N_i}, w_{I_i}} U_i(w_{N_i}, w_{N_j}^{DD*}, w_{I_i}, w_{I_j}^{DD*}), \text{ for } i, j = 1, 2,\ i \neq j.$$

Using (2.1) and (2.2) and solving the respective first-order conditions $\partial U_i(\cdot)/\partial w_{I_i} = 0$ and $\partial U_i(\cdot)/\partial w_{N_i} = 0$ for $i = 1, 2$ yields the following equilibrium wage rates charged to the national and the international firm, respectively:

$$w_N^{DD*} = \frac{1}{2} \text{ and } w_I^{DD*} = 3t.$$

Note that equilibrium wages are identical under scenario DD for $t = 1/6$. In this case, the unionization structure collapses to the case were both unions set uniform wages. Note that the wage charged to the international firm becomes larger than the wage of the national firm if international competition is relatively weak (i.e., $t > 1/6$ holds), while the opposite is true if competition is sufficiently strong (i.e., $t < 1/6$ holds).

International Uniform (UU)**.** Consider that both unions have adopted uniform wage-setting regimes so that the outcome is an international uniform unionization structure. In this case, a uniform wage rate $w_{N_i} = w_{I_i} = \bar{w}_i$ is set by each union to maximize the total wage bill. The optimal wage rate each union sets is the solution to

$$\{\bar{w}_i^{UU*}\} = \arg\max_{w_i} U_i(w_i, \bar{w}_j^{UU*}), \text{ for } i, j = 1, 2,\ i \neq j.$$

Again, we solve the first-order conditions $\partial U_i(\cdot)/\partial w_i = 0$ for $i = 1, 2$ using (2.1) and (2.2) to obtain the equilibrium wage rate each union sets, namely,

$$\bar{w}^{UU*} = \frac{6t}{1 + 6t}.$$

Obviously, national firms are now affected by the degree of competition in the international market. When international competition becomes more intense (i.e., t decreases), then the uniform wage level decreases for both the national and the international firm. Note that $w_N^{DD*} = w_I^{DD*} = \bar{w}^{UU*}$ is true at $t = 1/6$.

International Asymmetric (DU) **or** (UD)**.** Finally, we analyze the case when one union has adopted a discriminatory wage regime while the other union chooses to set uniform wages. The timing of our game postulates that the union located in country 1 chooses its wage regime first, with the union located in country 2 following. Let us assume at this point that union 1 adopts the discriminatory regime in an asymmetric outcome. Below in Section 4, we will show that whenever the asymmetric unionization structure is an equilibrium outcome, the union which determines its wage regime first will choose discrimination.

Given that union 1 has adopted a discriminatory regime in stage $1a$, it sets discriminatory wages in stage 2 which solve

$$\{w_N^{DU*}, w_I^{DU*}\} = \arg\max_{w_{N_1}, w_{I_1}} U_1(w_{N_1}, w_{I_1}, \bar{w}_2^{DU*}).$$

When the final unionization structure is asymmetric, union 2 has obviously opted for a uniform wage regime in stage $1b$. In stage 2, union 2 sets a uniform wage rate to maximize its wage bill which solves

$$\{\bar{w}^{DU*}\} = \arg\max_{\overline{w}_2} U_2(\overline{w}_2, w_N^{DU*}, w_I^{DU*}).$$

Solving the set of three first-order conditions, the equilibrium wage rates set by unions 1 and 2 are

$$\begin{aligned} w_N^{DU*} &= \frac{1}{2}, \\ w_I^{DU*} &= \frac{t(4+6t)}{1+4t}, \text{ and} \\ \bar{w}^{DU*} &= \frac{5t}{1+4t}. \end{aligned}$$

Note that, in contrast to the previous international unionization structures, firms competing in the international market will now face different labor costs. Which international firm pays the higher wage rate and thus obtains a lower profit than its rival will depend on the intensity of competition in the international market.

We solve for the equilibrium profits, wage bills, prices and consumer surplus for the three unionization structures in the Appendix. Before we analyze the equilibrium choices of wage regimes of the labor unions, we can compare the effects of different forms of unionization structures on unions and firms.

2.3 The Impact of Unionization Structures on Wages and Profits

We begin with an analysis of the different international unionization structures. Having solved for the wage rates and profit levels of firms, we can compare them under the different structures. Therefore, we abstract from the labor unions' choices of wage-setting regimes in stages $1a$ and $1b$ and treat them as given for the moment. To some extent, an exogenous determination of wage-setting regimes has been present in many European countries where wage bargaining between labor unions and firms has been institutionalized through labor market regulations and/or social norms. Institutional change, e.g., from an egalitarian wage system towards a more flexible, and hence, discriminatory wage regime comes not overnight but rather is the result of a transformation process which may take decades.[10]

2.3.1 Wages

The following Lemma summarizes the results of the comparison of wage levels.

Lemma 1. *The ranking of wage rates within different market structures depends on the intensity of competition in the international market and the prevailing unionization structures:*

i) If the intensity of competition in the international market is low, i.e., $t > 1/6$ *holds, then* $w_I^{DD*} > w_I^{DU*} > \bar{w}^{DU*} > \bar{w}^{UU*} > w_N^{DD*} = w_N^{DU*}$.

ii) If the intensity of competition in the international market is high, i.e., if $t < 1/6$ *holds, then* $w_N^{DD*} = w_N^{DU*} > \bar{w}^{UU*} > \bar{w}^{DU*} > w_I^{DU*} > w_I^{DD*}$.

Moreover, equality holds with $w_I^{DD*} = w_I^{DU*} = \bar{w}^{DU*} = \bar{w}^{UU*} = w_N^{DD*} = w_N^{DU*}$ *for* $t = 1/6$.

The interpretation of Lemma 1 is straightforward. Independent of the degree of competition in the international market, the level of uniform wages ($\bar{w}^{UU*}$ or $\bar{w}^{DU*}$) lies inbetween the discriminatory wage levels. This is the averaging effect of uniformity: each labor union optimally sets the uniform wage rate such that asymmetries between the firms are balanced.

In which market the highest (lowest) wage rates are paid by firms, depends on the intensity of competition between the international firms. For a low degree of competition, i.e., case *i)* holds, national firms pay the lowest (discriminatory) wages and international firms pay the highest wage rates.

This is the case, because, from a labor union point of view, the international market is the 'larger' market when $t > 1/6$. Obviously, the (discriminatory) wage rates are directly related to competitive pressure in this market: $\partial w_I^{DD*}/\partial t > 0$ (likewise $\partial w_I^{DU*}/\partial t > 0$), i.e., the larger the market power of the international firms, the more rent a labor union can extract from the firms. For $t > 1/6$, the degree of international competition is sufficiently low so that the unions will set discriminatory wages in this market which exceed the wage levels paid by national firms.

Note that, while the discriminatory wage rates paid by national firms in structures DD and DU are identical, the same is not true for the wage rates of the international firms, as $w_I^{DD*} > w_I^{DU*}$. This is due to the asymmetry in wage levels structure DU implies. As wage regimes are determined by the labor unions before the actual wage rates are set, each union knows which kind of wage behavior its rival displays. In structure DU, the discriminating union knows that its rival sets a

[10] In Germany, the dominant industry unions of the *Deutsche Gewerkschaftsbund* (as, e.g., *IG Metall*) strictly opposed any form of wage flexibility for at least twenty years; a position which was eventually given up in the last decade of the last century when opting out and opening clauses became widely adopted elements of collective agreements (see Haucap et al., 2007).

uniform wage, which must optimally be lower than a discriminatory wage because of the averaging effect described above. As a consequence, the discriminating union will set a wage $w_I^{DU*} < w_I^{DD*}$ because otherwise the international firm would lose too much of its market share vis-à-vis its competitor operating at lower wage costs.

For high intensity of competition in the international market, i.e., $t < 1/6$, the order of wage rates is reversed. From the point of view of a labor union, the international market is now the small market compared to the national market. Consequently, discriminatory wage rates paid by national firms will be highest, while those paid by the international firms in structure DD are lowest. The averaging effect of uniformity implies that levels of uniform wage rates (either in structure UU or DU) will be inbetween.

Note that the ordering of the two uniform wage rates is now reversed as well: $\bar{w}^{UU*} > \bar{w}^{DU*}$. In unionization structure DU, the uniform wage regime of union 2 now exhibits a *commitment effect*: a union setting the uniform wage in an asymmetric structure knows that it will put the firm paying $\bar{w}^{DU*}$ at a disadvantage in product market competition because the averaging effect of uniformity will cause the wage rate paid by the international firm to increase compared to a discriminatory level. Consequently, firm I_2 will behave less aggressively in the international market.

Union 1 can partially free-ride on this effect: it can raise its discriminatory wage rate w_I^{DU*} above the purely discriminatory level, because wages are strategic complements for the labor unions, and firm I_1 will still capture more than half of the international market, because it can price more aggressively than its competitor due to lower input costs. Here, union 1 gains twice: first through an increase of the wage level charged to the international firm and second through a higher level of employment.

2.3.2 Profits

The comparison of profits shows that firms are not only affected by the wage regime of the union in their home country, but also by that of the foreign union through the link of product market competition.

Lemma 2. *The profit levels of firms depend on the intensity of competition in the international market and the prevailing unionization structures:*

i) If the intensity of competition in the international market is low, i.e., $t > 1/6$ *holds, then the ordering of profits of the national firms and the international firms is given by* $\Pi_N^{DD*} = \Pi_{N_1}^{DU*} > \Pi_N^{UU*} > \Pi_{N_2}^{DU*}$ *and* $\Pi_{I_2}^{DU*} > \Pi_I^{UU*} = \Pi_I^{DD*} > \Pi_{I_2}^{DU*}$*, respectively.*

ii) If the intensity of competition in the international market is high, i.e., if $t < 1/6$*holds, then the ordering of profits of the national firms and the international firms is given by* $\Pi_{N_2}^{DU*} > \Pi_N^{UU*} > \Pi_N^{DD*} = \Pi_{N_1}^{DU*}$ *and* $\Pi_{I_1}^{DU*} > \Pi_I^{UU*} = \Pi_I^{DD*} > \Pi_{I_2}^{DU*}$*, respectively.*
Moreover, equality holds with $\Pi_N^{DD*} = \Pi_{N_1}^{DU*} = \Pi_N^{UU*} = \Pi_{N_2}^{DU*}$ *for* $t = 1/6$.

The intuition behind Lemma 2 is straightforward and can be summarized as follows. From the above analysis we know that the international market is the "large" market from the point of view of labor unions, when $t > 1/6$. A uniform wage, therefore, lowers the wage rate paid by an international firm. As profits must be identical for symmetric unionization structures, an interesting point arises when the unionization structure is asymmetric.

For $t > 1/6$, national firms prefer discriminatory wages in their home country, as the averaging effect of uniformity would cause higher wage rates for them compared to a discriminatory level. Comparing the profits of a national firm in structures UU and DU when the firm pays a uniform wage, we find that a firm prefers international uniform unionization over an asymmetric structure. Although the national firm faces no international competition, its profits are lower when the foreign union adopts a discriminatory regime when in the home country a uniform wage regime is in place.

This is the case, because the uniform wage rate is higher in the asymmetric structure DU than when both unions choose a uniform regime. The discriminating union sets a high discriminatory wage in the international market, thereby dampening competition and giving an incentive for the rival union to set a high uniform wage rate – to the detriment of the national firm.

In part *ii)* of Lemma 2, the ordering or profit levels according to unionization structures is reversed for both national and international firms. Obviously, this depends on the fact that for $t < 1/6$ the national market becomes the "large" market for the labor unions.

National firms paying discriminatory wage rates will earn the lowest profits in comparison to paying uniform wage rates, as they cannot benefit from the intense competitive conditions in the international market. Instead, labor unions will find it optimal to set high wage rates in the national markets and extract high rents from these firms. If competition in the international market is intense, national firms should support the introduction of uniform wages.

Obviously, the two symmetric international unionization structures DD and UU will yield the same profit levels to the two international firms due to the specific functional forms, but profits will now be highest in a DU structure for the firm paying a discriminatory wage and earning $\Pi_{I_1}^{DU*}$ and consequently lowest for the firm paying the uniform wage rate and obtaining $\Pi_{I_2}^{DU*}$.

In this setting, the labor union opting for the uniform wage regime will set a wage $\bar{w}^{DU*}$ which is higher than a discriminatory wage rate and thus reduces the competitive pressure in the international market. A uniform wage regime displays a commitment value: the labor union opting for the discriminatory wage regime will set a wage rate lower than $\bar{w}^{DU*}$ which enables the firm to serve more than half of the international market. However, due to the uniform wage regime of the other union, it will not set an excessively low wage, so that $w_I^{DU*} > w_I^{DD*}$ prevails. Consequently, the profits obtained by the firm paying the discriminatory wage rate in structure DU, $\Pi_{I_1}^{DU*}$, are highest while those of the firm paying the uniform wage rate, $\Pi_{I_2}^{DU*}$, are lowest.

The comparison of profits and wage rates shows that either of the three international unionization structures can result in higher or lower wage rates and firm profits, depending on the intensity of competition in the international market. Foremost, we are interested in the opportunity for labor unions to refrain from setting discriminatory wage rates for heterogeneous firms and to opt for a uniform wage regime instead when there is international competition.

Taking wage bills, profits and consumer surplus into account, we can show that it is possible that firms, labor unions and consumers are better off (each in aggregate) under an international uniform structure than under a discriminatory unionization structure. As the following Proposition states, this can only occur when the international market is the "small" market from the unions' perspective.

Proposition 1. *If the intensity of competition in the international market is relatively strong, so that $t < 1/6$ holds, then there exists a range of parameter values $t \in ((\sqrt{17}-3)/24, (\sqrt{145}-7)/96)$, such that labor unions, firms and consumers are each in aggregate better off under an international uniform than under an international discriminatory unionization structure.*

Proof. See Appendix.

If competition is sufficiently intense in the international market, the averaging effect of a uniform wage will induce the wage rate paid by the firms in the international market to rise while that of the national firms will fall. Only if this is the case producer surplus will be higher under an international uniform structure (UU). National firms gain through lower wage rates caused by the intense competition in the international market.

Consumer surplus will only increase if the gain of consumers in the national market can offset the loss in consumer surplus in the international market due to a higher price. A prerequisite is that competition in the international market is sufficiently intense so that the increase in labor costs (and consequently consumer prices) is sufficiently moderate. The lower firms' market power in the international market, the more limited is the power of a labor union to increase the wage rate in the given market. The condition for consumers to be better off on aggregate is therefore given by $t < (\sqrt{145}-7)/96$.

This is the upper threshold on parameter t derived in Proposition 1. For any $t > (\sqrt{145}-7)/96$ consumers as a whole will not benefit through a joint uniform unionization structure. Wage (and price) increases in the international market would be too high.[11]

Finally, labor unions gain if markets are not too heterogeneous, i.e., if the increase in the wage rate in the international market can compensate for the decrease in the wage rate paid by the national firms. Wages in the international market can only

[11] Quite obviously, this effect would become more pronounced if industry demand is elastic in the international market. Hence, with an overall elastic demand in the international market aggregate consumer surplus is less likely to increase under uniform wages.

be increased sufficiently if firms have enough market power, i.e., if competition is not too intense. This yields the lower bound on the transportation cost parameter t stated in Proposition 1, namely $(\sqrt{17} - 3)/24 < t$.

For any $t < (\sqrt{17}-3)/24$, labor unions cannot raise the wages in the international market sufficiently to offset the loss in wage bill through lower national wage rates.

We are aware of the fact that this result hinges upon the functional forms used in our example. Nevertheless, we observe that there is scope for uniform wage regimes by unions to be beneficial not only for the labor unions themselves, but also for firms and consumers. Quite intuitively, this is likely to be the case when international competition puts downward pressure on collective wage agreements (i.e., $t < 1/6$ holds). Moreover, international competition must not be too strong as this would induce unions to revert to discriminatory wage regimes that aim at extracting rents from the remaining monopoly power in national markets.

2.4 Equilibrium Wage-Setting Regimes

Although wage-setting structures seem to be rather rigid institutions, recent changes suggest that in the long-run wage-setting regimes can be adapted by labor unions. When we endogenize the decision on wage-setting regimes, we are able to analyze the incentives for labor unions to opt for either a uniform or a discriminatory wage regime.

This decision is particularly interesting when unions have the opportunity to observe and react to the wage regimes of labor unions in foreign countries, anticipating that the own wage regime choice will affect a firm's stand in international competition.

We analyze this choice sequentially to incorporate the option that labor unions react to the wage-setting regimes by foreign rivals. We have solved for the final wage bills obtained by labor unions in each unionization structure in the Appendix. Table 2.1 presents the choice of the labor unions in the first two stages 1a and 1b of the game between either uniform (U) or discriminatory (D) in a reduced form, indicating the associated wage bill levels, a union will obtain for either choice.

To find the equilibrium choice of wage regime, we need to consider two wage bill comparisons: namely union 2 choosing a discriminatory or a uniform wage-setting regime, given that union 1 has either adopted a discriminatory or a uniform regime. From Table 2.1 it is straightforward to determine the preferences of the two labor unions for either wage-setting regime and to calculate the subgame-perfect wage regime choices.

Union 1 \ Union 2	D	U
D	U_1^{DD*}, U_2^{DD*}	U_1^{DU*}, U_2^{DU*}
U	U_1^{UD*}, U_2^{UD*}	U_1^{UU*}, U_2^{UU*}

Table 2.1. Normal Form Representation of the Wage Regime Choices

We find that the equilibrium wage regimes -and therefore the international unionization structures which will result in equilibrium- depend on the intensity of competition in the international market.

Proposition 2. *If labor unions choose their wage-setting regimes sequentially, then there exist critical values $0 < \underline{t} < t' < \bar{t} := 1/6$ such that the resulting international unionization structures (DD, UU, DU) can be sustained as equilibrium unionization structures:*

i) If $t \in (0, \underline{t}) \cup (\bar{t}, \infty)$, then the unique equilibrium unionization structure is international discriminatory (DD).

ii) If $t \in (\underline{t}, t')$, then the resulting unionization structure is international asymmetric (DU), where the first union adopts a discriminatory wage regime.

iii) If $t \in (t', \bar{t})$, then the unique equilibrium unionization structure is international uniform (UU).

Proof. See Appendix.

Any of the three international unionization structures analyzed in this Chapter can occur in equilibrium depending on the value of the transportation cost parameter t. For $t \in (0, \underline{t})$ and $t \in (\bar{t}, \infty)$ the equilibrium unionization structure is given by DD. When competition intensity is very high or very low between the international firms, both unions will find it beneficial to choose a discriminatory wage regime to extract as much rent as possible from the firms. In such a case, firms are so heterogeneous that labor unions do not find it beneficial to forego a high wage rate in one market in order to obtain a higher wage in the other. If competition is too intense, a union could not profitably raise the international wage rate through uniformity to offset the loss due to a lower wage rate in the national market.

Note that the interests of firms and labor unions are only partially aligned here. If $t \in (\bar{t}, \infty)$, national firms prefer discriminatory wages just as unions do. As we showed in the previous Section a uniform wage would cause a rise in wages for the firms (compared to the discriminatory level) and therefore lead to lower profits. If, however, $t \in (0, \underline{t})$, national firms would prefer uniform wages in order to benefit from the intense competition in the international market through a lower wage level. This preference is contrary to that of the labor unions.

For an intermediate degree of competition in the international market, both unions prefer uniform wage-setting regimes. If firms are not too heterogeneous labor unions will benefit from a uniform wage. As $t < \bar{t} := 1/6$, the averaging effect of uniformity will work in the direction that the wage rate paid by international firms is higher, and that paid by national firms lower than if both unions had adopted discriminatory wage regimes. The gain for the union through setting a higher international wage rate here is large enough to compensate for the lowered wage rate in the national market.

From the viewpoint of a labor union, it can make sense not to exploit the differences in competitive conditions in the two product markets through discriminatory wages. The presence of international competition (and a rival union) in one of the markets adds a strategic motive to the choice of uniform wages. Obviously, a labor union will be willing to sacrifice its freedom to discriminate between markets if the losses in the wage bill due to a lower wage in one market will be offset by the higher income from the other market. As wages are strategic complements among unions, a choice of a uniform wage regime will have the effect of dampening competition in the international market for $t < \bar{t}$.

Finally, for $t \in (\underline{t}, t')$ we obtain an asymmetric equilibrium unionization structure where one union sets a discriminatory wage and the other sets a uniform wage. Comparing the wage bills in the asymmetric outcome yields that the union which sets discriminatory wages obtains a higher wage bill than the one which sets a uniform wage. Consequently, in an asymmetric equilibrium resulting in unionization structure DU, it will be the union which has the first mover advantage (union 1) which will choose the discriminatory wage-setting regime. The rival union 2 will respond with its best reply in stage $1b$: choosing a uniform wage regime.

Again, we can observe the commitment effect of uniformity: union 2 adopting a uniform wage-setting regime commits itself to set a relatively high wage rate, thereby providing a basis for the rival union to set a discriminatory, but higher wage rate than it would have been optimal if both unions had adopted discriminatory wage regimes. Both unions gain: the union which discriminates will set a wage rate such that the firm paying it will serve more than half of the international market. The labor union committed to uniformity will optimally set a higher uniform wage compared to unionization structure DD. Union 1 setting the discriminatory wages can free-ride on the dampening of competition in the international market union 2 provides.[12]

We analyzed the effects on firms' profits in Section 2.3. A uniform wage regime by one union will suffice to reduce the competitive pressure in the international market. Since firms can perfectly observe the wages set by both unions, an international firm paying a discriminatory wage will respond to an increased labor cost of its rival by a higher price in the product market. Therefore, competitive pressure is reduced and the union setting uniform wages will gain from a uniform wage regime which dampens competition.[13]

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[12]The asymmetric outcome DU mirrors the fact that that there are two pure strategy equilibria in the normal form representation of the regime adoption game of Table 2.1 for parameter values $t \in (\underline{t}, t')$. In each equilibrium -with changing roles- one union adopts a uniform wage strategy while the other union chooses a discriminatory policy. It is interesting to note that under a simultaneous timing structure, both unions would face a coordination problem similar to the battle-of-the-sexes game. Both unions want to "coordinate" on an asymmetric constellation but each union prefers to be the one which can discriminate. This observation may imply different adjustment times of wage-setting regimes to changes in international competition (parameter t) depending on whether the status quo is UU or DD. Starting from DD, both unions face a waiting game-like situation when an asymmetric constellation becomes an equilibrium as each union wants the other union to go first to adopt the uniform regime. In contrast, if unions start from UU, then each union wants to be the first one to commit to a discriminatory regime.

[13]Quite obviously, when national markets are asymmetric, the union facing the more profitable

A comparison of the equilibrium unionization structures with the results of the previous Section reveals that labor union preferences and consumer interests are not aligned. Although consumers and labor unions would be better off in structure UU for $t \in ((\sqrt{17}-3)/24, (\sqrt{145}-7)/96)$, unions will choose discriminatory wage regimes if they determine them non-cooperatively, resulting in unionization structure DD. This problem could be resolved if unions were able to coordinate their wage-setting regimes internationally and form a joint international unionization structure. This result is in line with the observation that labor unions have increased their activities on the European level (Schulten, 2002) to coordinate wage-setting regimes; an initiative which obviously mirrors increasing competitive pressure in international markets.

2.5 Conclusion

The model presented in this chapter provides an analysis of labor union preferences for discriminatory or uniform wage regimes vis-à-vis heterogeneous firms when national labor market institutions are linked through international competition in product markets. Although the model is based on specific functional forms, its implications may contribute to a better understanding of the development of labor market institutions.

With heterogeneous firms, a comparison of discriminatory and uniform wage-setting regimes reveals the averaging effect of uniformity we have analyzed above. As presented in our model, labor unions have to compare the benefits through an increased wage rate for one type of firm to the loss through a reduced wage rate paid by the other.

In a more general model, we could therefore observe this trade-off for labor unions, though the scope for an international uniform unionization structure would be less obvious. Nevertheless, we have characterized a situation in which unions, firms and consumers as a whole gain through uniform wages in both countries. Interestingly, such a constellation is only likely if international competition puts downward pressure on collective wage agreements.

An important insight of our model refers to the profitability of a uniform wage-setting regime to unions even if a rival union has adopted a discriminatory wage regime. This commitment effect of uniformity supports the observation that labor unions stick to centralized, uniform wage bargaining structures even when labor markets in foreign countries are more flexible and allow for undercutting regimes.

The commitment value of uniformity by one union provides a basis for the other union to set a discriminatory wage above the level of an international discriminatory unionization structure. In turn, the former will slightly benefit from this lessening

national market is more eager to reduce competition in the international market by committing to a uniform wage policy.

in competition in terms of wage bill rents. In the sequential order of wage regime choices, the union which moves first is clearly in the better position: it will optimally choose the discriminatory wage regime since it correctly anticipates that the other union will respond with a uniform wage regime.

A comparison with the results from Section 2.3 suggests that consumer and union preferences are not aligned. Although consumers and labor unions would be strictly better off in structure UU for $t \in ((\sqrt{17}-3)/24, (\sqrt{145}-7)/96)$, non-cooperative decisions of labor unions over wage-setting regimes will result in an international discriminatory unionization structure. An international coordination of labor unions over wage regimes as described by Schulten (2002) could resolve this problem.

Appendix

We solve our model for the three different unionization structures DD, UU, and DU. In the main part of this Chapter , we derived the wage levels. In this Appendix we present the solutions for profits, wage bills, and consumer surplus.

International Discriminatory (DD):

$$\Pi_N^{DD*} = \frac{1}{16}, \tag{2.3}$$
$$\Pi_I^{DD*} = \frac{t}{2}, \tag{2.4}$$
$$U^{DD*} = \frac{1}{8} + \frac{3t}{2}, \tag{2.5}$$
$$CS_N^{DD*} = \frac{1}{32}, \tag{2.6}$$
$$CS_I^{DD*} = \vartheta - 4t. \tag{2.7}$$

International Uniform (UU):

$$\Pi_N^{UU*} = \frac{1}{4(1+6t)^2} \tag{2.8}$$
$$\Pi_I^{UU*} = \frac{t}{2} \tag{2.9}$$
$$U^{UU*} = \frac{6t\,(1+3t)}{(1+6t)^2} \tag{2.10}$$
$$CS_N^{UU*} = \frac{1}{8\,(1+6t)^2} \tag{2.11}$$
$$CS_I^{UU*} = \vartheta + \frac{1}{1+6t} - 1 - t \tag{2.12}$$

International Asymmetric (DU):

The labor union in country 1 adopts a discriminatory wage-setting regime:

$$\begin{aligned} \Pi_{N_1}^{DU*} &= \frac{1}{16}, \\ \Pi_{I_1}^{DU*} &= \frac{2t(2+3t)^2}{9(1+4t)^2}, \\ U_1^{DU*} &= \frac{3+8t[11+6t\,(5+3t)]}{24(1+4t)^2}. \end{aligned} \tag{2.13}$$

The labor union in country 2 adopts a uniform wage-setting regime:

$$\begin{aligned} \Pi_{N_2}^{DU*} &= \frac{(t-1)^2}{4(1+4t)^2}, \\ \Pi_{I_2}^{DU*} &= \frac{2t(1+9t)^2}{9(1+4t)^2}, \\ U_2^{DU*} &= \frac{25t\,(1+3t)}{6\,(1+4t)^2}. \end{aligned} \tag{2.14}$$

Proof of Proposition 1. The proof of Proposition 1 follows immediately from the comparison of wage bills, profits and consumer surplus under the international uniform and international discriminatory unionization structures. A labor union will only be better off under UU if it earns a higher wage bill than in a DD structure, i.e., $\Delta U = U^{UU*} - U^{DD*} > 0$. Using (2.5) and (2.10) we obtain $\frac{1}{8}\left[3 - 12t - \frac{4}{(1+6t)^2}\right] > 0$. Solving this expression for t we find that the inequality is fulfilled for $(\sqrt{17}-3)/24 < t < 1/6$.

For firms to be better off under UU, we have to verify that producer surplus exceeds that under DD. Since $\Pi_I^{UU*} = \Pi_I^{DD*}$, it is sufficient to show that $\Delta\Pi = \Pi_N^{UU*} - \Pi_N^{DD*} > 0$. Using expressions (2.3) and (2.8) and solving for t, we find that firms are on aggregate better off under a uniform structure for $0 < t < 1/6$.

Finally, we analyze when overall consumer surplus increases, i.e. if $\Delta CS = CS_I^{UU*} + 2CS_N^{UU*} - (CS_I^{DD*} + 2CS_N^{DD*}) > 0$ holds. Substituting (2.6), (2.7), (2.11) and (2.12), we obtain that consumers are better off if $0 < t < (\sqrt{145}-7)/96$ or $t > 1/6$. Analyzing the above obtained results, it is easy to see that there exists a range of values of the transportation cost parameter where unions, firms, and consumers are better off under UU than under structure DD. This is the case, whenever $(\sqrt{17}-3)/24 < t < (\sqrt{145}-7)/96$ holds.

Proof of Proposition 2. Again, the proof of Proposition 2 involves a comparison of the wage bills the unions obtain under all three unionization structures. Using (2.5), (2.10), (2.13) and (2.14), the unions' decision problems in stages $1a$ and $1b$ can be displayed by the reduced form game presented in Table 2.1.

Comparing the resulting wage bills, we find that the equilibrium unionization structure depends on the intensity of competition in the international market.

Suppose union 1 chooses D in stage $1a$, international discriminatory (DD) will be an equilibrium structure only if $U^{DD*} - U_2^{DU*} > 0$; i.e., if $\frac{1}{8} + \frac{3t}{2} - \frac{25t(1+3t)}{6(1+4t)^2} > 0$. The difference $U^{DD*} - U_2^{DU*}$ has three roots of which only two are feasible; namely, $\underline{t} := (\sqrt{409}-11)/96$ and $\bar{t} := 1/6$. These solutions give rise to the result stated in part *i)* of the Proposition; namely, that DD is the equilibrium union structure, if $t \in (0, \underline{t})$ or if $t \in (\bar{t}, \infty)$.

Similarly, we can determine when uniformity is a best response for union 2 given that union 1 has chosen a uniform wage-setting regime. This is the case when $U^{UU*} - U_1^{DU*} > 0$. The sign of the difference $U^{UU*} - U_1^{DU*}$ is given by the sign of the expression

$$5184t^5 + 3456t^4 + 432t^3 - 180t^2 - 20t + 3.$$

That expression has only two feasible real roots; namely, 1/6 and $t' :\approx 0.10112$ (the latter solution is derived numerically). It is now easily checked that UU is the unique equilibrium union structure for $t \in (t', \bar{t})$.

We, finally, determine when unions prefer an asymmetric outcome. This is the case when both conditions $U_1^{DU*} - U^{UU*} > 0$ and $U_2^{DU*} - U^{DD*} > 0$ hold. It then follows from our previous results, that an asymmetric union structure emerges in equilibrium for $t \in (\underline{t}, t')$. Comparing the unions' wage bills (2.13) and (2.14) we obtain that the difference $U_1^{DU*} - U_2^{DU*}$ has two roots, 1/6 and 1/2, and obtains a global minimum at $t = 1/3$. As DU is only an equilibrium outcome for $t \in (\underline{t}, t')$, we can conclude that $U_1^{DU*} - U_2^{DU*} > 0$. Hence, the union which possesses the first mover advantage regarding the choice of wage-setting regime always selects a discriminatory regime. Finally, the ordering of the critical values fulfills $0 < \underline{t} < t' < \bar{t} := 1/6$.

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Chapter 3

How to Counter Union Power? Equilibrium Mergers in International Oligopoly

3.1 Introduction

We re-examine the question whether national or international mergers should be expected in the presence of powerful unions. Lommerud et al. (2006) argue in favor of an "only cross-border merger" equilibrium. By creating an "outside option" abroad, an international firm can threaten to move production into a different country which creates downward pressure on domestic wage demands. In contrast, we show that a domestic merger exhibits a "wage-unifying" effect which may more effectively counter union power than an international merger. For the wage-unifying effect to arise it is necessary that the merging firms differ with regard to their productive efficiency. Moreover the effect is re-enforced by product differentiation. An "only domestic merger" equilibrium then exists, in which asymmetric firms producing differentiated products merge in their home country to counter union power.

The wage-unifying effect of a merger is sometimes a direct result of labor law. For instance, in Germany the *tariff unity* ("Tarifeinheit") principle stipulates that only one collective agreement should apply within a firm to the same type of labor. Accordingly, a merged entity will "unify" labor contracts simply by the fact that it must reach a new collective agreement which then applies to all its employees. A recent example is the *RWTÜV/ TÜVNord* merger in 2011. Both firms had different collective agreements before the merger. After the merger, a new collective wage agreement was concluded with the services labor union *Verdi*. That collective contract defines a uniform wage profile for all workers of the merged firm (see Verdi, 2011).[1]

[1] The adjustment towards a more uniform wage structure after a merger may take some time as workers are protected to some extent by previous collective agreements (see Haucap et al., 2007,

Another recent example of the wage-unifying effect is the creation of Vattenfall Europe in Germany. The merger included previously independent public utility operators BEWAG, HEW and LAUBAG. Before the merger, employees at BEWAG and HEW enjoyed much better working conditions and higher wages than those employed by LAUBAG.[2] Right after the merger, Vattenfall Europe announced in a restructuring plan that it wants to reach a new collective agreement for the entire group to reduce wage levels at HEW and BEWAG locations.[3] On April 4th, 2010 the daily newspaper *Der Tagesspiegel* published an interview under the title *"Die BEWAG war am großzügigsten"* ("The BEWAG was most generous") with the Head of Human Resources at Vattenfall Europe, Mr. Udo Bekker. In that interview Mr. Bekker stated that the new tariff agreement concluded in 2007 has reduced annual salaries of employees at former BEWAG locations by 7,500 Euro. He also reported salary cuts at former HEW locations in Hamburg of about 2,000 Euro.[4]

Even in the absence of a legal provision as the tariff unity principle in Germany, the wage-unifying effect should be considered as a part of a (domestic) merger. *First*, unions have strong preferences for egalitarian wage-setting and it can be expected that this objective is most effective at the firm-level.[5] *Second*, there is some casual evidence that a unifying effect is also present in non-labor input markets. It should be expected that right after a merger contractual relations with suppliers are compared. If a certain supplier was able to discriminate before the merger, then the merged entity should be able to renegotiate contractual terms to the better. Such a behavior was expected by most suppliers according to an investigation conducted by the German Federal Cartel Office in association with its decision on the *EDEKA/Tengelmann* merger (see Bundeskartellamt, 2008).

By considering the uniformity effect of domestic mergers, our model combines aspects from the literature on price-discrimination in input markets (e.g., Yoshida, 2000) and downstream mergers in vertically related industries. More specifically, the model presented in this chapter builds on a growing literature which analyzes mergers in a vertical structure where upstream firms (or unions in the case of labor) have market power vis-à-vis downstream oligopolists.[6] Making the vertical struc-

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for more details on German labor market institutions).

[2]HEW (Hamburg) and BEWAG (Berlin) were located in former West Germany and West Berlin, respectively, whereas LAUBAG was active in former East Germany (Senftenberg/Brandenburg).

[3]Immediately after its formation Vattenfall Europe announced that wages at BEWAG and HEW locations had to be reduced significantly in order to align them with the much lower wage levels at LAUBAG. See newspaper article "Vattenfall plant neuen Tarifvertrag," *Hamburger Abendblatt*, 3 January 2006, online article (available at: http://www.abendblatt.de/wirtschaft/article372957/Vattenfall-plant-neuen-Tarifvertrag.html).

[4]The interview is available online (http://www.tagesspiegel.de/wirtschaft/unternehmen/udo-bekker-die-bewag-war-am-grosszuegigsten/1712310.html).

[5]The trade union principle "equal pay for equal work" summarizes this nicely. See Freeman (1982) for an early empirical study which shows that unionism reduces within-establishment wage dispersion.

[6]Works which assume linear wholesale prices (or, the right-to-manage approach in the case of

ture explicit this literature has uncovered new incentives for downstream mergers resulting from improved purchasing conditions on input markets. We depart from those works by analyzing an international setting and we apply the approach of endogenous merger formation as put forward by Horn and Persson (2001a, 2001b).[7]

We extend Lommerud et al. (2006) by considering asymmetric firms.[8] Lommerud et al. (2006) analyze a two-country model with four symmetric firms (two in each country), each producing an imperfect substitute. In each country a monopoly union sets wages at the firm level. Within such a symmetric setting, Lommerud et al. (2006) obtain their main result that the endogenous merger equilibrium only exhibits cross-country mergers. Under the resulting market structure wages reach their minimum as both merged firms can most effectively threaten to scale up production abroad if a union raises its wage.

By allowing for asymmetric firms in each country, we qualify the "only cross-border merger" result as follows:[9] *First*, given that products are sufficiently differentiated, a domestic merger equilibrium follows whenever cost asymmetries between national firms are large enough. *Second*, as products become more substitutable, the cross-country merger equilibrium becomes more likely; however, both a symmetric and an asymmetric cross-border merger outcome are possible. If products are close substitutes, then a cross-border merger induces intense competition between the unions to the benefit of the international firm. If, however, products become more differentiated the "threat-point" effect of "internal" union competition becomes less effective. Considering cost asymmetries gives then rise to our main result that a domestic merger equilibrium emerges.

From the perspective of the low-cost firm, a national merger with the high-cost firm becomes attractive as this constrains the wage demand of the domestic union. It is, therefore, the wage-unifying effect of a domestic merger that prevents the labor union from extracting rents from a low-cost plant in order to maintain employment at a high-cost plant. The merged entity can partially shift production domestically from a less towards a more efficient plant, rendering a domestic merger even more profitable.[10] As a result, depending on cost asymmetries among firms and the degree

labor) include Horn and Wolinsky (1988a), Dobson and Waterson (1997), von Ungern-Sternberg (1997), Zhao (2001), and Symeonidis (2010). Another approach is to assume "efficient contracts" in input market relations (see, for instance, Horn and Wolinsky, 1988b) which avoids double marginalization issues.

[7]Horn and Persson (2001b) analyze how international merger incentives depend on input market price setting and, in particular, on trade costs. They show how trade costs affect cross-country merger incentives and the type of mergers (unionized or non-unionized firms).

[8]Related are also Lommerud et al. (2005) and Straume (2003). Straume (2003) considers international mergers in a three-firm, three-country model where labor is unionized only in some firms. Lommerud et al. (2005) examine how different union structures affect downstream merger incentives in a three-firm Cournot oligopoly.

[9]Specifically, we assume that total costs are the sum of labor and non-labor costs. With regard to non-labor costs we suppose a high-cost and a low-cost firm in each country.

[10]Breinlich (2008) has shown that the liberalization of trade between the US and Canada trig-

of product differentiation, we find that either domestic or cross-border mergers may result in equilibrium.

There is some empirical evidence that the internationalization of firms unfolds negative effects on wages, so that it may serve as a mean to counter union power. For instance, Clougherty et al. (2011) show that international mergers unfold a threat effect which increases international firms' bargaining power vis-à-vis unions.[11] Concerning domestic merger outcomes, we note two empirical observations which are aligned with our finding. *First*, while cross-border mergers have become increasingly important, the major amount of mergers and acquisitions is still domestic in nature (Gugler et al., 2003; UNCTAD, 2012). *Second*, mergers typically occur between rather asymmetric firms which is documented in Gugler et al. (2003) who report that target firms are on average only 16 percent of the size of their acquirers.

The remainder of this chapter is organized as follows. In the following section, we present the basic model and the cooperative merger formation process. Firms' merger incentives, in the form of wage and employment effects of different merger types, are analyzed in Section 3.3. Based on these findings, we determine the equilibrium industry structure and discuss the welfare implications of our results in Sections 3.4 and 3.5. Finally, Section 3.6 offers a short discussion and concluding remarks.

3.2 The Model

We consider an oligopolistic industry with initially four independent firms, $i \in N = \{1, 2, 3, 4\}$. Each firm operates one single plant and produces one variant of a differentiated good. There are two countries A and B. Firms 1 and 2 are located in country A, while firms 3 and 4 reside in country B.

Firms compete in quantities in an internationally integrated product market. This set-up resembles a "third-market" model (see e.g. Brander, 1995). The (inverse) demand function for product i is given by

$$p_i = 1 - q_i - \beta \sum_{k \in I \setminus \{i\}} q_k \text{ for all } i \in N, \tag{3.1}$$

gered substantial merger activity between asymmetric firms in Canada. Those mergers allowed for an optimal re-allocation of production which strengthened the merged entities' competitiveness vis-à-vis US firms.

[11] Recent empirical labor research obtains mixed results concerning the relationship between labor demand and internationalization of firms. Fabbri et al. (2003) provide an empirical study which shows that labor demand of UK and US firms for low skilled workers between 1958 and 1991 (UK data are available until 1986) has become more elastic. They argue that increased activity of multinational firms is (partially) responsible for this trend. Barba-Navaretti et al. (2003) provide a cross-country firm-level study of European countries where they find that multinationals adjust their labor demand more rapidly than domestic firms in response to shocks. However, they report a more inelastic demand curve with respect to wages for multinationals which they contribute to differences in skill structure.

where q_i denotes the quantity supplied by plant i, and $\beta \in (0,1)$ measures the degree of product differentiation. As β approaches 1, products become perfect substitutes, while for $\beta \to 0$ products are virtually independent.

Firms use labor and non-labor inputs in fixed proportions to produce the good. We consider a constant-returns-to-scale production technology, such that one unit of output of product i requires one unit of labor at wage w_i and one unit of a non-labor input at unit-price c_i. Firms differ in their non-labor production costs. We assume that firms 1 and 3 are the low-cost firms with $c_1 = c_3 = 0$, while firms 2 and 4 are the high-cost producers, with $c_i =: c \geq 0$ for $i = 2, 4$.[12] We can express firm i's cost function (with $i \in N$) as

$$C_i(q_i) = [w_i + D(i)c]\, q_i \text{ with } D(i) := \begin{cases} 1, & \text{if } i = 1,3 \\ 0, & \text{if } i = 2,4 \end{cases}.$$

Note that $D(i) \in \{0,1\}$ is an indicator such that $D(i) = 1$ for the high-cost firms $i = 2, 4$ and $D(i) = 0$ for the low-cost firms $i = 1, 3$.[13] The profit function of firm i is thus given by

$$\pi_i = [p_i(\cdot) - w_i - D(i)c]\, q_i \text{ for all } i \in I. \tag{3.2}$$

Workers are organized in centralized labor unions in their respective countries.[14] We consider a monopoly union model and we adopt the right-to-manage approach, which stipulates that labor unions set wages for the firms residing in their countries, whereas the responsibility to determine employment remains with the firms. Unions make take-it or leave-it wage offers to firms to maximize their wage bills. The wage-setting of labor unions adjusts to the industry structure which the plant owners determine cooperatively.

Wage setting depends crucially on whether or not a domestic merger occurs. In market structures without a domestic merger (i.e., in which either cross-border mergers or no merger has taken place), each labor union $j = A, B$ sets a firm-specific (and hence, plant-specific) wage to maximize its wage bill

$$U_j = \sum\nolimits_i w_i q_i(D(i)), \tag{3.3}$$

where $i = 1, 2$ in country $j = A$ and $i = 3, 4$ in country $j = B$. We denote by w_i

[12] For $c = 0$, all firms are ex ante identical and we are back in the model analyzed by Lommerud et al. (2006).

[13] We abstract from the option that mergers induce efficiency gains with respect to marginal costs. We calculated another version of this model where mergers induced marginal cost savings for the high cost plants to μc, where $\mu \in (0,1)$ measures the degree of efficiency gains. Our results are not affected by the introduction of merger synergies, only the scope for domestic mergers is reduced the larger the cost savings through mergers becomes. The results are available from the authors upon request.

[14] A crucial assumption is that workers are unable to organize in unions across borders. Although there have been attempts towards more cooperation among labor unions at a European level, in general, labor market regimes are bound locally at the national level (Traxler and Mermet, 2003).

the wage paid by firm i and $q_i(D(i))$ is the labor demand of firm i which depends on its non-labor costs.[15]

If a domestic merger occurs, then the labor union offers a uniform wage rate to the merged entity which now operates two asymmetric plants.[16] The labor union j's wage bill in those cases is then given by

$$U_j = w_j \sum_i q_i(D(i)),$$

with $i = 1, 2$ in country $j = A$ and $i = 3, 4$ in country $j = B$, where w_j is the uniform wage rate in country $j \in \{A, B\}$.

We analyze the following three-stage game. In the first stage, firms merge in pairs according to the cooperative merger formation process proposed by Horn and Persson (2001a, 2001b).[17] In the second stage, labor unions simultaneously and non-cooperatively set wages after having observed the outcome of the merger process. Finally, in the third stage of the game, firms compete in quantities in the final product market ("Cournot competition").

We solve for the subgame perfect equilibrium. In the third stage of the game we obtain a unique quantity vector depending on the market structure and wages. In the second stage of the game, unions set wages depending on the market structure while foreseeing firms' subgame perfect quantity choices. In the first stage, a merger formation process applies, in which all parties foresee perfectly unions' wage demands and optimal Cournot quantities depending on the resulting market structure.

Merger formation process. We apply the method developed in Horn and Persson (2001a, 2001b) by modelling the merger formation process as a cooperative game of coalition formation. An ownership structure M^r describes a partition of the set N into voluntary coalitions. As in Lommerud et al. (2006), we consider only two-firm mergers. We obtain ten such partitions, two being mirror images, which leaves us with eight relevant industry structures of the merger formation process:[18]

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[15] Workers' reservation wages are normalized to zero.

[16] In an industry structure with two domestic mergers, both unions set uniform wages. In contrast, when only one domestic merger has occured (and the plants in the second country stay independent) only the union in whose country a merger has taken place sets a uniform wage rate. The second union sets two separate plant-specific wage rates.

[17] That is, we only allow mergers between two firms, so that the most concentrated market is a duopoly. We are interested in highlighting the incentives for domestic versus cross-border mergers and the role asymmetries between firms play in this formation process. If firms have the opportunity to monopolize the market, an all-encompassing merger is the obvious outcome, regardless of firm asymmetries. In addition, three- or four-firm mergers are more likely to be blocked by antitrust authorities. Finally, cost of administering a merger may grow overproportionally making mergers of three or four plants unprofitable.

[18] We use the following abbreviations for r to describe a market structure M^r. A merger can be domestic (D) or cross-border (C) and there can be one merger ($D1$; $C1$) or two mergers ($D2$; $C2$) in either case. If two cross-country mergers occur, then they can be symmetric ($C2s$) or asymmetric

1. no merger: $M^0 = \{1, 2, 3, 4\}$,
2. one domestic merger: $M^{D1} = \{12, 3, 4\}$ or $M^{D1'} = \{1, 2, 34\}$,
3. two domestic mergers: $M^{D2} = \{12, 34\}$,
4. one symmetric cross-border merger of the efficient firms: $M^{C1se} = \{13, 2, 4\}$,
5. one symmetric cross-border merger of the inefficient firms: $M^{C1si} = \{1, 3, 24\}$,
6. two symmetric cross-border mergers: $M^{C2s} = \{13, 24\}$,
7. one asymmetric cross-border merger: $M^{C1a} = \{14, 2, 3\}$ or $M^{C1a'} = \{1, 4, 23\}$,
8. two asymmetric cross-border mergers: $M^{C2a} = \{14, 23\}$.

As firms are not symmetric, cross-border mergers can take place in different constellations.[19] First, firms with the same non-labor production costs can merge, which we call *symmetric* cross-border mergers (cases *4.*, *5.* and *6.*). When there is only one international symmetric merger, it can either be the two efficient (M^{C1se}) or the two inefficient (M^{C1si}) firms that merge. The ownership structure with two mergers between the symmetric (low-cost and high-cost) firms is represented by structure M^{C2s}. Thus, in structure M^{C2s} there is one firm producing brands 1 and 3 at low costs, and one firm producing brands 2 and 4 at high costs.

Second, there can be cross-border mergers between two firms of different cost types, which we call *asymmetric* cross-border mergers (cases *7.* and *8.*). If there is only one asymmetric cross-border merger, the outcome is obviously identical for structures M^{C1a} and $M^{C1a'}$. Industry structure M^{C2a} indicates that there have been two cross-border mergers each between one low-cost and one high-cost firm. As a result each merged firm produces one brand at low cost and the other brand at high cost.

The determination of the outcome of the cooperative merger formation process is based on dominance relations between the partitions of N. If an ownership structure is dominated by another structure, it cannot be the equilibrium outcome of the cooperative merger formation game. The approach involves a comparison of each structure M^r against all other structures M^{-r} separately. M^r dominates a structure $M^{r'}$ if the combined profits of the decisive group of owners in structure M^r exceeds those in structure $M^{r'}$.

Decisive owners can influence which coalition is formed. All firm owners which belong to identical coalitions in ownership structures M^r and $M^{r'}$ are not decisive.

($C2a$). If one cross-border merger occurs, then it can be symmetric ($C1s$) or asymmetric ($C1a$). Finally, in case of a single cross-border merger between symmetric firms it can be either between the efficient firms ($C1se$) or between the inefficient ($C1si$).

[19] When firms are symmetric, then partitions M^{C1se}, M^{C1si}, and M^{C1a} are structurally equivalent. The same holds for structures M^{C2s} and M^{C2a}.

By that we exclude the possibility of transfer payments among all firms.[20] Within a coalition of firms, owners are free to distribute the joint profit among each other. Thus, an industry structure M^r dominates another structure $M^{r'}$ if the decisive group of owners prefers M^r over $M^{r'}$ which is the case if the combined profit of this group is larger in M^r than in $M^{r'}$.

Applying the bilateral dominance relationship, it is possible to rank different ownership structures. We then search for the equilibrium industry structure (EIS) which is undominated. Undominated structures belong to the core of a cooperative game of coalition formation where the characteristic function follows from the subgame perfect strategies unions and firms choose for a given industry structure.

Parameter restriction. A well-known problem associated with a uniform input price (or wage) is that the input supplier (or union) may prefer to set a price (wage) so high that the less efficient plant is shut down.[21] In our model, this issue arises in structures when domestic firms merge and marginal non-labor cost, c, of the inefficient firm becomes large. The following assumption ensures that all plants $i \in I$ produce strictly positive quantities under all market structures.[22]

Assumption 1. *The high-cost firms' marginal cost, c, fulfills* $0 < c < \overline{c}(\beta)$. *The critical value* $\overline{c}(\beta)$ *is monotonically decreasing in* β, *with* $\lim_{\beta \to 0} \overline{c}(\beta) = 2 - \sqrt{2}$ *and* $\lim_{\beta \to 1} \overline{c}(\beta) = 0$.

We maintain Assumption 1 throughout the entire analysis. In Appendix B we show that the critical value $\overline{c}(\beta)$ is derived from market structure M^{D1}. In case of a single domestic merger, the union has the strongest incentive to raise the uniform wage rate up to a level which makes production at the high-cost plant unprofitable. By assuming $c < \overline{c}(\beta)$ we ensure that the union prefers a relatively low wage rate which keeps the inefficient plant active.

Before we analyze the equilibrium of the merger formation process, we present the following preliminary result. All proofs are relegated to the Appendix.

Lemma 1. *The no-merger* (M^0) *and all one-merger structures* (M^{D1}, M^{C1se}, M^{C1si}, *and* M^{C1a}) *are dominated by at least one two-merger structure* (M^{D2}, M^{C2a}, *or* M^{C2s}).

A comparison of profit levels reveals that industry structures involving two mergers (M^{D2}, M^{C2a}, and M^{C2s}) unambiguously provide higher total profits for the decisive group of firms than industry structures in which more than two firms prevail in the market. The equilibrium outcome of the merger formation process will therefore always result in a downstream duopoly. As a consequence, when analyzing possible candidates for equilibrium industry structures, only structures with two merged

[20] Clearly, if we allow for transfers between all firms, then the equilibrium structure is the one which maximizes industry profits.

[21] For instance, Haucap et al. (2001) show that a union may have an incentive to raise a uniform industry-wide wage rate above a certain level to drive inefficient firms out of the market.

[22] We provide the derivation of Assumption 1 in Appendix B.

firms have to be considered. Therefore, we restrict our attention in the following analysis to the three candidate equilibrium industry structures: M^{D2}, M^{C2a} and M^{C2s}, i.e., we focus on the incentives for either two domestic or two cross-border mergers, where we distinguish between coalitions of symmetric plants (two efficient and two inefficient plants merge) and coalitions between asymmetric plants (one efficient producer merges with one inefficient producer each).

3.3 Merger Incentives

We solve our model for all possible industry structures in Appendix A. As we focus on the driving forces behind domestic and cross-border mergers when firms are asymmetric, it will be instructive to analyze first of all the impact of different types of mergers on wages and employment.

3.3.1 Wage and Employment Effects

As wage rates are determined endogenously, unions may react to each market structure by adjusting their wage demands accordingly. How do different types of mergers affect wage rates? As we can restrict attention to two-merger structures, wage rates in countries A and B are always symmetric in equilibrium. However, there can be differences in the wage rates paid by efficient and inefficient plants if labor unions set plant-specific wages (i.e., in structures M^{C2s} and M^{C2a}). In those cases, we use subscript I to indicate wages paid by *inefficient* plants (plants 2 and 4) and subscript E to indicate wages paid by *efficient* plants (1 and 3). As there is only one equilibrium uniform wage for M^{D2}, we do not use a subscript in this case.

When we compare the wage rates set by the labor unions in countries A and B for structures M^{D2}, M^{C2s} and M^{C2a}, we find that the plant-specific wages in industry structures involving cross-border mergers can be ranked unambiguously. When including the uniform wage set for domestic merger participants, the ranking is not distinctly possible. The relation between the wage rates in the different industry structures then depends on the degrees of product differentiation (β) and cost asymmetry between firms (c).

Proposition 1. *Consider all market structures with two mergers, i.e.,* M^{D2}, M^{C2s} *and* M^{C2a}*. Then, equilibrium wages can be ranked as follows:*

i) The ranking of wage rates set by labor unions in structures M^{C2s} *and* M^{C2a} *is unambiguously given by* $w_E^{C2a} > w_E^{C2s} > w_I^{C2s} > w_I^{C2a}$.

ii) The equilibrium wage under structure M^{D2} *is always larger than the equilibrium wage of the inefficient firms under market structures* M^{C2s} *and* M^{C2a}*, i.e.,* $w^{D2} > w_I^{C2s} > w_I^{C2a}$ *holds always.*

iii) The comparison of the equilibrium wage under structure M^{D2} *with the equilibrium wage of the efficient firms under market structures* M^{C2s} *and* M^{C2a} *depends on two uniquely determined critical values* $c_1(\beta)$ *and* $c_2(\beta)$*, with* $c_1(\beta) > c_2(\beta) > 0$

such that $w_E^{C2s} > w^{D2}$ *holds for* $c > c_1(\beta)$, $w_E^{C2a} > w^{D2} > w_E^{C2s}$ *holds for* $c_1(\beta) > c > c_2(\beta)$, *and* $w^{D2} > w_E^{C2a}$ *holds for* $c < c_2(\beta)$.
Moreover, $c_1(\beta \to 0) = c_2(\beta \to 0) = 0$ *and* $c_1(\beta)$ *and* $c_2(\beta)$ *are monotonically increasing.*

Part *i)* of Proposition 1 compares both cross-country merger structures and says that efficient plants pay unambiguously higher plant-specific wage rates than inefficient plants. Quite obviously, as labor unions can discriminate in case of cross-country mergers, they are able to extract a higher surplus from efficient plants. Post-merger wages depend on which type of plants have formed a coalition. Recall that in structure M^{C2a} each merged firm operates one efficient and one inefficient plant. To save on non-labor cost of production, each merged firm will partially reallocate production from the high- to the low-cost plant. The magnitude of this reallocation depends on the degree of substitutability between brands. Consequently, the efficient plants increase their market shares in M^{C2a} giving labor unions the opportunity to raise wages w_E^{C2a} while balancing wage demands and respective effects on employment.

In contrast, in structure M^{C2s} firms of the same cost type merge and do not create an option to reallocate production among each other to save on non-labor cost. Unions adjust their wage demands to these different constellations of ownership. The respective production shifting opportunities in the two structures yield higher wages for efficient plants in M^{C2a} than M^{C2s}. For inefficient plants, obviously the reverse holds true.

Comparing the uniform wage w^{D2} with the plant-specific wage rates under cross-border merger structures is less easy. Part *ii)* of Proposition 1 shows that the wage in case of domestic mergers is always larger than the wage which prevails at the inefficient plant in case of cross-country mergers. Hence, a domestic merger outcome is always good news for employees at inefficient firms which would otherwise suffer from wage cuts in case of cross-country mergers.

Part *iii)* of Proposition 1 shows that the comparison of the wages at the efficient plants depends on both the cost asymmetries and product differentiation. Figure 3-1 illustrates the different rankings. The three areas in Figure 3-1 follow from Proposition 1, such that the following orderings hold:

$$\begin{aligned} \text{Area } A &: \; w_E^{C2a} > w_E^{C2s} > w^{D2} > w_I^{C2s} > w_I^{C2a}; \\ \text{Area } B &: \; w_E^{C2a} > w^{D2} > w_E^{C2s} > w_I^{C2s} > w_I^{C2a}; \\ \text{Area } C &: \; w^{D2} > w_E^{C2a} > w_E^{C2s} > w_I^{C2s} > w_I^{C2a}. \end{aligned}$$

A domestic merger allows the merged entity to reallocate production domestically towards the more efficient plant. The union has an incentive to balance this threat of production shifting by adjusting the uniform wage rate downward. As part *iii)* of Proposition 1 shows, union power is most effectively constrained through a domestic merger when products are sufficiently differentiated and/ or firms are sufficiently asymmetric. In Figure 3-1, area A represents all parameter constellations where a

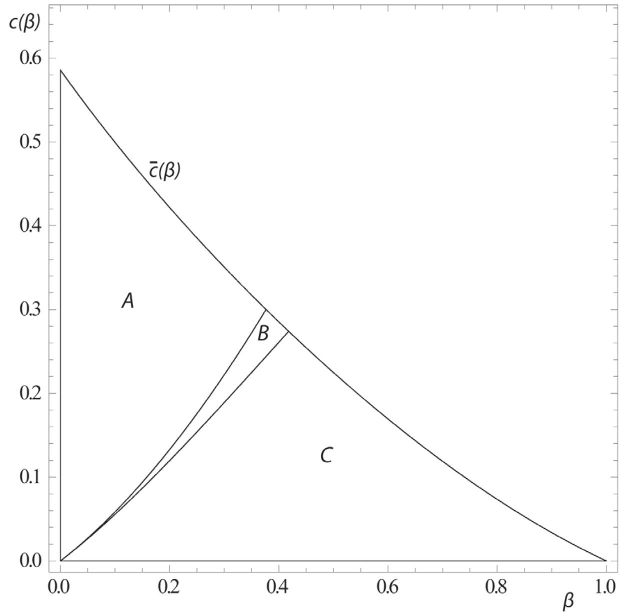

Figure 3-1: Wage effects of different merger types.

domestic merger allows to operate the efficient firms at the lowest possible wage level. If the labor unions were allowed to discriminate between efficient and inefficient firms in that area (as it is the case when firms merge cross-border), then unions would optimally increase the wage rates at the efficient plant in anticipation of increased production. Thus, as can be seen from Figure 3-1, for higher values of c, w^{D2} is driven below the levels of w_E^{C2a} and w_E^{C2s}.

The reason for this result is that the non-labor cost of the inefficient firms affects wage rates differently. Note that

$$\frac{\partial w^{D2}}{\partial c} = -\frac{1}{4+2\beta} < 0$$

for $\beta \in (0,1)$. When the non-labor cost of production of the inefficient plants marginally increases, the wage rate paid by the merged firm falls. As uniformity of wages restricts the labor union in exploiting the production efficiency of the low-cost producer, it limits its wage demand when firms become more asymmetric in order to maintain employment at the high-cost plant. In contrast, in cross-border merger structures, low-cost plants' wages rise if non-labor costs of high-cost plants increase; i.e., in equilibrium it holds that

$$\frac{\partial w_E^{C2a}}{\partial c} = \frac{\beta}{4-\beta} > 0 \text{ and } \frac{\partial w_E^{C2s}}{\partial c} = \frac{2\beta(1-\beta)}{(4-\beta)(4-3\beta)} > 0.$$

Next to the impact of firm asymmetry and uniformity of wages, a merger further affects the choice of wage rates through changes in the elasticities of labor demand at the merged firms. Different merger types may result in different changes in labor demand elasticities due to the relation between national labor unions and international firms. While for a domestic merger plants with relation to the same labor union merge, cross-border mergers induce rivalry between nationally organized labor unions due to the threat of moving production abroad.

To analyze the changes in labor demand elasticities, first consider structure M^{D2} in relation to the no-merger case. Using the results for derived labor demands presented in Appendix A, we can write the slopes of the labor demand curves as follows,

$$\begin{aligned}\frac{\partial \widehat{q}_E^0}{\partial w_E^0} &= \frac{\partial \widehat{q}_I^0}{\partial w_I^0} = \frac{2+2\beta^2}{(\beta-2)(2+3\beta)}, \text{ and}\\ \frac{\partial \widehat{q}_E^{D2}}{\partial w^{D2}} &= \frac{\partial \widehat{q}_I^{D2}}{\partial w^{D2}} = \frac{2-2\beta^2}{4(\beta-1)(1+2\beta)},\end{aligned}$$

for the pre- and post-merger cases, where $\widehat{q}_E^r$ and $\widehat{q}_I^r$, $r = \{0, D2\}$, are the derived labor demand functions of efficient and inefficient plants, respectively. Comparison of the two expressions reveals that

$$\left|\frac{\partial \widehat{q}_E^{D2}}{\partial w^{D2}}\right| - \left|\frac{\partial \widehat{q}_E^0}{\partial w_E^0}\right| = \frac{\beta(1+\beta)(4+3\beta)}{2(-4-12\beta-5\beta^2+6\beta^3)} < 0.$$

Reduced product market competition after the two domestic mergers reduces the responsiveness of firms' labor demand. Ceteris paribus, labor demand becomes less elastic in a domestic merger case and the labor unions have an incentive to raise wages. However, the previously described wage-unifying effect countervails this incentive, because the union would raise wages for all workers in both plants.

On the other hand, a cross-border merger induces union rivalry through the threat effect. The slope of labor demand in both cross-border merger structures M^{C2s} and M^{C2a} is given by

$$\frac{\partial \widehat{q}_E^{C2s}}{\partial w_E^{C2s}} = \frac{\partial \widehat{q}_I^{C2s}}{\partial w_I^{C2s}} = \frac{\partial \widehat{q}_E^{C2a}}{\partial w_E^{C2a}} = \frac{\partial \widehat{q}_I^{C2a}}{\partial w_I^{C2a}} = \frac{2+2\beta+\beta^2}{4(\beta-1)(1+2\beta)}.$$

Comparison with the slope of labor demands in the no-merger case reveals that

$$\left|\frac{\partial \widehat{q}_E^{C2s}}{\partial w_E^{C2s}}\right| - \left|\frac{\partial \widehat{q}_E^0}{\partial w_E^0}\right| = \frac{3\beta^2(2+2\beta+\beta^2)}{4(4-8\beta-7\beta^2-11\beta^3+6\beta^4)} > 0.$$

Ceteris paribus, cross-border mergers increase the responsiveness of labor demand of the firms, which would lead to a decrease in wage demands by unions. The difference in labor demand responsiveness for different merger types is in line with the results by Lommerud et al. (2006). However, a countervailing effect may arise in our model increasing firms' incentives to merge domestically: the constraining effect of a uniform wage on a labor union's ability to extract surplus from efficient firms.

To understand which types of mergers will be chosen in equilibrium, it is also instructive to look at the employment effects of different merger types. Total employment is given by the sum of firms' output levels. Accordingly, define $Q := \sum_i q_i$. The following Lemma summarizes the impact of different merger types on total employment when compared with the pre-merger employment level.

Lemma 2. *Total employment, Q, under the three two-merger structures (M^{D2}, M^{C2s}, and M^{C2a}) and the no merger structure M^0 can be ranked as follows: Employment levels are identical in the two cross-border merger structures ($Q^{C2s} = Q^{C2a}$). Employment is always lower in the domestic merger structure than in the cross-border and in the no merger structure ($Q^{C2s} = Q^{C2a} > Q^{D2}$ and $Q^0 > Q^{D2}$). Whether cross-border mergers reduce or increase total employment compared to no merger depends on the degree of product differentiation in the following way:*
i) $Q^0 > Q^{C2s} = Q^{C2a}$ if $\beta \in (0, 1/2)$, and
ii) $Q^{C2s} = Q^{C2a} > Q^0$ if $\beta \in (1/2, 1)$.
Moreover, equality holds, $Q^{C2s} = Q^{C2a} = Q^0$, if $\beta = 1/2$.

Three interesting observations can be made from Lemma 2. First of all, we find that total employment is always lowest in the domestic merger structure compared to cross-border merger structures and the no-merger benchmark.[23] Inspection of the plant-specific employment rates (see Appendix A) reveals that this mainly hinges upon the low employment of inefficient plants in the domestic merger structure. The increase in market concentration leads to a contraction of total employment.

Second, total employment in the two cross-border merger structures is identical, although different types of mergers are formed in the two structures. The reason for this result becomes obvious from the ranking of wage rates above. In the two cross-border merger structures, labor unions set wages as to balance total costs for the firms in the two structures. Note that, however, this does not mean that the distribution of output across plants is identical for the merger structures. This is not the case, as firms shift production towards more efficient plants in structure M^{C2a} while this is not possible for structure M^{C2s}, where plants with identical technologies merge.

Third, for lower degrees of product differentiation, total employment is higher with cross-border mergers than in the no merger case. If products are closer substitutes (β close to 1) the opportunity for firms to shift production, for either labor

[23] Note that uniformity of wages in the domestic merger structure M^{D2} does not influence this result. Essentially, uniformity has no effect on total employment compared to plant-specific (discriminatory) wages when market demand is linear (Schmalensee, 1981; Yoshida, 2000). Assuming symmetric firms, total employment is the same as in the model analyzed by Lommerud et al. (2006). Differences in total employment are therefore only a result of firm asymmetries.

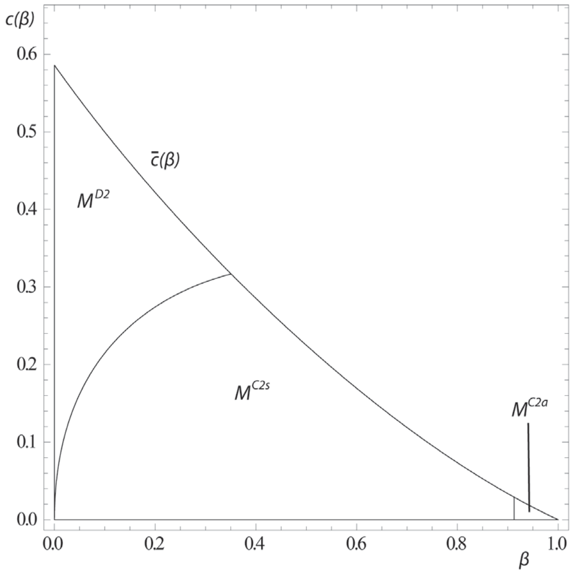

Figure 3-2: Equilibrium industry structures

or non-labor cost savings, becomes larger. Thereby, efficient firms produce a higher output compared to the no-merger case, which has an overall increasing effect on employment.

3.4 Equilibrium Industry Structures

The previous Section has examined how different merger types influence wage and employment levels. We now turn to the industry structures which will result in equilibrium as the outcomes of the merger formation process. Since firms will anticipate the wage-setting behavior of the unions, they will take into account the effect their merger decisions will have on union behavior. The following proposition summarizes which industry structures will arise in equilibrium.

Proposition 2. *If $\beta > \widetilde{\beta} \approx 0.913$, then the equilibrium industry structure is M^{C2a}. If $\beta < \widetilde{\beta}$, then there exists a critical value $\widetilde{c}(\beta)$, such that the equilibrium industry structure is M^{D2} if $c > \widetilde{c}(\beta)$ and M^{C2s} if $c < \widetilde{c}(\beta)$. Moreover, $\lim_{\beta \to 0} \widetilde{c}(\beta) = 0$ and $\partial \widetilde{c}(\beta)/\partial \beta > 0$ in the relevant interval $0 < \widetilde{c}(\beta) \leq \overline{c}(\beta)$ and $\widetilde{c}(\beta) = \overline{c}(\beta)$ for $\beta \approx 0.351$.*

In contrast to previous work with homogenous firms and purely plant-specific wages, the equilibrium industry structure in our model can consist of either domestic or cross-border mergers. Two domestic mergers will be the unique equilibrium if products are sufficiently differentiated and firms are sufficiently asymmetric, more specifically when $c > \widetilde{c}(\beta)$. Figure 3-2 illustrates these results. The result that either domestic or cross-border mergers can occur is in contrast to the findings by Lommerud et al. (2006), where domestic mergers never occur in equilibrium. The incentives for firms to merge domestically when plants are sufficiently asymmetric stem from the two effects described above. A domestic merger induces the labor unions to limit their wage demands from the efficient plant in order to maintain employment at the inefficient plant. The mergers decrease competition in the product market and induce a reduction in overall employment. Concerning the distribution of employment among the plants, merged firms domestically shift production from an inefficient to the efficient plant.

When these two effects dominate the gains from cross-border mergers – namely the reduction of market power of labor unions through the threat of reallocation – two domestic mergers will emerge as an equilibrium industry structure. More specifically, merging domestically becomes more attractive the more asymmetric firms become. Thus, we should expect that the threat effect will conversely dominate the wage-unifying effect if firms are rather symmetric or products are closer substitutes.

For a wide range of parameter values, we observe that cross-border mergers between symmetric firms ($M^{C2s} = \{13, 24\}$) will occur in equilibrium. In this region, the threat effect of cross-border mergers dominates the benefits of uniformity for the firms. When products become less differentiated, the reallocation of production becomes easier, thereby strengthening the firms' threat position vis-à-vis the labor unions.

Closer inspection of this equilibrium reveals that the driving factor is the gain in profits of the merged efficient plants compared to the other two industry structures in this parameter range. As they are not able to reshuffle production for non-labor cost savings, incentives are even stronger to threaten production reallocation to put downward pressure on wages. Nevertheless, also the inefficient plants gain through the increase in market concentration.

Finally, $M^{C2a} = \{14, 23\}$ is the equilibrium outcome for $\beta > \widetilde{\beta}$, i.e. when products and firms are almost homogeneous. In this area, the production shifting effect becomes strongest while market shares are distributed rather evenly between firms. Note that equilibrium cross-border mergers will not necessarily lead to higher employment compared to a no-merger case. Only for the region $\beta \in (0.5, 1)$ cross-border mergers will increase total employment.

3.5 Welfare

Finally, we inspect the welfare implications of our results. At first glance, a domestic merger might have welfare improving effects because of the redistribution of production from less efficient to more efficient firms. However, the employment effect of domestic mergers gives rise to the following result:

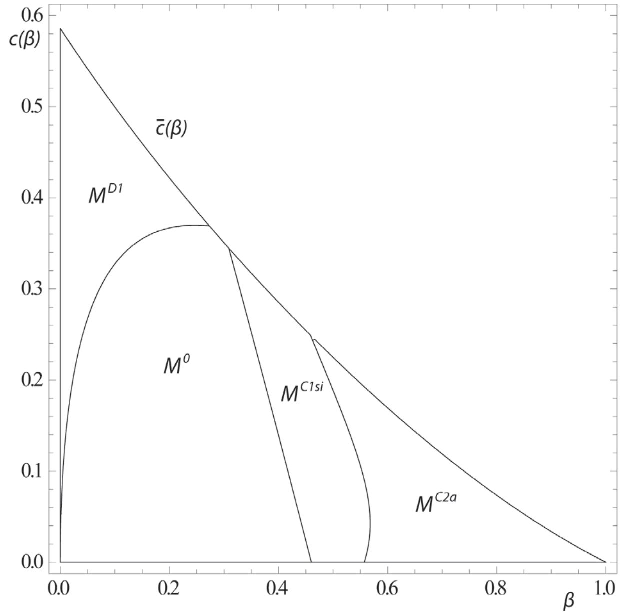

Figure 3-3: Welfare maximizing industry structures

Proposition 3. *The ownership structure involving two domestic mergers, M^{D2}, is never socially optimal. The optimal industry structure from a welfare perspective can be either no merger (M^0), one domestic merger (M^{D1}), one cross-border merger between the inefficient plants (M^{C1si}) or two asymmetric cross-border mergers (M^{C2a}).*

Calculating the global welfare as the sum of firms' profits, labor union wage bills and consumer surplus, we see that industry structure M^{D2} is never welfare optimal. For all parameter constellations of β and c, it is welfare dominated by other structures. Although a domestic merger results in a partial reallocation of production from less towards more efficient plants, the reduction in overall quantity in the market causes this structure to be never optimal from a welfare perspective.

Establishing which industry structure is welfare optimal (from a global welfare point of view) is, however, not easy in practice. Since the production asymmetry may cause a reallocation of production from inefficient to efficient plants in some structures, total quantity sold in the market does not necessarily indicate when a structure is also most desirable from a welfare perspective. Figure 3-3 summarizes the industry structures, which can be welfare optimal in given parameter regions.Interestingly, there can be also welfare optimal industry structures which will never be the equilibrium outcome of the merger formation process between firms (M^0, M^{D1}, and M^{C1si}). Most notably, while two domestic mergers are never optimal from a welfare perspective, an industry structure with one domestic merger can be when firms are rather asymmetric and product differentiation is rather strong. This parameter constellation roughly coincides with the area where two domestic mergers are the equilibrium industry structure (see Figure 3-2). From a welfare perspective, too many domestic mergers occur for these parameter constellations.

We do find, following Lommerud et al. (2006), that two cross-border mergers (M^{C2a}) always welfare dominate structure M^{D2}. However, this result is only true for asymmetric cross-border mergers which result in one efficient and one inefficient firm in the industry. In contrast, we cannot establish a pattern leading to the conclusion that cross-border mergers are the welfare optimal industry structure for a wide range of parameters.

A comparison with the results of the equilibrium outcomes of the merger formation shows that firms only choose the welfare maximizing industry structure when products are close substitutes, i.e. when $\beta > \widetilde{\beta}$. This result supports empirical findings of an increasing trend in cross-border mergers where target and acquiring firms may strongly differ in size (Gugler et al., 2003).

3.6 Concluding Remarks

We have presented an extension of the model analyzed by Lommerud et al. (2006) to uncover the role of cost asymmetries among firms in a unionized oligopoly. Our results suggest that domestic mergers may result as an equilibrium outcome of the merger formation process when firms are asymmetric in their non-labor costs of production.

The incentives for domestic mergers critically depend on the labor unions inability to discriminate among workers belonging to the same employer. Thereby, firms face a trade-off between domestic and cross-border mergers in the coalition formation game: cross-border mergers give rise to the threat effect — the opportunity to reallocate production from one country to another — which puts downward pressure on wages. Domestic mergers constrain the labor unions in their freedom to extract surplus from efficient plants. This uniformity effect provides incentives for firms to merge domestically. On the one hand a domestic merger may lower the wage paid by the efficient plant, on the other hand production may be reshuffled within one country from the less to the more efficient producer.

We obtain, therefore, both domestic and cross-border mergers in equilibrium, depending on the degree of product substitutability and the asymmetry between firms. If cross-border mergers occur, mergers between symmetric plants will be the prevailing industry structure for the widest range of parameter constellations. However, asymmetric international merger outcomes are also possible whenever products are sufficiently homogeneous.

A comparison with the optimal industry structures from a global welfare perspective reveals that firms do not choose the welfare optimal industry structures, unless products are close substitutes. While two domestic mergers are never welfare optimal, no unambiguous pattern in the industry structures according to welfare effects can be established. The welfare optimal structure can involve no mergers at all, one, or two mergers. For intermediate to low degrees of product differentiation, the global welfare maximizing industry structure involves two mergers between asymmetric firms, i.e. between an efficient and an inefficient plant each. Obviously, this result is enforced by the positive welfare effect of these mergers because of the reallocation of production from less to more efficient firms. A comparison to the equilibrium industry structure chosen by firms, reveals that such an industry structure is however rarely chosen by firms.

How do these results relate to the evaluation of merger proposals in the light of collective bargaining institutions? The presence of powerful labor unions and egalitarian wage-setting principles ("one firm, one wage") affects firms' merger decisions and gives rise to equilbrium industry structures which do not result when wages are set purely firm-specific. The wage-setting regime has a considerable impact on the optimal, welfare maximizing industry structure. In contrast to previous research on domestic and cross-border mergers, our model supports the idea that one domestic merger can be welfare maximizing under certain parameter constellations. However, the presence of a wage-unifying effect triggers too much merger activity from a welfare perspective. A domestic merger, or a no merger outcome, maximize global welfare when firms are rather heterogeneous in terms of productive efficiency and product differentiation. In our model firms choose two domestic mergers in this area. In reality we observe an increasing amount of international mergers in this region (when firms are rather asymmetric) as put foward in the introduction to this Chapter . A relevant question which arises in this context is, therefore, whether merger policies should take into account the prevailing wage-setting institutions and thereby generated wage effects of mergers when evaluating merger proposals.

Appendix A

In this Appendix we explicitly solve all possible industry structures. All structures are solved by backward induction.

No merger (M^0): {1,2,3,4} Given the demands (3.1), firms' profit functions are given by

$$\begin{aligned}
\pi_1(\cdot) &= (1 - q_1 - \beta(q_2 + q_3 + q_4) - w_1)\, q_1, \\
\pi_2(\cdot) &= (1 - q_2 - \beta(q_1 + q_3 + q_4) - w_2 - c)\, q_2, \\
\pi_3(\cdot) &= (1 - q_3 - \beta(q_1 + q_2 + q_4) - w_3)\, q_3, \\
\pi_4(\cdot) &= (1 - q_4 - \beta(q_1 + q_2 + q_3) - w_4 - c)\, q_4,
\end{aligned}$$

Solving the four first-order conditions yields the following optimal quantities which are also the derived labor demands:

$$\begin{aligned}
\widehat{q}_1(\cdot) &= \tfrac{-2c\beta+2w_1+\beta+2\beta w_1-\beta w_2-\beta w_3-\beta w_4-2}{(\beta-2)(3\beta+2)}, \\
\widehat{q}_2(\cdot) &= \tfrac{2c+\beta+2w_2+c\beta-\beta w_1+2\beta w_2-\beta w_3-\beta w_4-2}{(\beta-2)(3\beta+2)}, \\
\widehat{q}_3(\cdot) &= \tfrac{-2c\beta+2w_3+\beta-\beta w_1-\beta w_2+2\beta w_3-\beta w_4-2}{(\beta-2)(3\beta+2)}, \text{ and} \\
\widehat{q}_4(\cdot) &= \tfrac{2c+\beta+2w_4+c\beta-\beta w_1-\beta w_2-\beta w_3+2\beta w_4-2}{(\beta-2)(3\beta+2)}.
\end{aligned}$$

The labor unions' wage bills are given by

$$\begin{aligned}
U_A(\cdot) &= w_1\widehat{q}_1(\cdot) + w_2\widehat{q}_2(\cdot), \text{ and} \\
U_B(\cdot) &= w_3\widehat{q}_3(\cdot) + w_4\widehat{q}_4(\cdot).
\end{aligned}$$

The unions set wages to maximize their wage bills. Solving the four first-order conditions yields the optimal wage rates

$$w_1^0 = w_3^0 = \tfrac{(4+\beta(-2+c))}{8} \text{ and } w_2^0 = w_4^0 = \tfrac{(4+\beta(-2+c)-4c)}{8}.$$

Using the expressions for w_1^0, w_2^0, w_3^0 and w_4^0, we obtain the union wage bills

$$U_A^0 = U_B^0 = \tfrac{4(-2+\beta)^2(2+\beta)-4(-2+\beta)^2(2+\beta)c+(16+\beta(8+(-2+\beta)\beta))c^2}{32(2-\beta)(2+3\beta)},$$

and production quantities

$$\begin{aligned}
q_1^0 &= q_3^0 = \tfrac{8+\beta^2(-2+c)+6\beta c}{8(2-\beta)(2+3\beta)}, \text{ and} \\
q_2^0 &= q_4^0 = \tfrac{8+\beta^2(-2+c)-8c-6\beta c}{8(4+(4-3\beta)\beta)}.
\end{aligned}$$

It follows immediately that $\pi_1^0 = (q_1^0)^2$, $\pi_2^0 = (q_2^0)^2$, $\pi_3^0 = (q_3^0)^2$ and $\pi_4^0 = (q_4^0)^2$.

One Domestic Merger (M^{D1}): {12,3,4} Here, we only consider the interior solution in which all four plants produce a positive output. In Appendix B, we will derive a sufficient condition to ensure an interior solution in all market structures. When all plants produce positive outputs in the last stage of the game, the profit functions are given by

$$\begin{aligned}\pi_{12}(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_A)\,q_1+(1-q_2-\beta(q_1+q_3+q_4)-w_A-c)\,q_2,\\ \pi_3(\cdot) &= (1-q_3-\beta(q_1+q_2+q_4)-w_3)\,q_3, \text{ and}\\ \pi_4(\cdot) &= (1-q_4-\beta(q_1+q_2+q_3)-w_4-c)\,q_4.\end{aligned}$$

Solving the four first-order conditions yields the following optimal quantities which are also the derived labor demands:

$$\begin{aligned}\widehat{q}_1(\cdot) &= \frac{2+(\beta^2-3\beta)(1-c)+(\beta-\beta^2)(w_3+w_4)+(\beta+\beta^2-2)w_A}{2(\beta-1)\left(-2-3\beta+\beta^2\right)},\\ \widehat{q}_2(\cdot) &= \frac{2(1-c)\beta(\beta-3)+(\beta-\beta^2)(w_3+w_4)+(\beta+\beta^2-2)w_A}{2(\beta-1)\left(-2-3\beta+\beta^2\right)},\\ \widehat{q}_3(\cdot) &= \frac{4-2\beta+4\beta c-\beta^2 c-(4+4\beta-\beta^2)w_3+2\beta w_4+(4\beta-2\beta^2)w_A}{2\left(4+4\beta-5\beta^2+\beta^3\right)}, \text{ and}\\ \widehat{q}_4(\cdot) &= \frac{(4-2\beta)(1-c)+\beta^2 c+2\beta w_3-(4+4\beta-2\beta^2)w_4+(4\beta-2\beta^2)w_A}{2\left(4+4\beta-5\beta^2+\beta^3\right)}.\end{aligned}$$

In the second stage, unions maximize their wage bills by simultaneously setting their wage rates w_A, w_3 and w_4. The wage bills are given by

$$\begin{aligned}U_A(\cdot) &= w_A\left(\widehat{q}_1(\cdot)+\widehat{q}_2(\cdot)\right), \text{ and}\\ U_B(\cdot) &= w_3\widehat{q}_3(\cdot)+w_4\widehat{q}_4(\cdot).\end{aligned}$$

Solving the first-order conditions yields the optimal wage rates

$$\begin{aligned}w_A^{D1} &= \frac{(2-c)\left(2\beta+2-\beta^2\right)}{2(4+\beta(6+\beta))}\\ w_3^{D1} &= \frac{4+\beta(4+\beta(-1+c)+c)}{2(4+\beta(6+\beta))}\\ w_4^{D1} &= \frac{4-4c-\beta(-4+\beta+5c)}{2(4+\beta(6+\beta))}\end{aligned}$$

Using the expressions for w_A^{D1}, w_3^{D1} and w_4^{D1}, we obtain the union wage bills

$$\begin{aligned}U_A^{D1} &= \frac{(\beta+2)(c-2)^2\left(-\beta^2+2\beta+2\right)^2}{4\left(-\beta^2+3\beta+2\right)\left(\beta^2+6\beta+4\right)^2}, \qquad (3.4)\\ U_B^{D1} &= \frac{\left(34\beta^3-10\beta^4-\beta^6+124\beta^2+112\beta+32\right)c^2+(1-c)\left(-2\beta^6+18\beta^5-28\beta^4-80\beta^3+64\beta^2+160\beta+64\right)}{4(4+(-4+\beta)(-1+\beta)\beta)(4+\beta(6+\beta))^2},\end{aligned}$$

and optimal quantities

$$\begin{aligned} q_1^{D1} &= \frac{2c+2\beta+11c\beta-6\beta^2-\beta^3+\beta^4+11c\beta^2-c\beta^3-c\beta^4+4}{2\beta^5+4\beta^4-38\beta^3-16\beta^2+32\beta+16}, \\ q_2^{D1} &= \frac{-6c+2\beta-13c\beta-6\beta^2-\beta^3+\beta^4-5c\beta^2+2c\beta^3+4}{2\beta^5+4\beta^4-38\beta^3-16\beta^2+32\beta+16}, \\ q_3^{D1} &= \frac{12\beta+6c\beta-2\beta^2-5\beta^3+\beta^4+9c\beta^2+c\beta^3-c\beta^4+8}{2\beta^5+2\beta^4-44\beta^3+16\beta^2+80\beta+32}, \text{ and} \\ q_4^{D1} &= \frac{-8c+12\beta-18c\beta-2\beta^2-5\beta^3+\beta^4-7c\beta^2+4c\beta^3+8}{2\beta^5+2\beta^4-44\beta^3+16\beta^2+80\beta+32}. \end{aligned}$$

The final profits of the unmerged firms in country B are given by $\pi_3^{D1} = \left(q_3^{D1}\right)^2$ and $\pi_4^{D1} = \left(q_4^{D1}\right)^2$. The profit of the merged firm in country A is given by

$$\pi_{12}^{D1} = \frac{2(1-c)\left(1-\beta^2\right)\left(-4-6\beta+\beta^3\right)^2+(40+\beta(216+\beta(426+\beta(332+\beta(24+\beta(4+\beta)(-17+3\beta))))))c^2}{4(1-\beta)(-2+(-3+\beta)\beta)^2(4+\beta(6+\beta))^2}.$$

Two domestic mergers (M^{D2}): {12,34} As in the previous industry structure, we solve for an interior solution with all four firms producing a positive output. We will show below that whenever the sufficient condition $c < \overline{c}(\beta)$ is fulfilled, also in the two domestic mergers case all plants produce a positive output. The firms' profit functions are consequently given by

$$\begin{aligned} \pi_{12}(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_A)\,q_1+(1-q_2-\beta(q_1+q_3+q_4)-w_A-c)\,q_2, \text{ and} \\ \pi_{34}(\cdot) &= (1-q_3-\beta(q_1+q_2+q_4)-w_B)\,q_3+(1-q_4-\beta(q_1+q_2+q_3)-w_B-c)\,q_4. \end{aligned}$$

Solving the first-order conditions of the firms' profit maximization problems, the optimal quantities (derived labor demands) are given by:

$$\begin{aligned} \widehat{q}_1(\cdot) &= \frac{2-2\beta-2w_A+3c\beta+2\beta w_B+2\beta^2 w_A-2\beta^2 w_B}{4\beta-8\beta^2+4}, \\ \widehat{q}_2(\cdot) &= \frac{2-2c-2\beta-2w_A-c\beta+2\beta w_B+2\beta^2 w_A-2\beta^2 w_B}{4\beta-8\beta^2+4}, \\ \widehat{q}_3(\cdot) &= \frac{2-2\beta-2w_B+3c\beta+2\beta w_A-2\beta^2 w_A+2\beta^2 w_B}{4\beta-8\beta^2+4}, \text{ and} \\ \widehat{q}_4(\cdot) &= \frac{2-2c-2\beta-2w_B-c\beta+2\beta w_A-2\beta^2 w_A+2\beta^2 w_B}{4\beta-8\beta^2+4}. \end{aligned}$$

In the second stage, unions maximize their wage bills by simultaneously setting their wage rates w_A and w_B. The wage bills are given by

$$\begin{aligned} U_A(\cdot) &= w_A\left(\widehat{q}_1(\cdot)+\widehat{q}_2(\cdot)\right), \text{ and} \\ U_B(\cdot) &= w_B\left(\widehat{q}_3(\cdot)+\widehat{q}_4(\cdot)\right). \end{aligned}$$

Solving the first-order conditions yields the optimal wage rates

$$w_A^{D2} = w_B^{D2} = \frac{2-c}{4+2\beta}.$$

Using the expressions w_A^{D2} and w_B^{D2}, wage bills are given by

$$U_A^{D2} = U_B^{D2} = \frac{(\beta+1)(c-2)^2}{(\beta+2)(2\beta+4)(4\beta+2)}. \tag{3.5}$$

Finally, we obtain optimal quantities

$$\begin{aligned} q_1^{D2} &= q_3^{D2} = \frac{2+c+5\beta c+\beta^2(-2+3c)}{8+12\beta-12\beta^2-8\beta^3}, \\ q_2^{D2} &= q_4^{D2} = \frac{-2+3c+5\beta c+\beta^2(2+c)}{4\left(-2-3\beta+3\beta^2+2\beta^3\right)}, \end{aligned}$$

and firm profits

$$\pi_A^{D2} = \pi_B^{D2} = \frac{-4(-1+\beta)(1+\beta)^3+4(-1+\beta)(1+\beta)^3c+(5+\beta(22+3\beta(11+\beta(6+\beta))))c^2}{8(1-\beta)(2+\beta)^2(1+2\beta)^2}.$$

One efficient symmetric international merger (M^{1Cse}): {13,2,4} Firms' profit functions are given by

$$\begin{aligned} \pi_{13}(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_1)\,q_1+(1-q_3-\beta(q_1+q_2+q_4)-w_3)\,q_3, \\ \pi_2(\cdot) &= (1-q_2-\beta(q_1+q_3+q_4)-w_2-c)\,q_2, \text{ and} \\ \pi_4(\cdot) &= (1-q_4-\beta(q_1+q_2+q_3)-w_4-c)\,q_4. \end{aligned}$$

Solving the four first-order conditions yields the following quantities:

$$\begin{aligned} \widehat{q}_1(\cdot) &= \frac{(2-2w_1+\beta(-3+2c+2w_3+w_2-w_1+w_4-\beta(-1+2c+w_2-w_1+w_4)))}{2\left(2+\beta-4\beta^2+\beta^3\right)}, \\ \widehat{q}_2(\cdot) &= \frac{(-4(-1+c+w_2)+\beta(2(-1+\beta)c-\beta(w_1-2w_2+w_3)+2(-1+w_1-2w_2+w_3+w_4)))}{2(4+(-4+\beta)(-1+\beta)\beta)}, \\ \widehat{q}_3(\cdot) &= \frac{(2-2w_3+\beta(-3+2c+2w_1+w_2-w_3+w_4-\beta(-1+2c+w_2-w_3+w_4)))}{2\left(2+\beta-4\beta^2+\beta^3\right)}, \text{and} \\ \widehat{q}_4(\cdot) &= \frac{(\beta(2(-1+\beta)c-\beta(w_1+w_3-2w_4)+2(-1+w_1+w_2+w_3-2w_4))-4(-1+c+w_4))}{2(4+(-4+\beta)(-1+\beta)\beta)}. \end{aligned}$$

The labor unions' wage bills are given by

$$\begin{aligned} U_A(\cdot) &= w_1\widehat{q}_1(\cdot)+w_2\widehat{q}_2(\cdot), \text{ and} \\ U_B(\cdot) &= w_3\widehat{q}_3(\cdot)+w_4\widehat{q}_4(\cdot). \end{aligned}$$

The unions set wages to maximize their wage bills. Solving the four first-order conditions yields the optimal wage rates:

$$\begin{aligned} w_1^{C1se} &= w_3^{C1se} = \frac{2(1-\beta)(4+\beta(-2+c))}{16+(-12+\beta)\beta}, \\ w_2^{C1se} &= w_4^{C1se} = \frac{(2-\beta)(4-3\beta+2(-2+\beta)c)}{16+(-12+\beta)\beta}, \end{aligned}$$

and union wage bills

$$U_A^{C1se} = U_B^{C1se} = \frac{\left(2\beta^5-16\beta^4+54\beta^3-60\beta^2-32\beta+64\right)c^2+\left(-6\beta^5+38\beta^4-60\beta^3-48\beta^2+192\beta-128\right)c+(5\beta^5-32\beta^4+42\beta^3+84\beta^2-224\beta+128)}{(16-\beta(12-\beta))^2(2+\beta(3-\beta))}.$$

Finally, quantities and firm profits are given by

$$\begin{aligned} q_1^{C1se} &= q_3^{C1se} = \frac{(2-\beta)\left(-8+\beta^2-6\beta c\right)}{2(16+(-12+\beta)\beta)(-2+(-3+\beta)\beta)}, \\ q_2^{C1se} &= q_4^{C1se} = \frac{8(-1+c)+\beta(2+\beta(4+\beta(-1+c)-7c)+4c)}{(16+(-12+\beta)\beta)(-2+(-3+\beta)\beta)}, \end{aligned}$$

$$\begin{aligned} \pi_{13}^{C1se} &= \frac{(-2+\beta)^2(1+\beta)\left(-8+\beta^2-6\beta c\right)^2}{2(16+(-12+\beta)\beta)^2(-2+(-3+\beta)\beta)^2}, \\ \pi_2^{C1se} &= \pi_4^{C1se} = \frac{(8(-1+c)+\beta(2+\beta(4+\beta(-1+c)-7c)+4c))^2}{(16+(-12+\beta)\beta)^2(-2+(-3+\beta)\beta)^2}. \end{aligned}$$

One inefficient symmetric international merger (M^{C1si}): {1,3,24} Firms' profit functions are given by

$$\begin{aligned} \pi_{24}(\cdot) &= (1-q_2-\beta(q_1+q_3+q_4)-w_2-c)\,q_2+(1-q_4-\beta(q_1+q_2+q_3)-w_4-c)\,q_4, \\ \pi_1(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_1)\,q_1, \text{ and} \\ \pi_3(\cdot) &= (1-q_3-\beta(q_1+q_2+q_4)-w_3)\,q_3. \end{aligned}$$

Solving the four first-order conditions yields the following optimal quantities (derived labor demands):

$$\begin{aligned} \widehat{q}_1(\cdot) &= \frac{4-4w_1-\beta^2(2c-2w_1+w_2+w_4)+2\beta(-1+2c-2w_1+w_2+w_3+w_4)}{2(4+(-4+\beta)(-1+\beta)\beta)}, \\ \widehat{q}_2(\cdot) &= \frac{2(1-c-w_2)+\beta(-3+c+w_1-w_2+\beta(1+c-w_1+w_2-w_3)+w_3+2w_4)}{2\left(2+\beta-4\beta^2+\beta^3\right)}, \\ \widehat{q}_3(\cdot) &= \frac{4-4w_3-\beta^2(2c+w_2-2w_3+w_4)+2\beta(-1+2c+w_1+w_2-2w_3+w_4)}{2(4+(-4+\beta)(-1+\beta)\beta)}, \text{ and} \\ \widehat{q}_4(\cdot) &= \frac{2(1-c-w_4)+\beta(-3+c+w_1+2w_2+w_3-w_4+\beta(1+c-w_1-w_3+w_4))}{2\left(2+\beta-4\beta^2+\beta^3\right)}. \end{aligned}$$

The labor unions' wage bills are given by

$$\begin{aligned} U_A(\cdot) &= w_1\widehat{q}_1(\cdot)+w_2\widehat{q}_2(\cdot), \text{ and} \\ U_B(\cdot) &= w_3\widehat{q}_3(\cdot)+w_4\widehat{q}_4(\cdot). \end{aligned}$$

The unions set wages to maximize their wage bills. Solving the four first-order conditions yields the following optimal wage rates:

$$\begin{aligned} w_1^{C1si} &= w_3^{C1si} = \tfrac{(2-\beta)(4+\beta(-3+c))}{16+(-12+\beta)\beta}, \text{ and} \\ w_2^{C1si} &= w_4^{C1si} = \tfrac{2(1-\beta)(4+\beta(-2+c)-4c)}{16+(-12+\beta)\beta}. \end{aligned}$$

Using the results for w_1^{C1si}, w_2^{C1si}, w_3^{C1si} and w_4^{C1si}, we obtain the following optimal union wage bills

$$U_A^{C1si} = U_B^{C1si} = \tfrac{(2-\beta)((\beta^4-8\beta^3+20\beta^2+16\beta-32)c^2+(18\beta^3-4\beta^4+12\beta^2-96\beta+64)c-(22\beta^3-5\beta^4+2\beta^2-80\beta+64))}{(16-12\beta+\beta^2)^2(-2-3\beta+\beta^2)},$$

quantities

$$\begin{aligned} q_1^{C1si} &= q_3^{C1si} = \tfrac{-8+\beta(2-6c+\beta(4-\beta+3c))}{(16+(-12+\beta)\beta)(-2+(-3+\beta)\beta)}, \\ q_2^{C1si} &= q_4^{C1si} = \tfrac{(-2+\beta)(8+\beta^2(-1+c)-8c-6\beta c)}{2(-32-24\beta+50\beta^2-15\beta^3+\beta^4)}, \end{aligned}$$

and profits

$$\begin{aligned} \pi_{24}^{C1si} &= \tfrac{(-2+\beta)^2(1+\beta)(8+\beta^2(-1+c)-8c-6\beta c)^2}{2(16-12\beta+\beta^2)^2(-2-3\beta+\beta^2)^2}, \\ \pi_1^{C1si} &= \pi_3^{C1si} = \tfrac{(8+\beta^3-\beta^2(4+3c)+\beta(-2+6c))^2}{(16-12\beta+\beta^2)^2(-2-3\beta+\beta^2)^2}. \end{aligned}$$

Two symmetric cross-border mergers (M^{C2s}): {13,24} Firms' profit functions are given by

$$\begin{aligned} \pi_{13}(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_1)\,q_1+(1-q_3-\beta(q_1+q_2+q_4)-w_3)\,q_3, \text{ and} \\ \pi_{24}(\cdot) &= (1-q_2-\beta(q_1+q_3+q_4)-w_2-c)\,q_2+(1-q_4-\beta(q_1+q_2+q_3)-w_4-c)\,q_4. \end{aligned}$$

Solving the four first-order conditions yields the optimal quantities:

$$\begin{aligned} \widehat{q}_1(\cdot) &= \tfrac{2(-1+w_1)+\beta^2(2c-w_1+w_2-w_3+w_4)-\beta(-2+2c-2w_1+w_2+2w_3+w_4)}{-4-4\beta+8\beta^2}, \\ \widehat{q}_2(\cdot) &= \tfrac{2(-1+c+w_2)-\beta(-2+w_1-2w_2+w_3+2w_4+\beta(2c-w_1+w_2-w_3+w_4))}{4(-1+\beta)(1+2\beta)}, \\ \widehat{q}_3(\cdot) &= \tfrac{2(-1+w_3)-\beta(-2+2c+2w_1+w_2-2w_3+w_4)+\beta^2(2c-w_1+w_2-w_3+w_4)}{-4-4\beta+8\beta^2}, \text{ and} \\ \widehat{q}_4(\cdot) &= \tfrac{2(-1+c+w_4)-\beta(-2+w_1+2w_2+w_3-2w_4+\beta(2c-w_1+w_2-w_3+w_4))}{4(-1+\beta)(1+2\beta)}. \end{aligned}$$

The labor unions' wage bills are given by

$$\begin{aligned} U_A(\cdot) &= w_1\widehat{q}_1(\cdot)+w_2\widehat{q}_2(\cdot), \text{ and} \\ U_B(\cdot) &= w_3\widehat{q}_3(\cdot)+w_4\widehat{q}_4(\cdot). \end{aligned}$$

The unions set wages to maximize their wage bills. Solving the four first-order conditions yields the optimal wage rates

$$\begin{aligned} w_1^{C2s} &= w_3^{C2s} = \frac{2(1-\beta)(4+\beta(-3+c))}{(-4+\beta)(-4+3\beta)}, \text{ and} \\ w_2^{C2s} &= w_4^{C2s} = \frac{2(1-\beta)(4-3\beta+2(-2+\beta)c)}{(-4+\beta)(-4+3\beta)}. \end{aligned}$$

and the union wage bills

$$U_A^{C2s} = U_B^{C2s} = \frac{-2(4-3\beta)^2\left(-2+\beta+\beta^2\right)+2(4-3\beta)^2\left(-2+\beta+\beta^2\right)c+(-1+\beta)\left(-32+\beta^2(30+(-14+\beta)\beta)\right)c^2}{(4-3\beta)^2(-4+\beta)^2(1+2\beta)}.$$

Finally, quantities and firm profits are given by

$$\begin{aligned} q_1^{C2s} &= q_3^{C2s} = \frac{8+\beta(-2-3\beta+(6+(-4+\beta)\beta)c)}{2(4-\beta)(1+2\beta)(4-3\beta)}, \\ q_2^{C2s} &= q_4^{C2s} = \frac{8-8c-\beta(2+3\beta+(4+(-7+\beta)\beta)c)}{2(4-\beta)(1+2\beta)(4-3\beta)}, \\ \pi_{13}^{C2s} &= \frac{(1+\beta)(8+\beta(-2-3\beta+(6+(-4+\beta)\beta)c))^2}{2(4-3\beta)^2(-4+\beta)^2(1+2\beta)^2}, \text{ and} \\ \pi_{24}^{C2s} &= \frac{(1+\beta)(8(-1+c)+\beta(2+3\beta+(4+(-7+\beta)\beta)c))^2}{2(4-3\beta)^2(-4+\beta)^2(1+2\beta)^2}. \end{aligned}$$

One asymmetric cross-border merger (M^{C1a}): {14,2,3} Firms' profit functions are given by

$$\begin{aligned} \pi_{14}(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_1)\,q_1+(1-q_4-\beta(q_1+q_2+q_3)-w_4-c)\,q_4, \\ \pi_2(\cdot) &= (1-q_2-\beta(q_1+q_3+q_4)-w_2-c)\,q_2, \text{ and} \\ \pi_3(\cdot) &= (1-q_3-\beta(q_1+q_2+q_4)-w_3)\,q_3. \end{aligned}$$

Solving the four first-order conditions yields the optimal quantities:

$$\begin{aligned} \widehat{q}_1(\cdot) &= \frac{2-2w_1+\beta(-3+3c-w_1+w_2+w_3-\beta(-1+c-w_1+w_2+w_3)+2w_4)}{2\left(2+\beta-4\beta^2+\beta^3\right)}, \\ \widehat{q}_2(\cdot) &= \frac{-4(-1+c+w_2)+\beta((-2+\beta)c-\beta(w_1-2w_2+w_4)+2(-1+w_1-2w_2+w_3+w_4))}{2(4+(-4+\beta)(-1+\beta)\beta)}, \\ \widehat{q}_3(\cdot) &= \frac{4-4w_3-\beta^2(c+w_1-2w_3+w_4)+2\beta(-1+2c+w_1+w_2-2w_3+w_4)}{2(4+(-4+\beta)(-1+\beta)\beta)}, \text{ and} \\ \widehat{q}_4(\cdot) &= \frac{\beta(-3+2w_1+w_2+w_3-\beta(-1+w_2+w_3-w_4)-w_4)-2(-1+c+w_4)}{2\left(2+\beta-4\beta^2+\beta^3\right)}. \end{aligned}$$

The labor unions' wage bills are given by

$$\begin{aligned} U_A(\cdot) &= w_1\widehat{q}_1(\cdot)+w_2\widehat{q}_2(\cdot), \text{ and} \\ U_B(\cdot) &= w_3\widehat{q}_3(\cdot)+w_4\widehat{q}_4(\cdot). \end{aligned}$$

The unions set wages to maximize their wage bills. Solving the four first-order conditions yields the following optimal wage rates:

$$\begin{aligned}
w_1^{C1a} &= \frac{-64c\beta+96\beta+136\beta^2-132\beta^3+28\beta^4-8c\beta^2+50c\beta^3-13c\beta^4-128}{7\beta^4-96\beta^3+240\beta^2-256}, \\
w_2^{C1a} &= \frac{128c+64\beta-32c\beta+128\beta^2-106\beta^3+21\beta^4-120c\beta^2+74c\beta^3-12c\beta^4-128}{7\beta^4-96\beta^3+240\beta^2-256}, \\
w_3^{C1a} &= \frac{-32c\beta+64\beta+128\beta^2-106\beta^3+21\beta^4-8c\beta^2+32c\beta^3-9c\beta^4-128}{7\beta^4-96\beta^3+240\beta^2-256}, \text{ and} \\
w_4^{C1a} &= \frac{128c+96\beta-32c\beta+136\beta^2-132\beta^3+28\beta^4-128c\beta^2+82c\beta^3-15c\beta^4-128}{7\beta^4-96\beta^3+240\beta^2-256}.
\end{aligned}$$

Optimal quantities are given by

$$\begin{aligned}
q_1^{C1a} &= \frac{-192\beta+256c\beta-304\beta^2+288\beta^3-22\beta^4-33\beta^5+7\beta^6-80c\beta^2-244c\beta^3+162c\beta^4-23c\beta^5-c\beta^6+256}{-14\beta^7+248\beta^6-1262\beta^5+2084\beta^4+416\beta^3-3008\beta^2+512\beta+1024}, \\
q_2^{C1a} &= \frac{216\beta^3-384c\beta-704\beta^2-512c+196\beta^4-108\beta^5+14\beta^6+736c\beta^2+168c\beta^3-380c\beta^4+120c\beta^5-11c\beta^6+512}{-14\beta^7+262\beta^6-1496\beta^5+3112\beta^4-640\beta^3-4480\beta^2+2048\beta+2048}, \\
q_3^{C1a} &= \frac{384c\beta-704\beta^2+216\beta^3+196\beta^4-108\beta^5+14\beta^6-32c\beta^2-384c\beta^3+184c\beta^4-12c\beta^5-3c\beta^6+512}{-14\beta^7+262\beta^6-1496\beta^5+3112\beta^4-640\beta^3-4480\beta^2+2048\beta+2048}, \text{ and} \\
q_4^{C1a} &= \frac{-256c-192\beta-64c\beta-304\beta^2+288\beta^3-22\beta^4-33\beta^5+7\beta^6+384c\beta^2-44c\beta^3-140c\beta^4+56c\beta^5-6c\beta^6+256}{-14\beta^7+248\beta^6-1262\beta^5+2084\beta^4+416\beta^3-3008\beta^2+512\beta+1024}.
\end{aligned}$$

We can use the results for wage rates and profits to calculate the union wage bills $U_A^{C1a} = w_1^{C1a} \cdot q_1^{C1a} + w_2^{C1a} \cdot q_2^{C1a}$ and $U_B^{C1a} = w_3^{C1a} \cdot q_3^{C1a} + w_4^{C1a} \cdot q_4^{C1a}$ (explicit derivations are omitted here for reasons of space). Finally, the profits of the unmerged firms 2 and 3 are immediately given by $\pi_2^{C1a} = \left(q_2^{C1a}\right)^2$ and $\pi_3^{C1a} = \left(q_3^{C1a}\right)^2$. The merged firm earns a profit of

$$\pi_{14}^{C1a} = \frac{-2\left(\beta^2-1\right)(c-1)\left(-7\beta^5+26\beta^4+48\beta^3-240\beta^2+64\beta+256\right)^2+\phi c^2}{4(-1+\beta)(16+(-12+\beta)\beta)^2(-2+(-3+\beta)\beta)^2(-16+\beta(-12+7\beta))^2},$$

where

$$\begin{aligned}
\phi(\beta) &= \sigma\beta^7+188\,192\beta^6-160\,640\beta^5-218\,880\beta^4+219\,136\beta^3+159\,744\beta^2-98\,304\beta-65\,536, \\
\sigma(\beta) &= 12\beta^5+213\beta^4-4653\beta^3+27\,968\beta^2-64\,620\beta+7568.
\end{aligned}$$

Two asymmetric cross-border mergers (M^{C2a}): {14,23} Firms' profit functions are given by

$$\begin{aligned}
\pi_{14}(\cdot) &= (1-q_1-\beta(q_2+q_3+q_4)-w_1)\,q_1+(1-q_4-\beta(q_1+q_2+q_3)-w_4-c)\,q_4, \\
\pi_{23}(\cdot) &= (1-q_2-\beta(q_1+q_3+q_4)-w_2-c)\,q_2+(1-q_3-\beta(q_1+q_2+q_4)-w_3)\,q_3.
\end{aligned}$$

Solving the four first-order conditions yields the optimal quantities:

$$\begin{aligned}
\widehat{q}_1(\cdot) &= \tfrac{2(-1+w_1)+\beta^2(-w_1+w_2+w_3-w_4)-\beta(-2+3c-2w_1+w_2+w_3+2w_4)}{-4-4\beta+8\beta^2}, \\
\widehat{q}_2(\cdot) &= \tfrac{2(-1+c+w_2)+\beta(2+c-w_1+2w_2-2w_3-w_4)+\beta^2(w_1-w_2-w_3+w_4)}{-4-4\beta+8\beta^2}, \\
\widehat{q}_3(\cdot) &= \tfrac{2(-1+w_3)-\beta(-2+3c+w_1+2w_2-2w_3+w_4)+\beta^2(w_1-w_2-w_3+w_4)}{-4-4\beta+8\beta^2}, \text{ and} \\
\widehat{q}_4(\cdot) &= \tfrac{\beta^2(-w_1+w_2+w_3-w_4)+2(-1+c+w_4)+\beta(2+c-2w_1-w_2-w_3+2w_4)}{-4-4\beta+8\beta^2}.
\end{aligned}$$

The labor unions' wage bills are given by

$$\begin{aligned}
U_A(\cdot) &= w_1\widehat{q}_1(\cdot) + w_2\widehat{q}_2(\cdot), \\
U_B(\cdot) &= w_3\widehat{q}_3(\cdot) + w_4\widehat{q}_4(\cdot).
\end{aligned}$$

The unions set wages to maximize their wage bills. Solving the four first-order conditions yields the optimal wage rates

$$\begin{aligned}
w_1^{C2a} &= w_3^{C2a} = \tfrac{2+\beta(-2+c)}{4-\beta}, \text{ and} \\
w_2^{C2a} &= w_4^{C2a} = \tfrac{2-2\beta-2c+\beta c}{4-\beta}.
\end{aligned}$$

Firms produce the following optimal quantities

$$\begin{aligned}
q_1^{C2a} &= q_3^{C2a} = \tfrac{4-\beta^2(2+c)+\beta(-2+4c)}{4\left(4+3\beta-9\beta^2+2\beta^3\right)}, \text{ and} \\
q_2^{C2a} &= q_4^{C2a} = \tfrac{4-4c-2\beta(1+c)+\beta^2(-2+3c)}{(-4+\beta)\left(-4-4\beta+8\beta^2\right)}.
\end{aligned}$$

The wage bills of the unions are then given by

$$U_A^{C2a} = U_B^{C2a} = \tfrac{\beta^3(-2+c)^2+12\beta(-1+c)-2\beta^2c^2+4(2+(-2+c)c)}{2(-4+\beta)^2(1-\beta)(1+2\beta)}.$$

Finally, firms earn the following profits

$$\pi_{14}^{C2a} = \pi_{23}^{C2a} = \tfrac{3c^2\beta^4-16c^2\beta^3-2c^2\beta^2+16c^2\beta+8c^2+4c\beta^4+16c\beta^3+12c\beta^2-16c\beta-16c-4\beta^4-16\beta^3-12\beta^2+16\beta+16}{-32\beta^5+256\beta^4-488\beta^3-184\beta^2+320\beta+128}.$$

With the explicit solutions to industry structures, we can sketch the proofs of our Chapter . Since all proofs involve large expressions which are hard to include in the text, we restrict ourselves to outlining the relevant comparisons and calculations which need to be performed. All expressions used for these calculations are stated in the previous part of the Appendix.

Proof of Lemma 1 In this Lemma, we show that industry structures involving no or only one merger are always dominated by at least one industry structure involving two mergers for $\beta \in (0,1)$ and $c \in (0, \bar{c}(\beta))$. Thus, we need to compare the profit levels of the decisive owners in the relevant market structures.

- **No merger (M^0):** We can show that M^{D2} *dom* M^0 by considering $\pi_{12}^{D2} - (\pi_1^0 + \pi_2^0) > 0$ and $\pi_{34}^{D2} - (\pi_3^0 + \pi_4^0) > 0$.

- **One domestic merger (M^{D1}):** We can show that M^{D2} *dom* M^{D1} or M^{C2s} *dom* M^{D1} by considering $\pi_{34}^{D2} - (\pi_3^{D1} + \pi_4^{D1}) > 0$ and $\left(\pi_{13}^{C2s} + \pi_{24}^{C2s}\right) - (\pi_{12}^{D1} + \pi_3^{D1} + \pi_4^{D1}) > 0$.

- **One symmetric cross-border merger between the efficient plants (M^{C1se}):** We can show that M^{C2s} *dom* M^{C1se} by considering $(\pi_{24}^{C2s}) - (\pi_2^{C1se} + \pi_4^{C1se}) > 0$.

- **One symmetric cross-border merger between the inefficient plants (M^{C1si}):** We can show that M^{C2s} *dom* M^{C1si} by considering $(\pi_{13}^{C2s}) - (\pi_1^{C1si} + \pi_3^{C1si}) > 0$.

- **One asymmetric cross-border merger (M^{C1a}):** We can show that M^{C2s} *dom* M^{C1a} by considering $(\pi_{13}^{C2s} + \pi_{24}^{C2s}) - (\pi_{14}^{C1a} + \pi_2^{C1a} + \pi_3^{C1a}) > 0$.

Proof of Proposition 1

- **Part (i).** The ranking presented is unique. It is sufficient to show that $w_E^{C2a} - w_E^{C2s} = w_I^{C2s} - w_I^{C2a} = \frac{(2-\beta)\beta c}{(4-\beta)(4-3\beta)}$, and $w_E^{C2s} - w_I^{C2s} = \frac{2(1-\beta)c}{4-3\beta}$ are positive. Obviously, this is the case for $\beta \in (0,1)$ and $c \in (0, \overline{c}(\beta))$.

- **Part (ii).** Since $w_I^{C2s} - w_I^{C2a} > 0$, it is sufficient to show that $w^{D2} - w_I^{C2s} > 0$ holds for $\beta \in (0,1)$.

- **Part (iii).** To rank w_E^{C2s}, w_E^{C2a} and w^{D2}, it is useful to establish the relations bilaterally. First, we can show that there exists a critical value $c_1(\beta)$ such that $w_E^{C2s} - w^{D2} > 0$ if $c > c_1(\beta)$. Second, there exists a critical threshold $c_2(\beta)$ such that $w^{D2} - w_E^{C2s} > 0$ if $c > c_2(\beta)$. A comparison of these thresholds yields $c_1(\beta) > c_2(\beta) > 0$. Finally, we can establish that $w_E^{C2s} - w^{D2} < 0$ and $w^{D2} - w_E^{C2s} > 0$ if $c_1(\beta) > c > c_2(\beta)$.

Proof of Lemma 2 It can be easily checked from the solutions of firm specific output derived previously in this Appendix that $Q^{C2a} = Q^{C2s}$. The inequality $Q^{C2a} - Q^{D2} > 0$ reduces to $\frac{\beta(c-2)}{(-4+\beta)(2+\beta)} > 0$, which holds –given the restrictions on parameters– for all $\beta \in (0,1)$ and $c \in (0, \overline{c}(\beta))$. Equivalently, the inequality $Q^0 - Q^{D2} > 0$ reduces to $\frac{\beta\left(2+3\beta+2\beta^2\right)(2-c)}{8+32\beta+28\beta^2+12\beta^3} > 0$. Since $c < \overline{c}(\beta)$, the inequality is fulfilled for all $\beta \in (0,1)$. For the last part of Lemma 2, we consider the inequality $Q^0 - Q^{C2s} > 0$. It is easily confirmed that the expression on the LHS changes it sign at $\beta = 1/2$. More specifically, the difference $Q^0 - Q^{C2s}$ is positive for $\beta < 1/2$ and negative for $\beta > 1/2$.

Proof of Proposition 2 From Lemma 1, we know that the only candidates for equilibrium industry structures are those structures involving two mergers. In order to determine the EIS, we need to compare bilaterally the profits of the decisive owners in each of the two-merger industry structures against those of the other two structures.

Equilibrium M^{D2}: M^{D2} is the equilibrium industry structure if and only if M^{D2} *dom* M^{C2s} and M^{D2} *dom* M^{C2a}, i.e. $\pi_{12}^{D2} + \pi_{34}^{D2} - (\pi_{13}^{C2s} + \pi_{24}^{C2s}) > 0$ and $\pi_{12}^{D2} + \pi_{34}^{D2} - (\pi_{14}^{C2a} + \pi_{23}^{C2a}) > 0$.

Consider first M^{D2} *dom* M^{C2s}: Substituting the results for profits derived in this Appendix yields an expression which is quadratic in c:

$$\frac{1}{4\left(-2\beta^2+\beta+1\right)\left(3\beta^3-10\beta^2-16\beta+32\right)^2}\delta_1(c,\beta) > 0,$$

where $\delta_1(c,\beta) = r_1c^2 + s_1c + t_1$ and

$$\begin{aligned} t_1 &= 252\beta^6 - 384\beta^5 - 572\beta^4 + 896\beta^3 + 320\beta^2 - 512\beta, \\ s_1 &= 384\beta^5 - 252\beta^6 + 572\beta^4 - 896\beta^3 - 320\beta^2 + 512\beta, \text{ and} \\ r_1 &= 2\beta^9 - 15\beta^8 + 24\beta^7 + 103\beta^6 - 316\beta^5 + 381\beta^4 + 512\beta^3 - 1728\beta^2 + 512\beta + 768. \end{aligned}$$

We see that

$$\frac{1}{4\left(-2\beta^2+\beta+1\right)\left(3\beta^3-10\beta^2-16\beta+32\right)^2} > 0$$

for all $\beta \in (0,1)$. Additionally, we can unambiguously determine the signs of the rest of the terms. We have that $t_1 < 0$ for all $\beta \in (0,1)$ such that $\delta_1(\beta, c) < 0$ when $c \to 0$. Further, $s_1 > 0$ and $r_1 > 0$ for $\beta \in (0,1)$.

The existence of a unique critical value $\widetilde{c}(\beta) > 0$ such that $\delta_1\left(\widetilde{c}\left(\beta\right), \beta\right) = 0$ while $\delta_1(c,\beta) > 0$ for all $c > \widetilde{c}(\beta)$ follows from noting that $\partial^2\delta_1/\partial c^2 = 2r_1 > 0$. Solving the quadratic equation

$$\frac{1}{4\left(-2\beta^2+\beta+1\right)\left(3\beta^3-10\beta^2-16\beta+32\right)^2}\delta_1(c,\beta) = 0$$

yields two real roots, of which only one is feasible and given by

$$\widetilde{c}(\beta) := 2\left(\sqrt{-\frac{\varpi(\beta)}{(\rho(\beta))^2}} + \frac{(4-3\beta)^2(-1+\beta)\beta(1+\beta)(8+7\beta)}{\rho(\beta)}\right)$$

where

$\varpi(\beta) = 126\beta^{15} - 1137\beta^{14} + 2666\beta^{13} + 2809\beta^{12} - 24\,332\beta^{11} + 52\,332\beta^{10} + 12\,100\beta^9 - 265\,636\beta^8 + 267\,360\beta^7 + 380\,080\beta^6 - 614\,272\beta^5 - 147\,968\beta^4 + 454\,656\beta^3 - 20\,480\beta^2 - 98\,304\beta$, and

$\rho(\beta) = 2\beta^9 - 15\beta^8 + 24\beta^7 + 103\beta^6 - 316\beta^5 + 381\beta^4 + 512\beta^3 - 1728\beta^2 + 512\beta + 768.$

Thus, there exists a threshold $\widetilde{c}(\beta)$, which indicates that $\delta_1(c,\beta) > 0$ for all $c > \widetilde{c}(\beta)$. Inspection of this threshold function reveals that $\lim_{\beta\to 0}\widetilde{c}(\beta) = \lim_{\beta\to 1}\widetilde{c}(\beta) = 0$. Furthermore, in the relevant interval of $\beta \in (0,1)$, $\widetilde{c}(\beta)$ is a concave function which reaches a global maximum at $\beta \approx 0.494$.

Finally, we need to ensure that this solution is feasible with respect to Assumption 1. Thus, define $\Delta c_1(\beta) := \overline{c}(\beta) - \widetilde{c}(\beta)$. We need to show that $\Delta c_1(\beta) > 0$ for at least some values of β. We can easily check that $\lim_{\beta\to 0} \Delta c_1(\beta) = 2 - \sqrt{2}$ and $\lim_{\beta\to 1} \Delta c_1(\beta) = 0$. Looking for a numerical solution for $\Delta c_1(\beta) = 0$, we find that $\Delta c_1(\beta) = 0$ for $\beta \approx 0.351 \equiv \widehat{\beta}$. Thus, for all $\beta < \widehat{\beta}$, $\widetilde{c}(\beta) < \overline{c}(\beta)$. Hence, we know that there exists a feasible threshold $\widetilde{c}(\beta)$ such that M^{D2} *dom* M^{C2s} whenever $\widetilde{c}(\beta) < c \leq \overline{c}(\beta)$.

Next, we examine M^{D2} *dom* M^{C2a}, i.e. $\pi_{12}^{D2} + \pi_{34}^{D2} - (\pi_{14}^{C2a} + \pi_{23}^{C2a}) > 0$. We can use the expressions derived in this Appendix, so that we obtain for the LHS of the inequality

$$\frac{1}{4\left(-\beta^2+2\beta+8\right)^2\left(-2\beta^2+\beta+1\right)}\delta_2(c,\beta) > 0,$$

where $\delta_2(c,\beta) = r_2c^2 + s_2c + t_2$ and

$$\begin{aligned} r_2 &= 120\beta + 53\beta^2 - 4\beta^3 - \beta^4 + 48, \\ s_2 &= 32\beta + 28\beta^2 - 32\beta^3 - 28\beta^4, \text{ and} \\ t_2 &= -32\beta - 28\beta^2 + 32\beta^3 + 28\beta^4. \end{aligned}$$

We can easily see that

$$\frac{1}{4\left(-\beta^2+2\beta+8\right)^2\left(-2\beta^2+\beta+1\right)} > 0$$

for $\beta \in (0,1)$. By the same reasoning as above, we can establish that $t_2 < 0$ for all $\beta \in (0,1)$ such that $\delta_2(\beta, c) < 0$ when $c \to 0$, while $s_2 > 0$ and $r_2 > 0$ for $\beta \in (0,1)$. Thus it must be that $\delta_2(c,\beta)$ is a convex function since $\partial^2\delta_2(c,\beta)/\partial c^2 = 2r_2 > 0$ and there must exist a critical thershold $c^+(\beta)$ such that $\delta_2(c^+(\beta),\beta) = 0$ and $\delta_2(c,\beta) > 0$ for $c > c^+(\beta)$. Solving $\delta_2(c,\beta) = 0$ we obtain two real solutions, of which only one is feasible and given by

$$c^+(\beta) := \frac{2\left(-8\beta-7\beta^2+8\beta^3+7\beta^4\right)}{48+120\beta+53\beta^2-4\beta^3-\beta^4} + 4\sqrt{\frac{96\beta+340\beta^2+248\beta^3-259\beta^4-381\beta^5-95\beta^6+37\beta^7+14\beta^8}{\left(-48-120\beta-53\beta^2+4\beta^3+\beta^4\right)^2}}$$

Thus, there exists a threshold $c^+(\beta)$, which indicates that $\delta_2(c,\beta) > 0$ for $c > c^+(\beta)$. Inspecting $c^+(\beta)$ in more detail, we find that $\lim_{\beta\to 0} c^+(\beta) = \lim_{\beta\to 1} c^+(\beta) = 0$, and that $c^+(\beta)$ is a concave function in the relevant parameter range $\beta \in (0,1)$, which reaches a global maximum at $\beta \approx 0.483$.

Again, we need to determine that this threshold is feasible, i.e. that $c^+(\beta) < \overline{c}(\beta)$ for at least some values of β. Thus, define $\Delta c_2(\beta) := \overline{c}(\beta) - c^+(\beta)$, with $\lim_{\beta\to 0} \Delta c_2(\beta) = 2 - \sqrt{2}$ and $\lim_{\beta\to 1} \Delta c_2(\beta) = 0$. It can be verified that $\Delta c_2(\beta) > 0$ for all $\beta < \widehat{\widehat{\beta}}$, with $\widehat{\widehat{\beta}} \approx 0.367$. Thus, M^{D2} *dom* M^{C2a} for $c^+(\beta) < c < \overline{c}(\beta)$.

To establish that M^{D2} is an equilibrium in a given parameter range, we need to show that M^{D2} *dom* M^{C2s} and M^{D2} *dom* M^{C2a} at the same time. From the above considerations, we know that c must not be too small for M^{D2} dominating the other structures. Specifically, we have derived two thresholds on c, which determine when M^{D2} dominates either M^{C2s} ($c > \widetilde{c}(\beta)$) or M^{C2a} ($c > c^{+}(\beta)$). To derive when M^{D2} dominates the other structures *at the same time*, we compare $\widetilde{c}(\beta)$ to $c^{+}(\beta)$ to determine which one of the thresholds is tighter on c. Moreover, for this comparison we only need to consider the feasible parameter range $0 < \beta < \widehat{\beta}$, sind $\widehat{\beta} < \widehat{\widehat{\beta}}$. To this aim, we inspect the expression $\Delta c_3(\beta) := \widetilde{c}(\beta) - c^{+}(\beta)$. Mathematical manipulation reveals that $\Delta c_3(\beta)$ is always positive for $\beta < \widehat{\beta}$. Consequently, for $c > \widetilde{c}(\beta)$, M^{D2} *dom* M^{C2s} and M^{D2} *dom* M^{C2a}.

Equilibrium M^{C2s}: For two symmetric cross-border mergers to be the equilibrium result of the merger formation process, we need to determine when $\pi_{13}^{C2s} + \pi_{24}^{C2s} - (\pi_{12}^{D2} + \pi_{34}^{D2}) > 0$ and $\pi_{13}^{C2s} + \pi_{24}^{C2s} - (\pi_{14}^{C2a} + \pi_{23}^{C2a}) > 0$.

M^{C2s} *dom* M^{D2}: From the previous case we can deduct that for $\beta < \widehat{\beta}$ and $c < \widetilde{c}(\beta)$, it holds that M^{C2s} *dom* M^{D2}. Considering the range $\beta > \widehat{\beta}$, we find that M^{C2s} *dom* M^{D2} for $c < \overline{c}(\beta)$.

M^{C2s} *dom* M^{C2a}: To establish when two symmetric cross-border mergers dominate the two asymmetric cross-border mergers, it must hold that $\pi_{13}^{C2s} + \pi_{24}^{C2s} - (\pi_{14}^{C2a} + \pi_{23}^{C2a}) > 0$. Substitution of the expressions derived in this Appendix and simplifying yields

$$r_4 c^2 > 0,$$

where

$$r_4 = \frac{\beta(\beta-2)^2\left(8\beta^2-\beta^3-24\beta+16\right)}{4(1-\beta)\left(3\beta^2-16\beta+16\right)^2}.$$

Inspection of this term yields that $\lim_{\beta\to 0} r_4 = 0$. The sign of r_4 cannot be determined unambiguously. A numerical solution yields that $r_4 > 0$ for $\beta < 0.912\,62 \equiv \widetilde{\beta}$ and $r_4 < 0$ otherwise. Therefore, we can immediately conclude that M^{C2s} *dom* M^{C2a} if $\beta \in (0, 0.912\,62)$. As there is no restriction on c, it must only hold that $c < \overline{c}(\beta)$.

Equilibrium M^{C2a}: Finally, we can establish when two asymmetric cross-border mergers will result in equilibrium. This is the case whenever $\pi_{14}^{C2a} + \pi_{23}^{C2a} - (\pi_{12}^{D2} + \pi_{34}^{D2}) > 0$ and $\pi_{14}^{C2a} + \pi_{23}^{C2a} - (\pi_{13}^{C2s} + \pi_{24}^{C2s}) > 0$.

The proof for M^{C2a} *dom* M^{D2} and M^{C2a} *dom* M^{C2s} follows from the solutions above. Most simply, we know from the prior case that M^{C2a} *dom* M^{C2s} whenever $\beta > \widetilde{\beta}$ (otherwise, M^{C2s} *dom* M^{C2a}). Further, we know from above considerations that there exists a threshold $c < c^{+}(\beta) < \overline{c}(\beta)$ such that M^{C2a} *dom* M^{D2}.

However, we know that $c^{+}(\beta) < \overline{c}(\beta)$ only for $\beta < \widehat{\widehat{\beta}}$. Thus, for $\beta > \widetilde{\beta}$ it must be that $c < \overline{c}(\beta)$ in order that M^{C2a} *dom* M^{D2}.

Proof of Proposition 3. We define global welfare as the sum of consumer surplus, firm profits and union wage bills. More specifically, denote global welfare in structure M^r to be

$$W^r = V^r - \sum_{i=1}^{4}(p_i^r q_i^r) + \sum_{i=1}^{4}\pi_i^r + U_A^r + U_B^r,$$

where V^r denotes the utility function of a representative consumer in industry structure M^r ($r = 0$, $D1$, $D2$, $C1se$, $C1si$, $C2s$, $C1a$, $C2a$) and, following Singh and Vives (1984), is defined as

$$V^r = \sum_{i=1}^{4} q_i^r - \frac{1}{2}\left(\sum_{i=1}^{4}(q_i^r)^2 + 2\beta\sum_{i=1}^{4}\sum_{j=1}^{4} q_i^r q_j^r\right) + z,$$

where z denotes the outside numeraire good with a normalized price to 1, and $i, j = 1, 2, 3, 4$; $i \neq j$.

The welfare expressions for each industry structure can be calculated using the expressions presented in this Appendix. Through the relevant comparisons of the welfare expressions, the relation established in Proposition 3 and graphically presented in Figure 3-3 can be derived.

Appendix B

In order to obtain an interior solution in each industry structure, we derive a sufficient condition (which implies an upper bound on cost parameter c), which ensures that all plants produce a positive output in every possible industry structure. Most importantly, we need to inspect the incentives of labor unions in structures M^{D1} and M^{D2}, i.e. in industry structures with uniform wages, to raise the wage above some critical level such that the inefficient plant ceases production and exits the market.

The intuition for this consideration ist simple. With a uniform wage, a union is constrained in its wage choice. It can thus decide to set an intermediate uniform wage and obtain wage bill revenue from employment in both plants of the merged firm, or set a high wage, at which the merged firm closes down the inefficient plant. Obviously, the union only receives wage bill revenue from the efficient plant, but can consequently demand a higher wage rate. The higher is the non-labor cost c, the more we move into the direction of such a corner solution.

We begin our analysis by considering industry structure M^{D1}, where we distinguish between the interior solution (four-firm case), which we have derived in Appendix A, and the corner solution (three-firm case). For expositional purposes, denote by $U_j^{D1}|_{F=4}$ and $U_j^{D1}|_{F=3}$ the wage bill of union $j = A, B$ for the respective four- and three-firm cases.

Derivation of the three-firm case in structure M^{D1}

When plant 2 does not produce a positive output, profit functions of the firms are given by

$$\begin{aligned}\pi_1(\cdot) &= (1 - q_1 - \beta(q_3 + q_4) - w_A)q_1, \\ \pi_3(\cdot) &= (1 - q_3 - \beta(q_1 + q_4) - w_3)q_3, \text{ and} \\ \pi_4(\cdot) &= (1 - q_4 - \beta(q_1 + q_3) - w_4 - c)q_4.\end{aligned}$$

Solving the three first-order conditions of the firms' profit maximization problems, we obtain the following quantities

$$\begin{aligned}\widehat{q}_1(\cdot) &= \tfrac{2-\beta+\beta c+\beta w_3+\beta w_4-(2+\beta)w_A}{2\left(2+\beta-\beta^2\right)}, \\ \widehat{q}_3(\cdot) &= \tfrac{2-\beta+\beta c-(2+\beta)w_3+\beta w_4+\beta w_A}{2(2-\beta)(1+\beta)}, \text{ and} \\ \widehat{q}_4(\cdot) &= \tfrac{2-\beta-2c-\beta c+\beta w_3-(2+\beta)w_4+\beta w_A}{2(2-\beta)(1+\beta)}.\end{aligned}$$

Labor unions maximize their wage bills

$$\begin{aligned}U_A(\cdot) &= w_A\widehat{q}_1(\cdot), \text{ and} \\ U_B(\cdot) &= w_3\widehat{q}_3(\cdot) + w_4\widehat{q}_4(\cdot),\end{aligned}$$

by simultaneously setting their wage rates. Solving the first-order conditions yields the following optimal wage rates for the three-firm case:

$$w_A^{D1}|_{F=3} = \frac{4-\beta^2+\beta c}{8-(-4+\beta)\beta}, \tag{3.6}$$

$$w_3^{D1}|_{F=3} = \frac{4\beta-6\beta^2+c\beta^2+16}{32+16\beta-4\beta^2}, \tag{3.7}$$

$$w_4^{D1}|_{F=3} = \frac{-4c-2\beta+c\beta+4}{32+16\beta-4\beta^2}, \tag{3.8}$$

and the union wage bills

$$U_A^{D1}|_{F=3} = \frac{(2+\beta)(4+\beta(-\beta+c))^2}{2(2-\beta)(1+\beta)(-8+(-4+\beta)\beta)^2} \tag{3.9}$$

and

$$U_B^{D1}|_{F=3} = \frac{\left(\beta^5-3\beta^4-24\beta^3+48\beta^2+192\beta+128\right)c^2+\left(64\beta^3-24\beta^4+128\beta^2-192\beta-256\right)c+\left(36\beta^4-48\beta^3-176\beta^2+128\beta+256\right)}{8(2-\beta)(1+\beta)(-8+(-4+\beta)\beta)^2}.$$

We are now able to derive a condition such that all four plants will produce a positive output. To this aim, we examine the incentives of labor union A (or more general, the labor union setting a uniform wage rate) to have two rather than one plant in its country producing a positive output. Naturally, union A will only prefer to set a low wage and have two plants active if and only if $U_A^{D1}|_{F=4} - U_A^{D1}|_{F=3} > 0$. Using (3.4) and (3.9) and simplifying, the LHS is a u-shaped function which has two roots along the real axis. Solving for the two roots, we obtain one feasible solution

$$\overline{c}(\beta) := \frac{2\lambda(\beta)}{\mu(\beta)} - \sqrt{2}\sqrt{\frac{\psi(\beta)}{(\mu(\beta))^2}},$$

with

$$\begin{aligned}
\lambda(\beta) &= -512 - 1920\beta - 2112\beta^2+1016\beta^4+60\beta^5-244\beta^6+62\beta^7+33\beta^8-14\beta^9+\beta^{10}, \\
\mu(\lambda) &= -512 - 1792\beta - 1472\beta^2+1120\beta^3+1736\beta^4+36\beta^5-400\beta^6+46\beta^7+40\beta^8-13\beta^9+\beta^{10}, \\
\psi(\beta) &= 262144 + 2359296\beta + 8716288\beta^2+16285696\beta^3+13783040\beta^4-1695744\beta^5 \\
&\quad -12696576\beta^6-6645760\beta^7+3405056\beta^8+3706368\beta^9-275520\beta^{10}-971520\beta^{11} \\
&\quad -18640\beta^{12}+151872\beta^{13}+332\beta^{14}-13864\beta^{15}+832\beta^{16}+564\beta^{17}-57\beta^{18}-8\beta^{19}+\beta^{20}.
\end{aligned}$$

Note that $\lim_{\beta\to 0}\overline{c}(\beta) = 2-\sqrt{2}$ and $\lim_{\beta\to 1}\overline{c}(\beta) = 0$. Moreover, $\partial\overline{c}(\beta)/\partial\beta < 0$ holds everywhere.

Derivation of the three-firm and two-firm cases in structure M^{D2}

Now, we need to consider industry structure M^{D2}. Results for the interior solution (four-firm case) have been derived in Appendix A. Since in this case both unions set a uniform wage rate, we also need to consider the incentives for either one union or both unions to raise the wage(s) so high that the inefficient plant(s) is (are) closed down. Thus, we consider now the three- and two-firm corner solutions of industry structure M^{D2}. We will derive a condition on c so that both unions will always prefer the interior solution (four plants active) and compare it to the threshold derived from structure M^{D1}.

Again, denote by $U_j^{D2}|_{F=4}$, $U_j^{D2}|_{F=3}$, and $U_j^{D2}|_{F=2}$ the wage bill of a union $j = A, B$ in the four-firm, three-firm and two-firm case of industry structure M^{D2}, respectively.

The three-firm case ($q_1, q_2 > 0$ and $q_3 > 0$, $q_4 = 0$)

Consider the case when plant 4 in country B is closed down. Firms' profit functions are then given by

$$\begin{aligned} \pi_{12}(\cdot) &= (1 - q_1 - \beta q_2 - \beta q_3 - w_A)q_1 + (1 - q_2 - \beta q_1 - \beta q_3 - c - w_A)q_2, \text{ and} \\ \pi_3(\cdot) &= (1 - q_3 - \beta q_1 - \beta q_2 - w_B)q_3. \end{aligned}$$

Solving the three first-order conditions of the firms' profit maximization problems yields the optimal quantities

$$\begin{aligned} \widehat{q}_1(\cdot) &= \frac{4-6\beta+2\beta\beta^2+4\beta c-\beta^2 c-4w_A+4\beta w_A+2\beta w_B-2\beta^2 w_B}{4(1-\beta)\left(2+2\beta-\beta^2\right)}, \\ \widehat{q}_2(\cdot) &= \frac{4-6\beta+2\beta^2-4c+\beta^2 c-4w_A+4\beta w_A+2\beta w_B-2\beta^2 w_B}{4(1-\beta)\left(2+2\beta-\beta^2\right)}, \text{ and} \\ \widehat{q}_3(\cdot) &= \frac{2+\beta c+2\beta w_A-2w_B-2\beta w_B}{2\left(2+2\beta-\beta^2\right)}. \end{aligned}$$

The reduced wage bills of the unions are then given by

$$\begin{aligned} U_A(\cdot) &= w_A\left(\widehat{q}_1(\cdot) + \widehat{q}_2(\cdot)\right), \text{ and} \\ U_B(\cdot) &= w_B\left(\widehat{q}_3(\cdot)\right). \end{aligned}$$

Solving both first-order conditions we obtain as optimal wage rates:

$$\begin{aligned} w_A^{D2}|_{F=3} &= \frac{6\beta-4c-4c\beta-4\beta^2+c\beta^2+8}{16+16\beta-2\beta^2}, \text{ and} \\ w_B^{D2}|_{F=3} &= \frac{2\beta+c\beta-\beta^2+4}{8+8\beta-\beta^2}. \end{aligned}$$

Using the results for $w_A^{D2}|_{F=3}$ and $w_B^{D2}|_{F=3}$, we obtain the union wage bills

$$U_A^{D2}|_{F=3} = \frac{\left(6\beta-4c-4c\beta-4\beta^2+c\beta^2+8\right)^2}{2\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}, \text{ and} \tag{3.10}$$

$$U_B^{D2}|_{F=3} = \frac{(\beta+1)\left(2\beta+c\beta-\beta^2+4\right)^2}{\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}. \tag{3.11}$$

The two-firm case ($q_1, q_3 > 0$ and $q_2, q_4 = 0$)

When both inefficient plants are inactive, the profit functions of the two remaining firms are given by

$$\begin{aligned}\pi_1(\cdot) &= (1 - q_1 - \beta q_3 - w_A)q_1, \text{ and}\\ \pi_3(\cdot) &= (1 - q_3 - \beta q_1 - w_B)q_3.\end{aligned}$$

Solving the two first-order conditions of the firms' profit maximization problems, we obtain the solutions for optimal quantities

$$\begin{aligned}\widehat{q}_1(\cdot) &= \tfrac{2-\beta-2w_A+\beta w_B}{4-\beta^2}, \text{ and}\\ \widehat{q}_3(\cdot) &= \tfrac{2-\beta-2w_B+\beta w_A}{4-\beta^2}.\end{aligned}$$

The unions' wage bills are given by

$$\begin{aligned}U_A(\cdot) &= w_A\widehat{q}_1(\cdot), \text{ and}\\ U_B(\cdot) &= w_B\widehat{q}_3(\cdot).\end{aligned}$$

Solving the two first-order conditions, we obtain the optimal wage rates in the two-firm case:

$$w_A^{D2}|_{F=2} = w_B^{D2}|_{F=2} = \tfrac{2-\beta}{4-\beta},$$

and the wage bills

$$U_A^{D2}|_{F=2} = U_B^{D2}|_{F=2} = \tfrac{2(2-\beta)}{(\beta-4)^2(2+\beta)}. \tag{3.12}$$

We can now inspect under which circumstances a labor union finds it beneficial to reduce a wage rate in order to keep an inefficient plant active in the market. The union wage bills for all three cases are summarized in the following table.

Union A\Union B	$q_3, q_4 > 0$	$q_3 > 0, q_4 = 0$
$q_1, q_2 > 0$	$\frac{(\beta+1)(c-2)^2}{(\beta+2)(2\beta+4)(4\beta+2)}$ $\frac{(\beta+1)(c-2)^2}{(\beta+2)(2\beta+4)(4\beta+2)}$	$\frac{\left(6\beta-4c-4c\beta-4\beta^2+c\beta^2+8\right)^2}{2\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}$ $\frac{(\beta+1)\left(2\beta+c\beta-\beta^2+4\right)^2}{\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}$
$q_1 > 0, q_2 = 0$	$\frac{(\beta+1)\left(2\beta+c\beta-\beta^2+4\right)^2}{\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}$ $\frac{\left(6\beta-4c-4c\beta-4\beta^2+c\beta^2+8\right)^2}{2\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}$	$\frac{2(2-\beta)}{(\beta-4)^2(2+\beta)}$ $\frac{2(2-\beta)}{(\beta-4)^2(2+\beta)}$

Table 3.1

To this aim, start with the two-firm case in the lower right corner. In this case, both inefficient plants (2 and 4) are closed down. Now consider the decision by union A. Given that only plant 3 produces a positive output in country B, union A would earn a higher wage bill when both plants 1 and 2 produce a positive output in country A if and only if

$$U_A^{D2}|_{F=3} - U_A^{D2}|_{F=2} > 0.$$

Using expressions (3.10) and (3.12), this inequality can be written as

$$\left(\frac{\left(6\beta-4c-4c\beta-4\beta^2+c\beta^2+8\right)^2}{2\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}\right)-\left(\frac{2(2-\beta)}{(\beta-4)^2(2+\beta)}\right)>0,$$

where the LHS is quadratic in c. Solving for the roots, we obtain two roots, only one of which is feasible and is given by

$$c^*(\beta):=\frac{2\left(-4-3\beta+2\beta^2\right)}{-4-4\beta+\beta^2}-2\sqrt{\frac{256+640\beta+192\beta^2-416\beta^3-92\beta^4+114\beta^5-20\beta^6+\beta^7}{(2+\beta)\left(16+12\beta-8\beta^2+\beta^3\right)^2}}.$$

Now consider the *three-firm case*, where $q_1, q_3, q_2 > 0$ and $q_4 = 0$. Under which circumstances would union B be willing to deviate in a way such that also plant 4 produces a positive output? This will be the case if and only if

$$U_B^{D2}|_{F=4}-U_B^{D2}|_{F=3}>0.$$

Using expressions (3.5) and (3.11), we can write this inequality as

$$\left(\frac{(\beta+1)(c-2)^2}{(\beta+2)(2\beta+4)(4\beta+2)}\right)-\left(\frac{(\beta+1)\left(2\beta+c\beta-\beta^2+4\right)^2}{\left(2+2\beta-\beta^2\right)\left(8+8\beta-\beta^2\right)^2}\right)>0.$$

Again the LHS is quadratic in c and has two roots, only one is feasible and given by

$$c^{**}(\beta):=2\left(\frac{\varphi(\beta)}{\tau(\beta)}-\sqrt{-\frac{\left(-2-6\beta-3\beta^2+2\beta^3\right)\left(64+160\beta+104\beta^2-4\beta^3-10\beta^4+\beta^5\right)^2}{(-\tau(\beta))^2}}\right)$$

with

$$\begin{aligned}\varphi(\beta)&=128+416\beta+400\beta^2+48\beta^3-50\beta^4+8\beta^5-5\beta^6,\text{ and}\\ \tau(\beta)&=128+384\beta+272\beta^2-112\beta^3-114\beta^4+10\beta^5-\beta^6.\end{aligned}$$

As a next step, we can compare $c^*(\beta)$ and $c^{**}(\beta)$. Using the expressions derived above, it can be checked easily that $c^{**}(\beta) < c^*(\beta)$ for $\beta \in (0,1)$. Thus, for $c < c^{**}(\beta)$ a union always has a unilateral incentive to lower its own wage rate to have both plants in its country produce a positive output, independent of the number of active plants in the rival country.

Comparison of thresholds derived from structures M^{D1} and M^{D2}

We have derived two conditions, one from structure M^{D1} and one from structure M^{D2}, which ensure that within a given industry structure both inefficient plants produce a positive output, because the unions will prefer these cases over the cases where inefficient plants do not produce. We can summarize our previous results as follows

Structure	$q_1, q_2 > 0$ and $q_3, q_4 > 0$
M^{D2}	$c < c^{**}(\beta)$
M^{D1}	$c < \overline{c}(\beta)$

Table 3.2

Thus, to find a sufficient condition such that all plants produce a positive output in **all market structures** we can compare $c^{**}(\beta)$ and $\overline{c}(\beta)$. It can be shown that $\overline{c}(\beta) < c^{**}(\beta)$ for $\beta \in (0, 1)$. Thus, we only consider firm asymmetry within the valid parameter range $c \in (0, \overline{c}(\beta))$ to ensure an interior solution in every possible industry structure.

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Chapter 4

Union–Firm Wage Bargaining Order and Employers' Associations

4.1 Introduction

The organization of wage bargaining institutions has changed dramatically in the past decade and the traditional distinction between "centralized" and "decentralized" collective bargaining regimes has become blurred. Especially, the flexibilization of European labor markets has led to a change in bargaining levels and actors involved, with a clear tendency towards more flexibilization (OECD, 2004). In Germany, for example, the creation of new craft unions has created new forms of negotiation organization in industries, in which some groups of workers possess relatively large bargaining power due to their key function in production or service processes (e.g. pilots, train engine drivers or doctors).[1]

With decentralizing European wage bargaining regimes, negotiation protocols like pattern bargaining can be observed more frequently. This sequential form of negotiation between an industry union and competing downstream firms has been widespread in some US industries (e.g. the US automobile industry). In the United States, pattern bargaining typically is an intra-industry phenomenon where an industry union approaches one firm -the wage-leader- first and then opens negotiations with the competitors. Pattern bargaining in Europe often refers to a regional phenomenon, which can be intra- or inter-industry. Usually, a union starts a collective

[1]Since 2001, eight craft unions were founded in Germany (Bachmann et al., 2012). Although some craft unions existed already before, their rising power in wage bargaining has been a major change to the collective bargaining system in Germany. The first craft union bargaining for its own wage agreement was the association of pilots, *Vereinigung Cockpit*. This advance was a reaction to the creation of an encompassing service union in Germany (*Verdi*), in which the pilots did not perceive their interests to be sufficiently strongly represented. Later on, craft unions for railway engine drivers (*GDL*) and doctors (*Marburger Bund*) followed this leading example (Haucap, 2012).

bargaining round in one certain region and then successively opens negotiations in other regions. However, due to changing traditional collective bargaining structures and the formation of new labor unions, intra-industry patterns according to the US example can be observed in Europe as well. Observing this re-formulation of the traditional organization of union-firm wage bargaining, the questions arise which actor favors which kind of wage bargaining structure and whether there may be some form of bargaining organization which should be preferred over others from a social welfare perspective.

Previous literature on the timing of wage negotiations (Dobson, 1994; Marshall and Merlo, 2004; Creane and Davidson, 2011) has focused on the analysis and comparison of sequential and simultaneous wage bargaining between industry unions and downstream competitors. However, there are alternative constellations which should be considered. In the German passenger railway industry, for example, the craft union *Gewerkschaft Deutscher Lokführer* (GDL), which organizes approximately 34,000 members in total and roughly 75 percent of the employed train engine drivers in Germany,[2] conducts sequential bargaining with the incumbent railway company Deutsche Bahn AG first, and afterwards approaches the smaller competitors which have entered the market after the liberalization of European railway markets. During recent negotiations, the GDL repeatedly called for the creation of an industry employers' association with whom it could bargain over an industry-wide wage. So far, the incumbent as well as the smaller competitors have refused this proposal.[3]

This example highlights two interesting features related to the structure of collective wage negotiations. First, rather counter-intuitively the union calls for the creation of an employers' association, thereby demanding a strong bargaining partner on the other side. Second, firms refuse this offer, contrasting the common wisdom that firms (at least firms enjoying more market power) should have an incentive to form an association to counter union power.[4]

Previous literature on the timing and organization of wage bargaining has primarily focused on firm-level bargaining, neglecting the possibility that firms may join into an association to form a strong bargaining partner. Therefore, this chapter contributes to the discussion on preferences of actors involved in collective bargaining and analyzes the incentives of firms and a labor union for different bargaining modes when firms have the option to form such an employers' association.

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[2]See Bispinck and Dribbusch (2008) and "Lokführer drohen mit Arbeitskampf", *Handelsblatt*, 24 January 2010, online article (available at http://www.handelsblatt.com/unternehmen/handel-dienstleister/deutsche-bahn-lokfuehrer-drohen-mit-arbeitskampf/3352560.html).

[3]See, for example, "Lokführer-Löhne: Deutsche Bahn und GDL einigen sich in Tarifstreit", *Der Spiegel*, 2011, online article (available at http://www.spiegel.de/wirtschaft/soziales/lokfuehrer-loehne-deutsche-bahn-und-gdl-einigen-sich-in-tarifstreit-a-757345.html).

[4]There exists surprisingly little literature on the role of employers' associations. In two seminal contributions, Haucap et al. (2000, 2001) study the incentives of employers' associations to raise rivals' costs by applying coverage extension rules to induce a "cartelization effect" in the product market. Heidhues (2000) shows that firms' should always have an incentive to form an employers' association to counter union power in an efficient bargaining model.

We consider a model with two downstream firms, in which an incumbent and an entrant firm compete in Stackelberg-quantity competition.[5] The firms bargain with an industry labor union over wage rates. We model this negotiation using the cooperative Nash bargaining solution and differentiate between different forms of bargaining structures: Negotiations can take place either sequentially, simultaneously, or jointly, when the firms form an employers' association. In this instance, a uniform industry-wide wage is negotiated.

Our analysis specifically takes into account the critical role of disagreement payoffs in simultaneous bargaining and explores how different formulations of union disagreement payoffs influence the preferences of unions and downstream firms for bargaining structures. Previous literature on bargaining in vertically related industries (Horn and Wolinsky, 1988; Dobson, 1994; Iozzi and Valletti, 2013) highlights the importance of this modelling choice. Iozzi and Valletti (2013) use the Nash bargaining solution to compare different specifications of outside options of an upstream agent in simultaneous bargaining in vertically related markets. More precisely, the authors distinguish between cases where downstream firms can observe the breakdown of negotiations between the supplier and a rival firm ("Reaction") and those where it is not observed ("No Reaction"). The observation of breakdown influences the off-equilibrium conduct of the downstream firms in product market competition. In short, in the case of *Reaction* firms adjust their output decision off-equilibrium by producing their monopoly outputs, while they continue to produce their optimal oligopoly quantities in the case of *No Reaction*. Intuitively, the formulation of an outside option may affect the attractiveness of this type of bargaining structure. We therefore do not only distinguish between different sequences of negotiation, but also between different forms of off-equilibrium behavior of firms to model simultaneous bargaining.

We show that, when bargaining is sequential, both the union and the incumbent firm have an incentive to bargain first with each other. However, the most preferred bargaining mode for the union is a negotiation with an employers' association. In contrast, this is never preferred by the firms. The incumbent prefers wage-leadership in sequential negotiations, or simultaneous bargaining when a possible breakdown of negotiations is not observed by rivals. The entrant firm, on the other hand, always prefers sequential bargaining being the wage-leader.

In an extension of our model, we analyze merger incentives of the downstream firms, which depend on the alternative bargaining order in the industry. If there is an employers' association or simultaneous bargaining, with breakdowns observed, a merger is always profitable for the firms. In contrast, for sequential or simultaneous bargaining without the observation of breakdown, firms almost never have an incentive to monopolize the downstream market.

[5] We have in mind an industry which has been liberalized lately and thus exhibits an asymmetric form of market organization of an incumbent and smaller competitors, as, for example, railway markets in Europe.

The remainder of this chapter is organized as follows. The following section gives an overview of the related literature on bargaining order in vertically related industries. In Section 4.3, the model is presented and the different bargaining regimes considered are analyzed. Section 4.4 provides the main results of the analysis by exploring the union's and firms' preferences for different bargaining structures. In Section 4.5, we extend our model by looking at the incentives for firms to merge. Welfare implications of different negotiation orders are given in Section 4.6. Finally, Section 4.7 concludes and provides an outlook for future research.

4.2 Related Literature

There exists a limited amount of literature which examines the impact of bargaining order between one upstream agent (supplier or union) and multiple downstream firms.[6] Our analysis is most closely related to Dobson (1994), who compares sequential and simultaneous bargaining between an industry union and symmetric downstream Cournot duopolists. Bargaining is modelled using the cooperative Nash bargaining solution. The model uses four different specifications of union disagreement payoffs for the simultaneous setting, ranging from a zero disagreement point to a "free choice" disagreement payoff, which induces a sequential outcome. The intermediate cases consider *Reaction* and *No Reaction*. When firms have identical bargaining power, the most preferred bargaining structure by the union depends on this specification of disagreement payoffs in the simultaneous setting.

The analysis shows that the attractiveness of sequential bargaining for the union decreases in its possible disagreement payoff in the simultaneous setting. The union prefers sequential bargaining only when its disagreement point is realtively weak in the simultaneous bargaining environment (zero or *No Reaction*). Intuitively, the union is in a better bargaining position in the simultaneous setting the stronger its disagreement payoff becomes (*Reaction* or "free choice").

In the case of asymmetric bargaining power of the downstream firms, the union always prefers to approach the weaker firm (with less bargaining power) first in sequential negotiations since it can achieve a relatively higher wage with this firm. As wages are strategic complements, the wage agreed upon in the second bargaining round will be relatively higher as well. Firms' interests are usually opposed to those of the union. However, the firm which is approached first in sequential negotiations prefers this role, as the bargaining power of the union is weaker due to a lower disagreement utility in the first bargaining round.

Marshall and Merlo (2004) extend the previous paper by considering asymmetric downstream firms which differ according to their labor productivities. Additionally, they distinguish between pattern bargaining (in costs and in wages) and sequential

[6] There are several analyses of optimal bargaining order between one downstream firm and multiple sellers. See, for example, Marx and Shaffer (2007, 2010) and Krasteva and Yildirim (2012).

bargaining. Pattern bargaining here implies a sequential form of negotiation in which the union approaches one firm first and negotiates an industry-wage. Once the wage is settled, the union approaches the second firm and makes a take-it or leave-it offer of the previously determined wage rate to the firm. This structure is contrasted to pure sequential bargaining, where the union successively approaches the two firms and bargains with both of them over firm-specific wage rates. The two previous bargaining structures are compared to simultaneous bargaining. The main result of Marshall and Merlo (2004) is that the union always prefers pattern bargaining over the two other structures. When firms are sufficiently homogeneous, the union prefers a pattern as to equalize wages, whereas, for stronger asymmetries, the union induces a pattern to equalize marginal production costs of the firms. The authors do not distinguish between different types of union disagreement payoffs in the simultaneous setting. Instead, they only focus on the case of disagreement payoffs based on monopoly output levels.

A related study is Creane and Davidson (2011), who focus on the alignment of interests between an industry union and two downstream firms. The authors extend the analysis by Marshall and Merlo (2004) by introducing ex-ante uncertainty about the relative efficiency of each firm when firms differ according to either production efficiency or non-labor costs. Since simultaneous bargaining is never preferred by the union in Marshall and Merlo (2004), this paper compares preferences for either pattern bargaining or sequential bargaining of firms and the union. A major result is that firms as well as the union prefer pattern bargaining, irrespective of the target being chosen, when firm asymmetry in non-labor costs is sufficiently large. Due to the uncertainty about the ex-post relative position in downstream competition firms may also prefer pattern bargaining since it can yield higher expected profits to the more efficient firm than sequential bargaining.

Our model is also related to Horn and Wolinsky (1988), who examine bargaining over input prices (or wages) between two vertical chains and compare the outcome to a situation in which an industry supplier bargains simultaneously with the two identical downstream firms. Modelling simultaneous bargaining between the merged supplier and the firms, the authors take the approach of *No Reaction* in the case of disagreement. Considering downstream merger incentives, they show that a downstream merger is never profitable when there is a common industry supplier and products are substitutes, since it weakens the bargaining position of the merged firm vis-à-vis the supplier. The authors also consider the case of sequential (asymmetric) bargaining of the industry supplier. However, they do not compare the merger incentives to this change in bargaining structure.

We extend this literature by constructing a model where downstream competition takes place between an incumbent and an entrant firm in the form of Stackelberg-quantity competition. We compare different forms of bargaining structures, namely sequential and simultaneous bargaining, and additionally allow for downstream firms to either form an employers' association or merge to monopoly. So far, these options have not been considered in the previous literature on the organization of union-firm wage bargaining. We highlight the preferences of firms and the labor union for each form of negotiation structure and explicitly take into account that the attractiveness of simultaneous bargaining may depend on the option whether downstream firms react to the breakdown of negotiations between the union and a rival.

4.3 The Model

We consider a downstream duopoly industry with two firms, $i = 1, 2$, each producing one brand of a differentiated product. Firm i produces quantity q_i of brand i. Following Singh and Vives (1984), the system of demand functions is derived from the utility function of a representative consumer, which is specified as

$$V = \sum_{i=1}^{2} q_i - \frac{1}{2}\left[\sum_{i=1}^{2} q_i^2 - 2\gamma\left(\sum_{i=1}^{2}\sum_{j=1}^{2} q_i q_j\right)\right] + z, \text{ and } i \neq j, \tag{4.1}$$

where z defines the numeraire, or "outside" good, with a normalized price of 1. Product differentiation is measured by parameter $\gamma \in (0, 1]$, where $\gamma \to 0$ means that demand for the brands becomes virtually independent and $\gamma \to 1$ refers to the case where brands become perfect substitutes. This form of presentation of downstream competition is also helpful to understand pattern bargaining in intra-industry as well as regional terms. When products become less substitutable, i.e. $\gamma \to 0$, bargaining can be interpreted as a regional mode, in which a central union bargains successively with firms in different regions which do not necessarily interact in the product market. Following from (4.1), inverse demand for brand i is linear and given by $p_i(q_i, q_j) = 1 - q_i - \gamma q_j$, for $i, j = 1, 2$ and $i \neq j$.

Both firms use labor l_i as their only input and produce their output according to a constant returns to scale production technology, $q_i = l_i$. For each unit of labor, firm i pays a constant wage w_i. The profit of firm i is given by

$$\pi_i = p_i(l_i, l_j)l_i - w_i l_i, \; i, j = 1, 2 \text{ and } i \neq j.$$

We assume that downstream competition takes place as a Stackelberg quantity-setting game. Therefore, we assume that firm 1 is the Stackelberg leader, resembling the incumbent in the industry, whereas firm 2 behaves as a Stackelberg follower. We will refer to firm 1 therefore as the incumbent, and to firm 2 as the entrant firm.

There exists a labor union, which organizes all workers in the industry. The wage bill of the labor union is given by

$$U = (w_1 - \overline{w})l_1 + (w_2 - \overline{w})l_2, \tag{4.2}$$

where $\overline{w}$ is the reservation wage a worker can obtain by being employed outside this industry. For simplicity, we normalize $\overline{w}$ to zero.

We follow Oswald (1982) and related previous work and model union-firm interaction by the right-to-manage approach. Specifically, this approach stipulates that the labor union and the firm jointly determine a wage rate, while the right to set the level of employment is retained by the firm. Negotiations between the union and each firm are modelled using the symmetric Nash bargaining solution, which is the standard approach in modelling this type of negotiations and has been adopted in previous work on the organization of wage bargaining.[7]

We analyze a sequential game which consists of three stages. In stage 1 (the bargaining stage), bargaining takes place between the labor union and the two downstream firms. Depending on the bargaining regime in place, the union bargains either simultaneously, sequentially or jointly with the two firms. If bargaining is sequential, the union approaches one of the firms, the wage leader, in stage 1a, and then successively approaches the second firm in stage 1b. Given the outcome of the bargaining stage(s), the product market game follows. As we model competition between the downstream firms as a Stackelberg quantity game, the incumbent firm sets its quantity q_1 in stage 2. Observing the quantity choice of the incumbent, the entrant firm chooses q_2 in stage 3.

The aim of this model is to analyze the preferences of firms and the labor union for different types of wage negotiation regimes, which are often observed in different kinds of industries with union power. In detail, we consider five different negotiation scenarios:

1. SEQ_1: First, the union negotiates with the incumbent over w_1 in stage 1a. Observing the outcome of this bargaining round, the union then bargains with the entrant firm over w_2 in stage 1b.

2. SEQ_2: First, the union negotiates with the entrant firm over w_2 in stage 1a. Observing the outcome of this bargaining round, the union then bargains with the incumbent over w_1 in stage 1b.

3. SIM_{NR}: The union bargains simultaneously with the incumbent and the entrant firm over w_1 and w_2. In the case of negotiation breakdown between the union and firm i, firm j operates on its anticipated Stackelberg output level (*No Reaction*).

4. SIM_R: The union bargains simultaneously with the incumbent and the entrant firm over w_1 and w_2. In the case of negotiation breakdown between the union and firm i, firm j operates on its monopoly output level (*Reaction*).

5. EA: The two firms form an employers' association. The union bargains with the association over a common industry wage $\widehat{w}$.

We assume that the outcome of each bargaining round is observable by all parties. The game is solved by backward induction for a subgame perfect Nash equilibrium.

[7] As has been shown by Binmore et al. (1986), this cooperative bargaining approach can be interpreted as a limiting case to the sequential, non-cooperative bargaining process proposed by Rubinstein (1982) in bilateral negotiations.

4.3.1 Product Market Equilibrium

The two firms compete in Stackelberg quantity competition. Solving backwards, we first analyze the quantity choice of the entrant firm, which solves

$$l_2^*(l_1) = \arg\max_{l_2 \geq 0} \left(1 - l_2 - \gamma l_1\right) l_2 - w_2 l_2.$$

Solving the first-order condition yields the employment level of the entrant firm,

$$l_2^*(l_1) = \frac{1 - 2w_2 - \gamma l_1}{2}. \tag{4.3}$$

The incumbent anticipates the choice of the entrant firm. Substituting $l_2^*(l_1)$ into the profit function of the incumbent, it chooses

$$l_1^* = \arg\max_{l_1 \geq 0} \left(1 - l_1 - \gamma \frac{1 - 2w_2 - \gamma l_1}{2}\right) l_1 - w_1 l_1.$$

Solving the first-order condition yields the optimal employment choice of the incumbent, which depends on the previously negotiated wage levels

$$l_1^*(w_1, w_2) = \frac{2 - \gamma - 2w_1 + \gamma w_2}{2(2 - \gamma^2)}. \tag{4.4}$$

Substituting (4.4) back into (4.3) yields the optimal employment choice of the entrant firm,

$$l_2^*(w_1, w_2) = \frac{4 - 4w_2 - \gamma\left(2 + \gamma - 2w_1 + \gamma w_2\right)}{4(2 - \gamma^2)}. \tag{4.5}$$

Using (4.4) and (4.5), reduced profit functions can be written as

$$\pi_1^*(w_1, w_2) = \frac{2 - \gamma^2}{2}\left[l_1^*(w_1, w_2)\right]^2 \tag{4.6}$$

for the incumbent, and

$$\pi_2^*(w_1, w_2) = \left[l_2^*(w_1, w_2)\right]^2 \tag{4.7}$$

for the entrant firm.

4.3.2 Bargaining Structures

In the following, we examine the five possible bargaining structures presented in the previous Section.

Sequential Bargaining (SEQ$_i$)

In the sequential bargaining structure the union approaches one firm i ($i = 1, 2$) first, the wage-leader, and bargains over the firm-specific wage w_i. When this negotiation is settled, the union moves on to bargain with firm j, $j \neq i$, over w_j. Since the downstream firms in this model differ with respect to their relative positions in the product market, the two cases –whether the union approaches the incumbent or the entrant firm first– are not equivalent. We begin by presenting the case where the union bargains with the incumbent first.

SEQ$_1$: The Incumbent as the Wage-Leader. We solve the game by backward induction and therefore begin our analysis in the bargaining stage $1b$, where the union and the entrant firm bargain over w_2. The Nash product for this bargaining problem is given by

$$\prod\nolimits_2^{SEQ_1}(\overline{w}_1, w_2) = \left[U^{SEQ_1}(\overline{w}_1, w_2) - U_D^{SEQ_1}(\overline{w}_1)\right]^{\frac{1}{2}} \left[\pi_2^*(\overline{w}_1, w_2)\right]^{\frac{1}{2}},$$

where $U_D^{SEQ_1}(\overline{w}_1)$ denotes the disagreement payoff obtained by the union if the negotiations with the entrant firm fail. In that case, the entrant firm does not produce and the incumbent becomes a downstream monopolist and chooses in stage 2

$$l_{1D}^* = \arg\max_{l_{1D} \geq 0} \left(1 - l_{1D} - \overline{w}_1\right) l_{1D}.$$

Solving the first-order condition yields the optimal monopoly employment choice of the incumbent,

$$l_{1D}^*(\overline{w}_1) = \frac{1 - \overline{w}_1}{2}. \tag{4.8}$$

Using (4.8), the wage bill of the union in case of disagreement with the entrant firm in bargaining structure SEQ_1 is given by

$$U_D^{SEQ_1}(\overline{w}_1) = \frac{\overline{w}_1 \left(1 - \overline{w}_1\right)}{2}. \tag{4.9}$$

Note that the disagreement payoff $U_D^{SEQ_1}(\overline{w}_1)$ depends on $\overline{w}_1$, i.e. the wage rate negotiated between the union and the incumbent in stage $1a$. Since bargaining between them has happened already when the union bargains with the entrant firm, there will be no alternative disagreement wage in the case of bargaining failure. The disagreement payoff of the entrant is zero, as there is no alternative source of labor supply for the firm. It cannot produce a positive output when negotiations with the industry union fail.

Thus, the wage rate $w_2^{SEQ_1}$ negotiated between the union and the entrant firm solves

$$w_2^{SEQ_1}(\overline{w}_1) = \arg\max_{w_2 \geq 0} \prod\nolimits_2^{SEQ_1}(\overline{w}_1, w_2). \tag{4.10}$$

In stage $1a$, the union negotiates with the incumbent, which is the wage-leader in this case. The bargaining pair anticipates the outcome of the negotiations with the entrant firm in stage $1b$. The Nash product describing the bargaining problem is given by

$$\prod_1^{SEQ_1}\left(w_1, w_2^{SEQ_1}(w_1)\right) = \left[U^{SEQ_1}(w_1, w_2^{SEQ_1}(w_1))\right]^{\frac{1}{2}} \left[\pi_1^*(w_1, w_2^{SEQ_1}(w_1))\right]^{\frac{1}{2}}.$$

In the first negotiation round the disagreement points of the union and the incumbent are zero. We follow Dobson (1994) in using the *impasse point* (Binmore et al., 1989) as disagreement payoff for the two bargaining parties. Thus, we suppose that the union can only start negotiations with the entrant firm in stage $1b$ if and only if an agreement with the wage-leader in stage $1a$ has been reached. If, otherwise, the union and the incumbent do not reach an agreement forever, then both parties obtain a payoff of zero in expected terms, which is the *impasse point* in the sequential Rubinstein game (1982).[8]

The wage $w_1^{SEQ_1}$ then solves

$$w_1^{SEQ_1} = \arg\max_{w_1 \geq 0} \prod_1^{SEQ_1}\left(w_1, w_2^{SEQ_1}(w_1)\right). \tag{4.11}$$

SEQ$_2$: The Entrant Firm as the Wage-Leader. Now we consider the case in which the union bargains first with the entrant firm and afterwards it enters into negotiations with the incumbent. Again, the structure is solved by backward induction. We begin with the bargaining problem between the incumbent and the labor union in stage $1b$. The Nash product is given by

$$\prod_1^{SEQ_2}(w_1, \overline{w}_2) = \left[U^{SEQ_2}(w_1, \overline{w}_2) - U_D^{SEQ_2}(\overline{w}_2)\right]^{\frac{1}{2}} \left[\pi_1^*(w_1, \overline{w}_2)\right]^{\frac{1}{2}}.$$

As before, the disagreement payoff of the firm is zero, as it has no alternative labor supply source than the industry union. In contrast, the union's disagreement point is positive and given by $U_D^{SEQ_2}(\overline{w}_2)$. In case negotiations with the incumbent fail, it has still generated wage bill revenue in the negotiation with the wage-leader in stage $1a$. The entrant firm, however, would operate as a downstream monopolist in this case. Analogously to the previous case, the entrant firm will set its optimal monopoly labor demand

$$l_{2D}^*(\overline{w}_2) = \frac{1 - \overline{w}_2}{2}. \tag{4.12}$$

[8] An alternative specification of this disagreement point is to assume that the union can exit the first negotiation round and immediately approach the next firm. In this case the union may have a valuable outside option.

The wage bill in the case of disagreement with the incumbent is consequently given by

$$U_D^{SEQ_2}(\overline{w}_2) = \frac{\overline{w}_2\,(1-\overline{w}_2)}{2}. \tag{4.13}$$

The wage rate $w_1^{SEQ_2}$ solves

$$w_1^{SEQ_2}(\overline{w}_2) = \arg\max_{w_1 \geq 0} \prod\nolimits_1^{SEQ_2}(w_1, \overline{w}_2). \tag{4.14}$$

In stage $1a$, the union and the entrant firm bargain over the wage rate w_2 anticipating the outcome of the negotiations between the union and the incumbent in stage $1b$. The Nash product for the bargaining problem is given by

$$\prod\nolimits_2^{SEQ_2}\left(w_1^{SEQ_2}(w_2), w_2\right) = \left[U^{SEQ_2}\left(w_1^{SEQ_2}(w_2), w_2\right)\right]^{\frac{1}{2}}\left[\pi_2^*\left(w_1^{SEQ_2}(w_2), w_2\right)\right]^{\frac{1}{2}}.$$

With the same reasoning as above, the disagreement payoff of the union in the first round is again zero. Naturally, the entrant firm does not have a positive disagreement payoff either, since it has no alternative supply option. Thus, the wage rate $w_2^{SEQ_2}$ solves

$$w_2^{SEQ_2} = \arg\max_{w_2 \geq 0} \prod\nolimits_2^{SEQ_2}\left(w_1^{SEQ_2}(w_2), w_2\right). \tag{4.15}$$

Simultaneous Bargaining (SIM)

In the simultaneous bargaining structure, the union bargains with the firms at the same time, though independently. That is, each bargaining pair, union and firm i, with $i = 1, 2$, cooperatively determines the wage rate w_i, taking the outcome of the other simultaneous negotiation round as given. The bargaining problem between the union and each firm i can be described by the following Nash product,

$$\prod\nolimits_i^{SIM}\left(w_i, w_j^{SIM}\right) = \left[U^{SIM}\left(w_i, w_j^{SIM}\right) - U_{iD}^{SIM}\right]^{\frac{1}{2}}\left[\pi_i^*\left(w_i, w_j^{SIM}\right)\right]^{\frac{1}{2}},$$

with $i = 1, 2$ and $i \neq j$. The disagreement payoff of each firm is again zero. Each disagreement payoff of the union U_{iD}^{SIM} is non-negative. Its form is, however, not immediately obvious, but depends on the assumption regarding the behavior of firm j in case negotiations between the union and firm i break down. Naturally, U_{iD}^{SIM} will be positive as long as firm j will produce a positive level of output off-equilibrium and will employ at least some workers at wage w_j^{SIM}. Following Iozzi and Valletti (2013), we distinguish between two cases, namely *No Reaction* and *Reaction*.

In the first instance, firm j produces its anticipated Stackelberg output. This assumption is realistic when firm j believes that bargaining between the union and firm i will continue despite of disagreement (for example, after a period of strikes) or when firm j simply is not informed about the state of the parallel negotiation round (for example because of a no disclosure agreement between the union and firm i). In either way, firm j believes that agreement between the union and firm i is *eventually reached* in the future.

Second, we consider the case of *Reaction*. In this instance, firm j observes the breakdown of the simultaneous negotiation round, for example because it is publicly announced, and seizes the opportunity to expand its output to the optimal monopoly level.[9] Comparing these two options, one should expect that the relative bargaining position of the union increases in U_{iD}^{SIM}.

Intuitively, there may be examples of both occasions in wage bargaining. Although there are often public announcements on the state of negotiations, there are other situations where the bargaining parties decide not to disclose any information on their position in the bargaining process. Thus, it may be difficult for the competing firms to react and adjust their outputs, or they do not react immediately because agreement is assumed to be reached in the future. In the following, we present the formal description of the two cases.

SIM$_{NR}$: No Reaction. First, we consider the case of *No Reaction*. In this case, the breakdown of negotiations between firm i and the union is not observed by firm j. Thus, off equilibrium, firm j will always operate on its anticipated Stackelberg quantity level. Using (4.4) and (4.5), the output produced by each firm in the case of disagreement is given by

$$\begin{aligned} l_{1D}^{SIM_{NR}}\left(w_1^{SIM_{NR}}, w_2^{SIM_{NR}}\right) &= \frac{2-\gamma-2w_1^{SIM_{NR}}+\gamma w_2^{SIM_{NR}}}{2(2-\gamma^2)}, \text{ and} \\ l_{2D}^{SIM_{NR}}\left(w_1^{SIM_{NR}}, w_2^{SIM_{NR}}\right) &= \frac{4-4w_2^{SIM_{NR}}-\gamma\left(2+\gamma-2w_1^{SIM_{NR}}+\gamma w_2^{SIM_{NR}}\right)}{4(2-\gamma^2)}, \end{aligned}$$

for the incumbent and the entrant firm, respectively. The disagreement payoff of the union in the negotiation with firm i is then

$$U_{iD}^{SIM_{NR}}\left(w_i^{SIM_{NR}}, w_j^{SIM_{NR}}\right) = w_j^{SIM_{NR}} l_{jD}^{SIM_{NR}}\left(w_i^{SIM_{NR}}, w_j^{SIM_{NR}}\right), \ i,j=1,2 \text{ and } i \neq j. \tag{4.16}$$

The wage $w_i^{SIM_{NR}}$ solves

$$w_i^{SIM_{NR}} = \arg\max_{w_i \geq 0} \prod\nolimits_i^{SIM_{NR}}\left(w_i, w_j^{SIM_{NR}}\right). \tag{4.17}$$

SIM$_R$: Reaction For the case of reaction, we assume that firms observe the negotiation breakdown and adjust their quantities in the quantity setting stage by

[9] Note here the difference to the formulation of union disagreement payoffs in the sequential structure(s). For the sequential structure(s), bargaining in stage $1b$ only begins after negotiations in stage $1a$ are finished. In this case, the firm which negotiates in stage $1b$ always *knows* whether there has been an agreement in stage $1a$. This is, in contrast, not necessarily the case for simultaneous bargaining.

setting their monopoly quantities off equilibrium. Using (4.8) and (4.12) for the incumbent and the entrant firm, respectively, the output choice of firm j for *Reaction* in the case of disagreement is then given by

$$l_{jD}^{SIM_R}\left(w_j^{SIM_R}\right) = \frac{1 - w_j^{SIM_R}}{2},\ j = 1, 2.$$

Consequently, the disagreement payoff of the union when negotiating with firm i is

$$U_{iD}^{SIM_R}\left(w_j^{SIM_R}\right) = w_j^{SIM_R} l_{jD}^{SIM_R}\left(w_j^{SIM_R}\right),\ i, j = 1, 2 \text{ and } i \neq j. \tag{4.18}$$

The wage $w_i^{SIM_R}$ solves

$$w_i^{SIM_R} = \arg\max_{w_i \geq 0} \prod\nolimits_i^{SIM_R}\left(w_i, w_j^{SIM_R}\right). \tag{4.19}$$

Employers' Association (EA)

Finally, we consider the case where the two downstream firms form an employers' association. To form an association the firms enter into a cooperative agreement and bargain jointly with the union over an industry-wide wage $w_1 = w_2 = \widehat{w}$. In this case, the second stage labor demands derived in Section 4.3.1 depend only on the industry wage level $\widehat{w}$ and collapse to

$$l_1^*\left(\widehat{w}\right) = \frac{(2-\gamma)\left(1-\widehat{w}\right)}{2(2-\gamma^2)}, \text{ and} \tag{4.20}$$

$$l_2^*\left(\widehat{w}\right) = \frac{4\left(1-\widehat{w}\right) - \gamma\left(\left(1-\widehat{w}\right)(2+\gamma)\right)}{4\left(2-\gamma^2\right)}. \tag{4.21}$$

Using (4.20) and (4.21), the reduced profit functions of the downstream firms are therefore given by

$$\pi_1^*\left(\widehat{w}\right) = \frac{2-\gamma^2}{2}\left[l_1^*\left(\widehat{w}\right)\right]^2$$

and

$$\pi_2^*\left(\widehat{w}\right) = \left[l_2^*\left(\widehat{w}\right)\right]^2.$$

Consequently, the union obtains a wage bill of

$$U^{EA}\left(\widehat{w}\right) = \widehat{w}\left(l_1^*\left(\widehat{w}\right) - l_2^*\left(\widehat{w}\right)\right). \tag{4.22}$$

In the bargaining stage, the union bargains with the employers' association over the industry wage $\widehat{w}$. Since the firms now bargain jointly, there is only one bargaining round. Consequently, the disagreement point of the union is now zero. When the negotiations with the association fail, the union has no alternative firm to supply its union members to. As before, the firms do not have a valuable outside option.

The Nash product is given by

$$\prod^{EA}(\widehat{w}) = \left[U^{EA}(\widehat{w})\right]^{\frac{1}{2}} \left[\pi_1^*(\widehat{w}) + \pi_2^*(\widehat{w})\right]^{\frac{1}{2}}.$$

The industry wage w^{EA} solves

$$w^{EA} = \arg\max_{\widehat{w} \geq 0} \prod^{EA}(\widehat{w}). \tag{4.23}$$

4.4 Results

The derivations of the bargainig structures are presented in the Appendix. Since it is widely perceived that the labor union can influence the choice of bargaining structure, we begin this Section by presenting the preferences of the labor union and afterwards compare them to the preferences of the downstream firms.

4.4.1 Labor Union's Preferences for Bargaining Orders

Naturally, the union aims at maximizing its total wage bill, anticipating the choices of the downstream firms in the product market competition stage. The sequential and simultaneous negotiation structures differ also within each other. In the sequential order, either the incumbent or the entrant firm can be the wage-leader. In the simultaneous setting, results differ accordingly whether negotiation breakdown is observed by a rival. To understand the preferences of the labor union, we begin by analyzing the preferences of the union within the sequential and the simultaneous structures.

Lemma 1. *When bargaining is sequential, the union always prefers to bargain with the incumbent first, i.e.* $U^{SEQ_1} > U^{SEQ_2}$.
Proof. See Appendix.

If the union can choose the wage-leader in sequential negotiations, it will always choose the incumbent. This result is not surprising and in line with previous findings on sequential bargaining by Dobson (1994). Intuitively, the union prefers to negotiate first with the "stronger" firm, because it can settle at a relatively high wage with this firm. When the incumbent agrees to a high wage in the first place, competition in the downstream market is dampened and the scope for the follower to pay a higher wage rate increases. Since wages are strategic complements, it will also be able to settle at a high wage rate in the second bargaining round, when it negotiates with the entrant firm.

Considering the two simultaneous bargaining structures, the union will prefer the negotiation mode in which it has a better outside option.

Lemma 2. *When bargaining is simultaneous, the union always prefers the structure in which disagreement with one firm would be observed by the rival firm (Reaction) over the case in which disagreement would not be observed (No Reaction), i.e.* $U^{SIM_R} > U^{SIM_{NR}}$.
Proof. See Appendix.

Reaction unambiguously improves the bargaining position of the union vis-à-vis the downstream firms. When downstream firms react to breakdowns by producing monopoly output levels, the disagreement payoff of the union becomes stronger and therefore shifts the bargaining outcome in favor of the union. For union behavior in collective bargaining, this result implies that a labor union has an incentive to publicly announce the state of collective bargaining rounds, in order to put pressure on the negotiating firms but also to confer information to rival downstream firms.

Finally, we can compare the preferences of the union for all bargaining structures.

Proposition 1. *The union always prefers bargaining with an employers' association over all other bargaining structures. There exist two threshold values* γ^{U_1} *and* γ^{U_2}, *with* $0 < \gamma^{U_1} < \gamma^{U_2}$, *such that the order of union wage bills for different negotiation structures is given by:*
i) $U^{EA} > U^{SIM_R} > U^{SIM_{NR}} > U^{SEQ_1} > U^{SEQ_2}$ *if* $\gamma \in (0, \gamma^{U_1})$,
ii) $U^{EA} > U^{SIM_R} > U^{SEQ_1} > U^{SIM_{NR}} > U^{SEQ_2}$ *if* $\gamma \in (\gamma^{U_1}, \gamma^{U_2})$, *and*
iii) $U^{EA} > U^{SIM_R} > U^{SEQ_1} > U^{SEQ_2} > U^{SIM_{NR}}$ *if* $\gamma \in (\gamma^{U_2}, 1)$.
Moreover, $\gamma^{U_1} \approx 0.647$ *and* $\gamma^{U_2} \approx 0.665$.
Proof. See Appendix.

If the formation of an employers' association was at the discretion of the union, it would always urge the firms to form such an association and bargain jointly with them over a common industry wage rate. This preference is particularly surprising for two reasons. First, the union thereby gives up its ability to discriminate between the firms and to exploit their relative product market positions in wage bargaining. Second, the union apparently weakens its own position in the bargaining process, since it bargains with a joint group of firms and therefore has a disagreement payoff of zero in this negotiation, compared to, for example, two positive outside options in the simultaneous setting.

Why does the union prefer an employers' association over all other bargaining structures? Despite its zero disagreement payoff, it can raise the wage in the negotiation above the level of all other structures, independent of the type of firm. The reason is that the formation of an association weakens the bargaining position of the downstream firms. By bargaining jointly, the firms internalize the cross-effect an increased wage has on the profit of the rival firm ($\partial \pi_j / \partial w_i > 0$) which exists when bargaining separately. When firms negotiate on their own (either simultaneously or sequentially), this positive effect is disregarded. By internalizing this externality, firms make own concessions in the bargaining process less costly, thereby weakening their own position. The union, in turn, is able to extract the additional rents from the firms through a high uniform wage $\widehat{w}$.

If no employers' association exists, the union always prefers bargaining in the case of *Reaction*. This preference is based on the strictly positive disagreement payoffs the union has in each negotiation with the two firms. If, however, *Reaction* would not be feasible, the union's preferred bargaining mode depends on the degree of downstream competition. For a moderate degree of competition, the union prefers SIM_{NR} over sequential bargaining. If products are more differentiated (i.e. downstream competition is not very strong), Stackelberg quantity levels are still so large that the union prefers simultaneous bargaining even under *No Reaction*.

If, however, the degree of competition between the firms increases, the union prefers sequential bargaining (SEQ_1 and SEQ_2 for $\gamma \in (\gamma^{U_2}, 1)$) over SIM_{NR}. When products become close substitutes, competition becomes stronger between firms. In this case, the union has an incentive to dampen competition in the downstream market by conducting sequential bargaining. As we know from Lemma 1, the union will always choose the incumbent as the wage-leader in this situation, because it can achieve an overall higher wage level in the industry by approaching the stronger firm first.

4.4.2 Firms' Preferences for Bargaining Orders

The firms prefer the bargaining system which maximizes their individual profits. The complete preferences for bargaining structures are summarized by the following proposition.

Proposition 2. *The downstream firms do not have aligned interests for bargaining orders.*

i) The entrant firm always prefers bargaining sequentially being the wage-leader over all other structures. Its preferences for bargaining orders are given by $\pi_2^{SEQ_2} > \pi_2^{SIM_{NR}} > \pi_2^{SIM_R} > \pi_2^{SEQ_1} > \pi_2^{EA}$.

ii) The incumbent earns identical profits in cases EA, SEQ_2 *and* SIM_R, *i.e.* $\pi_1^{EA} = \pi_1^{SEQ_2} = \pi_1^{SIM_R}$. *These profits are always lower than in structures* SEQ_1 *and* SIM_{NR}.

iii) There exists a critical threshold value $\gamma^F \approx 0.887$, *such that the incumbent prefers either sequential bargaining being the wage-leader (*SEQ_1*) if* $\gamma < \gamma^F$, *or simultaneous bargaining with No Reaction (*SIM_{NR}*) if* $\gamma > \gamma^F$ *over all other bargaining structures.*

Proof. See Appendix.

Proposition 2 shows that the downstream firms have conflicting interests with respect to the organization of collective bargaining. The incumbent either prefers wage-leadership in sequential bargaining, or simultaneous bargaining with *No Reaction*. Which bargaining structure is preferred the most depends on the intensity of downstream competition.

For strong to moderate degrees of product differentiation, i.e. $\gamma < \gamma^F$, the incumbent prefers being the wage-leader in sequential negotiations. Intuitively, the sequential bargaining order is attractive for the wage-leader because the union has no positive outside option in the first bargaining round. The wage-leader therefore has a good relative bargaining position in this negotiation structure.

When products are almost homogeneous and downstream competition is accordingly strong, i.e. $\gamma > \gamma^F$, the incumbent prefers simultaneous bargaining with *No Reaction*, SIM_{NR}. When products are close substitutes, the union's outside option in SIM_{NR} is relatively weak compared to the other structures, because firms would produce their anticipated Stackelberg quantities off equilibrium. Especially, for given wage rates, the Stackelberg quantity of the entrant firm decreases in γ. Thus, the bargaining position of the incumbent improves in SIM_{NR} when products become less differentiated. At the same time, SEQ_1 becomes less attractive for the incumbent for larger values of γ, because the wage rate $w_1^{SEQ_1}$ increases in γ. Therefore, when product differentiation is very low, the incumbent prefers SIM_{NR} rather than SEQ_1.

The entrant firm, on the other hand, always prefers sequential bargaining being the wage-leader over all other negotiation structures. The entrant benefits from the zero disagreement payoff of the union in the first round and, therefore, improves its competitive position in the product market game compared to the other bargaining sructures. Especially since the incumbent faces a strong union in the second negotiation round, the entrant firm's competitiveness increases due to relatively lower labor costs.

Note that, if sequential bargaining were not allowed, both firms would prefer simultaneous bargaining with *No Reaction*. Here, a possibility for inter-firm agreements arises. If firms could credibly commit themselves to not changing their quantities once negotiations between the union and the rival firm have come to a halt, both firms would be better off than in a situation with *Reaction*. For wage negotiations, this would imply that firms do not have a strong incentive to disclose information on the state of bargaining with the labor union.

While there is no agreement between the firms for the most preferred bargaining structure, the firms' interests are aligned with respect to forming an employers' association. For both firms, such an association is the least preferred bargaining structure, contrasting conventional wisdom that firms' should form a bargaining association to counter monopoly union power in wage negotiations.

As outlined above, the formation of an employers' association weakens the bargaining position of the firms compared to other bargaining structures. Since the firms now internalize the cross-effect of their wage rates on the rival's profit, they can admit more easily to concessions in the bargaining round. The union takes advantage of this and is able to negotiate a wage which lies above the wage rates in other structures. The firms, however, still compete in the product market. Therefore, they cannot offset the decrease in profits caused by increased labor costs through a higher wage by cooperatively setting their quantities. Consequently, the firms are worse off with an employers' association.

The order of bargaining influences a firm's stand in downstream market competition as can be seen from the comparison of profits under the different bargaining structures. Firms prefer those structures, which improve their competitive position vis-à-vis the rival. Traditionally, in Stackelberg quantity competition, the market leader has an advantage over its rival since it can expand production compared to simultaneous Cournot competition, knowing that the follower will contract its output in response. However, the choice of bargaining structure may have an adverse effect on firms' competitive positions as the following corollary shows.

Corollary 1. *The entrant firm always earns lower profits than the incumbent in structures SIM_{NR}, SEQ_1 and EA. Conversely, there exist two threshold values γ^{E_1} and γ^{E_2} for structures SIM_R and SEQ_2, with $\gamma^{E_1} < \gamma^{E_2} < 1$, such that the entrant firm earns higher profits than the incumbent under SIM_R for $\gamma > \gamma^{E_1}$ and under SEQ_2 if $\gamma < \gamma^{E_2}$.*
Proof. See Appendix.

In contrast a situation where wages are set competitively upstream, the incumbent may be worse off than the entrant firm under SEQ_2 and SIM_R, depending on the degree of product differentiation. For SEQ_2, this result holds for almost all degrees of substitutability ($\gamma^{E_2} \approx 0.96$), only when products are almost homogeneous the incumbent earns a higher profit. As outlined above, the bargaining position of the target is better in sequential negotiations than the rival's in the second bargaining stage. Only when competition is very intense downstream, the incumbent benefits from its Stackelberg leader role.

For SIM_R the incumbent is worse off than the entrant for intermediate to high degrees of product substitutability ($\gamma^{E_1} \approx 0.45$). To see this, we can use expressions (4.36) and (4.37) from the Appendix for $w_1^{SIM_{NR}}$ and $w_2^{SIM_{NR}}$, respectively. Both wage rates monotonically decrease in the product differentiation parameter, i.e. $\partial w_1^{SIM_{NR}}/\partial\gamma < 0$ and $\partial w_2^{SIM_{NR}}/\partial\gamma < 0$. Comparing the two derivatives we see that the wage $w_2^{SIM_{NR}}$ decreases more rapidly in γ,

$$\left|\frac{\partial w_2^{SIM_{NR}}}{\partial\gamma}\right| - \left|\frac{\partial w_1^{SIM_{NR}}}{\partial\gamma}\right| = \frac{576\gamma^2 - 51\gamma^4}{2\left(64 - 17\gamma^2\right)^2} > 0$$

for $\gamma \in (0, 1]$. Thus, for low degrees of product differentiation, the entrant firm faces a relative input cost advantage over the incumbent and therefore obtains higher profits than its rival.

4.5 Merger Incentives

To complete the picture how different bargaining structures affect wages and firms, we now consider the option that the two downstream firms merge. The timing of our game is therefore altered in the following way: Prior to the bargaining stage, the firms can decide whether they want to merge. Afterwards, the wage bargaining stage begins. If the firms have merged, the union bargains with the merged firm. If the firms have decided not merge, bargaining takes place according to one of the five structures presented above. Finally, the quantity setting stage takes place.

As firms produce differentiated goods in our model, both plants are operated after a merger, such that the newly merged multi-product firm produces two brands, one at each plant. Given that a merger has occured, the timing of the game is now as follows: In stage 1, the union bargains with the merged firm over the plant-specific wage rates w_1 and w_2. Given the outcome of the wage negotiation, the merged firm then simultaneously determines its labor demand at the two plants, l_1 and l_2. The profit function of the merged firm is given by

$$\pi = \sum_{i=1}^{2} (1 - l_i - \gamma l_j)\, l_i - w_i l_i,\ \ i, j = 1, 2 \text{ and } i \neq j. \tag{4.24}$$

The merged firm chooses its labor demands l_1 and l_2 simultaneously[10] to maximize (4.24), i.e.

$$\{l_1^M, l_2^M\} = \arg \max_{l_1 \geq 0,\ l_2 \geq 0} \pi.$$

Solving the two first-order conditions yields the optimal labor demands

$$l_i^M(w_1, w_2) = \frac{1 - \gamma - w_i + \gamma w_j}{2(1 - \gamma^2)}, \text{ for } i, j = 1, 2 \text{ and } i \neq j. \tag{4.25}$$

The reduced profit function of the merged firm is given by

$$\pi^M(w_1, w_2) = \frac{2 - w_1(2 - w_1) - 2\gamma(-1 + w_1)(-1 + w_2) - (2 - w_2)w_2}{4(1 - \gamma^2)}. \tag{4.26}$$

Using (4.25) the union's wage bill is

$$U^M(w_1, w_2) = \frac{(w_1 + w_2)(1 - \gamma) - w_1^2 - w_2^2}{2(1 - \gamma^2)}. \tag{4.27}$$

In the first stage, the union bargains with the merged firm over the plant-specific wages w_1 and w_2 simultaneously. As there is no alternative (outside option) in this negotiation round for neither the firm nor the union, disagreement points for both parties are zero. The Nash product is given by

$$\prod^M(w_1, w_2) = \left[U^M(w_1, w_2)\right]^{\frac{1}{2}} \left[\pi^M(w_1, w_2)\right]^{\frac{1}{2}}.$$

[10] Obviously, since the merged firm internatlizes the externality its choice of q_1 has on q_2 and vice versa, there is no difference in modelling the quantity choice sequentially or simultaneously.

The two plant-specific wages solve

$$\{w_1^M, w_2^M\} = \arg \max_{w_1 \geq 0, w_2 \geq 0} \prod^M (w_1, w_2). \tag{4.28}$$

Since the two plants produce an equal amount of output under the merger, the wage rates resulting from the bargaining process are identical, i.e. $w_1^M = w_2^M = w^M$.

The following proposition summarizes the merger incentives of the firms, given that bargaining without a merger would take place in the form of one of the above described structures.

Proposition 3. *If the bargaining structure is SIM_R or EA, a merger is always profitable for the firms. If bargaining takes place sequentially (SEQ_1 or SEQ_2), a merger is only profitable if products are sufficiently homogeneous. If the bargaining structure is SIM_{NR}, a merger would never be profitable for the firms.*
Proof. See Appendix.

The wage bargaining structure has a strong impact on the profitability of a merger. We see that there are different forces at work which determine whether a merger is profitable. On the one hand, there is the bargaining effect described already in the case of an employers' association. In the case of a merger, the firms not only internalize the positive effect of increase in their own wage rate on the rivals' profit, but also the negative external effect their quantity decisions have on each other's profit ($\partial \pi_j / \partial q_i < 0$). When the bargaining structure is SIM_{NR} absent a merger, the bargaining effect weakens the bargaining position of the merged firm and offsets all gains generated through reduced product market competition. This is exactly the case analyzed by Horn and Wolinsky (1988).

In contrast, a merger is always profitable for SIM_R or EA. In both structures, the bargaining position of the labor union is rather good. For SIM_R the union has a positive and high outside option in both negotiation rounds, for EA the bargaining effect weakens the firms' position. A merger now makes the firms internalize the negative product market externality. In both instances these gains from monopolization are high enough to offset the losses due to the weakened bargaining position of the firm.

A merger is only profitable compared to SEQ_1 and SEQ_2, when products are sufficiently homogeneous. The line of argument why a merger is not profitable most of the time is analogous to the case of SIM_{NR}. For the sequential bargaining structures, especially the wage-leader has no incentive to form a merger, unless products are almost homogeneous. The wage-leader benefits from the low disagreement payoff of the union in the sequential first round. This benefit gets lost when the firms merge and the union extracts the additional rents from the merger. When products are almost homogeneous, however, the wage rates in the sequential structure are relatively high whereas downstream competition is rather fierce. Then, also the wage-leader benefits from a merger and the gains from downstream monopolization outweigh the wage increase due to the merger.

4.6 Welfare Implications

Up to this point, we have considered which negotiation structures the actors –union and firms– prefer. Obviously, all actors would implement a structure which maximizes their individual profits. However, it is unclear how bargaining organization evolves since wage bargaining regimes in each country depend on a variety of factors, such as traditional arrangements, firm and union preferences, and political considerations. In this Section, we therefore consider which bargaining structure is optimal from a social welfare perspective. Social welfare is defined as the sum of consumer surplus, union wage bill and firms' profits, i.e.

$$W^k = V^k - \sum_{i=1}^{2} p_i q_i + U^k + \sum_{i=1}^{2} \pi_i^k,$$

with $k = \{SEQ_1, SEQ_2, SIM_R, SIM_{NR}, EA, M\}$. Using the explicit solutions to the different bargaining structures, the expression simplifies to $W^k = V^k$. Using (4.1), we calculate the social welfare for all possible bargaining orders and the merger case.

Proposition 4. *Consider all possible bargaining structures SEQ_1, SEQ_2, SIM_R, SIM_{NR}, EA and M. Social welfare is either highest under SEQ_2 or SIM_{NR}, depending on the degree of product differentiation. There exists a critical threshold value $\gamma^W \approx 0.635$, such that the welfare maximizing structure is given by SEQ_2 if $\gamma < \gamma^W$ and by SIM_{NR} otherwise. Social welfare is always lowest in the merger case M.*
Proof. See Appendix.

There exists no bargaining structure which unambiguously produces the highest social welfare. Rather, which bargaining order should be preferred from a social welfare perspective dependes on the degree of product substitutability. For $\gamma < \gamma^W$ the socially optimal bargaining structure is SEQ_2. In this structure wages are relatively low, because the union bargains with the entrant -and, thus, the weaker firm- first. For the entrant it is very costly to make concessions in this bargaining round. It cannot commit to higher wages because of its weak position in downstream competition. In turn, the union will also not be able to negotiate a high wage rate with the incumbent in the second round, because the incumbent will not be able to make strong concessions. Otherwise, it would worsen its competitive position in the downstream market. As input prices are low for SEQ_2 firms expand their output and prices drop compared to other structures, which has a positive impact on consumer welfare.

For $\gamma > \gamma^W$ the welfare maximizing negotiation structure is SIM_{NR}. Similar to the reasoning in Section 4.4, the union's outside option for SIM_{NR} is weakened when the degree of product differentiation is low. Therefore, wages drop which has a positive effect on welfare.

Note that firms actually have preferences for the welfare maximizing bargaining structures. The entrant firm always most prefers SEQ_2. Thus, for low to intermediate degrees of product substitutability, the entrant's most preferred structure of bargaining also maximizes social welfare. This position is not shared by the incumbent. Rather, when products become almost homogeneous, the incumbent prefers simultaneous bargaining, SIM_{NR}, which is also the socially preferred structure. Comparing the threshold values γ^F and γ^W, we can see that the incumbent only has a strong preference for the welfare maximizing bargaining structure when competition is very intense downstream. From a social welfare perspective, SIM_{NR} is welfare optimal also for lower degrees of product substitutability.

4.7 Conclusion

In this Chapter we have analyzed the preferences of competing downstream firms and an industry labor union for different structures of wage bargaining order. In the light of rapidly changing bargaining environments, we have considered firms' incentives to counter monopoly union power and form an employers' association or merge to monopoly. Therefore, we have considered an asymmetric market in which an incumbent competes with an entrant firm in a Stackelberg game and analyzed how these different relative positions in the product market influence the firms' preferences. Our model explicitly takes into account how the specification of a union's outside option in simultaneous bargaining influences the attractiveness of this bargaining structure.

In contrast to conventional wisdom we find that neither the incumbent nor the entrant firm has an incentive to form an employers' association, which supports the observations in, for example, the German passenger railway industry. In contrast, the union always prefers to bargain with an association over an industry wage. Which bargaining order is preferred by the firms depends –at least for the incumbent– on the intensity of downstream competition. The entrant firm always prefers sequential bargaining being the wage-leader. The incumbent, on the other hand, either prefers sequential bargaining as the wage-leader or simultaneous bargaining in the case of *No Reaction*, i.e., when negotiation breakdown between the union and the rival would not be observed and a firm would operate at its anticipated Stackelberg quantity level off-equilibrium.

Clearly, wage-leadership in sequential bargaining is attractive for the firms, since they can benefit in first-round negotiations from the zero disagreement payoff of the union. If sequential bargaining is not possible, for example for institutional reasons, both firms prefer simultaneous bargaining with *No Reaction*, while the union always prefers the case of *Reaction*. The interests of the union and the firms to disclose information on the state of wage negotiations are therefore rather controversial. While it is in the union's interest to inform downstream firms about a possible negotiation breakdown, it is in the best interest of the firm not to reveal such information. If firms could credibly commit themselves not to increase their output above the Stackelberg quantities in the case of disagreement, firms could increase their profits compared to *Reaction*.

A further central result of this chapter is related to the incentives of firms to monopolize the downstream market for different bargaining modes. Our model shows that firms' merger incentives depend crucially on which bargaining structure would follow in the case of no merger decision. While a merger would always be profitable for SIM_R and EA, compared to sequential bargaining firms would only want to merge when products are almost homogeneous. In the case of simultaneous *No Reaction*, a merger is never profitable. These results depend on the impact a merger has on the bargaining position of the firms vis-à-vis the union. When the firms merge and bargain jointly, they weaken their position in negotiations through internalizing the positive effect an own wage increase would have on a rival's profit. Compared to SIM_{NR} and mostly SEQ_1 and SEQ_2, this bargaining effect offsets all gains from the merger. For SIM_R and EA, monopolization yields additional rents which make the merger decision profitable.

Finally, we have considered the different negotiation structures from a welfare perspective. This question is of great relevance for policy makers if they can influence the type of wage bargaining through regulation. Our model has shown that the welfare optimal structure is either SEQ_2 or SIM_{NR}, depending on the degree of product substitutability. In both structures the ability of the union to raise the wages is limited which increases the degree of product market competition and benefits the consumers. Thus, there can be instances when sequential or simultaneous bargaining can be welfare optimal. The firms actually have strong preferences for these structures being implemented, although their interests are rather controversial. For low to intermediate degrees of product substitutability, the entrant has preferences for the actual welfare maximizing bargaining structure. When products become close substitutes, the structure preferred by the incumbent should also be preferred from a welfare perspective.

The results of this model indicate some possibilities for further research. First, the modelling choice of the union's outside option in the first round of sequential negotiations might be of interest. While this analysis has focused on the *impasse* point to model this outside option and has concentrated on the role of disagreement payoffs in the simultaneous setting, there exist alternative specifications for outside options in sequential bargaining. One possibility would be to allow negotiations to break down. In this case, the union would have a positive outside option when bargaining with the wage-leader. Intuitively, the sequential setting would become more attractive to the union with this specification.

A second point for further research is to consider different mechanisms for implementing a wage regime. In this Chapter , we have considered the welfare effects of different negotiation structures to inspect how a policy maker should choose between the structures. In reality, how collective bargaining is organized depends on many factors, as outlined above. However, it would be interesting to see how different mechanisms, e.g. voting or implementation rules, affect the choice for one of the bargaining structures presented in this model.

Appendix

In this Appendix, we solve the bargaining structures examined in the main text.

Sequential Bargaining (SEQ_1)

Using the logarithmized version of the Nash product, the first-order condition for (4.10) is given by

$$\frac{\partial \prod_2^{SEQ_1}(\cdot)}{\partial w_2} = \frac{\pi_2^*(\cdot)}{U^{SEQ_1}(\cdot)-U_D^{SEQ_1}(\cdot)} + \frac{\partial \pi_2^*(\cdot)/\partial w_2}{\partial U^{SEQ_1}(\cdot)/\partial w_2} = 0.$$

Substituting (4.2), (4.6). (4.7) and (4.9), this can be expressed as

$$\frac{\partial \prod_2^{SEQ_1}(\cdot)}{\partial w_2} = \frac{-4+\gamma^2}{4+2\gamma\delta+\gamma^2(-1+w_2)-4w_2} + \frac{\alpha-4+2\gamma+\gamma^2}{2w_2\beta+4\gamma^2 w_1\delta-\alpha} = 0, \tag{4.29}$$

with

$$\alpha = 8w_2 - 4\gamma w_1 - 2\gamma^2 w_2, \tag{4.30}$$

$$\beta = 4w_2 + 2\gamma - 4\gamma w_1 - \gamma^2 w_2, \text{ and} \tag{4.31}$$

$$\delta = w_1 - 1. \tag{4.32}$$

Solving (4.29) yields two real solutions of which only one is feasible and given by

$$w_2^{SEQ_1}(w_1) = \frac{80-40\gamma-40\gamma^2+10\gamma^3+5\gamma^4+64\gamma w_1-16\gamma^3 w_1+\left(-4+\gamma^2\right)\varepsilon}{2(64-32\gamma^2+4\gamma^4)},$$

with

$$\varepsilon = \sqrt{144-144\gamma-36\gamma^2+36\gamma^3+9\gamma^4+128\gamma^2 w_1-64\gamma^4 w_1-128\gamma^2 {w_1}^2+64\gamma^4 {w_1}^2}.$$

The first-order condition to (4.11) is then given by

$$\frac{\partial \prod_1^{SEQ_1}(\cdot)}{\partial w_1} = \frac{\pi_1^*(\cdot)}{U^{SEQ_1}(\cdot)} + \frac{\partial \pi_1^*(\cdot)/\partial w_1}{\partial U^{SEQ_1}(\cdot)/\partial w_1} = 0.$$

Substituting $w_2^{SEQ_1}(w_1)$ and simplifying yields that $w_1^{SEQ_1}$ is given by the solution to the polynomial equation

$$\zeta + \eta w_1 + \theta w_1^2 + \kappa w_1^3 + \lambda w_1^4 + \mu w_1^5 = 0,$$

with

$\zeta = -23040 + 23040\gamma + 20736\gamma^2 - 20736\gamma^3 - 7712\gamma^4 + 6272\gamma^5 + 1680\gamma^6 - 744\gamma^7 - 186\gamma^8 + 28\gamma^9 + 7\gamma^{10}$,
$\eta = 276480 - 304128\gamma - 246272\gamma^2 + 275328\gamma^3 + 100416\gamma^4 - 90048\gamma^5 - 24880\gamma^6 + 13232\gamma^7 + 3044\gamma^8 - 894\gamma^9 - 130\gamma^{10} + 25\gamma^{11}$,
$\theta = -884736 + 995328\gamma + 985088\gamma^2 - 934656\gamma^3 - 562048\gamma^4 + 332928\gamma^5 + 179296\gamma^6 - 56640\gamma^7 - 27016\gamma^8 + 4716\gamma^9 + 1700\gamma^{10} - 162\gamma^{11} - 32\gamma^{12}$,
$\kappa = 589824 - 589824\gamma - 1622016\gamma^2 + 712704\gamma^3 + 1464576\gamma^4 - 333056\gamma^5 - 557248\gamma^6 + 74176\gamma^7 + 92720\gamma^8 - 7840\gamma^9 - 6632\gamma^{10} + 320\gamma^{11} + 160\gamma^{12}$,
$\lambda = 1310720\gamma^2 - 98304\gamma^3 - 1589248\gamma^4 + 98304\gamma^5 + 671744\gamma^6 - 32256\gamma^7 - 120064\gamma^8 + 4224\gamma^9 + 9344\gamma^{10} - 192\gamma^{11} - 256\gamma^{12}$, and
$\mu = -524288\gamma^2 + 655360\gamma^4 - 286720\gamma^6 + 53248\gamma^8 - 4352\gamma^{10} + 128\gamma^{12}$.

We can use the solution for $w_1^{SEQ_1}$ to obtain expressions for $w_2^{SEQ_1}$, $\pi_1^{SEQ_1}$, $\pi_2^{SEQ_1}$ and U^{SEQ_1}.

Sequential Bargaining (SEQ_2)

The first-order condition to (4.14) can be written as

$$\frac{\partial \prod_1^{SEQ_2}(\cdot)}{\partial w_1} = \frac{\pi_1^*(\cdot)}{U^{SEQ_2}(\cdot) - U_D^{SEQ_2}(\cdot)} + \frac{\partial \pi_1^*(\cdot)/\partial w_1}{U^{SEQ_2}(\cdot)/\partial w_1} = 0.$$

Using (4.2), (4.6), (4.7) and (4.13) this yields

$$\frac{1}{2w_1 - \gamma w_2} + \frac{3}{-2+\gamma+2w_1-\gamma w_2} = 0$$

and the solution

$$w_1^{SEQ_2}(w_2) = \frac{1}{8}(2 - \gamma + 4\gamma w_2).$$

The first-order condition to (4.15) is given by

$$\frac{\partial \prod_2^{SEQ_2}(\cdot)}{\partial w_2} = \frac{\pi_2^*(\cdot)}{U^{SEQ_2}(\cdot)} + \frac{\partial \pi_2^*(\cdot)/\partial w_2}{\partial U^{SEQ_2}(\cdot)/\partial w_2} = 0. \tag{4.33}$$

There are two real solutions to (4.33) of which only one is feasible and given by

$$w_2^{SEQ_2} = \frac{-40+6\gamma+17\gamma^2+\sqrt{3}\sqrt{320-160\gamma-196\gamma^2+68\gamma^3+27\gamma^4}}{32(-2+\gamma^2)}.$$

We can use the solution for $w_2^{SEQ_2}$ to obtain expressions for $w_1^{SEQ_2}$, $\pi_1^{SEQ_2}$, $\pi_2^{SEQ_2}$ and U^{SEQ_2}.

Simultaneous Bargaining: No Reaction (SIM_{NR})

The first-order-conditions for (4.17) are given by

$$\frac{\partial \prod_i^{SIM_{NR}}(\cdot)}{\partial w_i} = \frac{\pi_i^*(\cdot)}{U^{SIM}(\cdot) - U_{iD}^{SIM_{NR}}(\cdot)} + \frac{\partial \pi_i^*(\cdot)/\partial w_i}{\partial U^{SIM_{NR}}(\cdot)/\partial w_i} = 0,$$

with i, $j = 1, 2$ and $i \neq j$. Substituting (4.2), (4.6), (4.7) and (4.16) yields

$$\frac{\partial \prod_1^{SIM_{NR}}(\cdot)}{\partial w_1} = \frac{1}{2w_1} + \frac{3}{-2+\gamma+2w_1-\gamma w_2^{SIM_{NR}}} = 0, \text{ and} \tag{4.34}$$

$$\frac{\partial \prod_2^{SIM_{NR}}(\cdot)}{\partial w_2} = \frac{4-16w_2+\gamma(-2-\gamma+2w_1^{SIM_{NR}}+4\gamma w_2)}{2\left(4+2\gamma(-1+w_1^{SIM_{NR}})+\gamma^2(-1+w_2)-4w_2\right)w_2} = 0. \tag{4.35}$$

Solving (4.34) and (4.35) simultaneously yields the solutions

$$w_1^{SIM_{NR}} = \frac{32-12\gamma-10\gamma^2+3\gamma^3}{2(64-17\gamma^2)}, \text{ and} \tag{4.36}$$

$$w_2^{SIM_{NR}} = \frac{16-6\gamma-5\gamma^2}{64-17\gamma^2}. \tag{4.37}$$

We can use (4.36) and (4.37) to obtain solutions for $\pi_1^{SIM_{NR}}$, $\pi_2^{SIM_{NR}}$ and $U^{SIM_{NR}}$.

Simultaneous Bargaining: Reaction (SIM_R)

The first-order conditions to (4.19) are given by

$$\frac{\partial \prod_i^{SIM_R}(\cdot)}{\partial w_i} = \frac{\pi_i^*(\cdot)}{U^{SIM}(\cdot) - U_{iD}^{SIM_R}(\cdot)} + \frac{\partial \pi_i^*(\cdot)/\partial w_i}{\partial U^{SIM_R}(\cdot)/\partial w_i} = 0,$$

with i, $j = 1, 2$ and $i \neq j$. Substituting (4.2), (4.6), (4.7) and (4.18) and simplifying, we can rewrite the expressions as

$$\frac{\partial \prod_1^{SIM_R}(\cdot)}{\partial w_1} = \frac{1}{2w_1-\gamma w_2^{SIM_R}} + \frac{3}{-2+\gamma+2w_1-\gamma w_2^{SIM_R}} = 0, \text{ and}$$

$$\frac{\partial \prod_2^{SIM_R}(\cdot)}{\partial w_2} = \frac{-4+\gamma^2}{4+2\gamma\delta+\gamma^2(-1+w_2)-4w_2} + \frac{\alpha-4+2\gamma+\gamma^2}{2w_2\beta+4\gamma^2 w_1^{SIM_R}\delta-\alpha} = 0,$$

with α, β and δ given by (4.30), (4.31) and (4.32), respectively, substituting $w_1^{SIM_R}$ for w_1. There are two solution pairs of which only one is feasible and given by

$$w_1^{SIM_R} = \frac{12\gamma-14\gamma^2-3\gamma^3+\gamma^4+16+\gamma\sigma}{2(32-16\gamma^2+\gamma^4)}, \text{ and}$$

$$w_2^{SIM_R} = \frac{80-24\gamma-28\gamma^2+2\gamma^3+\gamma^4+4\sigma}{4(32-16\gamma^2+\gamma^4)},$$

with

$$\sigma = \sqrt{\gamma^6 - 3\gamma^5 - 9\gamma^4 + 48\gamma^3 - 12\gamma^2 - 144\gamma + 144}.$$

We can use $w_1^{SIM_R}$ and $w_2^{SIM_R}$ to obtain solutions for $\pi_1^{SIM_R}$, $\pi_2^{SIM_R}$ and U^{SIM_R}.

Employers' Association (EA)

The first-order condition for (4.23) is given by

$$\frac{\partial \prod^{EA}(\cdot)}{\partial \widehat{w}} = \frac{\pi_1^*(\cdot)+\pi_2^*(\cdot)}{U^{EA}(\cdot)} + \frac{\left(\partial\pi_1^*(\cdot)/\partial\widehat{w}\right)+\left(\partial\pi_2^*(\cdot)/\partial\widehat{w}\right)}{\partial U^{EA}(\cdot)/\partial\widehat{w}} = 0.$$

With the help of (4.6), (4.7) and (4.22), this expression can be written as

$$\frac{\partial \prod^{EA}(\cdot)}{\partial \widehat{w}} = \frac{1-4\widehat{w}}{2\widehat{w}-2\widehat{w}^2} = 0,$$

which immediately yields

$$\widehat{w} = \frac{1}{4}.$$

By using $\widehat{w}$, we can solve for π_1^{EA}, π_2^{EA} and U^{EA}.

The Merger Case (M)

The profit function of the merged firm and the union wage bill are given by (4.26) and (4.27), respectively. The first-order conditions for (4.28) are given by

$$\frac{\partial \prod^{M}(\cdot)}{\partial w_i} = \frac{\pi^M(\cdot)}{U^M(\cdot)} + \frac{\partial\pi^M(\cdot)/\partial w_i}{\partial U^M(\cdot)/\partial w_i} = 0,$$

for $i, j = 1, 2$ and $i \neq j$. Solving the two conditions simultaneously and imposing symmetry yields immediately

$$w^M = \frac{1}{4}.$$

Using the expression for w^M, we obtain solutions for π^M and U^M.

With the explicit solutions to all bargaining structures, we can sketch the proofs to the propositions stated in the main text. Since all derivations imply extensive expressions which are hard to include in the text, we present in this Appendix the relevant comparisons which have to made in order to complete the proofs and illustrate these derivations graphically for the propositions.

Proof of Lemma 1. The proof involves a mere comparison of the wage bills U^{SEQ_1} and U^{SEQ_2}. It can be shown that $U^{SEQ_1} - U^{SEQ_2} > 0$ holds for all $\gamma \in (0, 1)$.

Proof of Lemma 2. The proof involves a mere comparison of the wage bills U^{SIM_R} and $U^{SIM_{NR}}$. It can be shown that $U^{SIM_R} - U^{SIM_{NR}} > 0$ holds for all $\gamma \in (0, 1)$.

Proof of Proposition 1. The proof consists of three steps. First, we can show that $U^{EA} > U^{SIM_R} > U^{SEQ_1} > U^{SEQ_2} > 0$ holds for all $\gamma \in (0, 1]$.

Then, we inspect the relation of $U^{SIM_{NR}}$. Since we know from Lemma 2 that $U^{SIM_R} > U^{SIM_{NR}}$ holds for all $\gamma \in (0, 1]$, we only need to establish the position of $U^{SIM_{NR}}$ in the ranking compared to U^{SEQ_1} and U^{SEQ_2}. It can be shown that the difference $U^{SIM_{NR}} - U^{SEQ_1}$ is positive if $\gamma < \gamma^{U_1}$, with $\gamma^{U_1} \approx 0.647$. Finally, we can show that the difference $U^{SIM_{NR}} - U^{SEQ_2}$ is positive if $\gamma < \gamma^{U_2}$, with $\gamma^{U_2} \approx 0.665$. The relevant differences are presented in the following two figures.

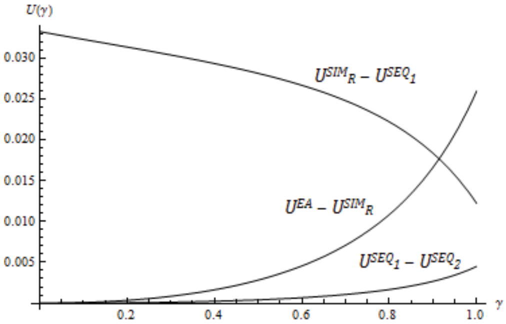

Figure 4-1

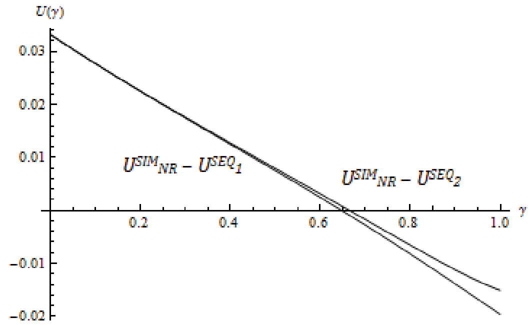

Figure 4-2

Figure 4-1 illustrates the unique ranking $U^{EA} > U^{SIM_R} > U^{SEQ_1} > U^{SEQ_2}$. It shows that the differences $U^{EA} - U^{SIM_R}$, $U^{SIM_R} - U^{SEQ_1}$ and $U^{SEQ_1} - U^{SEQ_2}$ are positive for all $\gamma \in (0, 1]$. Figure 4-2 illustrates the relevant comparison for $U^{SIM_{NR}}$. It shows that the difference $U^{SIM_{NR}} - U^{SEQ_1}$ decreases in γ and changes its sign at the threshold value $\gamma^{U_1} \approx 0.647$. Likewise, the difference $U^{SIM_{NR}} - U^{SEQ_2}$ decreases in γ and changes it sign at $\gamma^{U_2} \approx 0.665$.

Proof of Proposition 2. The proof involves a comparison of firms' profit functions using the derivations in the Appendix. We begin by inspecting the profits earned by the incumbent. First, we can establish that

$$\pi_1^{EA} = \pi_1^{SEQ_2} = \pi_1^{SIM_R}$$

holds for the incumbent. Then, we can show that the differences $\pi_1^{SIM_{NR}} - \pi_1^{EA}$ and $\pi_1^{SEQ_1} - \pi_1^{EA}$ are positive for all $\gamma \in (0, 1]$. Finally, we can bilaterally compare $\pi_1^{SEQ_1}$ and $\pi_1^{SIM_{NR}}$. By a numerical solution it can be shown that the difference $\pi_1^{SEQ_1} - \pi_1^{SIM_{NR}}$ is positive for $\gamma < \gamma^F$,with $\gamma^F \approx 0.89$, and negative otherwise. The following figures illustrate these results.

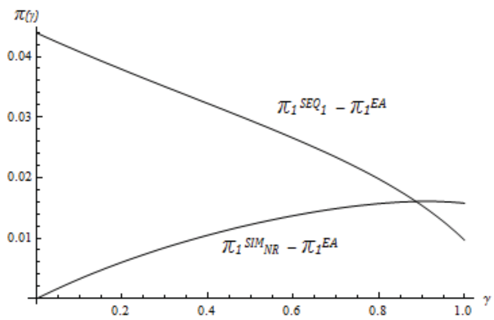

Figure 4-3

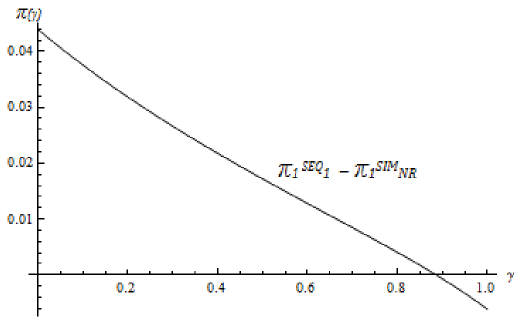

Figure 4-4

Figure 4-3 illustrates the first result, namely that the differences $\pi_1^{SIM_{NR}} - \pi_1^{EA}$ and $\pi_1^{SEQ_1} - \pi_1^{EA}$ are positive for all $\gamma \in (0, 1]$. Figure 4-4 illustrates the relation between $\pi_1^{SEQ_1}$ and $\pi_1^{SIM_{NR}}$. More specifically, the difference $\pi_1^{SEQ_1} - \pi_1^{SIM_{NR}}$ decreases in γ, and there exists a threshold value, $\gamma^F \approx 0.89$, such that the difference changes sign at γ^F.

Next, we consider the profits of the entrant firm. It can be established that there is an unambiguous ranking of profits as stated in the proposition, which holds for all $\gamma \in (0,1]$. The relevant comparisons are presented in Figure 4-5.

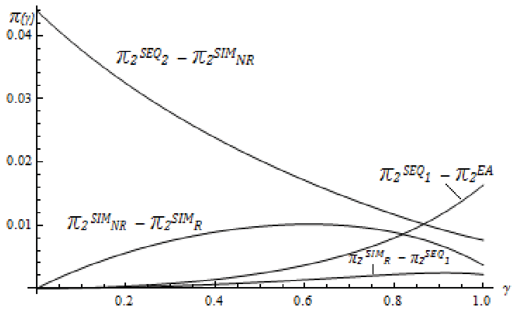

Figure 4-5

Proof of Corollary 1. Using the derivations in the Appendix, we compare the profits of the two firms within the different bargaining structures. It can be shown that $\pi_1^{SEQ_1} - \pi_2^{SEQ_1} > 0$, $\pi_1^{SIM_{NR}} - \pi_2^{SIM_{NR}} > 0$ and $\pi_1^{EA} - \pi_2^{EA} > 0$ for $\gamma \in (0,1]$. For structures SIM_R and SEQ_2 we consider the inequalities $\pi_2^{SEQ_2} - \pi_1^{SEQ_2} > 0$ and $\pi_2^{SIM_R} - \pi_1^{SIM_R} > 0$. For bargaining structure SIM_R, a numerical solution yields that the inequality is fulfilled for all $\gamma > \gamma^{E_1}$, with $\gamma^{E_1} \approx 0.45$. For SEQ_2, it can be established that the inequality holds whenever $\gamma < \gamma^{E_2}$, with $\gamma^{E_2} \approx 0.96$.

Proof of Proposition 3. The proof involves a comparison of profits of the two downstream firms in the previous bargaining structures to the joint profit of the merged firm in the merger structure. First, we can show that

$$\pi^M - \left(\pi_1^{SIM_R} + \pi_2^{SIM_R}\right) > 0 \text{ and } \pi^M - \left(\pi_1^{EA} + \pi_2^{EA}\right) > 0$$

for $\gamma \in (0,1]$.

Second, we can establish that

$$\pi^M - \left(\pi_1^{SIM_{NR}} + \pi_2^{SIM_{NR}}\right) < 0$$

for $\gamma \in (0,1]$.

Finally, we compare the merger outcome to the sequential bargaining structures. Inspection of the difference

$$\pi^M - \left(\pi_1^{SEQ_1} + \pi_2^{SEQ_1}\right)$$

and applying a numerical solution, yields that this difference is positive only for $\gamma > \gamma^{M_1}$, with $\gamma^{M_1} \approx 0.87$. Inspecting

$$\pi^M - \left(\pi_1^{SEQ_2} + \pi_2^{SEQ_2}\right),$$

a numerical solution yields that this difference is positive only for $\gamma > \gamma^{M_2}$, with $\gamma^{M_2} \approx 0.92$. Figures 4-6 and 4-7 illustrate these results.

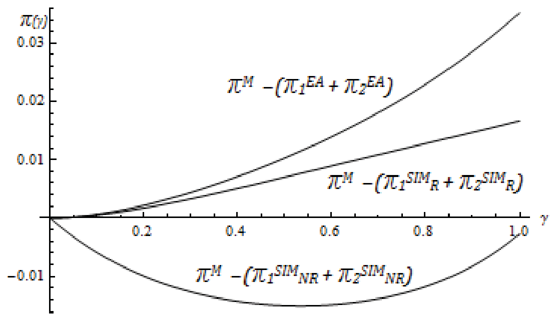

Figure 4-6

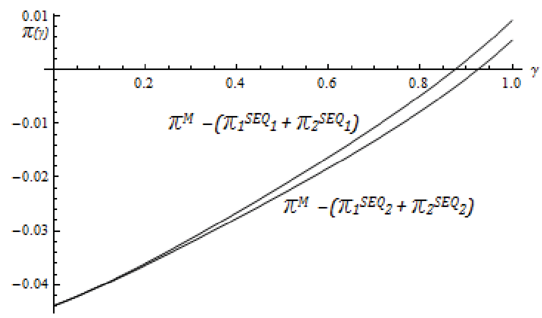

Figure 4-7

Figure 4-6 illustrates the first part of the proof. The differences $\pi^M - \left(\pi_1^{SIM_R} + \pi_2^{SIM_R}\right)$ and $\pi^M - \left(\pi_1^{EA} + \pi_2^{EA}\right)$ are positive for all $\gamma \in (0, 1]$ while $\pi^M - \left(\pi_1^{SIM_{NR}} + \pi_2^{SIM_{NR}}\right)$ is negative. Figure 4-7 illustrates the results for the comparison of profits between the merger case and the sequential structures. First, we see that the difference $\pi^M - \left(\pi_1^{SEQ_1} + \pi_2^{SEQ_1}\right)$ increases in γ and changes its sign at $\gamma^{M_1} \approx 0.87$.

Second, the difference $\pi^M - \left(\pi_1^{SEQ_2} + \pi_2^{SEQ_2}\right)$ also increases in γ and changes its sign at $\gamma^{M_2} \approx 0.92$. We have that $0 < \gamma^{M_1} < \gamma^{M_2}$.

Proof of Proposition 4. We can proceed in two steps. First, we can show that

$$W^{SEQ_2} > W^{SEQ_1} > W^{SIM_R} > W^{EA} > W^M > 0$$

holds for all $\gamma \in (0, 1]$. This relation is illustrated in Figure 4-8. We can see that the differences $W^{SEQ_2} - W^{SEQ_1}$, $W^{SEQ_1} - W^{SIM_R}$, $W^{SIM_R} - W^{EA}$ and $W^{EA} - W^M$ are positiv for all $\gamma \in (0, 1]$.

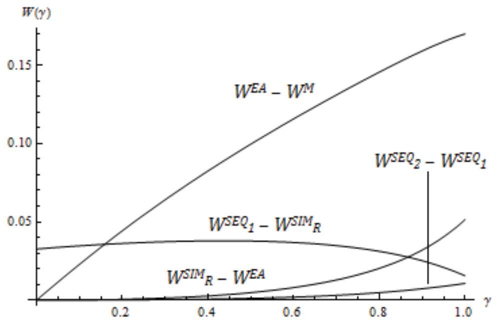

Figure 4-8

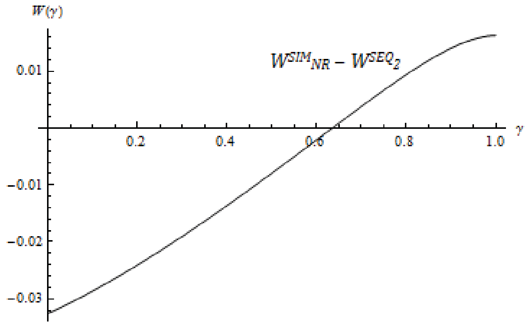

Figure 4-9

Second, we inspect the position of $W^{SIM_{NR}}$ in the ranking in relation to W^{SEQ_2}. By a numerical solution it can be established that the difference $W^{SIM_{NR}} - W^{SEQ_2}$ is positive for $\gamma > \gamma^W$, with $\gamma^W \approx 0.63$. We can see this relation in Figure 4-9. More specifically, the difference $W^{SIM_{NR}} - W^{SEQ_2}$ increases in γ and changes its sign at the critical value $\gamma^W \approx 0.63$.

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Chapter 5

Concluding Remarks

This thesis has aimed at providing new insights into the analysis of unionized oligopolies. Chapters 2 and 3 have analyzed the interaction between labor unions and firms in an international context. Chapter 4 has focused on the organization of collective bargaining within a single country.

In Chapter 2, we have considered how the change in competitive conditions in downstream markets affects the choice of wage-setting regimes by unions. The results indicate that the intensity of competition in an international market has a considerable impact on the outcome when unions choose their wage-setting regimes non-cooperatively. While unions tend to choose discriminatory, or "flexible", regimes when competition in the international market is either very soft or very intense, there exists a scope for centralized wage-setting in both countries, or an internationally asymmetric constellation in which a union with a first-mover advantage opts for a discriminatory, and the second union for a uniform regime. Thus, flexibilization in itself is not an automatic process which is triggered by increasing international competition. Instead, unions may prefer to commit themselves to centralized regimes even if flexibilization advances abroad. Each union balances its interests to extract high rents from "strong" firms with a strategic effect of "egalitarian" wages. The country with a centralized wage-setting regime provides a competition dampening effect which also benefits firms and the union abroad. Finally, we have shown that there exist parameter constellations such that all actors, firms, unions and consumers on aggregate benefit from centralized wage regimes in both countries.

In Chapter 3, we have analyzed the incentives of heterogeneous firms in international markets to counter national union power through mergers. Our results indicate that firms either prefer to merge domestically or cross-border to most effectively counter union power. When firms merge internationally, they threaten to shift production partially from one country to another and thereby put downward pressure on wages. Thus, through an international merger, the labor demand of firms becomes more wage sensitive, which ultimately results in the unions lowering their wage demands. In contrast, a domestic merger induces a "wage-unifying" effect at the merged firm. If the union is required to set an identical wage rate after a merger ("one firm, one wage") then firms most effectively counter union power by merging domestically. Although labor demand becomes ceteris paribus less responsive to wage increases after a domestic merger, the "wage-unifying" effect constrains the union in exploiting the relative efficiency of one of the plants. As a result, when firms differ sufficiently both in terms of product substitutability and non-labor productivity, the firms choose domestic mergers in equilibrium. When product substitutability increases and when firms become more homogeneous, the cross-border merger equilibrium is restored. However, in contrast to an analysis with symmetric firms, two different types of cross-border mergers can arise; namely between symmetric or asymmetric plants.

In Chapter 4 we have considered the preferences of an industry labor union and downstream firms for different forms of collective bargaining organization. The results reveal that the union always prefers to bargain with an employers' association. This is, in contrast, never preferred by the firms. Intuitively, an employers' association decreases the relative bargaining position of the firms, because they internalize the positive externality an increase in one firm's wage rate has on the rival's profit. As a consequence, concessions in bargaining would be less costly to make for the firms - a fact, which is used in turn by the union to negotiate a higher wage rate with the association.

A second major finding of this Chapter concerns the incentives of firms to merge to monopoly, which considerably depend on the alternative bargaining structure in the industry. While firms never have an incentive to merge when bargaining is simultaneous and possible negotiation breakdowns would not be observed, the reverse holds true for the case of an employers' association or the observation of breakdown in simultaneous negotiations. Intuitively, a merger weakens the bargaining position of the firms, however, there may be instances when this bargaining effect is offset by the gains from monopolizing the downstream market.

Ich erkläre hiermit an Eides Statt, dass ich die vorliegende Arbeit ohne Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht. Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

Düsseldorf, im März 2013,

Beatrice Pagel-Groba