Strategic profit–sharing in a unionized differentiated goods duopoly

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Abstract

We study firms' incentives to offer profit-sharing schemes in a unionized differentiated goods duopoly in which firms bargain with a sector-wide union or firm-specific unions over the selected remuneration schemes. We show that unions always prefer to form a sector-wide union and conduct coordinated bargaining. Under Cournot competition, ex-ante symmetric firms may choose to offer different remuneration schemes under coordinated bargaining and become ex-post asymmetric. Moreover, universal profit-sharing schemes arise as long as the union's bargaining power is low enough. In contrast, under Bertrand competition, firms never offer profit-sharing schemes and universal fixed wage schemes is the unique equilibrium. Our welfare analysis indicates that policymakers should institutionalize decentralized bargaining and encourage profit-sharing schemes.

JEL Classification: J23; J33; J41
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1 Introduction

Profit–sharing schemes, with one form or another, are in wide use in the real business world.[1] A survey of the largest 1,250 global corporations found that 33% of them offer some sort of a profit-sharing scheme to all employees, while an extra 11% had plans to introduce one (Weeden et al., 1998). Muller (2017) and Lorenzetti (2016) report a few cases of large enterprises offering profit-sharing schemes in the USA in 2015: Ford Motors paid an annual profit share $9,300 in cash per worker to 56,000 unionized workers, General Motors paid $11,000 per worker and Fiat Chrysler Automobiles paid $5,000 per worker to more than 40,000 unionized workers. Moreover, employees of Delta Airlines, Southwest and United Continental Airlines received $1.5 billion in profit shares the same year. In particular, for Delta Airlines, the profit shares accounted for 21% of the employee's base salary, roughly $18,000 per employee. American Airlines, the only one of the top four carriers in the USA that didn't offer a profit–sharing scheme, introduced a 5% profit–share ratio to all employees in March 2016 (Carey, 2016). Kato and Morishima (2003) reports that one out of four publicly traded firms in Japan uses a profit–sharing scheme, nearly all profit shares paid annually in cash. Huawei, the largest telecommunications equipment manufacturer in the world, has an extensive profit–sharing scheme: its founder Zheng Fei holds 1.4% of its stocks, while the rest are equally owned by more than 82,000 employees worldwide (De Cremer and Tao, 2015). Blasi et al. (2016) state that group incentive methods of compensation, such as profit–sharing, along with positive internal company policies and culture can help the most profitable firms do even better.

There is a wide variety of unionization structures and unionization levels across countries, or across sectors and within countries.[2] In the USA, UK, Australia, Canada, and Japan, negotiations are decentralized and take place between firm-specific unions and their firms.[3] In contrast, in almost all the euro–area countries plus the Scandinavian countries, negotiations take place either at a sector level or (rarely) at a nation-wide

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[1] A profit-sharing scheme dictates that employees, besides a fixed wage, also receive a share of the firm's profits. The employees' share of profits can be paid in cash, stocks, bonds or other forms. It can be paid annually, semi–annually, monthly or can be kept by the firm and be given to the employees in the form of a pension. In practice, a profit-sharing scheme can take a quite complex form that contains a wide set of different elements (OECD, 1995).

[2] Unionization structure refers to whether workers are organized in firm–specific unions or an industry–wide union (or a nationwide union). In the first case, *decentralized bargaining* over remuneration schemes takes place between each employer and its firm–specific union. In the second case, bargaining over the remuneration scheme(s) can take place either at a centralized level between the representative of all employers and the sector–wide union (*centralized bargaining*) or in a coordinated way between each employer and a representative of the sector–wide union (*coordinated bargaining*) (Haucap and Wey, 2004; Bronfenbrenner and Juravich, 2001). On the other hand, unionization level (or density) refers to the percentage of workers being members of a union which, to a large extent, determines the power of the union during the negotiations.

[3] There are a few exemptions, such as the metalworkers in the USA who are organized in a sector–wide union. In Japan, although negotiations take place at the firm level, there are some important institutions that ensure a high degree of bargaining centralization (Soskice, 1990).

level (Goeddeke, 2010). Yet, the current trend in the unionization structure in almost all advanced economies worldwide is towards more decentralization (Ellguth et al., 2014). Decentralized bargaining allows for greater flexibility and quicker adjustments, which are vital in globalized economies (Hübler and Meyer, 2000). Regarding the unionization levels, Visser (2006) reports a wide variety across countries. There are countries with unionization levels above 50% (e.g. Iceland, Belgium, Finland, Denmark, Norway, Sweden), and countries with unionization levels below 20% (e.g. France, Korea, USA, Japan, Spain, Turkey, Netherlands, Mexico). Many countries lie in unionization levels between 20% and 50% (e.g. United Kingdom, Canada, Italy, Ireland, Israel, Greece, Austria, Luxembourg). Nonetheless, the last three decades experienced a significant drop in the unionization levels. Pontusson (2013) notes that the deindustrialization and the shift from public to private employment are the two major factors of the de-unionization of the OECD countries, besides various political and institutional factors. It is critical to note that unionized labor could earn, on average, up to 15% higher compensation than the non-unionized (Tracy, 1986).

As profit–sharing schemes are widespread and are observed in most of the economies, it is natural to ask why firms offer such remuneration schemes and how the different unionization structures and unionization levels affect their decisions. Further, how the mode and the intensity of competition affect the firms' incentives to offer profit-sharing schemes? Finally, are such remuneration schemes socially desirable?

To address these questions, we consider a differentiated good unionized duopoly, in which firms hire labor exclusively from a worker's union (either firm–specific or sector–wide) and compete in quantities (or prices) in the product market. In stage 0, workers choose whether to form a sector–wide union and coordinate their bargaining efforts (coordinated bargaining, $\mathcal{C}$), or to form two firm-specific unions, each bargaining with its own firm (decentralized bargaining, $\mathcal{D}$). In stage 1, firms decide whether to offer a fixed wage ($\mathcal{FS}$) or a fixed wage plus a profit share ($\mathcal{PS}$). In stage 2, under decentralized bargaining, each firm-specific union and its firm negotiate over the terms of the selected remuneration scheme; while under coordinated bargaining, each firm negotiates with a representative of the sector-wide union over those terms. In the last stage, firms choose their employment levels[4] and set their quantities (or prices) in the product market.

We show that product market characteristics as well as the unionization structure and union power (which may be proxied by the unionization level) affect the firms' incentives to offer profit–sharing schemes. Under Cournot competition, the weaker the union in the bargaining table, the more likely are that firms offer $\mathcal{PS}$,[5] independently whether workers

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[4]This is a "right-to-manage" framework. Note that under "efficient bargains" profit–sharing has no effect on the firm's employment level and profitability (Anderson and Devereux (1989))

[5]Note that under $\mathcal{PS}$ a firm-union pair disposes of two instruments and can thus achieve a *bilaterally efficient* outcome during its negotiations. In particular, given any bargained outcome of the rival pair, it chooses the wage rate to maximize joint surplus and uses the profit share ratio to distribute this

are organized in firm-specific unions or in a sector-wide union. Moreover, the competitive pressure in the market (as measured by the degree of product substitutability) intensifies the firms' incentives to offer $\mathcal{PS}$. Yet, for intermediate levels of union power, firms bargaining with a sector–wide union offer $\mathcal{PS}$, while they offer $\mathcal{FS}$ when they bargain with firm-specific unions. This is because a sector–wide union, in contrast to firm–specific unions, disposes of a positive *outside option*, i.e., in case of disagreement with one firm it can still supply labor to the other firm which becomes a monopolist in the product market. It can thus push for higher wage rate and higher profit share comparing to equally powerful firm-specific unions.

Interestingly, when the products are rather poor substitutes and the sector-wide union's power is neither too high nor too low, ex-ante symmetric firms end up offering different remuneration schemes and producing different quantities in equilibrium. Moreover, there are parameter constellations for which multiple equilibria arise under both decentralized and coordinated bargaining: Both the universal $\mathcal{PS}$ and the universal $\mathcal{FS}$ are equilibrium remuneration scheme configurations, with the latter being a Pareto-superior equilibrium from the firms' point of view (and in which firms are expected to coordinate).

In contrast to Cournot competition, under Bertrand competition, a firm never offers a profit–sharing scheme, independently whether workers are organized in firm-specific unions or in a sector–wide union. Thus, the unique equilibrium remuneration scheme configuration is universal $\mathcal{FS}$. This is because prices are strategic complements and a firm-union bargaining pair has no incentive to agree to a lower wage rate in order to make the firm more aggressive in the product market. The latter could be achieved by the firm offering $\mathcal{PS}$ since a profit-sharing scheme allows a trade-off between wage rates and profit shares. In fact, under Cournot competition, this trade-off is exploited by the firm-union pair and thus the firm has incentives to offer $\mathcal{PS}$ under some circumstances. Notice that the way competitive pressure is proxied in the market is of paramount importance for the likelihood of appearance of profit–sharing schemes. If a competitive pressure increase is proxied by a move from Cournot to Bertrand competition, our findings imply that profit–sharing schemes to be less likely. Yet, if it is measured by an increase in product substitutability, the opposite holds.

Independently of whether firms compete in quantities or prices, in equilibrium the workers are better–off forming a sector–wide union and coordinating their bargaining efforts. This might not be surprising, at least for the case of Bertrand competition, in which firms always offer fixed wage remuneration schemes. Yet, under Cournot competition, although the equilibrium remuneration schemes may differ across unionization structures for the same parameter values, it turns out that coordinated bargaining leads to higher overall rents for the unionized workers. This finding makes the analysis of the

maximized surplus to the negotiating parties according to their respective bargaining powers.

coordinated bargaining case to be of great importance and our paper is the first in the literature that has undertaken this task.

Our welfare analysis points out that aggregate employment level and firms' gross profits (i.e., profits before distribution of profit shares) are highest under decentralized bargaining and universal $\mathcal{PS}$. It also reveals that in this case, the highest consumer surplus and social welfare are achieved. This is because firm-specific unions agree on low wages (below their workers outside option) in exchange of high profit–sharing ratios, making their firms more aggressive in the product market, thus increasing employment and output levels. A regulator should then design policy measures to facilitate more flexible bargaining structures and to provide incentives to firms to offer profit–sharing schemes. As mentioned above, there is a recent trend in the developed economies towards more decentralization and, at the same time, there is evidence that unionization levels decline over time. Under these conditions, one should expect that profit–sharing schemes become more prevalent than in the past and that consumers and the society as a whole benefit.

Our paper contributes to the extant literature on the usage of profit–sharing schemes and their market and societal effects. This literature has its origins in the seminal work of Weitzman (Weitzman (1983, 1984, 1985, 1987)), who points out that profit-sharing makes the cost of labour completely flexible and gives firms the incentive to hire as many workers as are willing to take jobs. This leads to a profit-sharing economy with low levels of unemployment and great macroeconomic stability. However, the author assumes away strategic effects by considering monopolistically competitive markets. Bensaid and Gary-Bobo (1991) and Steward (1989) view profit–sharing as a firm's strategic commitment: $\mathcal{PS}$ shifts the market equilibrium outcome in favor of the firm adopting such a remuneration scheme in an oligopolistic environment. According to Steward (1989), a firm's equilibrium profits increase whenever it substitutes fixed wages with an equal part of profit shares (holding the workers' income fixed). Bensaid and Gary-Bobo (1991) show that a firm offering $\mathcal{PS}$ is the best response to both $\mathcal{PS}$ and $\mathcal{FS}$ offered by its rivals, but in equilibrium, all firms are worse–off by adopting profit–sharing schemes.

Similarly to us, a branch of this literature has paid attention to the role of unionization structure for the firms' incentives to offer profit–sharing schemes. In a unionized Cournot duopoly in which firm-specific unions set wages, Fung (1989) shows that the firm with a positive profit share obtains higher market share and profits.[6] Sorensen (1992) considers a unionized homogenous good Cournot duopoly, in which remuneration schemes are negotiated between firms and their firm-specific unions (decentralized bargaining). The

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[6]The effect of profit–sharing can be decomposed into two parts. First, a sector-wide effect: $\mathcal{PS}$ causes a wage reduction, which leads to a lower retail price and thus to higher aggregate quantity and employment level. Second, a firm-specific effect: the firm offering a $\mathcal{PS}$ gains a higher market share, and has higher employment and lower wage rate. These beneficial effects give to the firm offering a $\mathcal{PS}$ a strategic advantage over those not offering such a remuneration scheme.

author shows that firms offer profit–sharing schemes only if their unions are not too powerful. Goeddeke (2010) extends Sorensen's model to n firms and also considers centralized bargaining in which the sector-wide union negotiates with the employers' federation over a uniform wage rate. She concludes that when only few firms offer $\mathcal{PS}$, their profitability increases, but when the majority of firms offers $\mathcal{PS}$, each obtains lower profits than under a universal fixed wage scheme.

However, none of these papers considers imperfectly substitutable goods, coordinated bargaining, or Bertrand competition in the product market. Moreover, they do not endogenize the workers' decision to form a sector-wide union or firm-specific unions. We contribute to the existing literature by pointing out that (i) workers are always better–off when they coordinate their bargaining efforts in a sector–wide union, making thus the analysis of coordinated bargaining all the more important; (ii) coordinated bargaining makes the appearance of profit–sharing schemes more likely and under some circumstances, ex–ante symmetric firms may end up ex–post asymmetric as they choose different remuneration schemes in equilibrium; (iii) the more differentiated the goods are, the less likely is that firms offer profit–sharing schemes, independently of the bargaining regime; and (iv) Bertrand competition never provides incentives for firms to adopt profit–sharing schemes.

There is also an extensive empirical literature on the usage and the effects of profit–sharing schemes. Sesil et al. (2002) study 229 US major *New Technology* firms (pharmaceuticals, semiconductors etc.) that offer broad-based profit–sharing schemes. Comparing to their rivals that do not offer $\mathcal{PS}$, those firms' productivity increases by 4%, total shareholder returns increase by 2%, and profit level increases by 14%. Kraft and Ugarkovic (2005), using panel data from more than 2,000 German firms from 1998 to 2002, report that the introduction of a $\mathcal{PS}$ improves firms' profitability. Kruse (1992), using data from almost 3,000 US firms from 1971 to 1985, reports that the introduction of a $\mathcal{PS}$ is associated with a productivity increase of 2.8% to 3.5% for manufacturing firms, and 2.5% to 4.2% for non-manufacturing firms. Kruse suggests that only the most profitable and most productive firms offer profit–sharing schemes in order to align firm's and workers' interests, and through this alignment to reach new, higher levels of profitability and market share. Long and Fang (2012), using data from more than 1,700 Canadian firms from 1999 to 2001, shows that the introduction of a $\mathcal{PS}$ could increase real employee earnings growth up to 15% over a five–year period. In a recent paper, Fang (2016) reviews empirical studies showing that profit–sharing is beneficial for employees through higher income and employment stability, and for employers through higher productivity and profitability.[7] Moreover, a profit–sharing scheme reduces the supervision costs and

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[7]It is well documented that the use of profit–sharing could increase employees' productivity through the attraction and retention of high–quality human capital, which could be translated into higher levels of firms' profitability. (Bhargava and Jenkinson (1995) for the UK, Cahuc and Dormont (1997) for France, Kato and Morishima (2003) for Japan, Long and Fang (2012) for Canada, and Kato et al. (2010) for

is a remedy for shirking behavior, while at the same time creates a bigger flexibility in wages. Our findings are in line with the aforementioned empirical literature. First, the introduction of a profit–sharing scheme (typically) increases aggregate employment and firms' market shares and gross profits. Second, profit–sharing schemes increase wage flexibility as they allow a trade–off between lower wages and higher profit shares. Third, there are sectors in which some firms offer $\mathcal{PS}$, while their rivals do not, with the former obtaining higher profit levels. And finally, profit–sharing schemes often lead to higher real earnings per employee.[8]

The remainder of the paper is organized as follows. In section 2 we describe the model structure, the sequence of events and the bargaining framework. We, also, analyze the benchmark case in which both firms offer a fixed wage scheme. In section 3, we characterize the equilibrium outcomes under different unionization structures and remuneration schemes and determine the equilibrium remuneration schemes under decentralized and coordinated bargaining. We, also, determine the equilibrium unionization structure. We perform a welfare analysis in section 4. In section 5 we extend our analysis by assuming Bertrand competition in the product market. Finally, section 6 offers the concluding remarks. All proofs are relegated to section 7.

2   The model

2.1   Market structure and remuneration schemes

Consider an economy with two sectors: a competitive non-unionized sector (the "numeraire") and an oligopolistic unionized sector in which two firms, namely F_i and F_j, produce a horizontally differentiated good and compete in quantities. F_i is facing the following inverse demand function $p_i = \alpha - q_i - \gamma q_j$, where p_i and q_i are retail price and quantity, while $0 < \gamma < 1$ is the degree of product's substitutability, and $\alpha > 0$.[9] Both firms are endowed with constant returns to scale technology that transforms one unit of labor into one unit of final good: $q_i = L_i$, where L_i is F_i's employment level.[10]

Each firm faces a constant non-labor marginal cost c, which is normalized to zero. Regarding the labor costs, we distinguish the following two cases. First, if F_i is using a

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STAGE 0	STAGE 1	STAGE 2	STAGE 3

Union formation Remuneration Bargaining Market
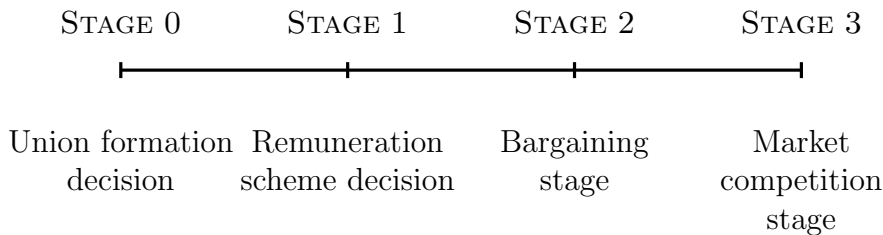decision scheme decision stage competition
stage

Figure 1: Game Timeline

$\mathcal{FS}$, its unitary and marginal labor cost is the firm-specific wage rate w_i. Second, if F_i is using a $\mathcal{PS}$ then F_i pays w_i per unit of labor plus a lump-sum transfer to its workers equal to $s_i\pi_i$, where $0 < s_i < 1$ is the profit share ratio and π_i are its gross profits.

The oligopolistic sector is unionized and all the workers have identical skills. Workers are organized either in two firm-specific unions, U_i and U_j (decentralized bargaining case, $\mathcal{D}$), or in one sector-wide union U (coordinated bargaining case, $\mathcal{C}$). The union's objective is *rent maximization* (Oswald, 1982). Under $\mathcal{FS}$, this is simply the workers' total wage surplus (i.e., the difference between total wage bill w_i and the workers' outside option w_0.) Under $\mathcal{PS}$, the union cares also for the profit share transferred to its members. In particular, F_i's specific union maximizes a Stone-Geary form utility function:

$$U_i = (w_i - w_0)L_i \qquad \text{under } \mathcal{FS}, \text{ and}$$
$$U_i = (w_i - w_0)L_i + s_i\pi_i \quad \text{under } \mathcal{PS}, \tag{1}$$

where $0 < w_0 < \alpha$ is the worker's outside option.[11] A sector-wide union maximizes

$$U = \sum_{i=1}^{2}[(w_i - w_0)L_i] \qquad \text{under } \mathcal{FS}, \text{ and}$$
$$U = \sum_{i=1}^{2}[(w_i - w_0)L_i + s_i\pi_i] \quad \text{under } \mathcal{PS}. \tag{2}$$

2.2 Sequence of events and bargaining framework

We consider a four-stage game with observable actions (Figure 1). This timing allows us to capture the strategic value of a firm's commitment to a specific remuneration scheme.

Stage 0: Union formation stage. Workers decide whether to form two firm-specific unions (decentralized bargaining case, $\mathcal{D}$) or to form a sector-wide union and coordinate their bargaining efforts (coordinated bargaining case, $\mathcal{C}$).

Stage 1: Remuneration scheme stage. Firms, simultaneously and separately, decide whether to offer a $\mathcal{FS}$ or a $\mathcal{PS}$ to their workers. Under a $\mathcal{PS}$, F_i commits to transfer

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[11]In this setting, w_0 can be seen as the wage a worker could earn in the competitive sector of the economy. One of the key findings in Bryson (2014) is that workers organized in trade unions benefit from higher wages, so the difference $w_i - w_0$ can, also, be seen as the union wage premium.

to its workers a portion of its profits (the specific value of which to be subject of the negotiations at a later stage). As a consequence, the following scenarios could arise: Both firms offering either $\mathcal{FS}$ (universal $\mathcal{FS}$ case) or $\mathcal{PS}$ (universal $\mathcal{PS}$ case), and one firm offering a $\mathcal{FS}$ while the other offers a $\mathcal{PS}$ (mixed cases).

Stage 2: Bargaining stage. Under decentralized bargaining, the two firm-union pairs (vertical chains) negotiate simultaneously and separately over the issue(s) included in their respective bargaining agendas. If F_i chooses to offer an $\mathcal{FS}$, then the (F_i, U_i) pair negotiates over w_i alone. Alternatively, if F_i commits to offer a profit-sharing scheme, then the (F_i, U_i) pair negotiates over both w_i and the profit sharing ratio s_i. Under coordinated bargaining, each firm and a representative of the sector-wide union negotiate in simultaneous and separate sessions over the issue(s) included in their respective bargaining agendas. (F_i, U) negotiate over w_i or (w_i, s_i) if F_i has opted for $\mathcal{FS}$ or $\mathcal{PS}$, respectively, in stage 1. In each bargaining session, the union and the firm have bargaining powers β and $(1 - \beta)$, $0 < \beta < 1$, respectively.[12]

Stage 3: Market competition stage. Firms choose simultaneously their employment and output levels. Note that this is a "right-to-manage" model, i.e., firms have the right to choose their employment levels. (In the extensions, we briefly consider Bertrand competition in the product market.)

To solve this dynamic multi-stage game, we evoke the *Nash-in-Nash* solution concept: the Nash equilibrium of the two Nash bargaining solutions. We also assume that the negotiated outcome of a bargaining pair is non-contingent on whether the rival pair has reached or not an agreement.[13] Moreover, to obtain a unique equilibrium under coordinated bargaining, we impose pairwise proofness on the equilibrium agreements. That is, we require that the negotiated agreement between U and F_i is immune to a bilateral deviation of U with the rival firm F_j, holding the agreement with F_i constant.[14]

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[12]As is standard, the bargaining power β is assumed to be exogenous. In fact, it is determined by various factors, such as the legal framework, the firm's internal organization, the union's ability to strike, the firm's costs of hiring, training, and firing, the unemployment rates, the difficulties to match firms' needs with workers' skills, labour market frictions, etc. Using data from 12 major US unionized firms from mid 1950's to late 1970's, Svejnar (1986) shows that the union's bargaining power was: for Ford's union $\beta = 0.25$, for Boeing's union $\beta = 0.86$, for US Steel's union $\beta = 0.36$, and for Rockwell's union $\beta = 0.85$.

[13]Non-contingency states that any breakdown in the negotiations between F_i and U_i (or U) will be non-permanent and non-irrevocable, and this is common knowledge (Horn and Wolinsky, 1988). This will lead pair F_j and U_j (or U) to bargain in a bilateral monopoly fashion, with F_j selling monopoly quantity in case of breakdown in the rival pair, but facing the same wage rate w_j and the same profit share percentage s_j as under duopoly. In other words, in case of a breakdown in the negotiations between F_i and U_i (or U), F_j and U_j (or U) do not renegotiate their remuneration terms (Milliou and Petrakis, 2007).

[14]Note that pairwise proofness and passive beliefs are closely related. Passive beliefs are appropriate when we perceive the asymmetric generalized Nash bargaining solution as the limit equilibrium of an alternating offers-counter-offers non-cooperative bargaining game (Binmore et al., 1986). In that case, passive beliefs state that F_i will handle any out-of-equilibrium offer from U as a "tremble", uncorrelated with any offer from U to rival F_j. That is, F_i believes that under any offer received from U, the pair U and F_j has reached an equilibrium outcome. Note that alternative beliefs lead to different equilibrium

2.3   The benchmark case: Universal $\mathcal{FS}$ regime

We will briefly present the benchmark case in which both firms offer fixed wage schemes. In the last stage of the game, F_i chooses employment level and output to maximize its net profits: $\pi_i = (\alpha - q_i - \gamma q_j - w_i)q_i$. Note that F_i's decision will remain the same under a profit sharing scheme too, as in the latter case it maximizes its net profits $(1 - s_i)\pi_i$, where s_i is fixed as it has been determined at an earlier stage. The first order condition (foc) gives rise to the following reaction function:

$$q_i(q_j, w_i) = \tfrac{1}{2}(\alpha - \gamma q_j - w_i)$$

A decrease in w_i shifts q_i upwards and turns F_i into a more aggressive competitor in the product market. Solving the system of reaction functions, we obtain the equilibrium outputs, employment levels and profits:

$$q_i^*(w_i, w_j) = L_i^*(w_i, w_j) = \frac{\alpha(2 - \gamma) - 2w_i + \gamma w_j}{4 - \gamma^2}$$
$$\pi_i^*(w_i, w_j) = [q_i^*(w_i, w_j)]^2$$

In stage 2, firm–union pairs bargain simultaneously and separately, each over its firm-specific wage rate. We consider in turn the decentralized and the coordinated bargaining cases.

2.3.1   Decentralized bargaining

Under decentralized bargaining, F_i and its firm-specific union U_i choose w_i to maximize their generalized asymmetric Nash product, taking as given the wage rate of the rival pair w_j:

$$NP_i^{\mathcal{DF}}(w_i, w_j) = [\pi_i^*(w_i, w_j)]^{1-\beta}[(w_i - w_0)q_i^*(w_i, w_j)]^{\beta} \tag{3}$$

where superscript $\mathcal{DF}$ stands for decentralized bargaining over a fixed wage. Note that in this case, the disagreement payoffs are nil for both F_i and U_i. From the foc, we obtain the reaction function of the bargaining pair (F_i, U_i):

$$w_i(w_j) = \tfrac{1}{4}[\alpha\beta(2 - \gamma) + 2(2 - \beta)w_0 + \beta\gamma w_j]$$

Notice that wages are strategic complements: an increase in w_j, allows (F_i, U_i) to agree on a higher wage rate. By symmetry, we get the equilibrium wage rate, employment and

outcomes (McAfee and Schwartz, 1994, 1995).

output:

$$w^{\mathcal{DF}} = w_0 + \frac{\beta(2-\gamma)\tilde{\alpha}}{4-\beta\gamma}$$

$$L^{\mathcal{DF}} = q^{\mathcal{DF}} = \frac{2(2-\beta)\tilde{\alpha}}{(2+\gamma)(4-\beta\gamma)} \tag{4}$$

where: $\tilde{\alpha} = \alpha - w_0 > 0$. The following Lemma summarizes:

Lemma 1. *When firms bargain with their firm-specific unions ($\mathcal{D}$) over a fixed wage remuneration scheme ($\mathcal{FS}$):*

(i) Equilibrium wages are above the competitive wage: $w^{\mathcal{DF}} > w_0$.

(ii) The higher the union's bargain power, the more capable it is to negotiate a higher wage: $\frac{\partial w^{\mathcal{DF}}}{\partial \beta} > 0$.

(iii) The closer substitutes the two goods are, the higher is the competitive pressure, thus the more valuable it is to be aggressive in the product market: $\frac{\partial w^{\mathcal{DF}}}{\partial \gamma} < 0$.

The intuition is straightforward. The mere existence of a union pushes wages above the competitive wage (i.e., the workers' outside option). A stronger union is able to negotiate higher wages for its members. Moreover, as goods become less differentiated and the competitive pressure increases for the firms, unions make more wage concessions in order to save jobs for their members. Note also that employment level and output are decreasing in both the union's bargaining power and the degree of product substitutability.

2.3.2 Coordinated bargaining

Under coordinated bargaining, F_i bargains with a representative of the sector-wide union U over the firm-specific wage w_i, taking as given the rival wage w_j negotiated between F_j and U. In this case, the disagreement payoffs are nil, again, for F_i, but positive for U. If U fails to reach an agreement with F_i, it can still extract economic rents from offering workers to rival F_j at the negotiated wage w_j. As F_j becomes now a monopolist in the product market, its output (equals employment) level is $q_j^m(w_j) = \frac{1}{2}(\alpha - w_j)$. Hence, U's disagreement payoff (or else *outside option*) is: $(w_j - w_0)q_j^m(w_j)$. Therefore, w_i is chosen to maximize the generalized asymmetric Nash product:

$$NP_i^{\mathcal{CF}}(w_i, w_j) = [\pi_i^*(w_i, w_j)]^{1-\beta}[U^{\mathcal{CF}}(w_i, w_j) - (w_j - w_0)q_j^m(w_j)]^{\beta}, \tag{5}$$

where the superscript $\mathcal{CF}$ stands for coordinated bargains over a fixed wage and

$$U^{\mathcal{CF}}(w_i, w_j) = \sum_{i=1, j\neq i}^{2} [(w_i - w_0)q_i^*(w_i, w_j)].$$

are the aggregate economic rents extracted by U. From the foc, we get the (F_i, U)'s reaction function

$$w_i(w_j) = \tfrac{1}{4}[\alpha\beta(2-\gamma) + (2-\gamma)(2-\beta)w_0 + 2\gamma w_j]$$

Once again, wages are strategic complements (Bulow et al., 1985). An increase in w_j will cause an increase in w_i. By imposing symmetry, the equilibrium wage rate, employment and output are:

$$w^{\mathcal{CF}} = w_0 + \tfrac{1}{2}\beta\tilde{\alpha}$$

$$L^{\mathcal{CF}} = q^{\mathcal{CF}} = \frac{(2-\beta)\tilde{\alpha}}{2(2+\gamma)} \tag{6}$$

The following Lemma summarizes.

Lemma 2. *When firms bargain with a sector-wide union ($\mathcal{C}$) over a fixed wage remuneration scheme ($\mathcal{FS}$):*

(i) Wages bargained by the sector-wide union are always higher than those bargained by the firm-specific unions: $w^{\mathcal{CF}} > w^{\mathcal{DF}} > w_0$, $\forall\beta, \gamma$.

(ii) The higher the union's bargaining power, the more capable it is to negotiate higher wages: $\frac{\partial w^{\mathcal{CF}}}{\partial\beta} > 0$.

(iii) The negotiated wage $w^{\mathcal{CF}}$ is independent of the degree of product substitutability: $\frac{\partial w^{\mathcal{CF}}}{\partial\gamma} = 0$.

As expected, U can effectively coordinate workers' bargaining efforts, and thus can achieve higher wages, compared to U_i. The more powerful the union is, the higher are the negotiated wages. Interestingly, in the coordinated bargaining, wages are independent of the degree of product differentiation. This is in line with Dhillon and Petrakis (2002) who have shown that this *wage rigidity* result applies to other market features too, such as the number of firms in the industry. In this case too, employment level and output are decreasing in both β and γ.

3   Equilibrium remuneration schemes

In this section we determine the configuration of remuneration schemes that arise in equilibrium. We consider in turn the decentralized and the coordinated bargaining cases. Remember that, independently whether a firm offers a $\mathcal{FS}$ or a $\mathcal{PS}$ remuneration scheme, the equilibrium outcome of stage 3 is the same as in the benchmark case.

3.1 Decentralized bargaining

Under decentralized bargaining, in stage 2 each firm and its firm–specific union bargain over the terms of the remuneration scheme that the firm has chosen in stage 1. Besides the benchmark case in which both firms offer a $\mathcal{FS}$ in stage 1 that has been analyzed above (the universal $\mathcal{FS}$ regime), there are two additional cases: (a) the universal $\mathcal{PS}$ regime, in which both firms offer a $\mathcal{PS}$, and (b) the mixed regime in which one firm offers a $\mathcal{FS}$ and the other offers a $\mathcal{PS}$.

3.1.1 Universal $\mathcal{PS}$ regime

In this case, (F_i, U_i) pair negotiates over the two issues included in their bargaining agenda: the wage rate w_i and the profit sharing ratio s_i. In particular, they choose (w_i, s_i) to maximize their generalized asymmetric Nash product:

$$NP_i^{\mathcal{DP}}(w_i, w_j, s_i) = [(1 - s_i)\pi_i^*(w_i, w_j)]^{1-\beta}[(w_i - w_0)q_i^*(w_i, w_j) + s_i\pi_i^*(w_i, w_j)]^\beta \quad (7)$$

where superscript $\mathcal{DP}$ stands for a decentralized bargain over a profit sharing scheme. Again, the disagreement payoffs are nil for both parties. Note that as the involved parties negotiate over two variables, the resulting bargaining outcome turns out to be *bilaterally efficient*, i.e., it maximizes (F_i, U_i) pair's joint surplus $\pi_i^*(w_i, w_j) + (w_i - w_0)q_i^*(w_i, w_j)$, given the bargaining outcome of the rival pair. In fact, w_i is chosen to maximize the joint surplus and s_i to split the maximized joint surplus to F_i and U_i according to their bargaining powers $(1 - \beta)$ and β, respectively.[15]

Maximizing $NP_i^{\mathcal{DP}}$ over w_i and s_i and exploiting symmetry, we get the equilibrium wage rate, profit sharing ratio, and employment and output:

$$
\begin{aligned}
w^{\mathcal{DP}} &= w_0 - \frac{\gamma^2 \tilde{\alpha}}{4 + \gamma(2 - \gamma)} \\
s^{\mathcal{DP}} &= \beta + \frac{1}{2}(1 - \beta)\gamma^2 \\
L^{\mathcal{DP}} = q^{\mathcal{DP}} &= \frac{2\tilde{\alpha}}{4 + \gamma(2 - \gamma)}
\end{aligned}
\quad (8)
$$

It can be readily verified that $0 < s^{\mathcal{DP}} < 1, \quad \forall \beta, \gamma \in (0, 1)$. The following Lemma summarizes:

Lemma 3. *When firms bargain with their firm-specific unions (D) over a profit sharing scheme (PS):*

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[15]Maximizing $NP_i^{\mathcal{DP}}(w_i, w_j, s_i)$ w.r.t. s_i we obtain $s_i^*(w_i, w_j)\pi_i^*(w_i, w_j) = \beta[\pi_i^*(w_i, w_j)] - (1-\beta)[(w_i - w_0)q_i^*(w_i, w_j)]$. Substituting this back to $NP_i^{\mathcal{DP}}(w_i, w_j, s_i)$, we get that the latter is proportional to (F_i, U_i)'s joint surplus. This is in line with the outcome of Nash bargaining games with transfer payments (see e.g. O'Brien and Shaffer (1992)).

(i) Negotiated wages are below the competitive wage, $w^{\mathcal{DP}} < w_0$.

(ii) A stronger union gets a higher profit share ratio, $\frac{\partial s^{\mathcal{DP}}}{\partial \beta} > 0$, but it doesn't get a higher wage, $\frac{\partial w^{\mathcal{DP}}}{\partial \beta} = 0$.

(iii) As the degree of product substitutability increases, the negotiated wage decreases, while the profit sharing ratio increases: $\frac{\partial w^{\mathcal{DP}}}{\partial \gamma} < 0$ and $\frac{\partial s^{\mathcal{DP}}}{\partial \gamma} > 0$.

This is an interesting result. The bargained wages are below the union's reservation wage (i.e., the competitive wage).[16] In a sense, the union "subsidizes" its firm. A firm–union pair agrees on a low wage rate in order to make the firm more aggressive in the product market. It thus increases its joint surplus which is then divided between the negotiating parties according to their respective bargaining powers. Clearly, the overall compensation of each worker, i.e., the sum of its wage $w^{\mathcal{DP}}$ plus its individual share from the firm i's profits, $\frac{s^{\mathcal{DP}}\pi^{\mathcal{DP}}}{L^{\mathcal{DP}}}$, is well above the competitive wage w_0. For the same reason, a stronger union has no incentive to push for a higher wage rate. A higher wage can only shrink the joint surplus which, as the union gets anyway a fixed portion β of its maximized value, is translated to lower union rents. Clearly, the stronger the union is, the higher is its rents. As expected, stronger competitive pressure (as expressed by a higher γ) leads to lower bargained wages, which however are accompanied by higher profit sharing ratios. Notice that in this case employment level and output are independent of the union's bargaining power, while they are again decreasing in γ.

3.1.2 Mixed regime

Under the mixed regime, and without any loss of generality, let (F_i, U_i) pair bargain over a $\mathcal{PS}$ and (F_j, U_j) pair bargain over a $\mathcal{FS}$. The former pair bargains over both w_i and s_i, while the latter pair bargains only over w_j. The different generalized asymmetric Nash products are:

$$NP_i^{\mathcal{DM}}(w_i, w_j, s_i) = \ [(1-s_i)\pi_i^*(w_i, w_j)]^{1-\beta}[(w_i - w_0)q_i^*(w_i, w_j) + s_i\pi_i^*(w_i, w_j)]^\beta \quad (9)$$

$$NP_j^{\mathcal{DM}}(w_i, w_j) = \ [\pi_j^*(w_i, w_j)]^{1-\beta}[(w_j - w_0)q_j^*(w_i, w_j)]^\beta, \quad (10)$$

where superscript $\mathcal{DM}$ stands for decentralized bargains over mixed remuneration schemes. As (F_i, U_i) pair disposes of two instruments, is able to maximize joint surplus and then divide it according to bargain power. That's not the case for the other pair (F_j, U_j). Solving the system of focs, we get the equilibrium wage rates, profit sharing ratio, and

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[16]In some countries, like France, it is forbidden to substitute the profit share for the base wage (Cahuc and Dormont, 1997). In this case: $w^{\mathcal{DP}} \equiv w_0$ and $s^{\mathcal{DP}} = \beta$ while $L^{\mathcal{DP}} = q^{\mathcal{DP}} = \frac{\tilde{\alpha}}{2+\gamma}$.

employment levels and outputs:

$$
\begin{aligned}
w_i^{\mathcal{DM}} &= w_0 - \frac{(2-\gamma)\gamma^2(4+\beta\gamma)\tilde{\alpha}}{32 + \beta\gamma^4 - 16\gamma^2} \\
s_i^{\mathcal{DM}} &= \beta + \tfrac{1}{2}(1-\beta)\gamma^2 \\
w_j^{\mathcal{DM}} &= w_0 + \frac{\beta(2-\gamma)(2+\gamma)(4-2\gamma-\gamma^2)\tilde{\alpha}}{32 + \beta\gamma^4 - 16\gamma^2} \\
q_i^{\mathcal{DM}} = L_i^{\mathcal{DM}} &= \frac{2(2-\gamma)(4+\beta\gamma)\tilde{\alpha}}{32 + \beta\gamma^4 - 16\gamma^2} \\
q_j^{\mathcal{DM}} = L_j^{\mathcal{DM}} &= \frac{2(2-\beta)(4-2\gamma-\gamma^2)\tilde{\alpha}}{32 + \beta\gamma^4 - 16\gamma^2}
\end{aligned}
\tag{11}
$$

Again, it is easy to check that $0 < s_i^{\mathcal{DM}} < 1, \quad \forall \beta, \gamma \in (0,1)$. The following Lemma summarizes:

Lemma 4. *When firms bargain with their firm-specific unions ($\mathcal{D}$) and offer different remuneration schemes ($\mathcal{MS}$):*

(i) The wage of the firm offering a $\mathcal{PS}$ is below the competitive wage, while the wage of the firm offering a $\mathcal{FS}$ is above the competitive wage: $w_i^{\mathcal{DM}} < w_0 < w_j^{\mathcal{DM}}$.

(ii) The stronger the union of a firm that offers a $\mathcal{PS}$ ($\mathcal{FS}$), the lower (higher) is the negotiated wage: $\frac{\partial w_i^{\mathcal{DM}}}{\partial \beta} < 0$ and $\frac{\partial w_j^{\mathcal{DM}}}{\partial \beta} > 0$.

(iii) Both wages decrease with the degree of the product's substitutability: $\frac{\partial w_i^{\mathcal{DM}}}{\partial \gamma} < 0$ and $\frac{\partial w_j^{\mathcal{DM}}}{\partial \gamma} < 0$.

The intuition for (i) and (iii) are along the lines of our discussion below Lemmata 1 and 3. Interestingly, as the union of the firm offering a profit sharing remuneration scheme becomes stronger, it agrees on a higher subsidization rate (i.e., $w_i^{\mathcal{DM}}$ decreases). In this way, its firm becomes more aggressive in the product market and the firm–union's (maximized) joint surplus increases, a fixed portion β of which the union then enjoys. On the other hand, the union of the firm offering a fixed wage scheme naturally presses for a higher wage as its bargaining power increases. Interestingly, and in contrast to those of the firm offering $\mathcal{FS}$, the employment level and output of the firm offering $\mathcal{PS}$ is increasing in the union's bargaining power and may also increase with γ but only if the products are close substitutes. Finally, notice that the profit sharing ratio of a firm offering $\mathcal{PS}$ is the same independently whether the rival firm offers $\mathcal{PS}$ or $\mathcal{FS}$ ($s^{\mathcal{DP}} = s_i^{\mathcal{DM}}$). Yet, its wage rate is higher under universal $\mathcal{PS}$ than in the mixed regime ($w^{\mathcal{DP}} > w_i^{\mathcal{DM}}$).

3.1.3 Equilibrium remuneration schemes under decentralized bargaining

In this subsection we determine the remuneration schemes that arise in equilibrium. Firms choose simultaneously between offering a fixed wage or a profit sharing scheme. If both firms offer $\mathcal{FS}$, each firm makes net profits $\pi^{\mathcal{DF}} = (q^{\mathcal{DF}})^2$; if both firms offer $\mathcal{PS}$,
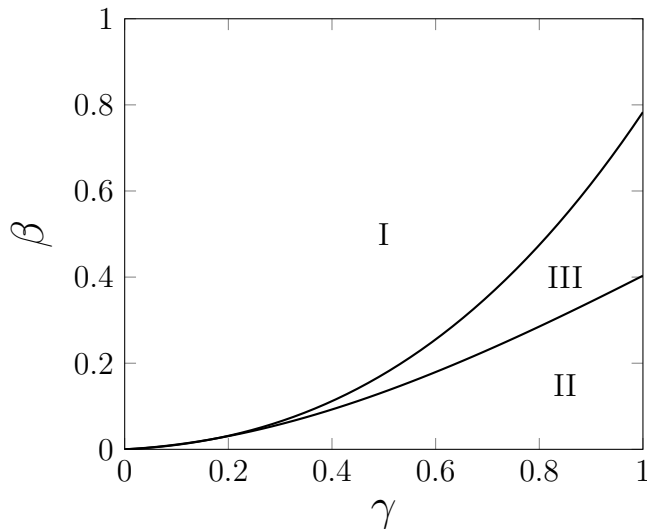
Figure 2: Equilibria under Decentralized Bargaining. Areas I+III: Universal $\mathcal{FS}$; Area II+III: Universal $\mathcal{PS}$; Area III: Universal $\mathcal{FS}$ Pareto–dominates Universal $\mathcal{PS}$.

each firm makes net profits $\pi^{\mathcal{DP}} = (1 - s^{\mathcal{DP}})(q^{\mathcal{DP}})^2$; if F_i offers a $\mathcal{PS}$, and F_j offers a $\mathcal{FS}$, then the net profits per firm are: $\pi_i^{\mathcal{DM}} = (1 - s_i^{\mathcal{DM}})(q_i^{\mathcal{DM}})^2$ and $\pi_j^{\mathcal{DM}} = (q_j^{\mathcal{DM}})^2$. The Nash equilibria of this matrix game are summarized in the following proposition and are illustrated in Figure 2.

Proposition 3.1. *When firms bargain with their firm-specific unions, in equilibrium:*

(i) Both firms offer fixed wage schemes for all $\beta \geq \beta^{\mathcal{DF}}(\gamma)$, with $\frac{d\beta^{\mathcal{DF}}}{d\gamma} > 0$, $\beta^{\mathcal{DF}}(0) = 0$ and $\beta^{\mathcal{DF}}(1) = 0.373$ (Areas I and III).

(ii) Both firms offer profit sharing schemes for all $\beta \leq \beta^{\mathcal{DP}}(\gamma)$, with $\frac{d\beta^{\mathcal{DP}}}{d\gamma} > 0$, $\beta^{\mathcal{DP}}(0) = 0$ and $\beta^{\mathcal{DP}}(1) = 0.694$ (Areas II and III).

(iii) If $\beta^{\mathcal{DF}}(\gamma) \leq \beta \leq \beta^{\mathcal{DP}}(\gamma)$, both universal $\mathcal{FS}$ and universal $\mathcal{PS}$ arise, with the former equilibrium Pareto dominating the latter (Area III).

When the union's bargaining power is high enough, both firms offer fixed wage remuneration schemes. In contrast, when unions are not too powerful, both firms offer profit sharing schemes to their workers. By introducing a $\mathcal{PS}$, a firm will face a substantially lower unit labor cost and will thus have a strong competitive advantage in the product market. A firm with a weak union (low β) will then enjoy the bulk of the additional profits. Nevertheless, if both firms offer a profit sharing remuneration scheme, they are trapped into a prisoner's dilemma and make lower profits than under universal $\mathcal{FS}$. Note that asymmetric equilibria never arise under decentralized bargaining; also that for intermediate values of β, there are multiple equilibria with the universal $\mathcal{FS}$ equilibrium Pareto dominating the universal $\mathcal{PS}$ one. Finally, the higher is the competitive pressure (higher γ), the more likely is for firms to offer profit sharing schemes.

16

3.2 Coordinated bargaining

Under coordinated bargaining, in stage 2 each firm bargains with a representative of the sector-wide union. Bargaining sessions are separate and simultaneous, and each (F_i, U) pair negotiates over the terms of the remuneration scheme that F_i has chosen in stage 1. As the universal $\mathcal{FS}$ regime has been analyzed above, we conduct the analysis of the universal $\mathcal{PS}$ and the mixed regimes in the sequel.

3.2.1 Universal $\mathcal{PS}$ regime

In this case, F_i bargains with a representative of the sector-wide union U over the firm-specific wage w_i and the profit sharing ratio s_i, taking as given the (w_j, s_j) bargained between F_j and U. F_i's disagreement payoff is again nil, while that of U equals: $(w_j - w_0) q_j^m(w_j) + s_j \pi_j^m(w_j)$, where $q_j^m(w_j) = \frac{1}{2}(\alpha - w_j)$ and $\pi_j^m(w_j) = [q_j^m(w_j)]^2$ are the equilibrium output and profits of F_j while acting as a monopolist in the product market. This is because if U fails to reach an agreement with F_i, it can still get rents from offering workers to the monopolist F_j at the negotiated wage w_j and from enjoying a portion s_j of F_j's monopoly profits. Therefore, w_i and s_i are chosen to maximize the Nash product:

$$NP_i^{\mathcal{CP}}(w_i, w_j, s_i, s_j) = [(1 - s_i) \pi_i^*(w_i, w_j)]^{1-\beta} [U^{\mathcal{CP}}(w_i, w_j, s_i, s_j) - \\ - (w_j - w_0) q_j^m(w_j) - s_j \pi_j^m(w_j)]^\beta$$

where $\mathcal{CP}$ stands for coordinated bargaining over profit sharing schemes and,

$$U^{\mathcal{CP}}(w_i, w_j, s_i, s_j) = \sum_{i=1, j \neq i}^{2} [(w_i - w_0) q_i^*(w_i, w_j) + s_i \pi_i^*(w_i, w_j)]$$

are the aggregate economic rents extracted by the union from both firms. As each (F_i, U) pair disposes of two instruments (namely: wage w_i and profit share s_i), their negotiated outcome is, again, bilaterally efficient: it maximizes the pair's (excess) joint surplus, given the bargained outcome (w_j, s_j) of the rival pair.[17] From the focs and exploiting symmetry, we obtain the firms' equilibrium wage, profit sharing ratio, and employment

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[17]In particular, w_i is chosen to maximize the joint surplus:

$$\pi_i^*(w_i, w_j) + \sum_{i=1, j \neq i}^{2} (w_i - w_0) q_i^*(w_i, w_j) - (w_j - w_0) q_j^m(w_j) - s_j \pi_j^m(w_j),$$

and s_i is chosen such that the maximized joint surplus is divided among the two parties according to their respective bargaining powers. Note that as the last two terms of the above expression do not depend on w_i, the (F_i, U)'s negotiated wage essentially maximizes their joint surplus.

and output levels:

$$w^{\mathcal{CP}} = w_0 + \frac{[\beta(8 - \gamma^2(4 + \gamma)) - \gamma(4 - 4\gamma - \gamma^2)]\gamma\tilde{\alpha}}{16 - 2\gamma[6\gamma - (2 + \gamma)(2\beta + (1 - \beta)\gamma^2)]}$$

$$s^{\mathcal{CP}} = \frac{2[2\beta + (1 - \beta)\gamma^2]}{4 - (1 - \beta)\gamma^2} \tag{12}$$

$$L^{\mathcal{CP}} = q^{\mathcal{CP}} = \frac{(2 - \gamma)(4 - (1 - \beta)\gamma^2)\tilde{\alpha}}{16 - 2\gamma[6\gamma - (2 + \gamma)(2\beta + (1 - \beta)\gamma^2)]}$$

It can be readily verified that $0 < s^{\mathcal{CP}} < 1 \quad \forall \beta, \gamma \in (0, 1)$. The following Lemma summarizes:

Lemma 5. *When firms bargain with a sector-wide union ($\mathcal{C}$) over profit-sharing schemes ($\mathcal{PS}$):*

(i) The negotiated wages are below the competitive wage only if the goods are differentiated enough and the union's bargaining power is low enough, i.e., $w^{\mathcal{CP}} < w_0$ only if $\gamma < 0.828$ and $\beta < \overline{\beta}(\gamma) \equiv \frac{\gamma(4 - 4\gamma - \gamma^2)}{8 - \gamma^2(4 + \gamma)}$. Otherwise: $w^{\mathcal{CP}} > w_0$.

(ii) The stronger the union is, the higher are the negotiated wages and profit sharing ratios: $\frac{\partial w^{\mathcal{CP}}}{\partial \beta} > 0$ and $\frac{\partial s^{\mathcal{CP}}}{\partial \beta} > 0$.

(iii) The negotiated profit sharing ratios always increase with the degree of product substitutability, $\frac{\partial s^{\mathcal{CP}}}{\partial \gamma} > 0$, while the negotiated wages increase with γ except if both γ and β are sufficiently low.

It can be readily verified that $w^{\mathcal{CP}} < w^{\mathcal{CF}}$ except if $\gamma > 0.828$ and $\beta < \widehat{\beta}(\gamma) \equiv \frac{\gamma^2 + 4\gamma - 4}{\gamma(2 + \gamma)}$, with $\frac{d\widehat{\beta}}{d\gamma} > 0$. The intuition behind this result is the following. When firms negotiate with a sector-wide union U over wages w_i and profit sharing ratios s_i, the union most often agrees on lower wages in exchange of higher profit sharing ratios. Further, and in contrast to the universal $\mathcal{FS}$ regime, under universal $\mathcal{PS}$ negotiated wages are sometimes below the competitive wage. This occurs only if the goods are rather poor substitutes ($\gamma > 0.828$) and the union's bargaining power is low enough. Under these circumstances, the positive effect on wages from the workers' coordination of bargaining efforts is outweighed by the negative effect from U's inability to (publicly) commit to wage rates. This is the well-known *commitment problem* (McAfee and Schwartz, 1994). F_i anticipates that U has incentives to behave opportunistically, i.e., to agree with F_j on a low wage rate (even below w_0) in order to make F_j more aggressive in the product market and enjoy thus its portion β of the higher (F_j, U)'s excess joint surplus. As a consequence, F_i will not agree on a wage well above w_0.[18] As expected, a stronger sector-wide union can put higher pressure to firms and obtain both higher wages and profit sharing ratios. Finally, as the goods become closer substitutes and the competitive pressure increases for firms,

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[18]Notice that subsidization of firms under coordinated bargaining occurs only under some parameter values, in contrast to the decentralized bargaining case in which it occurs always.

the union is more successful in coordinating its workers bargaining efforts, obtaining thus higher profit sharing ratios and (most often) higher wages. Finally, similar to the universal $\mathcal{FS}$ case, we check that employment level and output are decreasing in both β and γ.

3.2.2 Mixed regime

Under the mixed regime, let (F_i, U_i) pair bargain over a $\mathcal{PS}$ and (F_j, U_j) pair bargain over a $\mathcal{FS}$. Then the former pair chooses (w_i, s_i), while the latter pair chooses w_j, in order each to maximize its respective Nash product:

$$NP_i^{\mathcal{CM}}(w_i, w_j, s_i) = [(1 - s_i)\pi_i^*(w_i, w_j)]^{1-\beta}[U^{\mathcal{CM}}(w_i, w_j, s_i) - (w_j - w_0)q_j^m(w_j)]^{\beta}$$

$$NP_j^{\mathcal{CM}}(w_i, w_j, s_i) = [\pi_j^*(w_i, w_j)]^{1-\beta}[U^{\mathcal{CM}}(w_i, w_j, s_i) - (w_i - w_0)q_i^m(w_i) - s_i\pi_i^m(w_i)]^{\beta},$$

where $\mathcal{CM}$ stands for coordinated bargaining over mixed remuneration schemes and,

$$U^{\mathcal{CM}}(w_i, w_j, s_i) = \sum_{i=1, j\neq i}^{2} [(w_i - w_0)q_i^*(w_i, w_j)] + s_i\pi_i^*(w_i, w_j)$$

are the aggregate economic rents extracted by the union from both firms. Each firm's disagreement payoff is nil, while those of the sector-wide union U are the same as the ones discussed in the universal $\mathcal{CF}$ and $\mathcal{CP}$ cases, respectively. Note that given w_j, the negotiated outcome of (F_i, U) is bilaterally efficient. Solving the system of focs, we obtain the equilibrium wages, profit sharing ratio, employment and output levels: [19]

$$
\begin{aligned}
w_i^{\mathcal{CM}} &= w_0 + \frac{\Omega_i(\beta, \gamma)\gamma\tilde{\alpha}}{\Phi(\beta, \gamma)} \\
s_i^{\mathcal{CM}} &= \beta + \frac{1}{2}(1 - \beta)\gamma^2 \\
w_j^{\mathcal{CM}} &= w_0 + \frac{\Omega_j(\beta, \gamma)\tilde{\alpha}}{2\Phi(\beta, \gamma)} \\
L_i^{\mathcal{CM}} = q_i^{\mathcal{CM}} &= \frac{(2 - \gamma)\tilde{\alpha}}{2(2 - \gamma^2)} \\
L_j^{\mathcal{CM}} = q_j^{\mathcal{CM}} &= \frac{(2 - \beta)(2 - \gamma)[4 - (2 - \gamma^2)\beta\gamma - (2 + \gamma)\gamma^2]\tilde{\alpha}}{\Phi(\beta, \gamma)}.
\end{aligned}
\tag{13}
$$

Notice that $0 < s_i^{\mathcal{CM}} < 1$, $\forall \beta, \gamma \in (0, 1)$. The following Lemma summarizes.

Lemma 6. *When firms bargain with a sector-wide union ($\mathcal{C}$) over mixed remuneration schemes ($\mathcal{MS}$):*

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[19]$\Phi(\beta, \gamma) = 32 + [6(1 - \beta) + 4\beta^2]\gamma^4 - (1 - \beta)^2\gamma^6 - 4[6 - (1 - \beta)\beta]\gamma^2$
$\Omega_i(\beta, \gamma) = \beta(2 - \gamma^2)[4 + \gamma(2 - \gamma - 2\gamma^2) - \beta^2\gamma(2 - \gamma^2)^2 - \gamma(8 - (4 - \gamma^2)(\gamma + \gamma^2))]$
$\Omega_j(\beta, \gamma) = [\gamma^3 - \beta^2\gamma(2 - \gamma^2)][(8 - \gamma^2(2 + \gamma)) + 2\beta(16 + 8\gamma - 12\gamma^2 - \gamma^3(10 - \gamma(1 + \gamma)^2))]$

(i) The wage of the firm offering $\mathcal{FS}$ is always above that of the firm offering $\mathcal{PS}$, $w_j^{\mathcal{CM}} > w_i^{\mathcal{CM}}$. Moreover, $w_j^{\mathcal{CM}}$ is always above the competitive wage, $w_j^{\mathcal{CM}} > w_0$, while $w_i^{\mathcal{CM}}$ is above w_0 if and only if $\beta > \widetilde{\beta}(\gamma)$, with $\frac{d\widetilde{\beta}}{d\gamma} > 0$, $\widetilde{\beta}(0) = 0$, and $\widetilde{\beta}(1) = 1$.

(ii) The stronger the union is, the higher are both negotiated wages as well as F_i's profit sharing ratio, $\frac{\partial w_i^{\mathcal{CM}}}{\partial \beta} > 0$, $\frac{\partial w_j^{\mathcal{CM}}}{\partial \beta} > 0$ and $\frac{\partial s_i^{\mathcal{CM}}}{\partial \beta} > 0$.

(iii) As the products become closer substitutes, F_i's profit sharing ratio and F_j's negotiated wage increase, $\frac{\partial s_i^{\mathcal{CM}}}{\partial \gamma} > 0$, $\frac{\partial w_j^{\mathcal{CM}}}{\partial \gamma} > 0$; while F_i's negotiated wage increases only if γ is low and β is high.

Intuitively, as the (F_j, U) pair bargain over the wage rate alone, the sector-wide union agrees only if the latter is above the workers' outside option. In contrast, U may agree with F_i on a lower wage than w_0, subsidizing thus the firm and making it a strong competitor in the product market, because it will get back its share of the F_i's higher profits. This is the reason of why $w_j^{\mathcal{CM}} > w_i^{\mathcal{CM}}$ always holds. Further, the intuition behind (ii) and (iii) is along the lines explained in the previous subsection. The only exception is that (F_i, U)'s wage rate is often decreasing in γ, which is due to the flexibility of this bargaining pair to trade-off a lower wage rate with a higher profit sharing ratio. As above, the employment level and output of the firm offering $\mathcal{FS}$ are decreasing in both β and γ. In contrast, those of the firm offering $\mathcal{PS}$ is independent of the union's bargaining power and may increase with γ but only if the products are close substitutes. Finally, notice that both the profit sharing ratio and the wage rate of a firm offering $\mathcal{PS}$ is higher under universal $\mathcal{PS}$ than in the mixed regime ($s^{\mathcal{CP}} > s_i^{\mathcal{CM}}$ and $w^{\mathcal{CP}} > w_i^{\mathcal{CM}}$).

3.2.3 Equilibrium remuneration schemes under coordinated bargaining

In stage 1, each firm chooses between a fixed wage and a profit sharing remuneration scheme. As above, under universal $\mathcal{FS}$, $\pi^{\mathcal{CF}} = (q^{\mathcal{CF}})^2$; under universal $\mathcal{PS}$, $\pi^{\mathcal{CP}} = (1 - s^{\mathcal{CP}})(q^{\mathcal{CP}})^2$; and under mixed schemes, $\pi_i^{\mathcal{CM}} = (1 - s_i^{\mathcal{CM}})(q_i^{\mathcal{CM}})^2$ and $\pi_j^{\mathcal{CM}} = (q_j^{\mathcal{CM}})^2$. The Nash equilibria of this matrix game are summarized in the following proposition and are illustrated in Figure 3.

Proposition 3.2. *When firms bargain with a sector-wide union, in equilibrium:*

(i) Both firms offer fixed wage schemes for all $\beta \geq \beta^{\mathcal{CF}}(\gamma)$, with $\frac{d\beta^{\mathcal{CF}}}{d\gamma} > 0$, $\beta^{\mathcal{CF}}(0) = 0$ and $\beta^{\mathcal{CF}}(1) = 0.5$ (Area I and III).

(ii) Both firms offer profit sharing schemes for all $\beta \leq \beta^{\mathcal{CP}}(\gamma)$, with $\frac{d\beta^{\mathcal{CP}}}{d\gamma} > 0$, $\beta^{\mathcal{CP}}(0) = 0$ and $\beta^{\mathcal{CP}}(1) = 1$ (Area II and III).

(iii) One firm offers $\mathcal{FS}$ and the other offers $\mathcal{PS}$ when $\gamma < 0.6208$ and $\beta^{\mathcal{CP}}(\gamma) \leq \beta \leq \beta^{\mathcal{CF}}(\gamma)$ (Area IV).

(iv) If $\gamma > 0.6208$ and $\beta^{\mathcal{CF}}(\gamma) \leq \beta \leq \beta^{\mathcal{CP}}(\gamma)$, both universal $\mathcal{FS}$ and universal $\mathcal{PS}$ arise, with the former equilibrium Pareto dominating the latter (Area III).
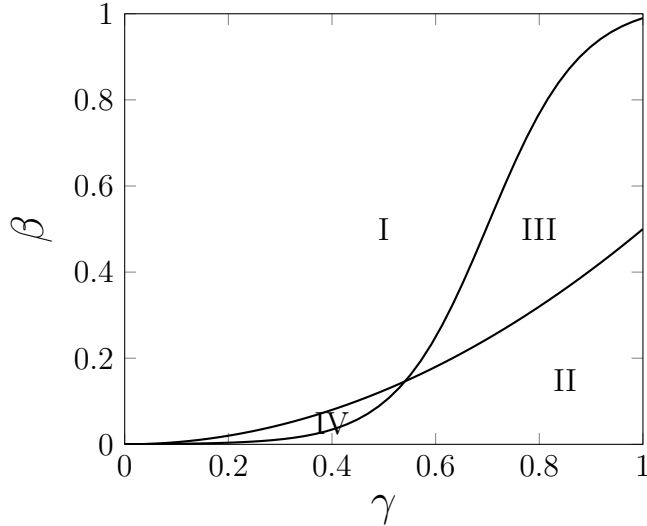
Figure 3: Equilibria under Coordinated Bargaining. Area I+III: Universal $\mathcal{FS}$; Area II+III: Universal $\mathcal{PS}$; Area IV: Mixed remuneration schemes ($\mathcal{MS}$); Area III: Universal $\mathcal{FS}$ Pareto dominates universal $\mathcal{PS}$.

Under coordinated bargaining too, universal $\mathcal{FS}$ and $\mathcal{PS}$ equilibria arise under qualitatively similar conditions as those of the decentralized bargaining case. Moreover, these equilibria coexist (and are Pareto ranked) but only if the degree of product substitutability is high enough ($\gamma > 0.6208$). The intuition is along the lines explained in the decentralized bargaining case. In contrast to the latter case, under coordinated bargaining asymmetric equilibria arise, provided that γ is rather low and the union's power is neither too high nor too low. In this case, the firm offering a $\mathcal{PS}$ remuneration scheme makes higher profits than the firm offering a $\mathcal{FS}$ scheme. Clearly then, the former firm cannot benefit from switching to $\mathcal{FS}$. And the latter firm stays with $\mathcal{FS}$ in order to avoid the prisoner's dilemma ensuing under universal $\mathcal{PS}$.

3.3 Union formation stage

In stage 0, the workers decide whether to form two firm-specific unions U_i and U_j, or a sector-wide union U, taking into account the equilibria that each such decision induces in the continuation of the game. In case of the multiple equilibria in the remuneration scheme selection stage, it is reasonable to assume that firms will coordinate on the Pareto superior equilibrium, and that workers expect that firms will do so.

Proposition 3.3. *Workers always prefer to form a sector-wide union and conduct coordinated bargaining.*

Proposition 3.3 suggests that, independently of the union bargaining power and the degree of product substitutability (i.e., the competitive pressure) in the product market, workers prefer to coordinate their bargaining efforts by forming a sector-wide union.

As a result, universal $\mathcal{FS}$, universal $\mathcal{PS}$, as well as mixed remuneration schemes are expected to prevail in the industry, depending on the specific values of β and γ (see Figure 3). Therefore, the analysis of the coordinated bargaining case turns out to be of great importance as it provides novel insights.[20] Under coordinated bargaining, all firms offering a profit sharing remuneration scheme is more likely than under decentralized bargaining - compare Figures 2 and 3. Moreover, and in contrast to the decentralized bargaining case, mixed remuneration schemes are likely to be observed under coordinated bargaining provided that products are sufficiently differentiated and the union is rather weak (but not too weak).

4   Welfare Analysis

In this section, we perform a welfare analysis and briefly discuss policy measures in order to improve on market outcomes. Social welfare is defined as the sum of consumer surplus, firms' profits and unions' rents:

$$SW = CS + (\pi_i + \pi_j) + U,$$

where $CS = \frac{1}{2}(q_i^2 + q_j^2 + 2\gamma q_i q_j)$,[21] and $U = U_i + U_j$ under decentralized bargaining. Substituting the relevant expressions into CS and SW, and after some simple algebraic manipulations, we obtain the following proposition.

Proposition 4.1. *(i) The highest consumer surplus as well as social welfare is attained under decentralized bargaining and a universal profit–sharing scheme.*
(ii) $CS^{\mathcal{D}k} > CS^{\mathcal{C}k}$ and $SW^{\mathcal{D}k} > SW^{\mathcal{C}k}$, $k \in \{\mathcal{F}, \mathcal{P}, \mathcal{M}\}$.
(iii) $CS^{\mathcal{DP}} > CS^{\mathcal{DM}} > CS^{\mathcal{DF}}$ and $SW^{\mathcal{DP}} > SW^{\mathcal{DM}} > SW^{\mathcal{DF}}$.
(iv) $CS^{\mathcal{CP}} > CS^{\mathcal{CF}}$ and $SW^{\mathcal{CP}} > SW^{\mathcal{CF}}$ except if $\gamma > 0.828$ and $\beta > \beta_W(\gamma)$, with:
$\frac{\partial \beta_W}{\partial \gamma} > 0$, $\beta_W(0.828) = 0$, and $\beta_W(1) = 0.333$.

The proof of the proposition can be found in the Appendix A2. Proposition 4.1 informs us that decentralized bargaining in which all firms offer profit sharing remuneration schemes is the most preferable regime in terms of both the consumers surplus and social welfare. This is mainly because in this case unions always "subsidize" their firms ($w^{\mathcal{DF}} < w_0$), which then produce large quantities in the market. In fact, aggregate employment/output and firms' gross profits are the highest under decentralized bargaining and universal $\mathcal{PS}$.[22] However, this situation will never arise in equilibrium if workers

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[20]In contrast, firms always prefer decentralized bargaining. In fact, $\pi^{\mathcal{DF}} > \pi^{\mathcal{CF}} > \pi^{\mathcal{DP}} > \pi^{\mathcal{CP}}$. Note that in line with the existing literature, the possibility of introducing profit–sharing schemes may lead firms to a prisoners' dilemma, independently of the unionization structure.

[21]We obtain the CS by substituting $p_i = a - q_i - \gamma q_j$ into the $u(q_i, q_j) - p_i q_i - p_j q_j$.

[22]It can be readily verified that $L^{\mathcal{D}k} > L^{\mathcal{C}k}$, $k \in \{\mathcal{F}, \mathcal{P}, \mathcal{M}\}$, i.e., aggregate employment is higher

are allowed to choose their unionization structure (Proposition 3.3). A regulator should then institutionalize negotiations at the firm– instead of the sector–level. In fact, independently of the firms' choices of remuneration schemes, decentralization of bargaining leads always to higher consumers surplus and social welfare than coordinated bargaining (Proposition 4.1(ii)). Moreover, under decentralized bargaining, universal $\mathcal{PS}$ is welfare superior than any other configuration of remuneration schemes. Interestingly, this is not always so when workers coordinate their bargaining efforts by forming a sector-wide union. Consumers surplus and social welfare are lower under universal $\mathcal{PS}$ than under universal $\mathcal{FS}$ as long as products are too close substitutes and the union's bargaining power is too low. (Remember that under these circumstances $w^{\mathcal{CP}} > w^{\mathcal{CF}}$). With this exception in mind, our findings suggest that a policy maker should provide incentives to firms to offer profit sharing schemes to their workers.

5 Bertrand competition

In this section, we consider that firms compete in prices in the product market. It is well-known that prices are strategic complements and that this often leads to different strategic interactions than when firms compete in quantities. In fact, a firm's unit cost increase results to softer price competition in the market and may thus increase the "pie" to be split between the firm and the union during their negotiations. As a consequence, each firm-union pair does not anymore have incentives to make its firm more aggressive in the market. It turns out that profit sharing schemes do not arise in equilibrium under Bertrand competition. The following Proposition summarizes our findings (For a proof see 7 A1.)

Proposition 5.1. *Under Bertrand competition in the product market:*

(i) Universal $\mathcal{FS}$ is the unique equilibrium, independently whether workers form a sector-wide union or two firm-specific unions.

(ii) Workers are better off by forming a sector-wide union than two firm-specific unions.

Proposition 5.1 states that no matter which is the workers' decision at stage 0, in equilibrium both firms always offer a fixed wage remuneration scheme. Intuitively, a profit sharing scheme (typically) leads to a lower negotiated wage – there is a trade–off between wages and profit sharing ratios – and thus to lower prices and firms' profits. As

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under decentralized than under coordinated bargaining for any given remuneration scheme configuration. Moreover, that $L^{\mathcal{DP}} > L_i^{\mathcal{DM}} + L_j^{\mathcal{DM}} > L^{\mathcal{DF}}$, i.e., aggregate employment is the highest under universal $\mathcal{PS}$ in the decentralized bargaining case. This is also true under coordinated bargaining except if $\gamma > 0.828$ and $\beta > \beta_W(\gamma)$. Clearly, a similar ranking holds for the firms' gross profits, as they are equal to the square of output/employment level. Finally, note that the firm offering $\mathcal{PS}$ in the mixed case produces more output and makes higher gross profits than under universal $\mathcal{PS}$.

a consequence, there will be a smaller surplus to be shared between the firm offering $\mathcal{PS}$ and the union. Therefore, no firm has incentives to unilaterally switch from $\mathcal{FS}$ to $\mathcal{PS}$. This is in sharp contrast to Cournot competition. Yet, in line with Cournot competition, workers have incentives to coordinate their bargaining efforts by forming a sector-wide union under Bertrand competition too.

Interestingly, our findings suggest that as the competitive pressure increases (measured by a move from a less competitive Cournot market to a more competitive Bertrand market), profit sharing schemes are less likely to be observed. This contrasts our previous finding that as the degree of product substitutability increases, which is an alternative measure of competitive pressure, it is more likely that $\mathcal{PS}$ arises in equilibrium.

6   Conclusions

Empirical evidence indicates that profit–sharing schemes are widespread and are common in many countries characterized by different labor market institutions and in particular, different unionization structures and unionization levels. Theoretical and empirical studies so far have emphasized the positive aspects of profit–sharing in aggregate employment, workers' productivity, firms' profitability and real employee earnings. Our paper has contributed to this literature by endogenizing the firms' decision to offer or not a profit–sharing scheme in a differentiated goods duopoly in which firms and union(s) bargain over the remuneration scheme selected by the firm.

We have shown that workers have always incentives to coordinate their bargaining efforts by forming a sector–wide union, which makes the analysis of the coordinated bargaining case of great importance. Under the latter bargaining regime and Cournot competition in the product market, asymmetric equilibria may arise in which one firm offers a profit–sharing scheme, while the other offers a fixed wage scheme. The latter never occurs under the decentralized bargaining regime that has exclusively been studied in the existing literature. We also show that under coordinated bargaining universal profit–sharing schemes are more prevalent than under decentralized bargaining. In addition, independently of the unionization structure, profit sharing schemes are more likely to be introduced when firms face union(s) with low bargaining power. Furthermore, competitive pressure as proxied by product substitutability favors the introduction of profit–sharing schemes. Finally, under Bertrand competition in the product market firms never use profit–sharing schemes, with universal fixed wage schemes being the unique equilibrium in this case.

We also have shown that aggregate employment, consumers surplus and social welfare are higher under decentralized bargaining and universal profit–sharing schemes. This finding suggests that a policymaker should facilitate the institutionalization of firm-level negotiations over remuneration schemes and should take policy measures to promote the

adoption of profit–sharing schemes. Nevertheless, the policy measures should carefully be designed taking into account product and labor market characteristics, such as the mode of competition, the degree of product differentiation, the unionization structure and unionization level of the industrial sector under consideration.

Our findings lead to a number of testable implications. First, the usage of profit-sharing schemes in sectors with Bertrand type competition must be relatively low. On the contrary, in sectors with Cournot type competition, we should expect asymmetric equilibria to arise, especially when workers form a sector–wide union. Further, the usage of profit–sharing from firms in sectors with coordinated bargaining must be significantly higher compared to sectors with firm-specific unions.

There are a few questions still open in the theoretical literature. For instance, Manasakis and Petrakis (2009) analyze the impact of unionization structures on the firms' incentives to form research joint ventures (RJV's) aiming to split high R&D costs and share positive spillovers. An interesting direction for further research could be to study the role of profit–sharing schemes on the formation of research joint ventures, and whether a profit–sharing scheme could ease the hold–up problem provoked by the presence of powerful unions.

7 Appendix

7.1 A1: Bertrand Competition

7.1.1 Stage 3

Firms F_i and F_j simultaneously choose prices each to maximize its gross profits:

$$\pi_i = (p_i - w_i)(\frac{\alpha(1 - \gamma) - p_i + \gamma p_j}{1 - \gamma^2}), \ i, j = 1, 2, \ i \neq j.$$

As under Cournot competition, the solution to the maximization problem does not depend on whether the firm offers a $\mathcal{FS}$ or $\mathcal{PS}$ remuneration scheme. Solving the system of the focs, we obtain the equilibrium prices, quantities, and (gross) profits:

$$p_i^*(w_i, w_j) = \frac{\alpha(2 - \gamma - \gamma^2) + 2w_i + \gamma w_j}{4 - \gamma^2}$$

$$q_i^*(w_i, w_j) = L_i^*(w_i, w_j) = \frac{a(2 - \gamma - \gamma^2) - (2 - \gamma^2)w_i + \gamma w_j}{4 - 5\gamma^2 + \gamma^4}$$

$$\pi_i^*(w_i, w_j) = (1 - \gamma^2)[q_i^*(w_i, w_j)]^2$$

7.1.2 Stage 2

Decentralized bargaining In the sequel, we shall assume that $\beta > \frac{\gamma^2}{2}$. This assumption guarantees that profit sharing ratios are always positive in equilibrium (see below). When this assumption is violated, the firm–union pair will choose a zero profit sharing ratio during their negotiations, essentially making void the selection of the profit sharing scheme by the firm in the previous stage. Therefore, when $\beta < \frac{\gamma^2}{2}$, the unique equilibrium in stage 1 is universal $\mathcal{FS}$.

Universal $\mathcal{FS}$ Each (F_i, U_i) chooses w_i to maximize its respective generalized asymmetric Nash product. From the focs and exploiting symmetry, we obtain the equilibrium outcome:

$$w^{\mathcal{DF}} = w_0 + \frac{\beta(2 - \gamma - \gamma^2)\tilde{\alpha}}{4 - \gamma(\beta + 2\gamma)}$$

$$L^{\mathcal{DF}} = q^{\mathcal{DF}} = \frac{(2 - \beta)(2 - \gamma^2)\tilde{\alpha}}{(2 - \gamma)(1 + \gamma)[4 - \gamma(\beta + 2\gamma)]}$$

As under Cournot competition, here too $w^{\mathcal{DF}} > w_0$, $\frac{\partial w^{\mathcal{DF}}}{\partial \beta} > 0$, $\frac{\partial w^{\mathcal{DF}}}{\partial \gamma} < 0$ and $\frac{\partial q^{\mathcal{DF}}}{\partial \beta} < 0$. Yet, $\frac{\partial q^{\mathcal{DF}}}{\partial \gamma} < 0$ only if γ is low enough. Otherwise, output is increasing in γ. As goods become closer substitutes, the fiercer Bertrand competition leads to lower input prices and higher quantities (when γ is not too low).

Universal $\mathcal{PS}$ Each (F_i, U_i) chooses w_i and s_i to maximize its respective generalized asymmetric Nash product. From the focs and exploiting symmetry, we obtain the equilibrium outcome:

$$w^{\mathcal{DP}} = w_0 + \frac{(1 - \gamma)\gamma^2\tilde{\alpha}}{4 - \gamma(2 + \gamma)}, \quad s^{\mathcal{DP}} = \frac{2\beta - \gamma^2}{2 - \gamma^2}, \quad L^{\mathcal{DP}} = q^{\mathcal{DP}} = \frac{(2 - \gamma^2)\tilde{\alpha}}{(1 + \gamma)(4 - \gamma(2 + \gamma))}$$

Note that: $s^{\mathcal{DP}} < 1$, but $s^{\mathcal{DP}} > 0$ if only if $\beta > \frac{\gamma^2}{2}$. As under Cournot competition, here too $\frac{\partial s^{\mathcal{DP}}}{\partial \beta} > 0$, $\frac{\partial w^{\mathcal{DP}}}{\partial \beta} = 0$, and $\frac{\partial q^{\mathcal{DP}}}{\partial \beta} = 0$. Yet, under Bertrand competition, there is no "subsidization": $w^{\mathcal{DP}} > w_0$. A firm-union pair settles on a relatively high wage rate in order to soften price competition in the product market stage (prices are strategic complements). In addition, $\frac{\partial w^{\mathcal{DP}}}{\partial \gamma} < 0$ and $\frac{\partial q^{\mathcal{DP}}}{\partial \gamma} < 0$ but only if γ is low. The reasoning for the latter is along the lines explained above. Further, $\frac{\partial s^{\mathcal{DP}}}{\partial \gamma} < 0$. As negotiated wages increase with γ (at least, for high enough γ's), these are accompanied by decreasing profit sharing ratios. Finally, it can be readily verified that $w^{\mathcal{DP}} < w^{\mathcal{DF}}$.

Mixed remuneration schemes (F_i, U_i) chooses w_i and s_i and (F_j, U_j) chooses w_j, each to maximize its respective generalized asymmetric Nash product. Solving the

system of focs, we obtain the equilibrium outcome:

$$w_i^{\mathcal{DM}} = w_0 + \frac{(2 - \gamma - \gamma^2)\gamma^2[4 + \beta\gamma - 2\gamma^2]\tilde{\alpha}}{32(1 - \gamma^2) + (8 - \beta)\gamma^4}, \quad s_i^{\mathcal{DM}} = \frac{2\beta - \gamma^2}{2 - \gamma^2}$$

$$w_j^{\mathcal{DM}} = w_0 + \frac{\beta(4 - \gamma^2)(1 - \gamma)[4 + (2 - \gamma)\gamma]\tilde{\alpha}}{32(1 - \gamma^2) + (8 - \beta)\gamma^4}$$

$$q_i^{\mathcal{DM}} = L_i^{\mathcal{DM}} = \frac{(2 + \gamma)(2 - \gamma^2)[4 + (\beta - 2\gamma)\gamma]}{(1 + \gamma)[32(1 - \gamma^2) + (8 - \beta)\gamma^4]}$$

$$q_j^{\mathcal{DM}} = L_j^{\mathcal{DM}} = \frac{(2 - \beta)(2 - \gamma^2)[4 + (2 - \gamma)\gamma]}{(1 + \gamma)[32(1 - \gamma^2) + (8 - \beta)\gamma^4]}$$

Again, $0 < s_i^{\mathcal{DM}} < 1$ as long as $\beta > \frac{\gamma^2}{2}$. As under Cournot competition, $w_i^{\mathcal{DM}} < w_j^{\mathcal{DM}}$. Yet, under Bertrand competition both negotiated wages are above the competitive wage. The intuition for $w_i^{\mathcal{DM}} > w_0$ is along the lines explained above. Moreover, under Bertrand competition, both wages increase in the union's bargaining power; also, although $\frac{\partial w_j^{\mathcal{DM}}}{\partial \gamma} < 0$, $w_i^{\mathcal{DM}}$ increases in γ whenever the products are close enough substitutes. Finally, as under Cournot competition, here too $\frac{\partial q_i^{\mathcal{DM}}}{\partial \beta} > 0$, and $\frac{\partial q_j^{\mathcal{DM}}}{\partial \gamma} > 0$ for γ high enough; also, $s^{\mathcal{DP}} = s_i^{\mathcal{DM}}$, but in contrast to Cournot competition $w^{\mathcal{DP}} < w_i^{\mathcal{DM}}$.

Coordinated bargaining In the sequel, we shall assume that $\beta > \frac{\gamma^2(2 - \gamma + \gamma^2)}{4 - 2\gamma - \gamma^3 + \gamma^4}$. As above, this assumption guarantees that profit sharing ratios are always positive in equilibrium (see below). When this assumption is violated, the unique equilibrium in stage 1 is universal FS.

Universal $\mathcal{FS}$ Each (F_i, U_i) chooses w_i and s_i to maximize its Nash product (5). From the focs and exploiting symmetry, we obtain the equilibrium outcome:

$$w^{\mathcal{CF}} = w_0 + \frac{\beta(2 - \gamma - \gamma^2)\tilde{\alpha}}{4 + \gamma(1 + \gamma)[(1 - \beta)(2 - \gamma)\gamma - 2]}$$

$$L^{\mathcal{CF}} = q^{\mathcal{CF}} = \frac{(4 - 2\gamma + \gamma^3 - \gamma^4 + \beta[(1 - \gamma)^2\gamma(\gamma + 1) - 2])\tilde{\alpha}}{(2 - \gamma)(1 + \gamma)(4 + \gamma(1 + \gamma)[(1 - \beta)(2 - \gamma)\gamma - 2])}$$

As under Cournot competition, here too $w^{\mathcal{CF}} > w^{\mathcal{DF}} > w_0$, $\frac{\partial w^{\mathcal{CF}}}{\partial \beta} > 0$, and $\frac{\partial q^{\mathcal{CF}}}{\partial \beta} < 0$. Yet, $\frac{\partial w^{\mathcal{CF}}}{\partial \gamma} < 0$, and $\frac{\partial q^{\mathcal{CF}}}{\partial \gamma} < 0$ only if γ is low enough. Otherwise, output is increasing in γ. Again, as goods become closer substitutes, the fiercer Bertrand competition leads to lower input prices and to higher quantities (when γ is not too low).

Universal $\mathcal{PS}$ Each (F_i, U_i) chooses w_i and s_i to maximize its Nash product (7). From the focs and exploiting symmetry, we obtain the equilibrium outcome:

$$w^{\mathcal{CP}} = w_0 + \frac{\gamma[\beta(2-\gamma)[4-\gamma(2-\gamma+\gamma^2)] - \gamma(4-8\gamma+3\gamma^2-\gamma^3)]\tilde{\alpha}}{4(1-\gamma)[4-\gamma^2+\gamma^3+\beta(2-\gamma)(1+\gamma)\gamma]}$$

$$s^{\mathcal{CP}} = \frac{2\beta(4-2\gamma-\gamma^3+\gamma^4) - 2\gamma^2[2-\gamma+\gamma^2]}{8-\gamma[4+\gamma(3-\gamma)(2-\gamma) - \beta(2-(5-\gamma)\gamma]}$$

$$L^{\mathcal{CP}} = q^{\mathcal{CP}} = \frac{[8-4\gamma-6\gamma^2+5\gamma^3-\gamma^4+\beta\gamma^2(2-5\gamma+\gamma^2)]\tilde{\alpha}}{4(1-\gamma^2)[4-\gamma^2+\gamma^3+\beta(2-\gamma)(1+\gamma)\gamma]}$$

Note that $s^{\mathcal{DP}} < 1$, but $s^{\mathcal{DP}} > 0$ if only if $\beta > \frac{\gamma^2(2-\gamma+\gamma^2)}{4-2\gamma-\gamma^3+\gamma^4}$. As under Cournot competition, here too $\frac{\partial s^{\mathcal{CP}}}{\partial \beta} > 0$, $\frac{\partial w^{\mathcal{CP}}}{\partial \beta} > 0$, and $\frac{\partial q^{\mathcal{CP}}}{\partial \beta} < 0$. Yet, under Bertrand competition, there is never "subsidization": $w^{\mathcal{CP}} > w_0$. In addition, $\frac{\partial s^{\mathcal{CP}}}{\partial \gamma} < 0$, and $\frac{\partial w^{\mathcal{CP}}}{\partial \gamma} < 0$ and $\frac{\partial q^{\mathcal{CP}}}{\partial \gamma} < 0$ for β and γ high enough. As the competitive pressure increases, profit sharing ratios decrease. Finally, note that $w^{\mathcal{CP}} < w^{\mathcal{CF}}$, except if both β and γ are quite large.

Mixed remuneration schemes (F_i, U_i) chooses w_i and s_i and (F_j, U_j) chooses w_j, each to maximize its respective Nash product. Again, w_i is chosen to maximize (F_i, U_i)'s excess joint surplus $js(w_i, w_j) = \pi_i^*(w_i, w_j) + U^*(w_i, w_j) - (w_j - w_0)q^m(w_j)$, with $U^*(w_i, w_j) = (w_i - w_0)q_i^*(w_i, w_j) + (w_j - w_0)q_j^*(w_i, w_j)$, which implies that $w_i(w_j) = \frac{(2-\gamma-\gamma^2)[(a-w_0)\gamma^2+4w_0]+4\gamma w_2}{4(2-\gamma^2)}$. While s_i is chosen to divide the maximized excess joint surplus $js^*(w_j) = js(w_i(w_j), w_j)$ to the parties according to their respective bargaining powers; hence $s_i(w_j) = \frac{\beta\pi_i^*(w_i(w_j), w_j) - (1-\beta)[U^*(w_i(w_j), w_j) - (w_j - w_0)q^m(w_j)]}{\pi_i^*(w_i(w_j), w_j)}$. Substituting these expressions into the focs of the (F_j, U_j)'s Nash product, we obtain a fourth degree polynomial of w_j, which can be solved analytically but the resulting relevant root $w_j^{\mathcal{CM}}$ is extremely long and cannot be reported here (it is available upon request). Using $w_j^{\mathcal{CM}}$, we obtain $w_i^{\mathcal{CM}}, s_i^{\mathcal{CM}}, q_i^{\mathcal{CM}}$, and $q_j^{\mathcal{CM}}$. The latter three, as well as $w_i^{\mathcal{CM}} - w_0$ and $w_j^{\mathcal{CM}} - w_0$, are proportional to $\tilde{\alpha}$, with the coefficient of proportionality being a high degree polynomial in β and γ.[23] It can be checked that $0 < s_i^{\mathcal{CM}} < 1$ for all β, γ. Moreover, as under Cournot competition, $\frac{\partial s_i^{\mathcal{CM}}}{\partial \beta} > 0$, $\frac{\partial s_i^{\mathcal{CM}}}{\partial \gamma} > 0$, $\frac{\partial w_i^{\mathcal{CM}}}{\partial \beta} > 0$, $\frac{\partial w_j^{\mathcal{CM}}}{\partial \beta} > 0$, and $\frac{\partial w_j^{\mathcal{CM}}}{\partial \gamma} > 0$. Further, $\frac{\partial w_i^{\mathcal{CM}}}{\partial \gamma} < 0$ except for low β and low γ. Finally, $w_j^{\mathcal{CM}} > w_0$, and $w_i^{\mathcal{CM}} < w_0$ but only if, given γ, β is high enough.

Turning to stage 1, firms choose simultaneously between $\mathcal{FS}$ and $\mathcal{PS}$. The entries in this matrix game are as follows. Under universal $\mathcal{FS}$, each firm's profits are $\pi^{k\mathcal{F}} = (1-\gamma^2)(q^{k\mathcal{F}})^2$; under universal $\mathcal{PS}$, they are $\pi^{k\mathcal{P}} = (1-s^{k\mathcal{P}})(1-\gamma^2)(q^{k\mathcal{P}})^2$; and under the mixed configuration, they are: $\pi_i^{k\mathcal{M}} = (1-s_i^{k\mathcal{M}})(1-\gamma^2)(q_i^{k\mathcal{M}})^2$ and $\pi_j^{k\mathcal{M}} = (1-\gamma^2)(q_j^{k\mathcal{M}})^2$, with $k \in \{\mathcal{D}, \mathcal{P}\}$. Substituting the relevant expressions and after cumbersome algebraic manipulations, it can be readily verified that $\pi^{\mathcal{DF}} > \pi_i^{\mathcal{DM}}$ and $\pi^{\mathcal{DP}} < \pi_j^{\mathcal{DM}}$ as long as $\beta > \frac{\gamma^2}{2}$; also, that $\pi^{\mathcal{CF}} > \pi_i^{\mathcal{CM}}$ and $\pi^{\mathcal{CP}} < \pi_j^{\mathcal{CM}}$ as long as $\beta > \frac{\gamma^2(2-\gamma+\gamma^2)}{4-2\gamma-\gamma^3+\gamma^4}$. These imply (i)

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[23]These results have also been confirmed by performing simulations over a fine grid of (β, γ) parameters.

that a firm offering $\mathcal{FS}$ has no incentives to switch to $\mathcal{PS}$ when its rival offers $\mathcal{FS}$. Thus, universal $\mathcal{FS}$ is always an equilibrium. (ii) a firm offering $\mathcal{PS}$ has always incentives to switch to $\mathcal{FS}$ when its rival offers $\mathcal{PS}$. Thus, universal $\mathcal{PS}$ never arises in equilibrium. (iii) a mixed remuneration scheme regime never arises in equilibrium. Remember that when $\beta < \frac{\gamma^2}{2}$ under decentralized bargaining and $\beta < \frac{\gamma^2(2-\gamma+\gamma^2)}{4-2\gamma-\gamma^3+\gamma^4}$ under coordinated bargaining, the only equilibrium that essentially arises is the universal $\mathcal{FS}$ one. We thus conclude that the unique equilibrium under Bertrand competition is universal $\mathcal{FS}$, independently whether we have decentralized or coordinated bargaining.

Finally, in stage 0, the workers decide whether to form a sector-wide union or two separate unions. It can be checked that $U^{\mathcal{CF}} = 2(w^{\mathcal{CF}} - w_0)q^{\mathcal{CF}} > 2U^{\mathcal{DF}} = 2(w^{\mathcal{DF}} - w_0)q^{\mathcal{DF}}$. As under Cournot competition, the workers, by coordinating their efforts, can attain higher rents in this case too.

7.2   A2: Proofs of Propositions

In this subsection of the Appendix, we state the proofs of all the major results presented in this paper.

Proof of Proposition 3.1. The equilibrium firms' profits under alternative remuneration schemes and decentralized bargaining are:

$$\pi^{\mathcal{DF}} = \frac{4(2-\beta)^2\tilde{\alpha}^2}{(2+\gamma)^2(4-\beta\gamma)^2}, \quad \pi^{\mathcal{DP}} = \frac{2(1-\beta)(2-\gamma^2)\tilde{\alpha}^2}{[4+(2-\gamma)\gamma]^2}$$

$$\pi_i^{\mathcal{DM}} = \frac{2(1-\beta)(2-\gamma)^2(2-\gamma^2)(4+\beta\gamma)^2\tilde{\alpha}^2}{(32-16\gamma^2+\beta\gamma^4)^2}$$

$$\pi_j^{\mathcal{DM}} = \frac{4(2-\beta)^2(4-\gamma(2+\gamma))^2\tilde{\alpha}^2}{(32-16\gamma^2+\beta\gamma^4)^2}$$

(i) It can be readily verified that $\pi_i^{\mathcal{DM}} \leq \pi^{\mathcal{DF}}$ if and only if $\beta \geq \beta^{\mathcal{DF}}(\gamma)$, with $\frac{d\beta^{\mathcal{DF}}}{d\gamma} > 0$, $\beta^{\mathcal{DF}}(0) = 0$ and $\beta^{\mathcal{DF}}(1) = 0.373$ (Areas I and III of Figure 2). Hence, universal $\mathcal{FS}$ is an equilibrium configuration in this case.

(ii) It can be readily verified that $\pi_j^{\mathcal{DM}} \leq \pi^{\mathcal{DP}}$ if and only if $\beta \leq \beta^{\mathcal{DP}}(\gamma)$, with $\frac{d\beta^{\mathcal{DP}}}{d\gamma} > 0$, $\beta^{\mathcal{DP}}(0) = 0$ and $\beta^{\mathcal{DP}}(1) = 0.694$ (Areas II and III of Figure 2). Hence, universal $\mathcal{PS}$ is an equilibrium configuration in this case.

(iii) As $\beta^{\mathcal{DF}}(\gamma) < \beta^{\mathcal{DP}}(\gamma)$ for all $\gamma > 0$, both universal $\mathcal{FS}$ and universal $\mathcal{PS}$ are equilibria when $\beta^{\mathcal{DF}}(\gamma) \leq \beta \leq \beta^{\mathcal{DP}}(\gamma)$ (Area III of Figure 2). Moreover, it can be checked that $\pi^{\mathcal{DF}} > \pi^{\mathcal{DP}}$ for all (β, γ); hence, the two equilibria can be Pareto-ranked in area III with universal $\mathcal{FS}$ Pareto dominating universal $\mathcal{PS}$.

Proof of Proposition 3.2. The equilibrium firms' profits under alternative remuneration schemes and coordinated bargaining are:

$$\pi^{\mathcal{CF}} = \frac{(2-\beta)^2\tilde{\alpha}^2}{4(2+\gamma)^2}, \quad \pi^{\mathcal{CP}} = \frac{(1-\beta)(2-\gamma)^2(4-3\gamma^2)(4-(1-\beta)\gamma^2)\tilde{\alpha}^2}{4(8-\gamma[6\gamma-(2+\gamma)(2\beta+(1-\beta)\gamma^2)])^2}$$

$$\pi_i^{\mathcal{CM}} = \frac{(1-\beta)(2-\gamma)^2\tilde{\alpha}^2}{8(2-\gamma^2)}$$

$$\pi_j^{\mathcal{CM}} = \frac{(2-\beta)^2(2-\gamma)^2[4-(2+\gamma)\gamma^2-\beta\gamma(2-\gamma^2)]^2\tilde{\alpha}^2}{(2-\gamma^2)^2[16-2\gamma^2(2-\beta+\beta^2)+(1-\beta)^2\gamma^4]^2}$$

(i) It can be readily verified that $\pi_i^{\mathcal{CM}} \leq \pi^{\mathcal{CF}}$ if and only if $\beta \geq \beta^{\mathcal{CF}}(\gamma)$, with $\frac{d\beta^{\mathcal{CF}}}{d\gamma} > 0$, $\beta^{\mathcal{CF}}(0) = 0$ and $\beta^{\mathcal{CF}}(1) = 0.5$ (Areas I and III of Figure 3). Hence, universal $\mathcal{FS}$ is an equilibrium configuration in this case.

(ii) It can be readily verified that $\pi_j^{\mathcal{CM}} \leq \pi^{\mathcal{CF}}$ if and only if $\beta \geq \beta^{\mathcal{CP}}(\gamma)$, with $\frac{d\beta^{\mathcal{CP}}}{d\gamma} > 0$, $\beta^{\mathcal{CP}}(0) = 0$ and $\beta^{\mathcal{CP}}(1) = 1$ (Areas II and III of Figure 3). Hence, universal $\mathcal{PS}$ is an equilibrium configuration in this case.

(iv) As $\beta^{\mathcal{CF}}(\gamma) < \beta^{\mathcal{CP}}(\gamma)$ for all $\gamma > 0.6208$, both universal $\mathcal{FS}$ and universal $\mathcal{PS}$ are equilibria when $\beta^{\mathcal{CF}}(\gamma) \leq \beta \leq \beta^{\mathcal{CP}}(\gamma)$ (Area III of Figure 3). Moreover, it can be checked that $\pi^{\mathcal{CF}} > \pi^{\mathcal{CP}}$ for all (β, γ); hence, the two equilibria can be Pareto-ranked in area III with universal $\mathcal{FS}$ Pareto dominating universal $\mathcal{PS}$.

(iv) It can be readily verified that for all $\gamma \leq 0.6208$ and $\beta^{\mathcal{CP}}(\gamma) < \beta^{\mathcal{CF}}(\gamma)$, we have $\pi^{\mathcal{CF}} \leq \pi_i^{\mathcal{CM}}$ *and* $\pi^{\mathcal{CP}} \leq \pi_j^{\mathcal{CM}}$. Hence, a mixed remuneration scheme is the equilibrium configuration (Area IV of Figure 3).

Proof of Proposition 3.3. Assuming that workers believe that their firms will coordinate on the Pareto superior equilibrium each time and superimposing Figures 2 and 3, we obtain five (γ, β)–areas as shown in Figure 4.

Substituting (4), (8), (11), (6), (12) and (13) into (1) and (2), we obtain the equilibrium unions' rents under alternative configurations of remuneration schemes. We then compare the relevant expressions for each (γ, β)–area. In particular,

Area I: Under both decentralized and coordinated bargaining, both firms choose $\mathcal{FS}$. It can be readily verified that $U_i^{\mathcal{DF}} + U_j^{\mathcal{DF}} < U^{\mathcal{CF}}$.

Area II: Under both decentralized and coordinated bargaining, both firms choose $\mathcal{PS}$. It can be readily verified that $U_i^{\mathcal{DP}} + U_j^{\mathcal{DP}} < U^{\mathcal{CP}}$.

Area III: Under decentralized (coordinated) bargaining both firms choose $\mathcal{FS}$ ($\mathcal{PS}$). It can be readily verified that $U_i^{\mathcal{DF}} + U_j^{\mathcal{DF}} < U^{\mathcal{CP}}$.

Area IV: Under decentralized bargaining, both firms choose $\mathcal{FS}$. While under coordinated bargaining, a mixed remuneration scheme configuration arises. It can be readily verified that $U_i^{\mathcal{DF}} + U_j^{\mathcal{DF}} < U^{\mathcal{CM}}$.
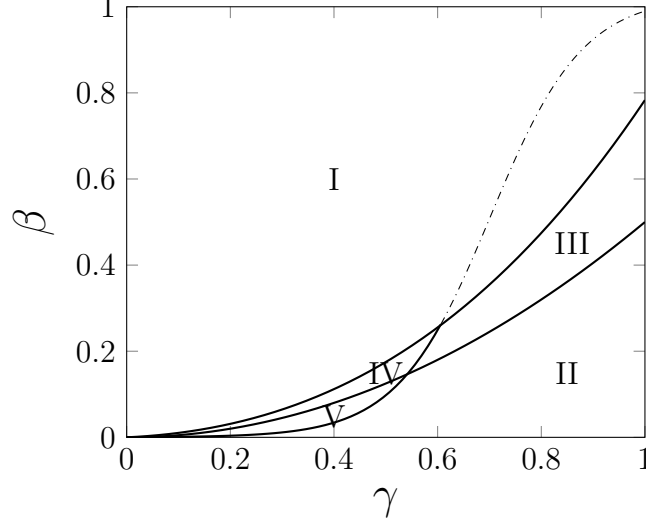
Figure 4: Superimpose of the equilibrium areas under decentralized and coordinated bargaining.

Area V: Under decentralized bargaining, both firms choose $\mathcal{PS}$. While under coordinated bargaining, a mixed remuneration scheme configuration arises. It can be readily verified that $U_i^{\mathcal{DP}} + U_j^{\mathcal{DP}} < U^{\mathcal{CM}}$.

In summary, in all (β, γ)–areas, workers rents are higher under coordinated than under decentralized bargaining; hence, workers have incentives to coordinate their efforts forming a sector–wide union.

Proof of Proposition 4.1. Substituting (4), (8), (11), (6), (12) and (13) into $CS(q_i, q_j) = \frac{1}{2}(q_i^2 + q_j^2 + 2\gamma q_i q_j)$, we obtain the consumers' surplus under alternative remuneration schemes and modes of bargaining. Further, using the relevant expressions for the firms' profits and the unions' rents (see above), we obtain the respective expressions for social welfare.

(ii) It can be readily verified that $\forall \beta, \gamma \in (0,1)$ the following inequalities hold for consumer surplus: $CS^{\mathcal{DP}} > CS^{\mathcal{CP}}$, $CS^{\mathcal{DF}} > CS^{\mathcal{CF}}$, and $CS^{\mathcal{DM}} > CS^{\mathcal{CM}}$; moreover, the same inequalities hold for social welfare: $SW^{\mathcal{DP}} > SW^{\mathcal{CP}}$, $SW^{\mathcal{DF}} > SW^{\mathcal{CF}}$, and $SW^{\mathcal{DM}} > SW^{\mathcal{CM}}$.

(iii) It can be readily verified that $\forall \beta, \gamma \in (0,1)$ the following inequalities hold for consumers surplus and social welfare: $CS^{\mathcal{DP}} > CS^{\mathcal{DM}} > CS^{\mathcal{DF}}$, and $SW^{\mathcal{DP}} > SW^{\mathcal{DM}} > SW^{\mathcal{DF}}$.

(iv) It can be readily verified that $CS^{\mathcal{CP}} > CS^{\mathcal{CF}}$ and $SW^{\mathcal{CP}} > SW^{\mathcal{CF}}$ except if $\gamma > 0.828$ and $\beta > \beta_W(\gamma)$, with $\frac{d\beta_W}{d\gamma} > 0$, $\beta_W(0.828) = 0$, and $\beta_W(1) = 0.333$.

(i) From (ii) and (iii) we get that $CS^{\mathcal{DP}}$ and $SW^{\mathcal{DP}}$ are the highest levels of consumers surplus and social welfare.

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