Strategic profit sharing in a unionized oligopoly

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Abstract

I study the incentives for firms and unions to establish profit sharing contracts in decentralized and centralized wage bargaining regimes and examine the stability of these institutional arrangements. Unions and firms collectively prefer classical wage contracts. However, individual firms and unions have incentives to conclude profit sharing agreements under decentralized negotiations. In centralized systems the semi-collusion covers agreements to bargain over classical contracts and jointly maximize profit, but product market quantities are set competitively. This semi-collusive agreement is stable against deviation to wage setting in an uncoordinated (i.e. decentralized) fashion. Once profit sharing is feasible, deviation to decentralized profit sharing contracts appears. JEL classification: D43, J50, K31, L13

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1 Introduction

In December 2005, Germany’s president Horst Köhler called for ‘worker-friendly’ labor reforms, especially profit sharing. “In an era of globalization sharing the capital means can help to narrow the growing divide between the rich and the poor,” Köhler said. “Today employers and employees have to realize that they are in the same boat as part of a company facing worldwide competition” (Köhler (2005)).

This paper addresses the question whether profit sharing is advantageous for unions, firms, consumers, and overall welfare under different unionized wage bargaining regimes. Whilst in the United States and the UK variable pay schemes are more common, flexible remuneration schemes have only become more popular in Germany in the mid 1990s. One question is whether these differences result from differences in labor market institutions. In the Anglo-American part of the world wages are usually bargained on a decentralized firm level between workers’ councils and firms. In contrast, in Germany, Austria, and Scandinavian countries negotiations take place either on an industry or the national level. Unions and employer associations agree on wages that are binding for the whole industry or even country. At the same time, profit sharing between employers and employees is unusual. Whether this is sheer coincidence or a result of institutional differences is the question I try to shed light on in this paper. Therefore, I examine the decision whether to bargain over classical wage (i.e. a basic pay) contracts or to bargain over contingent pay (i.e. a base wage and a share parameter) contracts within a framework of oligopolistic competition in the product market. Furthermore, I take two institutional arrangements into account: remuneration is either negotiated under a centralized or a decentralized setting.

I show that in a decentralized bargaining system firms and unions collectively prefer classical wage contracts as a convention for all firm–union pairs in the sector. However, due to a prisoners’ dilemma, single firm–union pairs have incentives to deviate and to enter into profit sharing contracts. For centralized wage negotiations it is in the interest of both parties to negotiate a semi-collusive agreement. This semi-collusive agreement consists of two collusive parts: to negotiate centralized and to negotiate classical wages but compete in the product market. It can be shown that this agreement is stable to a deviation to decentralized classical wage contracts, but not to decentralized profit sharing contracts. This is in line with empirical research. For example, Kurdelbusch (2002) concludes in her empirical study for German industrial relations: “Until now company specific pay systems have coexisted alongside collective bargaining on pay. As yet, variable wage components have not substituted for basic pay. Nevertheless, the emergence of company specific remuneration systems is reinforcing a decentralization of wage bargaining and the variation in employment relations.” To sum it up, once profit sharing becomes more usual, the predominant semi-collusive agreements break down and overall the prisoners dilemma occurs.

However, regarding consumers profit sharing is advantageous. It is also welfare enhancing under the assumption that production and consumption take place in the same country. Therefore, profit sharing can be interpreted as an instrument to introduce efficient-bargaining (where unions and firms negotiate over wages as well as employment). Under efficient-bargaining unions and firms agree on a wage-employment combination beside the demand curve where the indifference curves tangent, and therefore it is called “efficient”. When profit sharing is not feasible and unions only bargain over a base wage, employment can only be enhanced by lowering wages.

1 For Europe see OECD (1995) and for a more precise description of the situation in the USA see Lebow, Shleifer, Silberman, and Starr-McCluer (1999).
2 For institutional details of the German system see Kurdelbusch (2002) or Gürtzen (2004).
3 Anderson and Devereux (1989) find in their seminal paper that the outcomes for profit sharing are identical to efficient bargaining in a monopoly situation with one union and one firm.
With profit sharing unions can agree on a low base wage, and this reduces firms’ marginal costs. As a consequence more workers are employed. Joint-profit maximization between firm and union occurs here. Additionally, unions are able to extract rents through a profit sharing wage coefficient. Put differently: first unions and firms maximize the sum of their profits negotiating a low base wages and afterwards these profits are distributed by the share coefficient. This is the same effect that appears with efficient–bargaining negotiations, but in a more indirect way. From a realistic perspective, profit sharing negotiations are maybe a more tractable way to implement consumer surplus/welfare enhancing effects of efficient bargaining than negotiations over wages and employment.

To encapsulate my findings: I can show centralized wage systems to be relatively stable against deviation to decentralized wage bargaining over classical wages. Nevertheless, if there is the possibility to negotiate over profit shares as well, the probability rises that the semi-collusive agreement collapses. This implies a noteworthy result for countries with centralized bargaining: once profit sharing is feasible, the parameter space is enlarged where the industry specific remuneration scheme is replaced by a decentralized one.

Even though there is a broad literature on profit sharing in general, the literature on profit sharing as a strategic instrument in oligopolistic markets is relatively thin.

Notable exemptions are Stewart (1989) and Fung (1989), which both examine the effects of profit sharing on oligopolistic competition. Stewart (1989) shows that a monopolistic firm never implements a profit sharing contract, but he proves it for perfect competition in the upstream labor market. The reverse is true for an oligopolistic firm: profit sharing is always optimal for them. Fung (1989) introduces two firm–specific unions setting the base wage while one of the firms chooses the profit sharing parameter. He assumes the profit sharing firm to have lower marginal costs and therefore to increase output while the output of the firm that does not set a contingent pay declines. Consequently, the profit sharing firm gains, whereas the other loses through profit sharing. All in all, profit sharing results in a lower product price and higher employment. However, Bensaïd and Gary-Bobo (1991) develop a model in a decentralized wage–setting regime on a take–it–or–leave–it basis (i.e. without negotiations). In the first stage, a profit sharing scheme is offered to the employees. The workers can reject or accept the firm’s proposal, negotiations about a base wage and a share coefficient are not feasible. Refusing the contingent pay offered results in a wage equal to the ‘market wage’ in the competitive sector. The finding is a subgame-perfect equilibrium where all firms simultaneously implement a share-contract. Hence, my results refine the outcome of the decentralized bargaining regime of Bensaïd and Gary-Bobo by using of negotiations instead of take-it-or-leave-it offers. Probably Sørensen’s model (see Sørensen (1992)) is the most closely connected to my paper, analyzing a special case of my model with decentralized negotiations in a duopoly framework. He examines the outcome of a Cournot game between two union–firm pairs maximizing their utility. He finds profit sharing to be profitable for the firm as long as the union does not have ‘too much power’ which is similar to my model and my findings with \( n = 2 \) and decentralized bargaining.

Another rather small strand of literature related to my model is concerned with the strategic choice of the bargaining agenda in unionized oligopolies. Yang (1995), Vannini and Bughin

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1See Prendergast (1999) for a survey.
2Fershtman and Judd (1987) already analysed contingent pay as a strategic instrument in the output market. However, their examination focused on remuneration schemes for non-unionized managers, whilst I focus on workers represented by unions.
(2000), and Petrakis and Vlassis (2000) should be mentioned here. All papers focus on the
question whether firms and unions prefer efficient—bargaining or right— to—manage negotiations.
However, while profit sharing is an indirect instrument to enable unions to influence employment
by means of the base wages, my paper studies a related question.

The rest of the paper is organized as follows: I outline the basic model in the decentralized
bargaining system and analyze the stability of the classical remuneration agreement in the next
section. In Section 3, I set up the theoretical model for centralized wage negotiations and analyze
differences in the stability of the wage-setting regimes, focussing on the influence of profit sharing.
I conclude in the last section.

2 Decentralized wage negotiations (D)

2.1 Basic Setup

I analyze a noncooperative three stage game. In stage 1, each firm faces a single monopoly trade
union and both decide whether to bargain over a basic pay in a classical system or over a share
coefficient and a base rate in a profit sharing regime. Only when the particular firm and the
particular union agree on a profit sharing contract is profit sharing established. Otherwise, if
either the union or the firm prefers a classical base pay, classical wage contracts are negotiated.
Afterwards, in stage 2 negotiations over wages take place via a decentralized Nash-bargaining
process. In stage 3, the firms unilaterally choose their product market quantities in Cournot
fashion. There are \( n \) firms and \( n \) unions (indexed by \( i = 1, \ldots, n \)). Each firm produces a ho-

mogeneous good with labor as the only input. One unit of labor is used to produce one unit
of output. Thus, I can discuss output and employment interchangeably. Firm \( i \)’s profit in the
classical system is given by

\[
\Pi_i = (p(X) - b_i)x_i
\]

where

\[
p(X) = \max\{A - X, 0\}
\]

is the inverse demand function and \( b_i \) the base wage negotiated between firm \( i \) and union \( i \). Let
\( X = \sum_{i=1}^{n} x_i \) denote the total production, and \( x_i \) be the individual output. If a firm and a union
agree to negotiate a profit sharing contract, a firm’s profit is defined as

\[
\Pi_i = (1 - a_i) (p(X) - b_i)x_i
\]

with \( a_i \) being the share coefficient, \( 0 \leq a_i \leq 1 \).

The representative union is risk neutral and has a rent-maximization objective. Hence \( U_i \) is
the utility of the union and is represented by

\[
U_i = (t_i - w)x_i
\]

where \( w \) denotes the competitive wage in a non-unionized labor market and \( t_i \) the employees’
contractual wage rate. Let the total wages per worker be \( t_i = b_i \) in the classical system and
\( t_i = b_i + a_i (p - b_i) \) in the profit sharing regime. With profit sharing, the union controls two
independent variables: the share coefficient \( a_i \) and the basic pay \( b_i \). This differs significantly
from a fixed contract, where the union tries to achieve a high level of \( U_i \) via the negotiation of a
basic pay \( b_i \) only.
In this right-to-manage model neither the firm nor the union can obtain a reservation payoff, so that the Nash bargaining product is given by

$$B = U^c_i \Pi_1^{1-c}$$

Here, $0 \leq c \leq 1$ represents the union’s and $1 - c$ the firm’s bargaining power, respectively.

I solve the model backwards, first I analyze stage 3 where I examine the firms’ optimal production decision for a given set of wage contracts. For simplicity I shall restrict attention to solutions in pure strategies only. Then, I consider the second stage and obtain the wage contracts which result from the Nash–wage–bargaining; again, only solutions in pure strategies are considered. Here I have to distinguish between two cases: first, I assume that all firms and unions negotiate in the classical system. Afterwards, I solve the model for a profit sharing system and compare the findings. I can show that firm-union pairs are collectively better off if they bargain only over a base wage in an industry specific ‘semi-collusive agreement’. Analyzing asymmetric situations is the last step: is it beneficial for some union-firm pairs in the industry to leave this semi-collusive agreement and negotiate a profit sharing contract?

2.2 Decentralized negotiations in a classical wage system ($D_{cs}$)

In this section, a basic pay is negotiable whilst profit sharing is not feasible.

**Stage 3: The product market game** In the classical system and under the assumption of Cournot-Nash competition, differentiation of (1) with respect to $x_i$ yields the first-order condition for profit maximization by the representative firm $i$.

$$\frac{d\Pi_i}{dx_i} = A - b_i - 2x_i - \sum_{j \neq i}^n x_j = 0$$

This equation can now be solved to obtain the output of each firm (and the industry output) as a reaction function with respect to the unions’ chosen wages.

$$x_i = \frac{A - nb_i + \sum_{j \neq i}^n b_j}{(n + 1)}, \quad X = \frac{An - \sum_{i=1}^n b_i}{(n + 1)}$$

**Stage 2: The market game** In the second stage, each union-firm pair will bargain over a base wage to maximize their rents. I substitute Eqs. (1), (2), (4) and (6) into Equ. (5) and differentiate with respect to $b_i$. Here, I benefit from the fact of a symmetric game, substituting $\sum_{j \neq i}^n b_j = (n - 1)b_i$ after the derivation. Thus, I obtain the equilibrium base wage for the representative firm $i$

$$b_i(D_{cs}) = \frac{Ac + nw(2 - c)}{c + n(2 - c)}$$

Further substitution then yields the equilibrium levels for prices, profits, and union utility:

$$p(D_{cs}) = \frac{(A - w)(c + 2n)}{(c + (2 - c)n)(n + 1)}$$

$$x_i(D_{cs}) = \frac{(A - w)(2 - c)n}{(c + (2 - c)n)(n + 1)}$$

$$\Pi_i(D_{cs}) = [x_i(D_{cs})]^2$$

$$U_i(D_{cs}) = \frac{c}{2 - c} \frac{n + 1}{n} [x_i(D_{cs})]^2$$
Hence, welfare can be defined as $W = n\Pi_i + nU_i + \text{consumer surplus}$ and the explicit expression of welfare is

$$W(D_{cs}) = \left(\frac{2n + c - n^2}{2 - c} + \frac{n^2}{2}\right) [x_i(D_{cs})]^2.$$  

The fixed salary $b_i$ is positive and some comparative statics show that the basic pay increase in unions strength and declines in oligopoly size.\textsuperscript{6} Examining the welfare change due to a rise in union bargaining power I obtain:\textsuperscript{7}

**Proposition 1** In a decentralized classical bargaining regime welfare $W$ declines with stronger unions, $\frac{dW}{dc} < 0$.

This effect stems from the fact that the union can charge an increasingly high wage rate with a rise in $c$. With $c = 1$ the union can set a monopolistic wage leading to a reduction of production in the oligopolistic downstream market. For $0 < c < 1$ the problem is reduced but welfare is still not maximal; at $c = 0$ welfare would be at the maximum level.

### 2.3 Decentralized negotiations about a profit sharing scheme ($D_{ps}$)

Unions and firms maximize their rents by choosing a base wage and a share coefficient in this section.

**Stage 3: The product market game** In this regime, the firm maximizes (3) with respect to $x_i$ and I obtain the same firm reaction function as in the classical system (6).

**Stage 2: The labor market game** In the first stage each union-firm pair negotiates over the basic pay $b_i$ and the share coefficient $a_i$. Union and firm choose $a_i$ and $b_i$ to achieve a high level of Eq. (5) where Eqs. (3) and (4) are the profit and utility functions, respectively.\textsuperscript{8} This yields equilibrium base wage, share coefficient, and contractual wage rate:

$$a_i(D_{ps}) = \frac{c + n - 1}{n} \quad (13)$$

$$b_i(D_{ps}) = \frac{A(1 - n) + nw(1 + n)}{(n^2 + 1)} \quad (14)$$

$$t_i(D_{ps}) = \frac{c(A - w) + w(1 + n^2)}{(n^2 + 1)} \quad (15)$$

Substituting these equations back to the price, profit, and utility functions I obtain:

$$p(D_{ps}) = w + \frac{A - w}{n^2 + 1} \quad (16)$$

$$\Pi_i(D_{ps}) = \frac{(A - w)^2 (1 - c) n}{(n^2 + 1)^2} \quad (17)$$

$$U_i(D_{ps}) = \frac{(A - w)^2 cn}{(n^2 + 1)^2} \quad (18)$$

\textsuperscript{6}$db/dc > 0$ and $db/dn < 0$

\textsuperscript{7}All proofs are presented in the appendix.

\textsuperscript{8}For a deeper understanding of the changes in the remuneration reaction functions we refer to Sørensen (1992).
Using eqs (16), (17), and (18), it is possible to denote $W$ as:

\begin{equation}
W(D_{ps}) = \frac{(A-w)^2 n^2 (n^2 + 2)}{2 (n^2 + 1)^2}.
\end{equation}

The profit sharing regime entails interesting results. The share coefficient $a_i$ of the remuneration scheme is positive, smaller than unity, and increases with union strength. Notably, $b_i$ is independent of the union bargaining power $c$. The union achieves a higher level of utility by negotiating a higher $a_i$ if she can strengthen her position. The derivation of the sharing coefficient shows a constant increase of $a_i$ due to a rise in $c$.

\[ \frac{\partial a_i (D_{ps})}{\partial c} = \frac{1}{n} > 0 \]

In other words: in smaller industries unions gain more from an increased bargaining parameter. Interestingly, $b_i$ can decrease and become negative for some parameter constellations. In these cases, firms are faced with negative marginal cost, making them very aggressive in the Cournot product market game. Thereby, they produce higher output which yields a higher demand for workers. Unions gain by increased employment and higher profit of the firms due to $a_i$.

**Proposition 2** In a decentralized profit sharing regime welfare $W$ is independent of union strength $c$.

When firms and unions negotiate profit shares and basic pay, welfare $W$ is independent of union power. The intuition for this result can be described by the two parts of the contractual wage: the base rate $b_i$ is set to an optimal level by the firm and union. Both parties maximize the ‘cake’ they bargain over, which is welfare enhancing. However, the strength of the union and the firm influences how the cake is divided. This leads to welfare neutral transfers, meaning that the level of welfare does not change.

### 2.4 The classical wage system vs. profit sharing scheme (Stage 1)

The differences between a classical wage contract in the oligopoly and a profit sharing contract can be summarized in the following proposition.

**Proposition 3**

1. **Firms prefer the classical wage contract.**
2. **Unions in duopolies favor the profit sharing scheme for $c > \frac{3}{4}$.** In larger oligopolies unions gain a higher utility in the classical regime.
3. **Total wages in the classical wage system are higher than the basic wages and higher than the total contractual wage per worker under a profit sharing regime.**
4. **Profit sharing results in higher welfare.**

The profit sharing regime reduces the base wage rate so that firms produce with lower marginal costs. As a consequence, output rises and price decreases. Lower production costs and higher quantity cannot compensate the firm for the price decrease and extraction of rents through $a_i$ by the union. Unions also suffer from profit sharing. More workers are employed, but the contract
wage decreases by so much that the union’s utility declines. Basically, these effects arise from the fact that, as a consequence of profit sharing, more output is produced. This is individually rational because marginal cost $b_i$ decreases, but firms as a whole are faced with a price decrease. The unions earn a lower basic pay while more workers are employed and obtain a share of the profit. In view of the fact that profits decline when all pairs play ‘profit sharing’, $a_i$ does not increase overall utility.

Regarding welfare, profit sharing has positive effects. This results from an increase in consumer welfare. In my closed economy model production and consumption take place in the same country. If, however, only a share of consumer surplus is part of domestic welfare, the positive welfare effect of contingent pay will decrease. Especially for a country which exports the commodities it produces it is questionable whether a change of the bargaining regime from a classical to a profit sharing one is welfare enhancing. Additionally, it must be taken into consideration that usually employment rises whilst wage payments per worker decline.

It should be clarified again that profit sharing in a right–to–manage model could be considered as a device to introduce efficient–bargaining. While with efficient–bargaining unions and firms bargain directly over wages as well as employment, in the right–to–manage approach firms unilaterally determine employment. Without profit sharing, unions in right–to–manage negotiations can only enhance employment by lowering wages. However, when unions negotiate in profit sharing regimes they can agree on a low base wage to reduce firms’ marginal costs, leading to a high rate of employment. Simultaneously, unions can achieve the same utility level by extracting rents due to a high profit sharing coefficient. Even if employment is determined more indirectly, profit–sharing–right–to–manage negotiations’ than in efficient bargaining these negotiations are maybe a more tractable way than efficient bargaining to implement the positive effects of efficient bargaining in reality.

To sum up my findings: unions and firms collectively prefer the inefficient classical contract over more efficient profit sharing schemes in most cases. This is due to the negative competition externality in Cournot competition. If both firms and unions are monopolists they would strictly prefer profit sharing. Strikingly, profit sharing enlarges these negative Cournot competition or Prisoner’s Dilemma effects.

However, if unions and firms could collectively write binding contracts they would collude over the contract form and bargain over classical wage rates. Here, the ‘semi-collusive agreement’ involves the consent about the contract form. This contrasts the cartel literature discussing mostly quantity or price agreements. Instead, my model is probably more in line with the literature on semi-collusion where firms act in collusive action, maximizing joint profits by choosing one strategic variable while competing in the other variables. To avoid misunderstandings: the agreement in my model covers only the scope of bargaining. All unions and firms choose classical contracts in the first stage since this leads to higher profits for every single union and firm in the industry. This can be understood as a special case of joint profit maximization. However, the product market is still competitive. For the rest of the paper I refer to this kind of behavior as ‘semi-collusion’ like Fershtman and Muller (1986).

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9For details about right-to-manage see Nickell and Andrews (1983) or MacDonald and Solow (1981) for efficient–bargaining. A good reference for a survey about the advantages and disadvantages of these models is Naylor (2003).

10In my model I assume homogeneous products. Therefore, it may be desirable to extend my model to heterogeneous products. With more differentiated products my firm-union pairs approach the monopolistic situation and the negative competition effect is reduced. A threshold value for product differentiation may exist, where for more heterogeneous products unions and firms would prefer profit sharing. Unfortunately, the mathematical complexity of my model does not allow us to find an exact solution for the threshold values.

11This assumption is modified in Section 3.
Hitherto, I have not analyzed the stability of this semi-collusive agreement. Does a union-firm pair have an incentive to become an outsider and negotiate a profit sharing contract? I follow D’Aspremont, Jaquemin, Gabszewicz, and Weymark (1983) and assume a cartel or semi-collusive agreement to be stable if and only if a union-firm pair inside does not find it desirable to exit (internal stability) and an outside pair of firm and union does not find it desirable to join the agreement (external stability). To prove cartel instability it is therefore sufficient to demonstrate that the cartel is either externally or internally unstable.

2.5 Stability of the semi-collusive agreement \((D_{ts})\)

To answer this question, I investigate how firm profits and union utility vary if a firm–union pair leaves the semi-collusive agreement. At the outset, \(k\) of the \(n\) firms bargain semi-collusively over a classical wage contract while \(n-k\) union-firm pairs are outsiders to this agreement. I obtain the equilibrium profits and utility levels for firms and unions negotiating in the classical system \((\Pi_i, U_i)\) and under a profit sharing regime \((\Pi_r, U_r)\). Subsequently, I assume an additional pair to introduce profit sharing. Now, \(k-1\) firms and unions participate in the semi-collusive agreement while \(n-k+1\) firm–union pairs are outsiders. The equilibrium outcomes are given by \(\Pi_i^{+1}, U_i^{+1}, \Pi_r^{+1}\), and \(U_r^{+1}\). For a stable agreement \(\Pi_i\) or \(U_i\) must exceed \(\Pi_r^{+1}\) and \(U_r^{+1}\), respectively.

In other words, if the union as well as the firm benefit from deviating I assume that both will agree on a contingent contract. Firstly, I focus on the computations for the number of pairs \(k\) acting semi-collusively. Afterwards, similar computations can be made for a semi-collusive agreement with \(k+1\) participants, but I summarize the equilibrium outcomes in the appendix only.

For \(k\) semi-colluding pairs I assume a linear product demand

\[
\begin{align*}
\text{(20)} \quad p(X + Y) &= \max\{A - X - Y, 0\}
\end{align*}
\]

where \(X = \sum_{i=1}^{k} x_i\) is the cumulated output of the firms with a classical contract and \(Y = \sum_{r=1}^{n-k} y_r\) the production of all firms paying their employees wage according to a profit sharing scheme. The contractual wages, the profit, and the utility functions can now be written as

\[
\begin{align*}
\text{(21)} \quad t_i &= b_i \quad t_r &= b_r + a_r (p - b_r) \\
\text{(22)} \quad U_i &= (t_i - w) x_i \quad U_r &= (t_r - w) y_r \\
\text{(23)} \quad \Pi_i &= (p - b_i) x_i \quad \Pi_r = (1 - a_r) (p - b_r) y_r
\end{align*}
\]

From the profit functions (23) I can derive the first-order conditions for profit maximization in the product market game. In order to obtain the equilibrium levels of output for each representative firm I solve the first order conditions. This yields the following representative labor demand functions:

\[
\begin{align*}
x_i &= \frac{A - nb_i + \sum_{j \neq i}^{k} b_j + \sum_{r=1}^{n-k} b_r}{n + 1} \\
y_r &= \frac{A - nb_r + \sum_{s \neq r}^{n-k} b_s + \sum_{i=1}^{k} b_i}{n + 1}
\end{align*}
\]

In the labor market game, each of the \(k\) firm-union pairs in the classical remuneration system bargains just the fixed wage rate \(b_i\) maximizing the Nash-bargaining solution

\[
\max_{b_i} B = U_i^c \Pi_i^{1-c}
\]
Similarly, the other $n - k$ firm-union pairs will choose $a_r$ and $b_r$ by differentiating

$$\max_{a_r, b_r} B = U_r^c \Pi_r^{1-c}$$

Solving the Nash bargaining problem I find the equilibrium contracts. Hence, I can provide expressions for the price, the firm’s profit, and the union’s utility.

In order to answer the question whether or not the semi-collusive outcome is stable I have to solve for the product market and the labor market game again. Henceforth, I assume $n - k + 1$ firm-union pairs to negotiate a profit sharing scheme while $k - 1$ choose the classical system. Analogous calculations yield the results presented in the appendix.

In the following section, I consider the comparative static properties of the model, focusing on semi-collusive stability.

2.6 Comparative statics

First, consider the decision of one firm-union pair in an industry with all firms and unions bargaining in the classical system. Is it preferable for a pair to leave the agreement? I have analyzed the situation for all $k = n$ to $k = 1$ firm-union pairs. In other words: is it advantageous for every $n - k + 1$ firm-union pair to become a deviant on the assumption that the other $k - 1$ pairs act in a semi-collusive manner?

Whilst the unions unambiguously prefer to be outsiders, the situation for the firms alters with a variation in $k$. Therefore, a general examination for $1 \leq k \leq n$ for the firms is worthwhile. For the simple reason that the function of the profitability to be an outsider is of seventh degree nature, an explicit expression cannot be found. Instead, I present numerical solutions to receive some impressions on the instability if $k$ varies:

\[\text{[table 1 about here]}\]

The table shows the threshold values of the bargaining strength. Lower values indicate an incentive for the firm to become an outsider. To set an example: for $n = 5$ the first firm, $k = 5$, prefers deviating if $c < 0.66896$. The second finds it profitable for $c < 0.86926$, the third for $c < 0.90719$. Even though I cannot provide a general proof, two facts are obvious: the likelihood for a deviation is rising in oligopoly size and number of outsiders. This result stems from the aggressive behavior of the outsiders. Firms and unions in the semi-collusive agreement behave less aggressively by producing a smaller output due to higher marginal costs. Thereby, to participate in the agreement becomes increasingly harmful whenever another pair leaves the semi-collusive agreement and acts aggressively.

Summary 1 The instability of the collusive agreement increases in oligopoly size and number of outsiders and declines in union power.

This situation is a typical prisoners’ dilemma. All favor a semi-collusive behavior but the incentive to deviate is predominant. However, empirically it is very rare to find $c > 0.5^{12}$, indicating union power being larger than firm power. So an agreement instability will be common in most industries.

\[12\text{See Veugelers (1989) and Bughin (1996) for empirical evidence.}\]
3 Centralized wage negotiating (C)

In this alternative bargaining scenario, a centralized union bargains over an industry–specific wage with an employers’ confederation. Firms as well as unions act collusively, trying to maximize their rents in the labor market. The product market is still oligopolistic, and firms behave as competitors.

The structure of this section is as follows. First, I modify the basic model, assuming a central union and a central employers’ association and summarize the results for negotiations in the classical system. Second, outcomes are compared with the results for decentralized, firm–specific bargaining with profit sharing. I obtain an advantage for firms and unions in behaving collusively. To avoid misunderstandings: here, the semi-collusive agreement contains the arrangement on central bargaining and on classical wage contracts. The test of stability is separated to two steps shown in figure 3. The first step, analyzing the profitability to deviate from central classical wage negotiations, to decentralized classical negotiations shows a relatively low incentive for unions to deviate. Nevertheless, if the scope of bargaining changes as well to a share pay in the second step, the semi-collusive agreement becomes unstable. They desire to negotiate profit sharing schemes; resulting in a prisoners’ dilemma again.

3.1 Centralized negotiations in a classical wage system (Cc)

It is straightforward to derive the reaction functions assuming all firms to have the same industry specific labor costs. Each firm maximizes profits

$$\Pi_i = (p - b) x_i$$

where the linear inverse demand function is given by

$$p = \max \{0, A - X\}$$

and by producing a firm specific output of

$$x_i = \frac{A - b}{n + 1}$$

which yields an industry production of

$$X = \frac{(A - b) n}{n + 1}.$$ 

From these expressions, I derive the industry profit

$$\Pi = n \Pi_i = n \left( \frac{A - b}{n + 1} \right)^2.$$ 

Assuming that the industry specific union objective can be captured by the functional form

$$U = (t - w) X,$$

with $t$ being the industry fixed salary rate $b$, the Nash bargaining solution $B = U^c \Pi^{1-c}$ can be rearranged to:

$$\max_b B = \left( \frac{(A - b) (b - w) n}{n + 1} \right)^c \left( \frac{n (A - b)^2}{(n + 1)^2} \right)^{1-c}.$$
Differentiating with respect to \( b \) yields the findings presented in the appendix.

It is worth noting that the base wage rate is independent of the industry size.\(^{13}\) This is due to the fact that an industry union and an industry employers’ association bargain about the remunerations. Furthermore, welfare decreases with a rise in union strength.

### 3.2 Is a semi-cartel agreement advantageous for firms and unions?

Hitherto, I computed equilibrium results for central bargaining with classical contracts in the last section and the outcomes for the decentralized profit sharing bargaining were presented in section 2.3. Hence, I now examine the condition which determines whether a centralized base wage or a decentralized profit sharing contract is profitable.

For an individual firm the profit resulting from a sharing contract exceeds the profit from an industry specific base wage contract if \( \Pi_i(C_{ps}) > \Pi_i(C_{cs}) \).\(^{14}\) This is not the case. Thus, it is always preferable for a firm to be an insider to the semi–collusive agreement. Similarly, \( U_i(C_{ps}) > U_i(C_{cs}) \) must be true for all unions to make profit sharing worthwhile. However, \( U_i(C_{ps}) - U_i(C_{cs}) < 0 \).\(^{15}\) Consequently, both parties benefit from the industry collusion. Nevertheless, I have to analyze semi–collusive agreement stability from individual deviation again. To shed light on the reason why a semi-collusive agreement results in higher profits and utility, I proceed in two separate steps: First, I examine whether firm-union pairs would break away from an industry specific classical wage contract if only a firm specific base wage contract\(^{16}\) without profit sharing is achievable. In a second step I analyze the profitability of a change to decentralized profit sharing contracts.

#### Step 1: are decentralized classical wages profitable?

A prevalent finding in the literature on static oligopolies\(^{17}\) is a disadvantage for substitutable workers being organized in different unions. I can confirm this result by finding collusive wage bargaining to be in the interest of the first union as long as its bargaining strength is not extremely high and the oligopoly is not very large.\(^{18}\) Even in a dynamic analysis the union prefers centralized bargaining, as can be seen on the left of the function\(^{19}\) in Figure 4 where \( U_r^{+1}(C_{dcs}) < U_i(C_{dcs}) \) is true under the line. All in all, the semi-collusive agreement is relatively stable against a union infringement.

To elucidate my proceeding: I demonstrate a disadvantage for the first union in deviating from the agreement for a large parameter space. In consequence, there is no important reason to examine the incentive for the second or third union en detail because this situation will only appear rarely. Hence, for the sake of completeness, I present numerical findings in appendix C.3, \( \text{C}_{3} \).

---

\(^{13}\)db\( (C_{cs}) /dn = 0 \). Dhillon and Petrakis (2002) provide sufficient conditions under which the base wage is independent of product market features (like the industry size) and bargaining institutions. Referring to Dhillon and Petrakis (2002), with centralized wage bargains between an employers’ confederation and a single industry union the negotiated wage turns out to be the same under efficient–bargaining and right-to-manage.

\(^{14}\)\( \frac{(A - w)^2 ((2 - c) (w - A)^2 c)/[4 (n + 1)] > 0 \)

\(^{15}\)\( \frac{((w - A)^2 c (c + 4 n - 2 n^2 + 2 c n^2 + 2 n^3) /[4 (n^2 + 1)^2 (n + 1)] < 0 \)}

\(^{16}\)Results can be found in appendix C.4.

\(^{17}\)See e.g. Horn and Wolinsky (1988) or Gürtzen (2003) for a more detailed analysis.

\(^{18}\)\( U_{r}^{+1}(C_{dcs}) > U_i(C_{dcs}) \) with \( n = k \) if \( [(2 - c) (w - A)^2 c]/[4 (n + 1)] > 0 \)

\(^{19}\)\( U_{r}^{+1}(C_{dcs}) - U_i(C_{dcs}) = 0 \)
showing a decline in the incentive for unions for a later deviation, so that the union will not agree.

Contrarily, but in line with the literature, I find it unambiguously in the interest of the first firm to bargain over a firm specific contract.\textsuperscript{20} As long as an agreement between firm and union is a requirement for a firm specific contract, the incentive to leave the industry contract is low for a high bargaining power of the firm or for smaller oligopolies.

**Conclusion 1** The semi-collusive agreement ‘central classical wages’ is relatively stable against a deviation to ‘decentralized classical wages’.

**Step 2: are decentralized profit sharing schemes profitable?\textsuperscript{21}**

Is it profitable for one firm-union pair to leave the agreement? Deviating from the industry specific contract means that the employers leave their association and negotiate decentralized with a firm specific union about profit sharing wage contracts.

Again, I am confronted with the problem of giving a general solution for this parameter constellation, so numerical computations are necessary and are presented in Table 2 for firms and in Table 3 for unions.

Unfortunately, the profitability function for firms deviating is of ninth degree nature, and the results are non-monotonic. The values presented indicate the threshold union strength necessary to make a deviation of firms unprofitable. As long as the strength of the union is lower than this threshold value firms will deviate. The situation for the unions is less complicated. Whilst it is questionable if the first union deviates, as soon as one outsider exists all other unions unambiguously want to become an outsiders. The thresholds for the first unions are stated in Table 3. The unions prefer decentralized bargaining for lower values than these thresholds. Evidently, only for the first union is it questionable whether a deviation is advantageous. As soon as one union-firm pair does not participate in the semi-collusive agreement all other unions will deviate, too.

With reference to the empirical findings of Bughin (1996) and Veugelers (1989) the firms will not act collusively. In touch with reality I can ascertain that all firm–union pairs will deviate once the first pair has deviated. For the first pair the profitability crucially depends on union strength. To see it from a different perspective: as soon as a single competitor in the product market is not a member of the agreement anymore, all union–firm pairs will deviate for an empirically validated value of $c$. This will be the case if I extend this model by an international aspect. When I assume that one firm in the product market is located in a foreign country and has to bargain profit sharing contracts with a foreign union, the domestic agreement will break down. Semi-collusive agreement stability is therefore very improbable.

**Conclusion 2** A semi–collusive agreement of centralized classical wage bargaining is very unstable against a deviation to decentralized profit sharing contracts.

To sum up my findings:

\begin{equation}
\Pi^{+1} (C_{dc}) - \Pi_i (C_{dc}) > 0
\end{equation}

\textsuperscript{21}The findings for $k$ pairs negotiating a collusive classical wage contract and $n-k$ ones deviating can be found in Appendix C.2.
Summary 2

1. The union–firm–semi–collusive agreement is relatively stable against deviation in the centralized bargaining scenario when only classical contracts are allowed. The stability of the agreement declines in oligopoly size and union strength.

2. The semi-collusive agreement stability declines considerably more when the firm-union pairs have the possibility of signing profit sharing contracts, too.

To clarify this result: basically, workers being substitutes for firms favor to be organized in a single union and not to be faced with internal competition. Hence, incentives to deviate on centralized wage bargaining are low for workers as long as only a basic pay is negotiated. In contrast, with the possibility of bargaining over a contingent and a basic pay unions leave the semi-collusive agreement. This can be an advantage for a union as it grants a competitive gain to their firms exceeding the disadvantages from internal competition.

Apparently, unions in my model are confronted with a dilemma: on the one hand, it is an advantage for substitutable workers to be organized in a single union in the centralized system. Nonetheless, they can only negotiate the value of the basic pay to achieve high employment and wages. On the other hand, in the decentralized profit sharing system unions have two instruments to attain their two goals, which is an advantage for the pair deviating; but the workers are engaged in competition.

4 Conclusion and further remarks

This paper analyzed the emergence of profit sharing contracts when wages are negotiated in a centralized or a decentralized bargaining system. Assuming a union strength smaller than the firm’s bargaining strength, I have shown the following: in a decentralized bargaining system profit sharing in an industry is not in the collective interest of firms and unions. Nevertheless, individual firm union pairs find it profitable to leave the ‘non–profit–sharing’ semi–collusive agreement being welfare enhancing due to an increase in consumer surplus. Similarly, a centralized system gains by classical ‘non–profit–sharing’ contracts. It can be shown that deviating to decentralized classical contracts will not be an equilibrium solution for smaller industries. For instance, if the union is strong with $c = 0.5$, more than $n = 45$ firms must compete in the industry to make deviating advantageous. In contrast, unions and firms will remain outside the agreement if the scope of bargaining includes a profit sharing coefficient and union power exceeds a critical value falling in $n$ and number of outsiders.

On the assumption that increasing globalization can be approximated by an increase in $n$ the semi-collusive agreement becomes even less efficient and profit sharing more likely. Consequently, firms and unions in countries with centralized wage bargaining will have an incentive to negotiate decentralized profit sharing contracts in the future. Especially a competitor in a foreign country not being able to join the agreement but acting in the same market leads to an increased incentive for the participants to become deviants. For instance, IBM Germany was a member of the employers’ association and no earlier than 1994 they quit so as to negotiate on a decentralized level with the workers’ council over a profit sharing contract. Empirically, Kurdelbusch (2002) shows that companies which operate internationally have a greater incentive to deviate from centralized wage bargaining and agree over profit sharing schemes with workers’ councils. She writes: “Multinational companies play a vanguard role in the diffusion of variable pay. (...) The increase [of contingent pay] can be explained by the growing internationalization of product and capital markets as it is the multinational companies with a high percentage of
foreign sales and a strong orientation toward shareholder value that are most likely to use flexible pay.” With respect to welfare I have found that firms and unions suffer from the change, but due to price decreases consumers gain. Total welfare increases as a result of sharing contracts. Profit sharing can be understood as an instrument to introduce the welfare enhancing effects of efficient bargaining in a much more indirect way: unions are able to negotiate low base wages to enlarge employment and extract rents by means of a high share coefficient. High employment is equal to high production and therefore advantageous for consumers. For export countries, in contrast, the situation may differ if consumers are located outside the home country. It is doubtful whether Horst Köhler’s advice to negotiate profit sharing contacts increases national welfare if it is applied in export sectors. However, it is also important to note that employment rises.

This model provides first insights into the effects of profit sharing as a strategic instrument for firms and unions. Future research could explicitly model globalization processes and their impact. In addition, different assumptions about demand and risk attitudes may be applied. If I allow firms to make losses for some periods, results may also change. Possibly, risk–averse workers suffer from profit sharing even though the expected wage remains unchanged. It seems reasonable to suppose that these workers will ask for a risk premium. Additionally, linking this result to the literature on management incentives may be interesting. The bargaining solutions should change when managers, being representatives of the firm’s owners, bargain over wages, maximizing their own utility. Possibly, managers will not deviate from the semi-collusive agreement if their own wages decline once profit sharing agreements are concluded.

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References


A Proofs

A.1 Proposition 1
Proof. The welfare is declining in $c$ as long as

$$\frac{dW}{dc} = \frac{2(c + 2n)(A - w)^2 n^2}{(c(n - 1) - 2n)^2 (n + 1)^2} < 0.$$ 

A.2 Proposition 2
Proof. It is sufficient to show that (19) is independent of $c$. ■

A.3 Proposition 3
Proof.

1. Subtracting the profit under the classical regime from the profit sharing system I obtain

$$(17) - (10) = \frac{(A - w)^2 \Psi (c + n - 1) n}{(cn - 2n - c)^2 (n^2 + 1)^2 (n + 1)^2}$$

with $\Psi = 4n - 4cn - c^2 - 4n^4 - 4cn^2 + 4cn^4 + 2c^2n^2 - c^2n^4$. Thus, the sign of (17) – (10) is given by the sign of $\Psi$. $\Psi$ is strictly negative whenever $n > 1$ and $0 \leq c \leq 1$.

2. For the union

$$(18) - (11) = \frac{(A - c)^2 (c + n - 1) \Upsilon cn}{(cn - 2n - c)^2 (n^2 + 1)^2 (n + 1)}$$

must be positive if she prefers profit sharing. (18) – (11) is positive if $\Upsilon = c + 2n - cn + 2n^2 - 2n^3 - cn^2 + cn^3 + 2 > 0$. Only for $n = 2$ and $c > \frac{2}{3}$ this is true, otherwise $\Upsilon$ is negative.
3. By subtracting it can be shown that the base rate in the classical wage regime always exceeds the base rate and the contractual wage rate combined under the profit sharing regime \((7) > (15) > (14))\).

4. The difference between the share contract and the classical system can be calculated by subtracting

\[
(19) - (12) = \frac{2(A - w)^2 n^2 (c + 2n + n^2 + n^3) (c + n - 1)}{(cn - 2n - c)^2 (n^2 + 1)^2 (n + 1)^2},
\]

being positive.

\[\blacksquare\]

A.4 Proposition 4

**Proof.** Wages decline for the first pair only if \(n - k^* < 1\), or

\[
\frac{-2n (n - 1) + (n^2 - 2n - 1) c}{2 (c + n - 1) n} < 0
\]

The salary in a stable semi-collusive agreement \(b_i (n = k)\) with \(k = n\) participants is higher than wages after deviating \(t_r^{+1}\) for all \(n\) and \(k\) if

\[
b_i (n = k) - t_r^{+1} > 0.
\]

I can rewrite the condition as:

\[
\frac{(A - w) c (c + n - 1) (2n (n - k) + c (n - 1))}{(c (n + 1)^2 + 2n^2 (n - k) + 2n (n - ck) + 2kn) (c + n (2 - c))} > 0
\]

\[\blacksquare\]
B Test of Cartel stability ($D_{ts}$)

B.1 $k$ members of the semi-collusive agreement

The union-firm pairs bargaining over a contingent pay are indexed with $r$, pairs negotiating a classical wage with $i$.

$$b_i (D_{ts}) = \frac{Ac(n + 1) + nw(2 - c) + 2knw(1 - c) + wn^2(c + 2(n - k))}{\Omega}$$

$$a_r (D_{ts}) = \frac{c + n - 1}{n}$$

$$b_r (D_{ts}) = \frac{A(c + 2n)(1 - n) + wn(c + 2k(1 - n - c)) + wn^2(c + 2n + 2)}{\Omega}$$

$$\Pi_i (D_{ts}) = \frac{(A - w)^2(2 - c)^2n^2}{\Omega^2}$$

$$\Pi_r (D_{ts}) = \frac{(A - w)^2(c + 2n)^2n(1 - c)}{\Omega^2}$$

$$U_i (D_{ts}) = \frac{(A - w)^2(2 - c)(1 + n)cn}{\Omega^2}$$

$$U_r (D_{ts}) = \frac{(A - w)^2(c + 2n)^2nc}{\Omega^2}$$

with $\Omega = 2kn(1 - c) + 2n^2(n - k) + c + 2n + cn^2$

B.2 $k - 1$ members of the semi-collusive agreement

$$b_i^{+1} (D_{ts}) = \frac{(Ac(n + 1) + 2wnk(1 - c) + 2wn^2(n - k) + wn(c + 2n + cn))}{\Phi}$$

$$a_r^{+1} (D_{ts}) = \frac{c + n - 1}{n}$$

$$b_r^{+1} (D_{ts}) = \frac{wn(3c + 4n + cn + 2n^2) - 2nw - A(n - 1)(c + 2n) - 2wnk(c + n - 1)}{\Phi}$$

$$t_r^{+1} (D_{ts}) = b_r^{+1} + a_r^{+1}(p^{+1} - b_r^{+1})$$

$$\Pi_i^{+1} (D_{ts}) = \frac{(A - w)^2(2 - c)^2n^2}{\Phi^2}$$

$$\Pi_r^{+1} (D_{ts}) = \frac{(A - w)^2(c + 2n)^2n(1 - c)}{\Phi^2}$$

$$U_i^{+1} (D_{ts}) = \frac{(A - w)^2(2 - c)nc(n + 1)^2}{\Phi^2(n + 1)}$$

$$U_r^{+1} (D_{ts}) = \frac{(A - w)^2(c + 2n)^2cn}{\Phi^2}$$

with $\Phi = 2n^2(n - k) + 2nk(1 - c) + c(2n + 1) + n^2(c + 2)$
C Centralized Bargaining \((C)\)

C.1 Classical bargaining regime \((C_{cs})\)

\[
\begin{align*}
\text{b}(C_{cs}) &= \frac{2w + c(A - w)}{2} \\
\Pi_i(C_{cs}) &= \frac{(A - w)^2 (c - 2)^2}{4(n + 1)^2} \\
\Pi(C_{cs}) &= \frac{(A - w)^2 n (c - 2)^2}{4(n + 1)^2} \\
U_i(C_{cs}) &= \frac{(A - w)^2 c (2 - c)}{4(n + 1)} \\
U(C_{cs}) &= \frac{(A - w)^2 cn (2 - c)}{4(n + 1)} \\
W(C_{cs}) &= \frac{(A - w)^2 n (2n + cn + 4) (2 - c)}{8(n + 1)^2}
\end{align*}
\]

C.2 Classical regime, test of stability \((C_{ts})\)

C.2.1 \(k\) members of the agreement

\[
\begin{align*}
\text{b}(C_{ts}) &= \frac{w\Theta - Ac(1 + n)}{\Upsilon} \\
\text{a_r}(C_{ts}) &= \frac{n}{(c + n - 1)} \\
\text{b_r}(C_{ts}) &= \frac{A(n - 1)((c - 2)k + 2(n + 1)) - w\Psi}{\Upsilon} \\
\Pi_i(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)^2 (c - 2)^2}{\Upsilon^2} \\
\Pi(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)^2 (c - 2)^2 k}{\Upsilon^2} \\
\Pi_r(C_{ts}) &= \frac{(A - w)^2 (2n - 2k + ck + 2)^2 n (1 - c)}{\Upsilon^2} \\
U_i(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)(n + 1)(2 - c)c}{\Upsilon^2} \\
U(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)(n + 1)(2 - c)ck}{\Upsilon^2} \\
U_r(C_{ts}) &= \frac{(A - w)^2 cn (2(n - k) + ck + 2)^2}{\Upsilon^2}
\end{align*}
\]

with \(\Upsilon = (k - n) ((c - 2)k(n - 1) + 2n(1 + n)) - 2(1 + n)\)
C.2.2 $k - 1$ members of the semi-collusive agreement:

\[
\begin{align*}
    b^{+1} (C_{ts}) &= \frac{Ac (1 + n) + w\Omega}{\Delta} \\
    \text{with } \Omega &= \left( - (c - 2) k^2 (n - 1) + n (n + 1) (4 - c + 2n) + k \left( c (n - 2 + n^2) - 4 (n - 1 + n^2) \right) \right) \\
    a^{+1} (C_{ts}) &= \frac{(c + n - 1)}{n} \\
    b^{+1} (C_{ts}) &= \frac{-A (n - 1) (4 + c (k - 1) - 2k + 2n) - (k - 2 - n) \Phi w}{\Delta} \\
    \text{with } \Phi &= \left( c (k - 1) (n - 1) + 2 (k - 1 - kn + n (2 + n)) \right) \\
    \Pi^{+1} (C_{ts}) &= \frac{(A - w)^2 (n - k + 2)^2 (e - 2)^2}{\Delta^2} \\
    \Pi^{+1} (C_{ts}) &= \frac{(A - w)^2 (n - k + 2)^2 (e - 2)^2 (k - 1)}{\Delta^2} \\
    \Pi^{+1} (C_{ts}) &= \frac{(A - w)^2 (1 - c) (2n - 2k - c + ck + 4)^2 n}{\Delta^2} \\
    U^{+1}_i (C_{ts}) &= \frac{(A - w)^2 (n - k + 2) (n + 1) (c - 2) c}{(1 - k) \Delta^2} \\
    U^{+1} (C_{ts}) &= \frac{(A - w)^2 (k - n - 2) (2 - c) (-n - 1) c}{\Delta^2} \\
    U^{+1}_r (C_{ts}) &= \frac{(A - w)^2 nc (c + 2k - 2n - ck - 4)^2}{\Delta^2} \\
    \text{with } \Delta &= e (k - 1) (k - n - 1) (n - 1) - 2 (k - n - 2) (k (n - 1) - n (1 + n))
\end{align*}
\]

C.3 Incentives for unions to deviate from a centralized classical system to a decentralized classical regime

[Table 4 about here]
C.4 Centralized system, deviating to a decentralized classical remuneration contract \((C_{dcs})\)

C.4.1 \(k\) members of the semi-collusive agreement

\[
\begin{align*}
\begin{array}{l}
b(C_{dcs}) = \frac{(Ac(c+2n)+(c-2)(2n(k-1-n)+c(k^2-kn-1))w)}{\Xi} \\
b_r(C_{dcs}) = \frac{Ac((c-2)k+2(1+n))+(c-2)(k-n-1)(ck+2n)w}{\Xi} \\
\\text{with } \Xi = c^2k(k-n)+4n(1+n-k)-2c((n-k)^2-1) \\
\Pi_i(C_{dcs}) = \frac{(A-w)^2(n-k+1)^2(c+2n)^2(2-c)^2}{\Lambda^2(n+1)^4} \\
\Pi(C_{dcs}) = \frac{(A-w)^2(n-k+1)^2(c+2n)^2k(2-c)^2}{F^2(n+1)^4} \\
\Pi_r(C_{dcs}) = \frac{(A-w)^2(2(n-k)+ck+2)^2(2-c)^2n^2}{\Lambda^2(n+1)^4} \\
U_i(C_{dcs}) = \frac{(A-w)^2(n-k+1)(2-c)(c+2n)^2c}{F^2(n+1)} \\
U(C_{dcs}) = \frac{(A-w)^2(n-k+1)(2-c)(c+2n)^2ck}{\Lambda^2(n+1)^4} \\
U_r(C_{dcs}) = \frac{(A-w)^2(2-c)n(2k-2n-ck-2)^2c}{\Lambda^2(n+1)}
\end{array}
\end{align*}
\]

with \(\Lambda = 2c+4n-4kn+4ckn+4n^2-2ck^2-2cn^2-c^2kn+c^2k^2\)

with \(F = 4kn-4n-2c-4ckn-4n^2+2ck^2+2cn^2+c^2kn-c^2k^2\)
C.4.2 \( k - 1 \) members of the semi-collusive agreement

\[
\begin{align*}
b^{+1}(C_{dcs}) &= \frac{Ac(c + 2n) + (c - 2)(2n(k - 2 - n) + c(k - n - 2) + n)}{\Gamma} w \\
b_i^{+1}(C_{dcs}) &= \frac{Ac(c - 4 + 2k - ck - 2n) - (c - 2)(k - n - 2)(c(k - 1) + 2n)}{-\Gamma} w \\
\Pi_i^{+1}(C_{dcs}) &= \frac{(A - w)^2 (n - k + 2)^2 (c + 2n)^2 (c - 2)^2}{\Gamma^2 (n + 1)^2} \\
\Pi_i^{+1}(C_{dcs}) &= \frac{(A - w)^2 (n - k + 2)^2 (c + 2n)^2 (c - 2)^2 (k - 1)}{\Gamma^2 (n + 1)^2} \\
\Pi_r^{+1}(C_{dcs}) &= \frac{(A - w)^2 (2n - 2k - c + 4)^2 (c - 2)^2 n^2}{\Gamma^2 (n + 1)^2} \\
U_i^{+1}(C_{dcs}) &= \frac{(A - w)^2 (k - n - 2) (c - 2) (c + 2n)^2 c}{\Gamma^2 (n + 1) (k - 1)} \\
U_i^{+1}(C_{dcs}) &= \frac{(A - w)^2 (k - n - 2) (c - 2)(c + 2n)^2 c}{\Gamma^2 (n + 1)} \\
U_r^{+1}(C_{dcs}) &= \frac{(A - w)^2 (2c + c + 2k - 2n - ck - 4)^2 c}{\Gamma^2 (n + 1)} \\
\text{with } \Gamma &= c^2 + (c - 2) (c(k - 2)k - 2n^2) - n(4(k - 2) + (c - 4)c(k - 1))
\end{align*}
\]