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Union structure and product quality differentiation

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Abstract

This paper investigates the issue of how alternative unionization structures in labour markets affect the choice of product quality differentiation by firms in product markets, and how this determines relative welfare outcomes of different union structures. In the presence of decentralized wage bargaining (firm-specific or coordinated unionization), increasing product differentiation not only reduces competition between firms but it also affects wage setting. Instead, when wage setting is centralized, wages do not depend on product quality differentiation in the product market but when the bargained wage is sufficiently high, the high-quality firm monopolizes the market. In turn, union wage setting does affect the endogenous choices by firms of the quality level of their products: especially when unionization is decentralized and unions have high relative bargaining power, the average product quality in the product market increases remarkably. However, as unionization reduces output, consumer surplus and overall welfare are always lower with respect to the case in which labour market is perfectly competitive, and decentralized unionization is generally welfare enhancing with respect to centralized unionization.

Keywords: unionization structures; vertical differentiation; welfare

JEL codes: J51; L13; L15

1 Introduction

The purpose of this work is to investigate the effect of alternative unionization structures on quality differentiation in the product market and, as a result, on welfare outcomes. Indeed, a substantial

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body of economic literature exists which deals with interaction between imperfect labour markets and imperfect product markets.¹ However, the issue of how labour unions affect the strategic choice by firms on the degree of product vertical or quality differentiation has not yet been considered in the literature, although it is relevant to the concerns of industrial organization, management strategy and labour economics.

Empirical evidence documents the presence of imperfect competition in both product and labour markets at both industry and sectoral levels. Among others, [Dobbelaere \(2004\)](#), using firm-level data over the period 1988-1995 for the Belgian manufacturing industry, investigates the relationship between the degree of labour market imperfections and the price-cost margin of firms. She finds that sectors with higher workers' bargaining power typically show higher price-cost margins. More recently, [Soares \(2020\)](#), using firm-level data between 2004 and 2012 for 11 countries of the European Union, points out substantial heterogeneity between sectors in the levels of the price-cost margin and union bargaining power and she also finds positive correlation between labour and product market imperfections. Motivated by this empirical evidence, we wonder how imperfections in the labour market affect firms' quality competition and, in turn, the average quality in the market as well as consumer and producer surplus.

It is well known that quality differentiation is widespread as a firm's strategy to relax price competition. More precisely, in a vertically differentiated duopoly with uncovered market, as quality differentiation increases firms face a trade-off between a price effect and a demand effect. In the benchmark model with competitive labour markets, [Choi and Shin \(1992\)](#) show that in the absence of quality improvements costs, either firm has the incentive to choose the highest quality available in the market. The other firm has the incentive to partially differentiate its variant by choosing a lower quality that is, however, higher than the minimal quality available in the market: in this way it can relax price competition without losing too much demand. Thus, at first sight, one could guess that as the presence of labour unions makes milder the competition in the product market, firms' incentive to differentiate should reduce. Even assuming that this is the case, which, anyway, has to be verified, it is not, however, clear whether a lower differentiation leads to a larger average quality in the market.

¹[Booth \(1995, p. 95\)](#) points out that “[i]t appears to be an empirical regularity that imperfections in the labor market are correlated with imperfections in the product market”.

Indeed, the canonical argument about how unions affect product quality investment (or innovation) is that unions, by raising wages, reduce profits and hence the return on investment (the so-called *hold-up problem*). Moreover, the larger is the bargaining power of unions, the lower is the rate of return for the firm and, as a result, the lower is the innovation investment (e.g., [Ulph and Ulph, 1998](#)). Thus, it may well happen that, *ceteris paribus*, an increase of the quality induces an increase of the wage set in the bargaining process thus refraining the high quality firm from choosing the highest available quality. As far as the low-quality firm is concerned, unionization may also modify its incentives to strategically choose its product (relative) quality, and union bargaining power *vis-à-vis* firms is expected to play an important role in determining endogenous quality differentiation and average quality in the product market. Moreover, unionization, by increasing production costs, will reduce output in the market, hence it is further unclear the impact of unionized labour markets on consumer surplus (which positively depends on both output quantity and quality) and overall welfare.

Unionization structure differs across industries and countries. At the industry level, a decentralized wage setting structure, involving firm-specific unions, is commonly contrasted with a completely centralized one, in which a single industry union bargains a standard wage for the entire industry (e.g., [Freeman, 1988](#); [Calmfors, 1993](#); [Nickell and Layard, 1999](#); [Flanagan, 1999](#)). In addition, an intermediate structure also does exist, in which an industry union bargains wages at the firm-level, hence adopting a discriminatory or coordinated wage setting strategy. Assessing the role of union structure in affecting the strategic choices by firms on product quality differentiation and, as a result, welfare market outcomes represents another important issue, which also assumes particular importance in the light of the current policy debate on the more socially desirable unionization regime (e.g., [Cournède et al., 2016](#)).

In order to formalize the above ingredients, we consider a vertically differentiated unionized duopoly and we develop the following three stage game. First, firms choose the quality of their variant. Second, wages are determined through a bilateral bargaining process according to three unionization structures: decentralization, coordination and centralization. Finally, firms compete by setting their prices.

Paper's main results can be summarized as follows. When wage bargaining is decentralized (i.e., in the presence of firm-specific unions or coordinated wage setting by an industry-wide union),

increasing product differentiation not only reduces competition between firms in the product market but it also affects wage setting. In particular, while the bargained wage to produce the high quality good is always increasing in its quality level, the bargained wage to produce the low quality good proves to be non-monotone in its quality: initially, improving the low quality permits to increase sales by stealing some consumers to the rival high quality firm and, by increasing employment and reducing wage elasticity of labour demand, this leads to higher wages. However, when low quality becomes sufficiently close to high quality, the effect of tough competition in product market also translates to the wage setting process, which makes the wage of the low-quality firm decreasing as its quality increases further. Moreover, while this holds true under both decentralized and coordinated wage setting, in the latter case wages are *ceteris paribus* higher because the industry-wide union internalizes the positive effect of increasing wages in a given firm on the rival's employment.

Instead, when wage setting is centralized, the uniform wage set through (centralized) bargaining does not depend on product quality differentiation in the product market. At the same time, it affects the product market structure leading to either a duopoly or a monopoly. Specifically, when the bargained wage is higher than a given threshold, the high-quality firm monopolizes the market.

The above discussed effects of quality differentiation on wages play a key role in determining the choices by firms of the quality level of their products. In particular, although wages, *ceteris paribus*, are increasing in the quality of the high-quality firm, the latter always (i.e., independently of union's bargaining power and unionization structure) opts for improving its quality as much as possible.² Instead, the quality choice of the low-quality firm remarkably changes according to unionization regime and union's relative bargaining power.

In particular, under decentralized unionization, the presence of firm-specific unions makes the overall effect of increasing quality on the price-wage margin stronger than in a perfectly competitive (non-unionized) labour market and leads the low-quality firm to increase its quality level. As a result, average quality in the market is greater than with perfectly competitive labour markets and it increases with unions' relative bargaining power. A similar outcome also applies when unionization is coordinated but, in this case, the choice of low-quality level is not monotonically

²As specified below, this outcome (which confirms that obtained in a standard framework without unions) depends also on the fact that, in order to concentrate the analysis on the role of union wage bargaining, no other production or investment costs are considered.

increasing in the union's bargaining power: when union's bargaining power is sufficiently high, increasing it further leads to lower low-quality (and, in turn, average quality) level. Interestingly, when union has all the bargaining power *vis-à-vis* firms, the same outcome of perfectly competitive labour markets is obtained. Finally, centralized unionization entails complete different outcomes. First, a duopoly market arises only if the ratio between the minimum quality standard and the maximal achievable quality is not excessively low, otherwise the bargained wage is such that the high-quality firm monopolizes the market. Furthermore, when a duopoly arises, the low-quality firm always (i.e., independently of the industry-wide union bargaining power) opts for the lowest (minimum standard) quality, hence maximal quality differentiation derives.

Clearly, the quality choices by firms have implications on equilibrium welfare outcomes and comparisons among different unionization structures. While common wisdom seems to suggest that wages increase and profits decrease with the degree of union centralization, in the presence of (endogenous) product quality differentiation wages and profits are not always monotone with respect to the degree of wage setting (de)centralization, depending on the union relative bargaining power and the endogenous degree of quality (vertical) differentiation. In particular, when the maximal achievable quality is large enough with respect to the minimal quality standard, a centralized wage setting structure leads to both higher wages and higher profits, but this occurs at the expense of consumers. Surprisingly, in some circumstances, firms may even benefit from imperfect labour markets by gaining higher profits than in the benchmark case without unions. More in general, even if unionization may increase the average product quality in the market, it always decreases, by reducing output, consumer surplus and overall welfare with respect to a perfectly competitive (non-unionized) labour market. Furthermore, a higher degree of union centralization generally entails lower consumer surplus and overall welfare.

The remaining part of the paper is organized as follows. Section 2 describes the contribution of this work with respect to the received literature. In Section 3, the basic framework is introduced, while equilibrium outcomes under alternative unionization structures are derived and discussed in Section 4. In Section 5, equilibrium product qualities and welfare outcomes obtained under alternative unionization structures are compared and discussed. Section 6 concludes while technical details and proofs are relegated to the final Appendix.

2 Related literature

The interaction among imperfectly competitive labour and product markets is considered by the literature on *unionized oligopolies* (see the seminal works of [Davidson, 1988](#); [Dowrick, 1989](#); [Horn and Wolinsky, 1988](#)), which investigates how endogenous wage setting can affect the decision on strategic variables by oligopolistic firms and how this reflects on final market outcomes and social welfare. In this theoretical framework, there is a vast literature studying the interplay between unions and firms' incentives to innovate leading to controversial results. The main issues pointed out are that higher wages set by powerful unions increase firms' production costs and, in turn, may induce firms to invest more in labour-saving technologies; also, larger labour protection may lead workers to increase their effort and, as a result, a larger labour productivity. At the same time, however, powerful unions may reduce the returns firms get from investments in innovation thus reducing the incentives to innovate because of the hold-up problem.

The seminal contribution by [Haucap and Wey \(2004\)](#) emphasizes the role of the unionization structure: they consider a homogeneous good Cournot duopoly to analyze how the degree of wage setting centralization affects both the hold-up problem associated with unionization and the strategic interaction between firms.³ More precisely, they consider two firms racing to be the first to introduce a cost-reducing technology incurring a sunk investment cost and find that firms' investment incentives are largest under the centralized union structure and smallest under the coordinated one. The intuition being that under the coordinated structure the monopoly union, via discriminating wages set for the two firms, is able to appropriate a large part of firms' returns from the investment. In contrast, under centralized wage determination, the union is constrained to set a uniform wage thus reducing the union's hold-up potential more than under the decentralized structure. [Manasakis and Petrakis \(2009\)](#) also focus on firms' incentives to invest in cost-reducing *R&D* in the presence of monopoly unions. They compare decentralized and centralized wage setting structures and point out the role of spillovers in *R&D*. They show that, instead, for high enough

³In unionized oligopolies literature, outcomes obtained under alternative unionization structures are also compared in the presence of part foreign-owned firms ([Bárcena-Ruiz, 2003](#)), licensing, foreign direct investment and cross-border merger incentives ([Leahy and Montagna, 2000](#); [Mukherjee and Pennings, 2011](#); [Mukherjee and Suetrong, 2012](#); [Mukherjee and Zhao, 2016](#)), union's care about environmental protection ([Asproudis and Gil-Moltó, 2015](#)), capacity choice commitment ([Fanti and Meccheri, 2017](#)) and biased managers ([Meccheri, 2023](#)).

spillovers, *R&D* investments are higher under the decentralized rather than under the centralized regime. [Calabuig and Gonzalez-Maestre \(2002\)](#) also compare decentralized and centralized union structures considering, however, a wage bargaining between the firm and the union. They show that with a large enough market size, the incentive to adopt a cost-reducing innovation is higher under a decentralized union structure than under an industry-wide union. The reverse occurs for a small market size, that is for sufficiently drastic potential innovation; in this case the new technology is more likely to be adopted in the centralized structure.

While most of the papers in this literature analyze cost-reducing process innovations, there are a few exceptions which consider instead quality product innovation. [Vlassis and Varvataki \(2014\)](#) study the impact of unions' decisions regarding their structure, i.e. decentralized or centralized wage-setting regimes according to whether they decide to collude on product quality improvement innovation, the latter being modelled as an increase of the linear demand intercept.⁴ They show that union collusive play (coordinated structure) decreases product quality and output level with respect to decentralization. More recently, [Berton et al. \(2021\)](#) also consider product innovation modelled as an increase of demand and analyze a Cournot duopoly model where labor productivity is allowed to differ across unionized and non-unionized sectors due to collective voice mechanism, that is, based on some empirical evidence, they assume that the union presence may increase labor productivity. They find that the unionized sector may outperform the non-unionized sector in terms of both process and product innovation thanks to the voice mechanism.⁵ Finally, [Basak and Mukherjee \(2018\)](#) also focusing on monopoly unions, in a Cournot duopoly, study the incentives for firms to become multiproduct, that is to develop a new product in addition to the existing ones. They compare the centralized and the decentralized structures and they find that when products are symmetrically differentiated the latter structure provides higher incentives than the centralized one. However, when the products are asymmetrically differentiated, the centralized union can be more conducive to innovation than the decentralized one.

⁴As first shown by [Häckner \(2000\)](#), a demand system *à la* [Dixit \(1979\)](#) and [Singh and Vives \(1984\)](#) can be generalized to the case of two firms producing goods of different qualities. [Correa-López \(2007\)](#) also adopts the same demand system to analyze the choice of price or quantity competition with exogenous vertical product differentiation in a vertical structure with input suppliers.

⁵Their theoretical results are also supported by an empirical analysis they conduct on a large representative sample of Italian firms.

In contrast with the above discussed works, our contribution is based on the vertically differentiated model *à la* [Mussa and Rosen \(1978\)](#), and quality improvement product innovation is modelled in terms of endogenous vertical differentiation.⁶ Moreover, we consider in turn different unionization structures where a Nash bargaining over the wage(s) takes place. Indeed, to the best of our knowledge, [Bacchiega \(2007\)](#) is the only paper that studies Nash bargaining over wages in a vertically differentiated duopoly even if its focus is on a different issue, namely the welfare effects of non-competitive behaviours in the labour market for the high quality good.

3 Model

We consider a vertically differentiated industry with two unionized firms: firm H produces and sells the high quality good at price p_H and firm L produces and sells the low quality good at price p_L . Manufacturing the final good requires labour as unique input and, as usual in the literature, we assume that one unit of labour is embodied in each unit of output (perfect vertical complementarity): $x_i = L_i$, where x_i and L_i denote the level of firm i 's output and employed labour, respectively, with $i = \{H, L\}$.

On the demand side, there is a continuum of consumers indexed by θ which is uniformly distributed in the interval $[0, 1]$. Thus, parameter θ measures consumers' taste for quality. Consumers' preferences are standard (e.g., [Mussa and Rosen, 1978](#); [Gabszewicz and Thisse, 1979](#)), namely, consumers are willing to purchase if and only if they get non-negative utility from buying. Formally, consumer θ 's utility from buying and consuming good i takes the following form:

$$U(\theta) = \theta u_i - p_i \tag{1}$$

with $u_H > u_L$ indicate the qualities of the two goods. The consumer indifferent between buying the low-quality good and not buying at all is:

$$\theta_L = \frac{p_L}{u_L}$$

⁶Some recent contributions (e.g., [Chen, 2017](#); [Brito et al., 2019](#); [Wang and Wang, 2021](#); [Wang, 2022](#)) study models of downstream vertical differentiation in vertically-related markets with input supplier(s). However, they differ with respect to this work for two reasons. First, they do not consider union wage bargaining under alternative unionization structures. Secondly, and most importantly, while this work studies the endogenous choice by firms of quality differentiation, they consider the latter as exogenous.

while the consumer indifferent between buying the low and the high quality good is:

$$\theta_H = \frac{p_H - p_L}{u_H - u_L}.$$

As a result, assuming an uncovered duopoly, the demands for the goods are $x_L = \theta_H - \theta_L$ and $x_H = 1 - \theta_H$. As we aim to enucleate the effects of wage bargaining under alternative unionization structures on product quality differentiation, we abstract from any firms' costs (including quality production costs) other than wages, hence the profit of firm i is $\pi_i = (p_i - w_i)x_i$, where w_i is the wage rate paid by firm i to its workers.⁷

We develop a three-stage game with the following timing. In the first stage, firms choose the optimal quality of their variant whose possible range is assumed to be the exogenous interval $[u_{min}, u_{max}]$: $u_{min} > 0$ represents the minimal quality standard required (e.g., institutional defined product requirements) and u_{max} the maximal achievable quality given the current state of know-how.

In the second stage, wages are determined through a bilateral bargaining process according to three unionization structures: decentralization, coordination and centralization. In the former scenario, there are two firm-specific unions and wages are set independently through a bilateral bargaining between each firm and its union; in the second scenario, there is an industry-wide union that negotiates wages with the two firms simultaneously; and, in the last scenario, there is an industry-wide union that negotiates an uniform industry wage with a representative of the industry employers.

In the third stage, the firms engage in a Bertrand-Nash pricing game. At the end of the last stage, the consumers make purchases. As usual, the game is solved according to the backward induction logic.

4 Equilibrium analysis

We start with the price competition; we proceed with the wage setting stage, where we consider in turn the three unionization structures; we conclude with the quality competition.

⁷It is worth noting that the nil quality cost assumption is in line with other contributions in the literature on vertical product differentiation (e.g., [Tirole, 1988](#); [Choi and Shin, 1992](#); [Wauthy, 1996](#)).

4.1 Price competition

Given qualities chosen at the first stage, u_L, u_H , and the wages chosen at the second stage, w_H, w_L , standard price competition at the last stage leads to the following prices:

$$p_H = u_H \frac{2(u_H - u_L) + 2w_H + w_L}{4u_H - u_L} \quad (2)$$

$$p_L = \frac{u_L(u_H - u_L) + u_L w_H + 2u_H w_L}{4u_H - u_L}. \quad (3)$$

As well-known, prices increase in the quality gap ($u_H - u_L$). Furthermore, they also increase in the wage levels (w_H, w_L). Substituting third-stage equilibrium prices (2) and (3), we find the third stage equilibrium demands for the goods:

$$x_H = \frac{2(u_H - u_L)u_H - (2u_H - u_L)w_H + u_H w_L}{(u_H - u_L)(4u_H - u_L)} \quad (4)$$

$$x_L = \frac{u_H [u_L(u_H - u_L) + u_L w_H - (2u_H - u_L)w_L]}{(u_H - u_L)(4u_H - u_L)u_L}. \quad (5)$$

Note, also for future reference, that, as expected, for given qualities, the demand for good H (resp., L) decreases with w_H (resp., w_L).

4.2 Wage setting

Wages are determined, for given qualities, according to a bilateral bargaining which arises from the three possible unionization structures.

Let $\beta \in [0, 1]$ be the union's bargaining power *vis-à-vis* firms⁸ and we apply the Nash bargaining solution to each bilateral negotiation (e.g., [Oswald, 1985](#); [Pencavel, 1985](#); [Booth, 1995](#)).

In what follows, we analyze wage determination according to the unionization structure, starting from the more decentralized to the more centralized structure. Note that, in each scenario, during the bargaining process, the parties involved anticipate the effect of wages on third-stage equilibrium prices and, in turn, demands as well as profits.

⁸Clearly, the particular case $\beta = 0$ corresponds to a (perfectly competitive) labor market without unions where workers are paid the competitive wage, which is normalized to zero. Instead, the opposite polar case with $\beta = 1$ represents the *monopoly union* model, in which unions can unilaterally set wages to maximize their objective function.

4.2.1 Decentralized union structure

In the decentralized structure, each firm-specific union negotiates independently the wage with its firm to maximize the following Nash product:

$$\mathcal{N}_i^D = \{w_i x_i(w_i, w_j^D)\}^\beta \{\pi_i(w_i, w_j^D)\}^{1-\beta}$$

where x_i (which coincides with the employment level of firm i) depends on both wages w_i, w_j , with $j = \{H, L\}$ and $j \neq i$.

Specifically, during the bargaining to determine w_i , both parties take w_j as given, anticipating correctly, its equilibrium value $w_j = w_j^D$, so that w_j affects the negotiations only indirectly through its effect on x_i and, in turn, on π_i . Moreover, since without an agreement production does not take place by firm i , disagreement payoffs are zero for both parties.

From the first order condition of Nash product maximization,⁹ using some algebra we can obtain the following (standard) condition for the bargained wage, which must equalize percentage marginal benefits and percentage marginal costs weighted for each party relative bargaining power (e.g., [Booth, 1995](#)):

$$\beta = \beta\eta_x + (1 - \beta)\eta_\pi \tag{6}$$

where $\eta_x \equiv -\frac{\partial x_i}{\partial w_i} \frac{w_i}{x_i}$ and $\eta_\pi \equiv -\frac{\partial \pi_i}{\partial w_i} \frac{w_i}{\pi_i}$ represent firm i 's wage elasticity of labor demand and profits, respectively.

In particular, in the choice of firm-specific wage which maximizes the Nash product, negotiators trade off a positive income effect of increasing wages for a given level of employment (weighted for the union's relative bargaining power)¹⁰ against a negative demand effect (weighted for the union's relative bargaining power) –due to the fact that as w_i increases, firm i 's employment is reduced– and a further negative effect (weighted for the firm's relative bargaining power) on firm i 's profit.¹¹

⁹The first order condition for the firm-specific bargaining process is:

$$\pi_i^{1-\beta} \beta \left[x_i(w_i, w_j^D) w_i \right]^{\beta-1} \left[x_i(w_i, w_j^D) + w_i \frac{\partial x_i}{\partial w_i} \right] + \left[x_i(w_i, w_j^D) w_i \right]^\beta (1 - \beta) \pi_i^{-\beta} \frac{\partial \pi_i}{\partial w_i} = 0.$$

¹⁰Keeping employment constant, a one percent wage increase leads to a one percent total wage bill increase.

¹¹Note that, in case of monopoly union ($\beta = 1$), the last effect disappears, hence it does not play any role in determining union's wage choice.

Simultaneous bargaining leads to the following second-stage (subgame) equilibrium wages as a function of qualities:

$$w_L = \frac{2\beta(u_H - u_L)[(2 + \beta)u_H - u_L]u_L}{16u_H^2 - (16 + \beta^2)u_H u_L + 4u_L^2} \quad (7)$$

$$w_H = \frac{\beta u_H(u_H - u_L)[8u_H - (4 - \beta)u_L]}{16u_H^2 - (16 + \beta^2)u_H u_L + 4u_L^2}. \quad (8)$$

It can be easily verified that, as expected, *ceteris paribus*, wages increase with the union's bargaining power, β . Moreover, wages (w_H and w_L) are increasing in u_H . Indeed, for a given u_L , an increase of u_H softens competition between firms (as their products become more differentiated). This also translates in lower competition between unions, which leads to higher wages.¹²

Instead, an increase of u_L , for a given u_H , makes competition fiercer, which leads to a reduction of w_H , while the behavior of w_L proves to be non-monotone: it initially increases with u_L and then it decreases. Indeed, when u_L is sufficiently lower than u_H , firm L , by increasing its product quality, can steal some consumers to firm H and, as a result, increase its employment. As higher employment corresponds to a point along the labour demand curve where wage elasticity is lower, this also leads to a higher bargained wage. However, when u_L is sufficiently close to u_H , the effect related to tougher competition prevails and w_L becomes to reduce as u_L increases. Note that the higher is β , the higher is the u_L 's value, for which w_L begins to decrease as the low quality level increases.

4.2.2 Coordinated union structure

In the coordinated structure, there is an industry-wide union that negotiates the wages with the two firms simultaneously. As in [Horn and Wolinsky \(1988\)](#), we consider that in the negotiation between the union and firm i , the parties anticipate correctly the wage from the other negotiation, w_j^{Co} and the the disagreement point is $(0, w_j^{Co}x_j^{Co})$.¹³ The objective Nash bargaining to maximize with respect to w_i is then:

$$\mathcal{N}_i^{Co} = \{x_i(w_i, w_j^{Co})w_i + x_j(w_i, w_j^{Co})w_j^{Co} - w_j^{Co}x_j^{Co}\}^\beta \{\pi_i(w_i, w_j^{Co})\}^{1-\beta}.$$

¹²Considering condition (6) that must be satisfied with Nash wage setting, on the one hand, wage elasticity of labor demand increases because, with higher wages, employment *ceteris paribus* decreases. On the other hand, wage elasticity of profits is reduced.

¹³See [Horn and Wolinsky \(1988\)](#) for greater details.

Similarly to the case with decentralized unions, from the first order condition of Nash product maximization,¹⁴ we can obtain the following condition for the bargained wage:

$$\beta \left(1 + \frac{\partial x_j}{\partial w_i} \frac{w_j^{Co}}{x_i} \right) = \beta \eta_x + (1 - \beta) \eta_\pi \quad (9)$$

where $\frac{\partial x_j}{\partial w_i} \frac{w_j^{Co}}{x_i}$ captures, for given w_j^{Co} and x_i , the (percent marginal) effect of increasing w_i on the demand of the rival good j , as also this one contributes to the Nash product through the union wage bill.

Simultaneous bargaining leads to the following wage levels as a function of qualities:

$$w_L = \frac{\beta(u_H - u_L)[2(1 + \beta)u_H - u_L]u_L}{8u_H^2 - 2(4 + \beta^2)u_H u_L + 2u_L^2} \quad (10)$$

$$w_H = \frac{\beta u_H(u_H - u_L)[4u_H - (2 - \beta)u_L]}{8u_H^2 - 2(4 + \beta^2)u_H u_L + 2u_L^2} \quad (11)$$

where the behavior of w_H and w_L with respect to product qualities (and β) parallels that already discussed above for the decentralized wage setting case.

However, by comparing condition (6) with condition (9), as $\frac{\partial x_j}{\partial w_i} > 0$, it is worth noting that the firm-specific wages set in the coordinated negotiations are expected to be larger than the corresponding wages bargained by decentralized unions.

4.2.3 Centralized union structure

In a centralized structure, there is one industry-wide union that negotiates an uniform industry wage, say $w_H = w_L = w$, with a representative of the industry. In this case, the disagreement point is (0, 0), and the Nash bargaining product to maximize with respect to w is then given by:

$$\mathcal{N}^C = \{w[x_H(w) + x_L(w)]\}^\beta \{\pi_H(w) + \pi_L(w)\}^{1-\beta}.$$

Given the uniform wage, third stage equilibrium demands (4) and (5) reduce to:

$$x_H = \frac{2u_H - w}{4u_H - u_L} > 0 \iff w < \frac{u_H}{2}$$

¹⁴The first order condition from Nash bargaining with a coordinated union is:

$$\begin{aligned} & \pi_i^{1-\beta} \beta \left[x_i(w_i, w_j^{Co})w_i + x_j(w_i, w_j^{Co})w_j^{Co} - w_j^{Co}x_j^{Co} \right]^{\beta-1} \left[x_i(w_i, w_j^{Co}) + w_i \frac{\partial x_i}{\partial w_i} + w_j^{Co} \frac{\partial x_j}{\partial w_i} \right] \\ & + \left[x_i(w_i, w_j^{Co})w_i + x_j(w_i, w_j^{Co})w_j^{Co} - w_j^{Co}x_j^{Co} \right]^\beta (1 - \beta) \pi_i^{-\beta} \frac{\partial \pi_i}{\partial w_i} = 0. \end{aligned}$$

$$x_L = \frac{u_H(u_L - 2w)}{(4u_H - u_L)u_L} > 0 \iff w < \frac{u_L}{2}.$$

For both demands to be positive we need the second and more stringent condition to hold, i.e. $w < u_L/2$. If, instead, $w \in [\frac{u_L}{2}, \frac{u_H}{2}]$ the low quality firm is not active in the market. As a result, in the choice of w , the centralized union might also strand the low quality firm out of the market.

Suppose first that $w < u_L/2$. We call this case *centralized duopoly* and the first order condition of Nash product maximization writes:

$$\begin{aligned} & [\pi_H + \pi_L]^{1-\beta} \beta [w(x_H + x_L)]^{\beta-1} \left[(x_H + x_L) + w \left(\frac{\partial x_H}{\partial w} + \frac{\partial x_L}{\partial w} \right) \right] \\ & + [w(x_H + x_L)]^\beta (1 - \beta) [\pi_H + \pi_L]^{-\beta} \left[\frac{\partial \pi_H}{\partial w} + \frac{\partial \pi_L}{\partial w} \right] = 0 \end{aligned}$$

from which we can obtain:

$$\beta = \beta \tilde{\eta}_x + (1 - \beta) \tilde{\eta}_\pi \quad (12)$$

where $\tilde{\eta}_x \equiv - \left(\frac{\partial x_i}{\partial w} + \frac{\partial x_j}{\partial w} \right) \frac{w}{x_H + x_L}$ and $\tilde{\eta}_\pi \equiv - \left(\frac{\partial \pi_i}{\partial w} + \frac{\partial \pi_j}{\partial w} \right) \frac{w}{\pi_H + \pi_L}$. Through wage bargaining, the centralized union and the employers' representative take into account (percent marginal) benefits and costs of increasing wages on overall industry.

The unconstrained maximization implies an interior solution that is greater than $u_L/2$, so that we conclude for the corner solution $w = u_L/2 - \epsilon$, with $\epsilon > 0$ negligible,¹⁵ which implies that the demand for the low quality good is positive but negligible.

Suppose next that $w \in [\frac{u_L}{2}, \frac{u_H}{2}]$, so that $x_L = 0$ and the high quality firm monopolizes the product market. We call this case *centralized monopoly* and, in wage bargaining, the Nash product reduces to $(wx_H)^\beta \pi_H^{1-\beta}$. Third stage equilibrium price is $p_H = \frac{u_H + w}{2}$, and in turn, the demand is $x_H = \frac{u_H - w}{2u_H}$, while the bargained wage at the second stage is $w = \beta \frac{u_H}{2}$. Note that this ‘‘candidate’’ equilibrium wage satisfies the initial assumption $w \in [\frac{u_L}{2}, \frac{u_H}{2})$ if and only if $\frac{u_L}{u_H} < \beta$.

4.3 Quality competition

Given the second stage equilibrium wages, each firm i chooses the equilibrium quality maximizing its profit $\pi_i(u_H, u_L) = [p_i(u_H, u_L) - w_i(u_H, u_L)] x_i(u_H, u_L)$, that is, anticipating the effect of u_i on

¹⁵This is proved by verifying that the first order condition is positive in $w = u_L/2$. Also note that this wage is independent of distribution of the bargaining power β .

wages and prices. The first order conditions for firms H and L write as, respectively:

$$\frac{\partial \pi_H}{\partial u_H} = \left(\frac{\partial p_H}{\partial u_H} - \frac{\partial w_H}{\partial u_H} \right) x_H + (p_H - w_H) \frac{\partial x_H}{\partial u_H} = 0 \quad (13)$$

$$\frac{\partial \pi_L}{\partial u_L} = \left(\frac{\partial p_L}{\partial u_L} - \frac{\partial w_L}{\partial u_L} \right) x_L + (p_L - w_L) \frac{\partial x_L}{\partial u_L} = 0. \quad (14)$$

As in the standard model of vertical differentiation (see, [Choi and Shin, 1992](#)), that can be here considered as the benchmark case of perfectly competitive labour markets without union where workers are paid the (exogenous) competitive wage, (for a given u_L) firm H faces a positive price effect ($\frac{\partial p_H}{\partial u_H} > 0$) because competition is softened, and a negative demand effect ($\frac{\partial x_H}{\partial u_H} < 0$) since increasing u_H leads some consumer with intermediate taste for quality to switch from firm H to firm L . However, due to the presence of union wage setting, there is a further negative effect: as u_H increases, *ceteris paribus*, also the wage set in the second stage increases and this lowers the price-wage margin. Nevertheless, it can be easily verified that, independently of the unionization structure, the standard outcome that firm H 's profit is monotonically increasing in u_H holds true. Accordingly, we can state the following result, where the apexes D , Co , Cd and Cm refer to the different unionization (and market) regimes (decentralized, coordinated, centralized duopoly and centralized monopoly, respectively).

PROPOSITION 1. *In equilibrium, regardless of the wage setting and the negotiators' bargaining power, the high quality firm chooses the maximal quality available in the market, that is, $u_H^D = u_H^{Co} = u_H^{Cd} = u_H^{Cm} = u_{max}$.*

As far as the rival firm L is concerned, the choice of product quality proves to be more elaborated (and interesting). Indeed, as u_L increases there is, similarly, a price effect ($\frac{\partial p_L}{\partial u_L}$), a demand effect ($\frac{\partial x_L}{\partial u_L}$) and a wage effect ($-\frac{\partial w_L}{\partial u_L}$) but they differ according to the unionization structure.

In the *decentralized union*, the demand effect is positive as in the standard model: for given u_H , firm L , increasing the quality of its variant, steals some consumers to firm H . Relative to the price effect, it is non-monotone with respect to the quality gap: it is positive as long as the quality gap is large enough and becomes negative when the quality gap is low and price competition intensifies. While this result is qualitatively similar to the one detected under quality competition in the standard model, it is important to point out that with decentralized unions the price effect is positive for a wider range of qualities and the threshold for the quality gap is increasing in the

union's relative bargaining power β .¹⁶ Moreover, as described in Section 4.2.1, the wage effect is also non-monotone, with unions' relative bargaining power that positively affects the threshold for the sign of the wage effect. Overall, the net effect of u_L on the price-wage margin is such that it increases in u_L if and only if u_L/u_H is sufficiently low.¹⁷ As a result, this implies a stronger positive effect of u_L on the price-wage margin with respect to the standard model, resulting in a larger u_L chosen at equilibrium.

The following proposition summarizes the above results and, while a formal proof is provided in the final appendix, Figure 1 shows a graphical representation of them.

PROPOSITION 2. *In the presence of decentralized wage setting, the quality level chosen by the low quality firm is greater than with perfectly competitive labor markets and it increases with the union's relative bargaining power. In particular, it ranges from $\frac{4}{7}u_{max}$, when $\beta = 0$ and labour markets are perfectly competitive (unions have no bargaining power) to $\frac{7}{10}u_{max}$, when $\beta = 1$ and unions have all the bargaining power.*

Proof. See Appendix A.1. □

In the *coordinated union*, the demand effect is also positive. As far as the price and the wage effects are concerned, they are non-monotone as in the decentralized union case, unless $\beta = 1$. In this latter case, the price effect is always positive and the wage effect is always negative: as u_L increases, both p_L and w_L increase. In particular, the novel result that p_L increases with u_L even when quality differentiation becomes small depends on the fact that the wage w_L set by the coordinated union is always increasing in u_L and, since the price is positively related to the wage, this drives firm L to increase its price too.¹⁸ Interestingly, these two opposite effects perfectly offset so that the net effect of u_L on the price-wage margin is the same as in the standard model. In other words, as the union becomes very powerful ($\beta \rightarrow 1$), the further positive effect of u_L on the price-wage margin disappears: the monopoly union fully appropriates the benefit from a quality improvement through a higher wage. This, in turn, induces the low quality firm to reduce

¹⁶In the standard model, $\frac{\partial p_L}{\partial u_L} > 0 \iff u_L/u_H < 0.53$; in case of decentralized bargaining, according to β , this threshold is in the interval (0.53, 0.64).

¹⁷Again, we find a threshold for u_L/u_H that increases with β and falls in the interval (0.53, 0.6).

¹⁸Note that when goods becomes strict substitutes, that is, $u_L \rightarrow u_H$, we have that $p_i \rightarrow w_i$ for any i , hence (as expected) firm profit goes to zero.

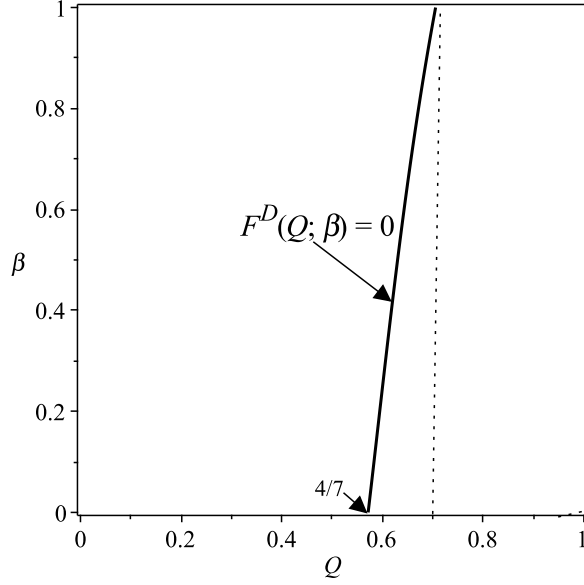


Figure 1: Optimal low quality choice under decentralized wage setting

Note: $Q = u_L/u_{max}$ with $u_{max} = 1$; $F^D(Q; \beta) = 0$ denotes the first order condition for the quality L maximization problem under decentralized unionization

its quality. Formally, for the particular case $\beta = 1$, this net effect increases in u_L if and only if $u_L/u_H < 0.53$, that is the same that holds for $\beta = 0$.

For any bargaining power $\beta \in [0, 1]$, the net effect of u_L on the price-wage margin of the firm L is again non-monotone: it increases in u_L if and only if u_L/u_H is low enough.¹⁹ Such results are summarized in the following proposition and shown by Figure 2.

PROPOSITION 3. *In the presence of coordinated wage setting, the balance between the non-monotone price-wage margin effect and the positive demand effect leads to an interior solution for u_L , which is a non-monotone function of the union relative bargaining power: it increases for low β and it decreases for high β . Interestingly, at the two extremes (competitive labor market with $\beta = 0$ and monopoly union with $\beta = 1$), the resulting equilibrium quality chosen by the low quality firm is equal to $\frac{4}{7}u_{max}$.*

Proof. See Appendix A.2. □

¹⁹Note that such threshold for u_L/u_H is non-monotone in β , it is however in the interval (0.53, 0.58).

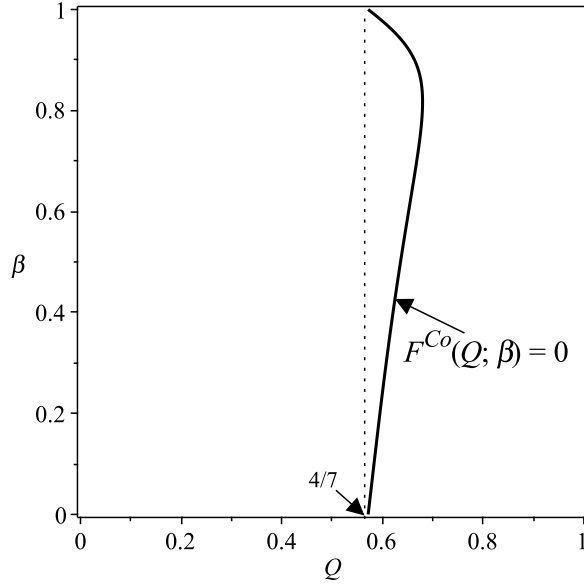


Figure 2: Optimal low quality choice under coordinated wage setting

Note: $Q = u_L/u_{max}$ with $u_{max} = 1$; $F^{Co}(Q; \beta) = 0$ denotes the first order condition for the quality L maximization problem under coordinated unionization

In the *centralized union*, quality competition takes place only in the centralized duopoly. In this case, where the second stage uniform wage is set such that the demand for the low quality good is positive but negligible, the demand effect is insignificant (it tends to zero as ϵ goes to zero). As for the price and the wage effects, the former is always positive and the latter is always negative. In contrast with the previous scenarios, the negative wage effect more than compensates the positive price effect, so that the profit of the low quality firm is monotonically decreasing in u_L .²⁰ As a result, maximal vertical differentiation arises and $u_L^{Cd} = u_{min}$ for any level of β . Indeed, given its very low demand, firm L prefers to differentiate as much as possible to attenuate price competition. Then, the candidate wage equilibrium is $w^{Cd} = u_{min}/2$. Instead, in the centralized monopoly, the candidate wage equilibrium is $w^{Cm} = \beta u_{max}/2$.²¹

²⁰Formally, given the wage stage, at the quality stage firm L 's profit is $\pi_L = \frac{4\epsilon^2 u_H (u_H - u_L)}{u_L (-4u_H + u_L)^2}$ that is decreasing in u_L .

²¹This is due to the fact that firm H maximizes its profit $\pi_H = \frac{u_H (2-\beta)^2}{16}$ by choosing u_H equal to the maximal available quality.

Accordingly, we are now in the position to check the condition that permits to establish which of the above candidate equilibria is actually the wage equilibrium of the centralized wage setting scenario. In particular, the Nash product under the centralized duopoly, for ϵ that goes to zero, is:

$$\mathcal{N}^{Cd} = \frac{(u_{max} - u_{min})^{1-\beta} u_{min}^\beta}{4}$$

whereas under the centralized monopoly (implementable for $\frac{u_{min}}{u_{max}} < \beta$) it is:

$$\mathcal{N}^{Cm} = \frac{[(2 - \beta)^2 u_{max}]^{1-\beta} [(2 - \beta)\beta u_{max}]^\beta}{2^{4-\beta}}.$$

Hence, we can conclude that the negotiators prefer to set $w^{Cd} = u_{min}/2$ as long as $\mathcal{N}^{Cd} \leq \mathcal{N}^{Cm}$ and $\frac{u_{min}}{u_{max}} < \beta$. Accordingly, the following proposition can be stated (see also Figure 3).

PROPOSITION 4. *In the presence of centralized wage setting, a duopoly product market arises when the ratio between the minimum quality level, u_{min} , and the maximal achievable quality, u_{max} , say $Q^* = \frac{u_{min}}{u_{max}}$, is not excessively low. Otherwise, only firm H operates as a monopolist in the market. In addition, as the union relative bargaining power decreases, the threshold for Q^* (above which a duopoly arises) becomes increasingly low (e.g., a duopoly always emerges when $\beta = 0$). In this (duopoly) case, firm L always (i.e., independently of β) opts for the lowest quality level u_{min} , hence maximal vertical differentiation applies.*

Proof. See Appendix A.3. □

5 Product quality and welfare outcomes comparison

Following the previous analysis, we next compare the three unionization structures in terms of quality differentiation and welfare outcomes.²² We define the consumer surplus and overall welfare as, respectively:

$$CS = \int_{\theta_L}^{\theta_H} (\theta u_L - p_L) d\theta + \int_{\theta_H}^1 (\theta u_H - p_H) d\theta$$

²²Subgame perfect Nash equilibrium (SPNE) outcomes are obtained by substituting back the equilibrium qualities for each unionization scenario. For the sake of space they are all reported in the final Appendix A.4. We also check that at each SPNE the market is an uncovered duopoly.

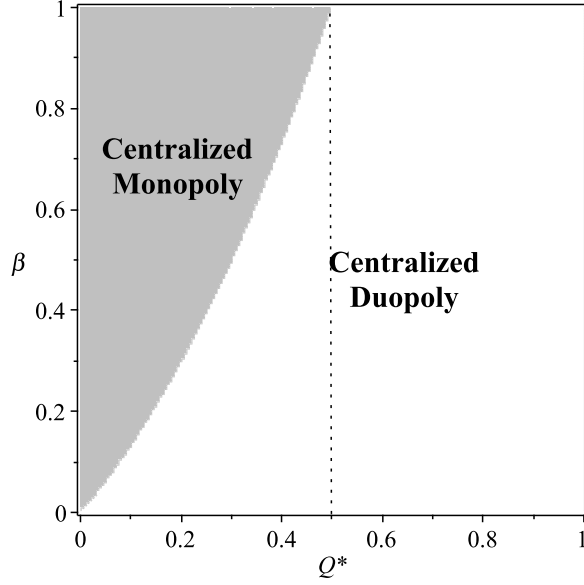


Figure 3: Centralized duopoly and centralized monopoly

Note: $Q^* = u_{min}/u_{max}$ with $u_{max} = 1$

$$W = CS + \sum_i \pi_i + \sum_i w_i L_i.$$

Before proceeding, as a benchmark, we recall the equilibrium values for $\beta = 0$, that is the standard model without union, where wages are set at the competitive level, i.e. $w_H = w_L = 0$.

$$\tilde{u}_H = u_{max}, \tilde{u}_L = \frac{4}{7}u_{max}, \tilde{\pi}_H = \frac{7}{48}u_{max}, \tilde{\pi}_L = \frac{1}{48}u_{max}, \tilde{P}S = \frac{1}{6}u_{max}, \tilde{C}S = \frac{7}{24}u_{max}, \tilde{W} = \frac{11}{24}u_{max}.$$

For sake of space and given their importance, in the comparisons we will focus on the two particular cases mostly widespread in the literature: $\beta = 1/2$, in which the union and the firms are equally powerful in the wage bargaining, and $\beta = 1$, which represents the monopoly union model, in which unions have full bargaining power and can set wages unilaterally. Importantly, recall that, as shown in Proposition 4, in the former case, under centralized unionization a duopoly is active as long as $Q^* = \frac{u_{min}}{u_{max}} > 1/3$, while, in the latter case, in the centralized union case, a duopoly is active if and only if $Q^* > 1/2$.

Table 1 and Figures 4–6²³ display the rankings that can be easily verified looking at the equilibrium variables reported in Appendix A.4. These rankings give rise to some interesting conclusions

²³Figures 4–6 refer to the cases in which rankings are not stable and change in some range of u_{min}/u_{max} .

that we gather and discuss in what follows, distinguishing between concerns related to product qualities differentiation and welfare outcomes.

	$\beta = 1/2$	
	$0 < Q^* < 1/3$	$1/3 < Q^* < 1$
High quality	$u_H^D = u_H^{Co} = u_H^{Cm} = \tilde{u}_H = u_{max}$	$u_H^D = u_H^{Co} = u_H^{Cd} = \tilde{u}_H = u_{max}$
Low quality	$u_L^D = u_L^{Co} > \tilde{u}_L$	$u_L^D = u_L^{Co} > \tilde{u}_L > u_L^{Cd} = u_{min}$
Wages	$w^{Cm} > w_H^{Co} > w_H^D > w_L^{Co} > w_L^D$	$w^{Cd} > w_H^{Co} > w_H^D > w_L^{Co} > w_L^D$
Profits	$\tilde{\pi}_H > \pi_H^{Cm} > \pi_H^D > \pi_H^{Co} > \pi_L^D > \tilde{\pi}_L > \pi_L^{Co}$	see Fig. 4
Consumer surplus	$\tilde{CS} > CS^D > CS^{Co} > CS^{Cm}$	$\tilde{CS} > CS^D > CS^{Co} > CS^{Cd}$
Welfare	$\tilde{W} > W^D > W^{Co} > W^{Cm}$	$\tilde{W} > W^D > W^{Co} > W^{Cd}$
	$\beta = 1$	
	$0 < Q^* < 1/2$	$1/2 < Q^* < 1$
High quality	$u_H^D = u_H^{Co} = u_H^{Cm} = \tilde{u}_H = u_{max}$	$u_H^D = u_H^{Co} = u_H^{Cd} = \tilde{u}_H = u_{max}$
Low quality	$u_L^D > u_L^{Co} = \tilde{u}_L$	$u_L^D > u_L^{Co} = \tilde{u}_L > u_L^{Cd} = u_{min}$
Wages	$w^{Cm} = w_H^{Co} > w_H^D > w_L^{Co} > w_L^D$	see Fig. 6
Profits	$\tilde{\pi}_H > \pi_H^{Cm} > \pi_H^D > \pi_H^{Co} > \tilde{\pi}_L > \pi_L^D > \pi_L^{Co}$	see Fig. 5
Consumer surplus	$\tilde{CS} > CS^D > CS^{Co} > CS^{Cm}$	$\tilde{CS} > CS^D > CS^{Cd} > CS^{Co}$
Welfare	$\tilde{W} > W^D > W^{Co} > W^{Cm}$	$\tilde{W} > W^D > W^{Cd} > W^{Co}$

Table 1: Welfare outcomes comparison for $\beta = 1/2$ and $\beta = 1$ ($Q^* = u_{min}/u_{max}$)

5.1 Qualities and vertical differentiation

Comparing equilibrium qualities in the alternative unionization structures, the following holds in both cases of equal distribution of bargaining power and monopoly union.

PROPOSITION 5. *As long as the minimal quality standard in the market is not very far from the maximal available quality, i.e., Q^* is large enough, the centralized union structure leads to a lower average quality and a larger quality differentiation with respect to the decentralized and the coordinated structures as well as with respect to the competitive labour market case. Otherwise, for Q^* low enough, the centralized union structure leads to a higher average quality than the decentralized and*

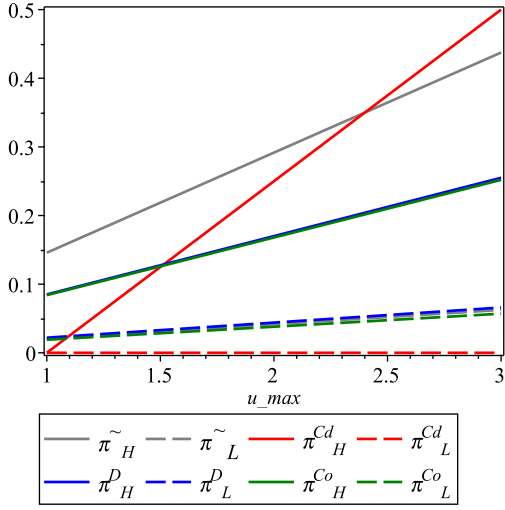


Figure 4: Profits for $\beta = 1/2$ and $Q^* > 1/3$

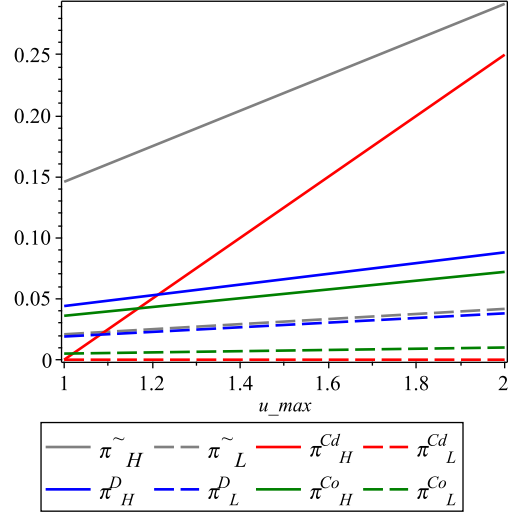


Figure 5: Profits for $\beta = 1$ and $Q^* > 1/2$

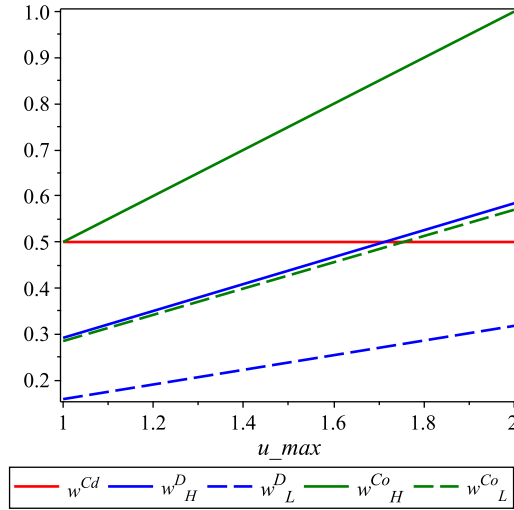


Figure 6: Wages for $\beta = 1$ and $Q^* > 1/2$

Note: In all figures, $Q^* = u_{min}/u_{max}$ with $u_{min} = 1$

the coordinated structures and quality differentiation reduces with respect to the case of competitive labour markets.

Interestingly, the initial guess according to which imperfectly competitive labour markets by reducing the toughness of price competition should reduce the quality differentiation chosen by

firms does not always hold. Indeed, under a centralized union, when the gap between the minimal and the maximal available qualities is low enough, the uniform wage bargained for both firms induces a limit situation where the demand of the low quality firm is negligible so that this firm has incentive to differentiate from the high quality as much as possible: maximal differentiation arises at equilibrium. In all other cases, vertical differentiation reduces with respect to the case of competitive labour markets with an increase of the average quality in the market.

5.2 Welfare outcomes

We next assess how the effects on equilibrium qualities feed back into welfare components, namely wages, consumer surplus, profits and overall welfare.

PROPOSITION 6. *Relative to welfare outcomes, the following results can be stated:*

- *In case of equal distribution of bargaining power, $\beta = 1/2$, independently of Q^* , wages increase whereas consumer surplus and social welfare decrease with the degree of union centralization. In case of monopoly union, $\beta = 1$, the ranking of wages, consumer surplus and overall welfare depend on Q^* and they may be non-monotone in the degree of union centralization.*
- *The ranking of profits depends on Q^* , and it may be non-monotone with respect to the degree of union centralization.*

Under wage bargaining with equal power of parties, wages are monotonically increasing with the degree of wage setting centralization. Indeed, the wage in the coordinated union structure is higher than the wage set in the decentralized structure as in the former the cross effect of the firm-specific wage on the demand of the rival firm is also taken into account by the union. Moreover, under the centralized structure, as long as a duopoly arises, negotiators' objective basically consists of maximizing the value of industry production. With this aim, the wage is set such that the production of the low quality good tends to zero. For this to happen the centralized wage is higher than in the other duopoly scenarios. Anticipating the wage setting, the low quality firm sets its quality as low as possible with the result that the equilibrium uniform wage is $w^{Cd} = \frac{u_{min}}{2}$.

Moreover, as the average quality in the market and total output are lower under centralized duopoly than in the other union structures, it is quite intuitive that, consumer surplus and total

welfare turn out to be lower too. The same result, however, holds even when a centralized monopoly arises at equilibrium, hence the average quality is higher under wage setting centralization than in the other structures. The reason now is that a monopoly output is too low.

Results differ in case of monopoly union where the wage is set in order to maximize the wage bill given that firms do not have any bargaining power. The implication is that wages set by the coordinated union for the high-quality firm are higher than in the case of centralized union because, through wage setting discrimination, the former is able to fully appropriate the firm's benefit from high-quality. Moreover, also under decentralized unionization, wages set for the high-quality firm can be higher than under a centralized structure, especially when the average quality is sufficiently large and competition between firms, as well as between unions, is soft. In other words, the uniform wage (institutional) policy adopted by a centralized union restrains the possibility to exploit its full bargaining power to fix higher wages to more profitable (because high-quality) firms.²⁴

As for consumer surplus and social welfare, it is worth noting that their value can be minimal under the coordinated structure. Indeed, this holds true when, under centralized wage setting, a duopoly structure arises at equilibrium. This is because, under coordinated wage setting, the monopoly union is able to fully appropriate the benefit from a quality improvement by setting higher wages thus inducing the same average quality in the market as in the standard model but with higher market prices and, in turn, lower market coverage with respect to the other union structures.²⁵

As far as profits are concerned, the expected outcome that they increase with the degree of union decentralization is obtained as long as the maximal available quality (chosen by the high quality firm) is not very far from the minimal quality that is available in the market. This ranking is quite intuitive for $\beta = 1/2$ and it reflects the fact that wages decrease with the degree of decentralization.

²⁴Regarding wages for low-quality firm, instead, the centralized uniform wage is always higher than the decentralized wage. Instead, in comparison with the coordinated wage, the latter becomes larger when u_{max} is high enough.

²⁵This result is somewhat in line with Brito et al. (2019), that compare the monopoly pricing strategies (either uniform pricing or input price discrimination) of an upstream producer selling an essential input to a vertically differentiated downstream market. They find that the uniform pricing regime, that corresponds to our centralization structure, as long as it does not lead to an unconstrained monopoly is welfare improving with respect to input price discrimination (that corresponds to our coordinated structure). They focus, however, on a monopolist input supplier with full bargaining power and take exogenous the qualities in the downstream market. As we show, considering labour as the essential input, this result ceases to hold when firms have some bargaining power.

It also holds for $\beta = 1$ even if for u_{max} low enough, $w_H^{Co} > w^{Cd}$.

However, when u_{max} is much larger than u_{min} , it is the centralized structure that ensures the highest profit for the high quality firm.²⁶ The intuition is that as u_{max} increases relative to u_{min} , the positive effect of serving (almost) all consumers willing to buy (either because the demand of firm L is negligible or because firm H becomes a monopoly) prevails. This also leads to the result that the centralized union structure with a uniform wage is not always characterized by a conflict of interest between the union and the industry: they may both gain when moving from a decentralized to a centralized structure. Clearly, this occurs at the expense of consumers.

Finally, relative to profits, it is also worth comparing the results obtained under alternative unionization structures with those in a (perfectly competitive) labour market without unions. As one could guess, with monopoly unions, firms always suffers from unionization: the presence of unions, by increasing production costs reduces firms' profits with respect to the benchmark case without unions. Interestingly, this does not always hold under bargaining with parties that have equal power (see Table 1 and Figure 4), as highlighted by the following corollary.

COROLLARY 1. *When parties have equal bargaining power, the profits of the high quality firm are higher under centralized unionization than in a perfectly competitive labour markets without unions when a duopoly arises in the product market and u_{max} is large enough with respect to u_{min} . The presence of unions can also increase the profits of the low quality firm and this actually applies under decentralized bargaining with firm-specific unions.*

The rationale for which a centralized union structure may be beneficial for the high quality firm is that, in a centralized duopoly, the presence of the union, by inducing a positive limit wage that is proportional to the minimal quality standard, involves two opposite effects as compared to the benchmark case. On the one hand, it implies larger productions costs but, by constraining the demand for the low quality good (that is negligible), on the other hand, it also relaxes price competition and allows the high quality firm to further increase its price. For given minimal quality standard, this latter positive effect increases with the maximal quality and it overcompensates the

²⁶Note that the ranking of the overall producer surplus follows the ranking of firm H 's profit. Also this ranking is qualitatively the same under bargaining ($\beta = 1/2$) and under monopoly union ($\beta = 1$) as displayed in Figure 4 and Figure 5. Note, however, that for $\beta = 1$ the positive difference between π_H^D and π_H^{Co} is larger than for $\beta = 1/2$, so that the ranking in the intermediate interval of u_{max} is clearer than for $\beta = 1/2$.

negative one when u_{max} becomes sufficiently high.²⁷ As for the low quality firm, it can also benefit from the presence of unions. In particular, this happens under decentralized bargaining because, even if this firm suffers from a higher (unionized) wage, its quality increases inducing a higher price and a higher demand with respect to the case with $\beta = 0$.

6 Conclusion

Unions in labour markets play a prominent institutional role and the interaction between imperfections in labour markets and imperfections in product markets are relevant from both a theoretical and an empirical point of view. With this motivation, we have investigated the effects of alternative institutional unionization structures, typically observed all around the world, on product quality differentiation and welfare outcomes.

Alternative union wage setting regimes prove to affect crucially and differently the choice by firms on product quality and, as a result, the degree of vertical differentiation in the product market. Indeed, when unionization is decentralized or coordinated, vertical differentiation generally decreases with respect to the case in which labour markets are perfectly competitive without unions. However, under decentralized unions, average quality in the market always increases with unions' relative bargaining power while, under coordinated union, there is a non-monotone relationship between them. By contrast, when unionization is centralized, wage setting can affect the product market structure, determining either a duopoly or a monopoly, and when a duopoly arises the low-quality firm opts for the minimal quality, which increases vertical differentiation.

Finally, relative to welfare comparisons, wages and profits are not always monotone with respect to the degree of wage setting (de)centralization, depending on the union relative bargaining power and the endogenous degree of quality (vertical) differentiation. Furthermore, even if unionization generally increases average product quality, it always lowers consumer surplus and overall welfare because the negative impact on output quantity outweighs the positive impact on output quality. At the same time, a more decentralized union structure is generally welfare superior than a more centralized one.

²⁷Note that this result does not extend to the case of centralized monopoly. Indeed, when an unconstrained monopoly arises as a result of centralized wage setting, the bargained wage is proportional to u_{max} and the larger market revenue does not compensate anymore the larger production cost of the high quality firm.

A Appendix

A.1 Proof of Proposition 2

Given $u_H^D = u_{max}$, computing $\frac{\partial \pi_L}{\partial u_L}$, we find that π_L first increases and then decreases in u_L . More precisely, denoting $Q = \frac{u_L}{u_{max}} \in (0, 1)$, the first order condition for this maximization problem is of the form $F^D(Q; \beta) = 0$, with:

$$F^D(Q; \beta) = 128(2 + \beta) - 8(120 + \beta(36 - \beta(2 + \beta)))Q + 2(640 + \beta(72 + (2 - \beta)\beta))Q^2 \\ - (800 - \beta(40 - \beta(32 + 3\beta)))Q^3 + (240 - \beta(44 - 17\beta))Q^4 - 2(14 - (4 - \beta)\beta)Q^5.$$

$F^D(Q; \beta)$ is a fifth-degree polynomial in Q with a unique root in the interval $(0, 1)$. Also it is non-negative in $Q = \frac{4}{7}$ (that is also the root of $F^D(Q; 0) = 0$), and it is non-positive in $Q = \frac{7}{10}$ (that is also the root of $F^D(Q; 1) = 0$) so that the optimal quality is such that $Q^D(\beta) \in [\frac{4}{7}, \frac{7}{10}]$ and it is increasing in β . Indeed, although we cannot find a closed-form solution for $Q^D(\beta)$, applying the implicit function theorem, in the interval of interest we verify that:²⁸

$$\frac{dQ}{d\beta} = -\frac{\partial F/\partial \beta}{\partial F/\partial Q} > 0.$$

As a result, the optimal low quality choice, indicated as $u_L^D(\beta)$ is an increasing function of β , and it is equal to $\frac{4}{7}u_{max}$ for the particular case $\beta = 0$ and equal to $\frac{7}{10}u_{max}$ for the other extreme $\beta = 1$.

A.2 Proof of Proposition 3

Given $u_H^{Co} = u_{max}$, computing $\frac{\partial \pi_L}{\partial u_L}$, we find that π_L first increases and then decreases in u_L . More precisely, denoting $Q = \frac{u_L}{u_{max}} \in (0, 1)$, the first order condition for this maximization problem is of the form $F^{Co}(Q; \beta) = 0$, with:

$$F^{Co}(Q; \beta) = 64(-2 + \beta^2) + 16(30 - \beta(6 + 8\beta - \beta^3))Q - 4(160 - \beta(62 - \beta(5 - 2(1 - \beta)\beta)))Q^2 \\ + (400 - \beta(220 - \beta(116 - (26 - \beta)\beta)))Q^3 - (120 - \beta(82 - \beta(53 - 17\beta)))Q^4 + (2 - \beta)(7 - 2(1 - \beta)\beta)Q^5.$$

$F^{Co}(Q; \beta)$ is a fifth-degree polynomial in Q with a unique root in the interval $(0, 1)$. Also it is non-negative in $Q = \frac{4}{7}$ (that is also the root of $F^{Co}(Q; 0) = 0$), and it is non-positive in $Q = \frac{68}{100}$ (that is also the root of $F^{Co}(Q; 1) = 0$) so that the optimal quality is such that $Q^{Co}(\beta) \in$

²⁸See also Figure 1 in the main text for a graphical proof of Proposition 2.

$[\frac{4}{7}, \frac{68}{100}]$. Although we cannot find a closed-form solution for $Q^{Co}(\beta)$, numerical simulations show that it is non-monotone. In particular, we verify that $Q^{Co}(0) = Q^{Co}(1) = 4/7$ as well as that $Q^{Co}(0.8) = 0.68$. As a result, the optimal low quality choice, indicated as $u_L^{Co}(\beta)$ is such that $u_L^{Co}(\beta) \in [\frac{4}{7}u_{max}, \frac{68}{100}u_{max}]$ and it is equal to $\frac{4}{7}u_{max}$ for the particular case $\beta = 0$ and for the other extreme $\beta = 1$.²⁹

A.3 Proof of Proposition 4

Denoting $Q^* = \frac{u_{min}}{u_{max}}$, we find that

$$\mathcal{N}^{Cd} \leq \mathcal{N}^{Cm} \iff \frac{((2-\beta)^2)^{1-\beta}((2-\beta)\beta)^\beta}{2^{4-\beta}} - \frac{1}{4} \left(1 - Q^{*(1-\beta)}\right) Q^{*(\beta)} \geq 0.$$

Although we cannot find a closed form solution for Q^* as a function of β , say $\bar{Q}^*(\beta)$, Figure 3 in the main text displays the implicit plot of the above condition showing that $\mathcal{N}^{Cd} \leq \mathcal{N}^{Cm} \iff Q^* \leq \bar{Q}^*(\beta)$. As verifiable from this Figure, $\bar{Q}^*(\beta)$ is increasing: as the union becomes relatively more powerful, the centralized monopoly is more likely to arise. For instance, note that for $\beta = 0$ (benchmark standard model), $\bar{Q}^*(0) = 0$ and the centralized duopoly arises for any value of \bar{Q} ; for $\beta = 1/2$ (equal distribution of bargaining power between the union and the firms), $\bar{Q}^*(1/2) = 1/3$ and the centralized duopoly arises iff $Q^* > 1/3$; finally, for $\beta = 1$ (monopoly union), the centralized duopoly arises iff $Q^* > 1/2$.

A.4 Equilibrium outcomes

In the centralized union case, whenever the quality ratio u_{min}/u_{max} is large enough, at equilibrium the centralized duopoly arises. Note that while the threshold on the quality ratio depends on the level of the bargaining power, equilibrium variables are independent of β and they are, with ϵ that tends to zero:

$$\begin{aligned} w^{Cd} &= \frac{u_{min}}{2} - \epsilon \rightarrow \frac{u_{min}}{2} \\ x_L^{Cd} &= \frac{2\epsilon u_{max}}{4u_{max}u_{min} - u_{min}^2} \rightarrow 0, \quad x_H^{Cd} = \frac{1}{2} + \frac{\epsilon}{4u_{max} - u_{min}} \rightarrow \frac{1}{2} \\ \pi_L^{Cd} &= \frac{4\epsilon^2 u_{max}(u_{max} - u_{min})}{u_{min}(-4u_{max} + u_{min})^2} \rightarrow 0; \quad \pi_H^{Cd} = \frac{(u_{max} - u_{min})(u_{min} - 2\epsilon - 4u_{max})^2}{4(-4u_{max} + u_{min})^2} \rightarrow \frac{u_{max} - u_{min}}{4} \end{aligned}$$

²⁹See also Figure 2 in the main text for a graphical proof of Proposition 3.

$$CS^{Cd} = \frac{1}{8}u_{max}$$

$$W^{Cd} = \frac{3}{8}u_{max}.$$

In contrast, whenever the quality ratio u_{min}/u_{max} is low enough at equilibrium the centralized monopoly takes place. Equilibrium variables are then:

$$w^{Cm} = \frac{\beta}{2}u_{max}$$

$$x_L^{Cm} = 0, x_H^{Cm} = \frac{2-\beta}{4}, x_L^{Cm} + x_H^{Cm} < 1$$

$$\pi_L^{Cm} = 0, \pi_H^{Cm} = \frac{(2-\beta)^2}{16}u_{max}$$

$$CS^{Cm} = \frac{(2-\beta)^2}{32}u_{max}$$

$$W^{Cm} = \frac{(2-\beta)(6+\beta)}{32}u_{max}.$$

As for the other two unionization structures, equilibrium variables depend on β and they are reported for the two cases analyzed in the text.

Equal distribution of bargaining power. For $\beta = 1/2$, equilibrium variables turn out to be the following. In the decentralized structure:

$$w_L^D = \frac{3}{50}u_{max}, w_H^D = \frac{73}{500}u_{max}$$

$$x_L^D = \frac{31}{100}, x_H^D = \frac{12}{25}, x_L^D + x_H^D = \frac{79}{100} < 1.$$

$$\pi_L^D = \frac{11}{500}u_{max}, \pi_H^D = \frac{17}{200}u_{max}$$

$$CS^D = \frac{6}{25}u_{max}$$

$$W^D = \frac{109}{250}u_{max}.$$

In the coordinated structure:

$$w_L^{Co} = \frac{2}{25}u_{max}, w_H^{Co} = \frac{41}{250}u_{max}$$

$$x_L^{Co} = \frac{36}{125}, x_H^{Co} = \frac{477}{1000}, x_L^{Co} + x_H^{Co} = \frac{383}{500} < 1$$

$$\pi_L^{Co} = \frac{19}{1000}u_{max}, \pi_H^{Co} = \frac{21}{250}u_{max}$$

$$CS^{Co} = \frac{227}{1000}u_{max}$$

$$W^{Co} = \frac{54}{125}u_{max}.$$

Monopoly union. For $\beta = 1$, equilibrium variables turn out to be the following. In the decentralized structure:

$$w_L^D = \frac{159}{1000}u_{max}, w_H^D = \frac{59}{202}u_{max}$$

$$x_L^D = \frac{3}{10}, x_H^D = \frac{19}{50}, x_L^D + x_H^D = \frac{341}{500} < 1$$

$$\pi_L^D = \frac{19}{1000}u_{max}, \pi_H^D = \frac{11}{250}u_{max}$$

$$CS^D = \frac{37}{200}u_{max}$$

$$W^D = \frac{407}{1000}u_{max}.$$

In the coordinated union case, they are:

$$w_L^{Co} = \frac{2}{7}u_{max}, w_H^{Co} = \frac{1}{2}u_{max}$$

$$x_L^{Co} = \frac{7}{48}, x_H^{Co} = \frac{7}{24}, x_L^{Co} + x_H^{Co} = \frac{7}{16} < 1$$

$$\pi_L^{Co} = \frac{u_{max}}{192}, \pi_H^{Co} = \frac{7u_{max}}{192}$$

$$CS^{Co} = \frac{7}{96}u_{max}$$

$$W^{Co} = \frac{29}{96}u_{max}.$$

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