

Strategic profit sharing in a unionized oligopoly

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Abstract

This paper studies the incentives for firms and unions to establish profit sharing contracts as a strategic instrument in a Cournot product market oligopoly with decentralized and centralized wage bargaining. Therefore, we examine the stability of these institutional arrangements and show that unions and firms collectively prefer classical wage contracts. However, under decentralized wage bargaining individual firms and unions have incentives to replace classical wage contracts by profit sharing agreements. Under a centralized wage bargaining system semi-collusion—where firms collude over the form of the labor contract but set product market quantities in a competitive fashion—is externally and internally stable. It can be shown that firms do not have incentives to deviate to negotiate separate firm-level wages unless profit-sharing is feasible. Hence, the possibility to conclude profit-sharing agreements can destabilize the so-called semi-collusive agreement and lead to more decentralized wage negotiations.

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 wage bargaining regimes. Whilst in the United States and the UK variable pay schemes are common¹, more flexible remuneration schemes have only become more popular in Germany in the mid 1990s. One question is whether these differences can 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,² Austria, and Scandinavian countries negotiations take place either on an industry or the national level. Unions and employer associations agree on wages 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 we try to shed light on in this paper. Therefore, we examine the decision whether to bargain over classical wage contracts or to bargain over contingent pay contracts within a framework of oligopolistic competition in the product market. Furthermore, we take two institutional arrangements into account: remuneration is either negotiated under a centralized or a decentralized setting.

We 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. The same is true for centralized industry relations: classical wages are in the collective interest of both parties. Furthermore, we now find an agreement on central classical wage contracts to be relatively stable against a deviation when only firm-specific *classical* contracts are feasible. We also show this deviating from the semi-collusive agreement is more likely if firms and unions are allowed to negotiate over a base wage as well as a profit share coefficient. In this particular case, firms and unions gain by a deviation. As a consequence, negotiations take place on a decentralized level. The scope of bargaining includes now a base wage as well as a sharing coefficient. Hence, depending on union strength, oligopoly size, and collusively acting firm-union pairs this result arises when the union's bargaining power exceeds a critical value, decreasing with oligopoly size and number of outsiders of the agreement. Apparently, centralized bargaining systems will become uncommon within larger oligopolies or with more outsiders when the scope of bargaining is expanded to a contingent pay.

However, profit sharing is welfare enhancing under the assumption that production and consumption take place in the same country. It can be interpreted as an instrument to introduce efficient-bargaining (where unions and firms negotiate over wages as well as employment).³ 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. With profit sharing unions can agree on a low base wage, and

¹For Europe see OECD (1995) and for a more precise description of the situation in the USA see Lebow, Sheiner, Slifman, and Starr-McCluer (1999).

²For institutional details of the German system see Kurdelbusch (2002) or Görtzgen (2004).

³Anderson and Devereux (1989) in their seminal paper find that the outcomes for profit sharing are identical to efficient bargaining in a monopoly situation with one union and one firm.

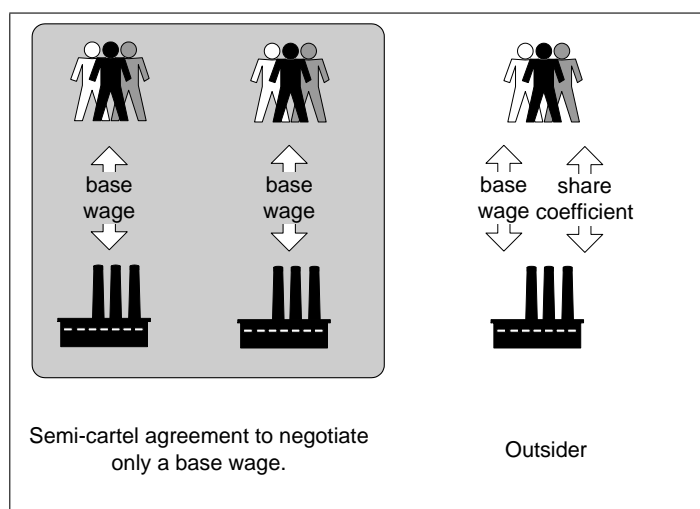


Figure 1: Decentralized wage negotiations

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 afterward these profits are distributed by the share coefficient. This is the same effect appearing with efficient-bargaining negotiations but in a more indirect way, here. Regarding to realism profit sharing negotiations are maybe a more tractable way to implement welfare enhancing effects of efficient bargaining than negotiations over wages and employment.

To encapsulate our findings: we can show centralized wage systems to be relatively stable against deviating 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 where the industry specific remuneration scheme is replaced by a decentralized one is enlarged.

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. This might have major implications for trade unions and workplace representation."

Even though there is a broad literature on profit sharing in general⁴, the literature on profit sharing as a strategic instrument in oligopolistic markets is relatively thin. Notable exemptions are Stewart (1989) and Fung (1989),⁵ which both examine the effects of profit sharing on oligopolistic competition. Stewart (1989) shows that a monopolistic firm never implements a profit sharing

⁴See Prendergast (1999) for a survey.

⁵Fershtman 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 we focus on workers represented by unions.

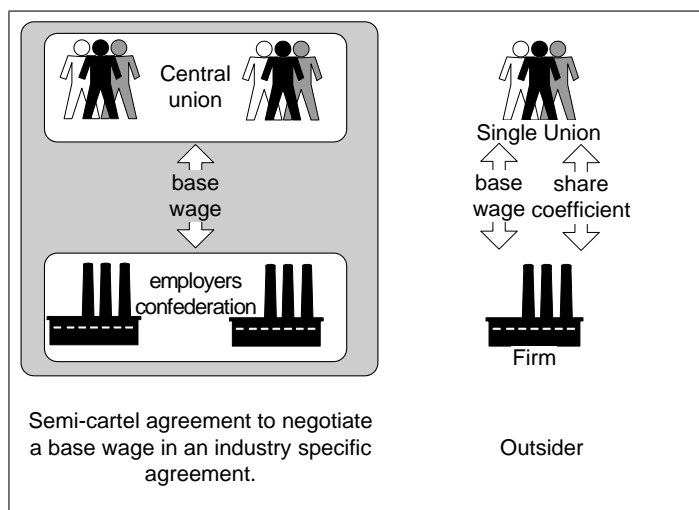


Figure 2: Centralized wage negotiations

contract, but under 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 choose 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 without negotiations in a decentralized wage-setting regime on a take-it-or-leave-it basis. 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, our results refine the outcome of the decentralized bargaining regime of Bensaïd and Gary-Bobo by the use of negotiations instead of take-it-or-leave-it offers. Probably Sørensen's model (see Sørensen (1992)) is most closely connected to our paper, analyzing a special case of our 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 our model and our findings with $n = 2$ and decentralized bargaining. Another rather small strand of literature related to our model is the one concerning the strategic choice of bargaining agenda in unionized oligopolies. Yang (1995), Vannini and Bughin (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 through the base wages, our paper studies a related question.

The rest of the paper is organized as follows: we 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 we 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. We conclude in the last section.

2 Decentralized wage negotiations (D)

2.1 Basic Setup

2.1.1 The game

We 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 profit sharing is 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.

2.1.2 Firms' and unions' objectives

There are n firms and n unions (indexed by $i = 1, \dots, n$). Each firm produces a homogeneous good with labor as the only input. One unit of labor is used to produce one unit of output. Thus, we can discuss output and employment interchangeably.

Firm i 's profit in the classical system is given by

$$(1) \quad \Pi_i = (p(X) - b_i) x_i$$

where

$$(2) \quad p(X) = \max\{A - X, 0\}$$

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 of all firms, 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

$$(3) \quad \Pi_i = (1 - a_i)(p(X) - b_i) x_i$$

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 by⁶

$$(4) \quad U_i = (t_i - w) x_i$$

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 has the control over 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.

⁶Equation (4) can also be interpreted as a special case of a Stone-Geary utility of a union attaching an equal weight on employment and wages.

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

$$(5) \quad B = U_i^c \Pi_i^{1-c}$$

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

We solve the model backwards, first we analyze stage 3 where we examine the firms' optimal production decision for a given set of wage contracts. For simplicity we shall restrict attention only to solutions in pure strategies. Then, we consider the second stage and obtain the wage contracts which result from the Nash-wage-bargaining, again only solutions in pure strategies are under consideration. Here we have to distinguish two cases: first, we assume that all firms and unions negotiate in the classical system. Then, we solve the model for a profit sharing system and compare the findings. We 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.

$$(6) \quad x_i = \frac{A - nb_i + \sum_{j \neq i}^n b_j}{(n+1)}, \quad X = \frac{An - \sum_{i=1}^n b_i}{(n+1)}$$

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

$$(7) \quad b_i(D_{cs}) = \frac{Ac + nw(2-c)}{c + n(2-c)}.$$

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

$$(8) \quad p(D_{cs}) = w + \frac{(A-w)(c+2n)}{(c+(2-c)n)(n+1)}$$

$$(9) \quad x_i(D_{cs}) = \frac{(A-w)(2-c)n}{(c+(2-c)n)(n+1)}$$

$$(10) \quad \Pi_i(D_{cs}) = [x_i(D_{cs})]^2$$

$$(11) \quad U_i(D_{cs}) = \frac{c}{2-c} \frac{n+1}{n} [x_i(D_{cs})]^2$$

Hence, welfare can be defined as $W = n\Pi_i + nU_i + \text{consumer surplus}$ and the explicit expression of welfare is

$$(12) \quad W(D_{cs}) = \left(\frac{c+2n}{2-c} + \frac{n^2}{2} \right) [x_i(D_{cs})]^2$$

Unsurprisingly, the fixed salary b_i is positive and some comparative statics show that the basic pay increases in unions strength and declines in oligopoly size.⁷ Examining the welfare change due to a rise in union bargaining power we obtain:⁸

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 we 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.⁹ This yields equilibrium base wage, share coefficient, and contractual wage rate:

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

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

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

Substituting these equations back in the price, profit, and utility function we obtain:

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

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

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

⁷ $db/dc > 0$ and $db/dn < 0$

⁸ All proofs are presented in the appendix.

⁹ 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:

$$(19) \quad W(D_{ps}) = \frac{(A-w)^2 n^2 (n^2 + 2)}{2(n^2 + 1)^2}$$

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 about profit share 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 $c > \frac{2}{3}$. 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 rises¹⁰ and price decreases. Lower production costs and higher

¹⁰This effect of profit sharing and its macroeconomic consequences has been made widely known through the work of Weitzman. For an introduction, see Weitzman (1984) or for a summary OECD (1995). In his model of monopolistic competition (Weitzman (1985)), he shows an advantage of profit sharing with regard to unemployment and inflation without attention of trade unions’ influences.

quantity cannot compensate the firm for the price decreases 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 costs 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 our 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 mainly exports its commodities produced 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.¹¹ 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 through 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 our findings: unions and firms collectively prefer the inefficient classical contract over more efficient profit sharing schemes in most cases. This 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. In our model we assume homogeneous products. Therefore, it may be desirable to extend our model to heterogeneous products. With more differentiated products our 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 our model does not allow us to find an exact solution for the threshold values.

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, our 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 our model covers only the scope of bargaining.¹² 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

¹¹For 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).

¹²This assumption is modified in Section 3.

product market is still competitive. For the rest of the paper we refer to this kind of behavior as ‘semi-collusion’ like Fershtman and Muller (1986).

Hitherto, we have not analysed 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? We 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 another pair of firm and union does not find it desirable to join the agreement (external stability). To proof 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, we 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-collusive over a classical wage contract while $n - k$ union-firm pairs are outsiders of this agreement. We obtain the equilibrium profits and utility levels for firms and unions negotiating in the classical system (Π_i, U_i) and under a profit sharing regime (Π_r, U_r) . Subsequently, we 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 Π_i or U_i must exceed Π_r^{+1} and U_r^{+1} , respectively. In other words, if the union as well as the firm benefit by deviating we assume that both will agree on a contingent contract. Firstly, we focus on the computations for the number of pairs k acting in a semi-collusive behavior. Afterwards, similar computations can be made for a semi-collusive agreement with $k - 1$ participants, but we summarize the equilibrium outcomes in the appendix only.

For k semi-colluding pairs we assume a linear product demand

$$(20) \quad p(X + Y) = \max\{A - X - Y, 0\}$$

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 a profit sharing scheme to their employees. The contractual wages, the profit, and the utility functions can now be written as

$$(21) \quad t_i = b_i \qquad t_r = b_r + a_r(p - b_r)$$

$$(22) \quad U_i = (t_i - w)x_i \qquad U_r = (t_r - w)y_r$$

$$(23) \quad \Pi_i = (p - b_i)x_i \qquad \Pi_r = (1 - a_r)(p - b_r)y_r$$

From the profit functions (23) we 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 we solve the first order conditions. This yields the following representative labor demand functions:

$$x_i = \frac{A - nb_i + \sum_{j \neq i}^k b_j + \sum_{r=1}^{n-k} b_r}{n + 1}$$

$$y_r = \frac{A - nb_r + \sum_{s \neq r}^{n-k} b_s + \sum_{i=1}^k b_i}{n + 1}$$

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 we find the equilibrium contracts. Hence, we 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 we have to solve for the product market and the labor market game again. Henceforth, we 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, we consider the comparative static properties of the model, focusing on semi-collusive stability.

2.6 Comparative statics

2.6.1 Firms' profits and unions' utility

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? We have analyze 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 can not be found. Instead, we present numerical solutions to receive some impressions on the instability if k varies:

| $n \setminus k$ | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|-----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 2 | — | — | — | — | — | — | — | — | 0.373 41 | 0.693 98 |
| 3 | — | — | — | — | — | — | — | 0.520 07 | 0.789 27 | 0.849 76 |
| 4 | — | — | — | — | — | — | 0.608 74 | 0.838 72 | 0.885 32 | 0.903 74 |
| 5 | — | — | — | — | — | 0.668 96 | 0.869 26 | 0.907 19 | 0.922 02 | 0.929 83 |
| 6 | — | — | — | — | 0.712 76 | 0.890 03 | 0.922 02 | 0.934 45 | 0.940 97 | 0.944 98 |
| 7 | — | — | — | 0.746 12 | 0.905 10 | 0.932 75 | 0.943 45 | 0.949 05 | 0.952 49 | 0.954 80 |
| 8 | — | — | 0.772 43 | 0.916 52 | 0.940 89 | 0.950 27 | 0.955 18 | 0.958 19 | 0.960 22 | 0.961 68 |
| 9 | — | 0.793 73 | 0.925 49 | 0.947 26 | 0.955 62 | 0.959 99 | 0.962 67 | 0.964 47 | 0.965 77 | 0.966 75 |
| 10 | 0.811 33 | 0.932 72 | 0.952 39 | 0.959 93 | 0.963 87 | 0.966 28 | 0.967 90 | 0.969 07 | 0.969 95 | 0.970 64 |

Table 1: Incentives for the firm to deviate

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 $c < 0.668 96$. The second finds it profitable for $c < 0.869 26$, the third for $c < 0.907 19$. Even though we 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 aggressive by producing a smaller output arising from 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 semicollusive behavior but the incentive to deviate is predominant. However, empirically it is very rare to find $c > 0.5$ ¹³ indicating union power being larger than firm power. So a agreement instability will be common in most industries.

2.6.2 Wages

For the sake of completeness and to gain additional answers, we show the variation of wages following the change in the semi-collusive agreement structure.

Therefore, contractual pay before and after defecting must be compared. For the first firm-union negotiating classical wage contracts, the contractual wage rate t_r^{+1} is lower than the basic remuneration b_i .¹⁴ The firm has to pay lower wages that is to say a worker in the first firm will earn less if the firm becomes an outsider. Conversely, when considering the last firm and union bargaining over a profit sharing scheme, t_r^{+1} is unambiguously higher than b_i .¹⁵ Wages for the last pair rise. We have to find a critical k^* where wages inside and outside are equivalent. This threshold value is:

$$k^* := \frac{c - 2n^2 + 2n^3 + cn^2}{2n(c + n - 1)}$$

By doing some comparative statics we achieve the appreciable result that only the first pair leaving the semi-collusive agreement pays lower wages per worker. The derivation of k^* with respect to c and n yields:

$$\frac{dk^*}{dc} = -\frac{(n-1)^2(n+1)}{2(c+n-1)^2n} < 0 \quad \frac{dk^*}{dn} = \frac{(n-1)((n-1)(c+2n^2) + c^2(1+n) + 4cn^2)}{2(c+n-1)^2n^2} > 0$$

Hence, because k^* is an increasing function in n and a declining one in c , we choose $n = 2$ and $c = 1$ to find a relatively small k^* . Still in this case $k^* = 1.625$. In other words, wages decrease only for the first pair deviating. When the next firm-union pair negotiates a share contract, wages increase. A more general analysis shows:

Proposition 4

1. *Total wages for the first union-firm pair deviating are lower than the base wage before deviating.*
2. *If another pair switches to profit sharing their total pay rises.*
3. *Nevertheless, the total wages in a stable semi-collusive agreement with all firm-union pairs participating are unambiguously higher than total pays after deviating.*

¹³See Veugelers (1989) and Bughin (1996) for empirical evidence.

¹⁴ $t_r^{+1} - b_i = [(A-w)(1-c-n)(n-1)c^2]/[(cn-2n-c)(cn^2-2cn-4n^2-c)] < 0$.

¹⁵ $t_r^{+1} - b_i = [(A-w)(n-1)^2(n+c-1)c]/[(c+4n-2cn-2n^2+2n^3+cn^2)(n^2+1)] > 0$

The first part of the proposition is a result of the increase in employment if the first firm leaves the agreement. For the first pair behaving no-collusively the rents created are transferred to the union through a higher y_r^{+1} . Remembering part 3 of the proposition we know b_i to be at its maximum in a ‘full’ semi-collusive agreement so that a transfer of rents through a higher remuneration per worker is not optimal. For the remaining members the semi-collusive remuneration per worker and employment fall when the number of collusive pairs declines. Consequently, being an outsider leads to a higher employment for later deviants albeit pays per worker rise, too. However, unions of later deviants extract rents by a higher remuneration, but the pay per worker is smaller than in a ‘complete’ industry specific semi-collusive agreement. The fall in overall wages can be explained by the rise in employment. The union tries to achieve a high utility being a product of employment and remuneration rent per worker. Therefore the profit sharing results in lower marginal costs by reducing the fixed wage leading to more employment and increased union utility. As a consequence, unions with a constant bargaining strength can accept a lower remuneration per worker due to a higher employment, maximizing their utility.

It is worth noting that a_i is independent of k . That is to say, all unions receive the same share of profits no matter whether they deviate first or are the last outsider. In contrast, the base wage is increasing in k so that the base wage is decreasing for the deviants.¹⁶

Thus far, the analysis told us that firms and unions always prefer an oligopoly specific classical wage system if $n > 2$, or if $n = 2$ and $c < \frac{2}{3}$. However, a profit sharing scheme would maximize welfare. While testing for semi-collusive agreement stability we find a higher agreement instability with a rise in oligopoly size, number of outsider, and firms’ strength. For an empirically validated size of c , unions and firms gain by leaving the agreement. This leads to a prisoners’ dilemma for unions and firms. Nevertheless, this dilemma can be welfare enhancing as a consequence of an increase in consumer surplus.

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 in a collusive behavior, 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, we 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. We obtain an advantage for firms and unions to behave collusively. To avoid misunderstandings: here, the semi-collusive agreement contains the arrangement on a central bargaining and classical wage contracts. The test of stability is separated in two steps show 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. Apparently, this is consistent with the fact that in Germany the centralized wage bargaining is relatively stable. 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.

¹⁶ $b_r^{+1} - b_i < 0$

3.1 Centralized negotiations in a classical wage system (C_{cs})

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, we 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 in the appendix.

It is worth noting that the base wage rate is independent of the industry size.¹⁷ This is due to the fact that an industry union and an industry employers' association are bargaining 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, we 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, we now examine the condition among which it is beneficial for an industry to bargain a centralized base wage or a decentralized profit sharing contract.

For an individual firm the profit with a sharing contract exceeds the profit with an industry specific base wage contract if $\Pi_i(C_{ps}) > \Pi_i(C_{cs})$.¹⁸ This is not the case. Thus, it is always

¹⁷ $db(C_{cs})/dn = 0$. 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.

¹⁸ $[(A - w)^2 (4(c + n - cn + n^3 - n^4 - cn^3 + cn^4 - 1) - c^2 - 2c^2n^2 - c^2n^4)]/[4(n^2 + 1)^2(n + 1)^2] > 0$

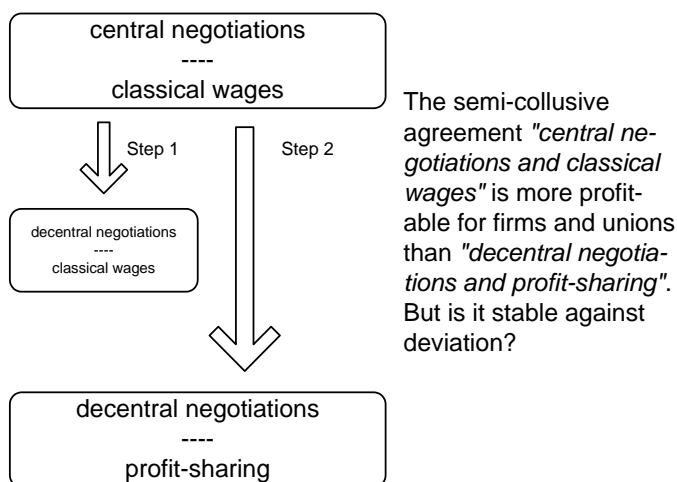


Figure 3: Stable against deviation?

preferable for a firm to be an insider of 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, $U_i(C_{ps}) - U_i(C_{cs}) < 0$.¹⁹ Consequently, both parties benefit from the industry collusion. Nevertheless, we have to analyze semi-collusive agreement stability for individual deviation again. Top shed light on the reason why a semi-collusive agreement results in higher profits and utility, we explain two separate steps: First, we examine whether firm-union pairs would break away from an industry specific classical wage contract if only a firm specific base wage contract²⁰ *without* profit sharing is achievable. In a second step we 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 oligopolies²¹ is a disadvantage for substitutable workers being organized in different unions. We can confirm this result by finding a collusive wage bargaining to be in the interest of the first union as long as its bargaining strength is not extremely high or oligopoly very large.²² Even in a dynamic analysis the union prefers the centralized bargaining as can be seen on the left of the function²³ 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 our proceeding: we demonstrate a disadvantage for the first union to deviate on the agreement for a grand 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 rarely appear. Hence, for the sake of completeness, we present numerical findings in appendix D, showing a decline in the incentive of unions for a later deviation.

Contrarily, but in line with the literature, we find it unambiguously in the interest of the first firm to bargain over a firm specific contract.²⁴ As long as the agreement of firm and union is a

¹⁹ $[(w - A)^2 c (c + 4n - 2n^4 + 2cn^2 + cn^4 - 2)] / [4(n^2 + 1)^2(n + 1)] < 0$

²⁰ Results can be found in appendix D.1.

²¹ See e.g. Horn and Wolinsky (1988) or Görtzgen (2003) for a more detailed analysis.

²² $U_r^{+1}(C_{dcs}) > U_i(C_{dcs})$ with $n = k$ if $[(2 - c)(w - A)^2 c] / [4(n + 1)] > 0$

²³ $U_r^{+1}(C_{dcs}) - U_i(C_{dcs}) = 0$

²⁴ $\Pi_r^{+1}(C_{dcs}) - \Pi_i(C_{dcs}) > 0$

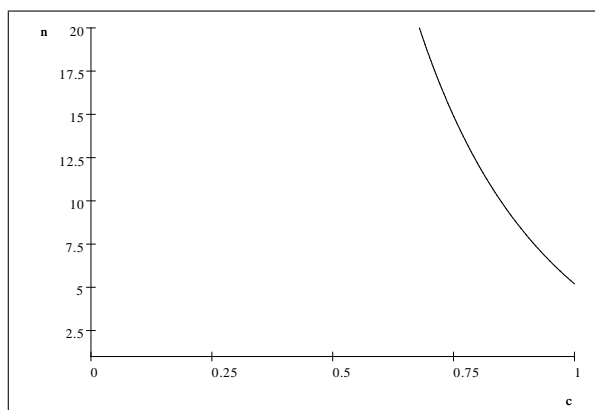


Figure 4: Incentive for a union to join the fringe

requirement for a firm specific contract, the incentive to leave the industry contract is low for a high bargaining power of the firm or 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?²⁵

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, we are confronted with the problem to give a general solution for this parameter constellations so numerical computations are necessary and are presented in Table 2 for firms and Table 3 for unions.

| $n \setminus k$ | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|-----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 2 | — | — | — | — | — | — | — | — | 0.708 02 | 0.693 98 |
| 3 | — | — | — | — | — | — | — | 0.835 99 | 0.874 71 | 0.849 76 |
| 4 | — | — | — | — | — | — | 0.888 89 | 0.932 77 | 0.919 51 | 0.903 74 |
| 5 | — | — | — | — | — | 0.917 23 | 0.958 85 | 0.950 70 | 0.940 20 | 0.929 83 |
| 6 | — | — | — | — | 0.934 66 | 0.972 70 | 0.967 22 | 0.959 80 | 0.952 23 | 0.944 98 |
| 7 | — | — | — | 0.946 34 | 0.980 85 | 0.976 96 | 0.971 46 | 0.965 73 | 0.960 13 | 0.954 80 |
| 8 | — | — | 0.954 67 | 0.986 00 | 0.983 12 | 0.978 92 | 0.974 46 | 0.970 03 | 0.965 75 | 0.961 68 |
| 9 | — | 0.960 86 | 0.989 44 | 0.987 23 | 0.983 94 | 0.980 39 | 0.976 82 | 0.973 33 | 0.969 96 | 0.966 75 |
| 10 | 0.965 64 | 0.991 82 | 0.990 09 | 0.987 45 | 0.984 58 | 0.981 65 | 0.978 76 | 0.975 95 | 0.973 23 | 0.970 64 |

Table 2: Incentives for the first firm to cheat in a centralised bargaining system

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 not profitable. 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 an outsider exists all other unions

²⁵The findings for k pairs negotiating a collusive classical wage contract and $n - k$ ones deviating can be found in Appendix C.2.

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 it is 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.

| n = k | union strength |
|-------|----------------|
| 2 | 0.318 94 |
| 3 | 0.353 46 |
| 4 | 0.349 39 |
| 5 | 0.335 82 |
| 6 | 0.320 00 |
| 7 | 0.304 23 |
| 8 | 0.289 29 |
| 9 | 0.275 42 |
| 10 | 0.262 65 |

Table 3: Incentives for unions to leave the cartel in a centralised system

With reference to the empirical findings of Bughin (1996) and Veugelers (1989) the firms will not act collusively. In touch with reality we 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 we extend this model to an international aspect. When we 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 our findings:

Summary 2

1. *The union-firm-semi-collusive agreement is relatively stable against deviating in the centralized bargaining scenario when only classical contracts are allowed. The stability of the agreement is declining in oligopoly size and union strength.*
2. *The semi-collusive agreement stability declines considerably more when the firm-union pairs have the possibility to sign 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 to bargain 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 our 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 over the value of the basic pay to achieve a high employment and wages. On the other hand, in the decentralized profit sharing system unions

have two instruments to attain their two goals, being 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. Whilst we assume a union strength being smaller than the firm's bargaining strength we 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 which is 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 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 to the participants to become deviants. For instance, IBM Germany was a member of the employers association and no earlier than 1994 they quit 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 the 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 we 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 through 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 contracts 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. When we 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.²⁶ Possibly, managers will not deviate from the semi-collusive agreement if their own wages decline once profit sharing agreements are concluded.

²⁶See Chatterjee and Saha (2005) for details.

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A Proofs

A.1 Proposition 1

Proof. The welfare is declining in c as long as

$$\frac{dW}{dc} = \frac{2(c+2n)(A-w)^2 n^2}{(c(n-1)-2n)^3 (n+1)^2} < 0.$$

■

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 we obtain

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

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 Ψ . Ψ is strictly negative whenever $n > 1$ and $0 \leq c \leq 1$.

2. For the union

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

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 Υ 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 under the profit sharing regime ((7) > (15) > (14)).
4. The difference between the share contract and the classical system can be calculated by subtracting

$$\begin{aligned} & (19) - (12) \\ &= \frac{2(A-w)^2 n^2 (c+2n+n^2+n^3)(c+n-1)}{(cn-2n-c)^2 (n^2+1)^2 (n+1)^2}, \end{aligned}$$

being positive.

■

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

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

We can rewrite the condition as:

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

■

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 .

$$\begin{aligned}
 b_i(D_{ts}) &= \frac{Ac(n+1) + nw(2-c) + 2knw(1-c) + wn^2(c+2(n-k))}{\Omega} \\
 a_r(D_{ts}) &= \frac{c+n-1}{n} \\
 b_r(D_{ts}) &= \frac{A(c+2n)(1-n) + wn(c+2k(1-n-c)) + wn^2(c+2n+2)}{\Omega} \\
 \Pi_i(D_{ts}) &= \frac{(A-w)^2(2-c)^2n^2}{\Omega^2} \\
 \Pi_r(D_{ts}) &= \frac{(A-w)^2(c+2n)^2n(1-c)}{\Omega^2} \\
 U_i(D_{ts}) &= \frac{(A-w)^2(2-c)(1+n)cn}{\Omega^2} \\
 U_r(D_{ts}) &= \frac{(A-w)^2(c+2n)^2nc}{\Omega^2} \\
 &\text{with } \Omega = 2kn(1-c) + 2n^2(n-k) + c + 2n + cn^2
 \end{aligned}$$

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

$$\begin{aligned}
 b_i^{+1}(D_{ts}) &= \frac{(Ac(n+1) + 2wnk(1-c) + 2wn^2(n-k) + wn(c+2n+cn))}{\Phi} \\
 a_r^{+1}(D_{ts}) &= \frac{c+n-1}{n} \\
 b_r^{+1}(D_{ts}) &= \frac{wn(3c+4n+cn+2n^2) - 2nw - A(n-1)(c+2n) - 2wnk(c+n-1)}{\Phi} \\
 t_r^{+1}(D_{ts}) &= b_r^{+1} + a_r^{+1}(p^{+1} - b_r^{+1}) \\
 \Pi_i^{+1}(D_{ts}) &= \frac{(A-w)^2(2-c)^2n^2}{\Phi^2} \\
 \Pi_r^{+1}(D_{ts}) &= \frac{(A-w)^2(c+2n)^2n(1-c)}{\Phi^2} \\
 U_i^{+1}(D_{ts}) &= \frac{(A-w)^2(2-c)nc(n+1)^2}{\Phi^2(n+1)} \\
 U_r^{+1}(D_{ts}) &= \frac{(A-w)^2(c+2n)^2cn}{\Phi^2} \\
 &\text{with } \Phi = 2n^2(n-k) + 2nk(1-c) + c(2n+1) + n^2(c+2)
 \end{aligned}$$

C Centralized Bargaining (C)

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

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

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

C.2.1 k members of the agreement

$$\begin{aligned}
b(C_{ts}) &= \frac{w\Theta - Ac(1 + n)}{\Upsilon} \\
\text{with } \Theta &= (c(1 + n + k(k - n)(n - 1)) - 2(k - n - 1)(k(n - 1) - n^2 - 1)) \\
a_r(C_{ts}) &= \frac{(c + n - 1)}{n} \\
b_r(C_{ts}) &= \frac{A(n - 1)((c - 2)k + 2(n + 1)) - w\Psi}{\Upsilon} \\
\text{with } \Psi &= (c - 2)(k - 1)k - k(2 + (c - 2)k)n + (4 + (c - 4)k)n^2 + 2(n + n^3) \\
\Pi_i(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)^2 (c - 2)^2}{\Upsilon^2} \\
\Pi(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)^2 (c - 2)^2 k}{\Upsilon^2} \\
\Pi_r(C_{ts}) &= \frac{(A - w)^2 (2n - 2k + ck + 2)^2 n (1 - c)}{\Upsilon^2} \\
U_i(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)(n + 1)(2 - c)c}{\Upsilon^2} \\
U(C_{ts}) &= \frac{(A - w)^2 (n - k + 1)(n + 1)(2 - c)ck}{\Upsilon^2} \\
U_r(C_{ts}) &= \frac{(A - w)^2 cn(2(n - k) + ck + 2)^2}{\Upsilon^2} \\
\text{with } \Upsilon &= (k - n)((c - 2)k(n - 1) + 2n(1 + n)) - 2(1 + n)
\end{aligned}$$

C.2.2 $k - 1$ members of the semi-collusive agreement:

$$\begin{aligned}
b_i^{+1}(C_{ts}) &= \frac{Ac(1+n) + w\Omega}{\Delta} \\
\text{with } \Omega &= (-(c-2)k^2(n-1) + n(n+1)(4-c+2n) + k(c(n-2+n^2) - 4(n-1+n^2))) \\
a_r^{+1}(C_{ts}) &= \frac{(c+n-1)}{n} \\
b_r^{+1}(C_{ts}) &= \frac{-A(n-1)(4+c(k-1)-2k+2n) - (k-2-n)\Phi w}{\Delta} \\
\text{with } \Phi &= (c(k-1)(n-1) + 2(k-1-kn+n(2+n))) \\
\Pi_i^{+1}(C_{ts}) &= \frac{(A-w)^2(n-k+2)^2(c-2)^2}{\Delta^2} \\
\Pi^{+1}(C_{ts}) &= \frac{(A-w)^2(n-k+2)^2(c-2)^2(k-1)}{\Delta^2} \\
\Pi_r^{+1}(C_{ts}) &= \frac{(A-w)^2(1-c)(2n-2k-c+ck+4)^2 n}{\Delta^2} \\
U_i^{+1}(C_{ts}) &= \frac{(A-w)^2(n-k+2)(n+1)(c-2)c}{(1-k)\Delta^2} \\
U^{+1}(C_{ts}) &= \frac{(A-w)^2(k-n-2)(2-c)(-n-1)c}{\Delta^2} \\
U_r^{+1}(C_{ts}) &= \frac{(A-w)^2 nc(c+2k-2n-ck-4)^2}{\Delta^2} \\
\text{with } \Delta &= c(k-1)(k-n-1)(n-1) - 2(k-n-2)(k(n-1) - n(1+n))
\end{aligned}$$

D Incentives for unions to deviate from a centralized classical system to a decentralized classical regime

| $n \backslash k$ | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|------------------|----------|----------|----------|----------|----------|----|----|----|----|----|
| 2 | - | - | - | - | - | - | - | - | >1 | >1 |
| 3 | - | - | - | - | - | - | - | >1 | >1 | >1 |
| 4 | - | - | - | - | - | - | >1 | >1 | >1 | >1 |
| 5 | - | - | - | - | - | >1 | >1 | >1 | >1 | >1 |
| 6 | - | - | - | - | 0.968 23 | >1 | >1 | >1 | >1 | >1 |
| 7 | - | - | - | 0.932 75 | 0.983 53 | >1 | >1 | >1 | >1 | >1 |
| 8 | - | - | 0.901 23 | 0.946 51 | 0.990 02 | >1 | >1 | >1 | >1 | >1 |
| 9 | - | 0.872 98 | 0.913 94 | 0.955 27 | 0.994 17 | >1 | >1 | >1 | >1 | >1 |
| 10 | 0.847 46 | 0.884 95 | 0.924 62 | 0.962 25 | 0.997 07 | >1 | >1 | >1 | >1 | >1 |

Table 4: Incentives for the union to deviate from a centralised classical bargaining system to a decentralised classical regime

D.1 Centralized system, deviating to a decentralized classical remuneration contract (C_{dcs})

D.1.1 k members of the semi-collusive agreement

$$\begin{aligned}
b(C_{dcs}) &= \frac{(Ac(c+2n) + (c-2)(2n(k-1-n) + c(k^2 - kn - 1)))w}{\Xi} \\
b_r(C_{dcs}) &= \frac{Ac((c-2)k + 2(1+n)) + (c-2)(k-n-1)(ck + 2n)w}{\Xi} \\
\text{with } \Xi &= c^2k(k-n) + 4n(1+n-k) - 2c((n-k)^2 - 1) \\
\Pi_i(C_{dcs}) &= \frac{(A-w)^2(n-k+1)^2(c+2n)^2(2-c)^2}{\Lambda^2(n+1)^2} \\
\Pi(C_{dcs}) &= \frac{(A-w)^2(n-k+1)^2(c+2n)^2k(2-c)^2}{F^2(n+1)^2} \\
\Pi_r(C_{dcs}) &= \frac{(A-w)^2(2(n-k) + ck + 2)^2(2-c)^2n^2}{\Lambda^2(n+1)^2} \\
U_i(C_{dcs}) &= \frac{(A-w)^2(n-k+1)(2-c)(c+2n)^2c}{F^2(n+1)} \\
U(C_{dcs}) &= \frac{(A-w)^2(n-k+1)(2-c)(c+2n)^2ck}{F^2(n+1)} \\
U_r(C_{dcs}) &= \frac{(A-w)^2(2-c)n(2k-2n-ck-2)^2c}{\Lambda^2(n+1)} \\
\text{with } \Lambda &= 2c + 4n - 4kn + 4ckn + 4n^2 - 2ck^2 - 2cn^2 - c^2kn + c^2k^2 \\
\text{with } F &= 4kn - 4n - 2c - 4ckn - 4n^2 + 2ck^2 + 2cn^2 + c^2kn - c^2k^2
\end{aligned}$$

D.1.2 $k - 1$ members of the semi-collusive agreement

$$\begin{aligned}
b^{+1}(C_{dcs}) &= \frac{Ac(c+2n) + (c-2)(2n(k-2-n) + c(k(k-n-2) + n))w}{\Gamma} \\
b_r^{+1}(C_{dcs}) &= \frac{Ac(c-4 + 2k - ck - 2n) - (c-2)(k-n-2)(c(k-1) + 2n)w}{-\Gamma} \\
\Pi_i^{+1}(C_{dcs}) &= \frac{(A-w)^2(n-k+2)^2(c+2n)^2(c-2)^2}{\Gamma^2(n+1)^2} \\
\Pi^{+1}(C_{dcs}) &= \frac{(A-w)^2(n-k+2)^2(c+2n)^2(c-2)^2(k-1)}{\Gamma^2(n+1)^2} \\
\Pi_r^{+1}(C_{dcs}) &= \frac{(A-w)^2(2n-2k-c+ck+4)^2(c-2)^2n^2}{\Gamma^2(n+1)^2} \\
U_i^{+1}(C_{dcs}) &= \frac{(A-w)^2(k-n-2)(c-2)(c+2n)^2c}{\Gamma^2(n+1)(k-1)} \\
U^{+1}(C_{dcs}) &= \frac{(A-w)^2(k-n-2)(c-2)(c+2n)^2c}{\Gamma^2(n+1)} \\
U_r^{+1}(C_{dcs}) &= \frac{(A-w)^2(2-c)n(c+2k-2n-ck-4)^2c}{\Gamma^2(n+1)} \\
\text{with } \Gamma &= c^2 + (c-2)(c(k-2)k - 2n^2) - n(4(k-2) + (c-4)c(k-1))
\end{aligned}$$