Discussion Papers

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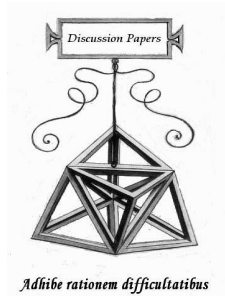
Luciano Fanti - Nicola Meccheri

Capacity choice and welfare under alternative unionisation structures

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Abstract

This paper studies how unionisation structures that differ in the degree of wage setting centralisation interplay with the strategic choice of production capacity by firms and how this affects product market outcomes. When labour markets are unionised and firms compete in quantities, they typically opt for under-capacity in order to dampen the unions' wage claims. This is in contrast with the conventional choice of over-capacity that applies when labour markets are competitive. Moreover, the level of capacity is generally more efficient under centralised unionisation than in a decentralised structure. Relative to more general welfare outcomes, profits are always higher under decentralised unionisation, but both consumer surplus and overall welfare can be higher under a centralised structure, depending on the unions' preference towards wages or employment. Introducing product differentiation and price competition enlarges the range of situations, in which centralised unionisation is welfare-enhancing.

Contents

I. Introduction

For some years, the debate on the economic effects of alternative unions' structures is high on the political agenda in many countries (e.g. OECD, 2004). At the industry level, a decentralised wage setting structure, involving firm-specific unions, is commonly contrasted with a completely centralised one, in which a single industry union sets a standard wage for the entire industry. At the country level, centralised unions representing all workers in an industry are widespread in Continental Europe while firm-specific unions and decentralised wage setting are largely predominant in UK, North America and Japan (e.g. Calmfors and Driffill, 1988; Freeman, 1988; Layard and Nickell, 1999; Flanagan, 1999). However, it has been documented that decentralised unions are gaining popularity in countries such as Sweden, Germany and Italy, which are currently moving towards a more decentralised unionisation structure (Katz, 1993; Del Boca et al., 1999; Haucap et al., 2007). Indeed, the greater rigidities associated with centralised wage setting have recently come under attack in the policy debate, so that any move towards a more decentralised structure is commonly considered as good for overall economic prosperity.

The prominent role played by unions on industrial organization outcomes has been recently recognised by the growing literature on unionised oligopolies (e.g. Horn and Wolinsky, 1988; Dowrick, 1989; Naylor, 1999; Correa-López and Naylor, 2004; Correa-López, 2007; Lommerud et al., 2005; Pal and Saha, 2008). In such a framework, recent theoretical contributions have studied in detail the performance of alternative unionisation institutions in relation to both firms' profitability and overall welfare. For instance, the role of alternative unionisation structures is considered in affecting innovation incentives (Haucap and Wey, 2004; Mukherjee and Pennings, 2011), incentives for foreign direct investment (Mukherjee and Zhao, 2007; Mukherjee and Suetrong, 2012) and welfare effects of downstream mergers (Brekke, 2004; Symeonidis, 2010). Fanti and Meccheri (2013), instead, study the effects of unionisation un-

der managerial delegation showing that, while without managerial delegation social welfare is higher under firm-specific unions, delegating output decisions to managers makes unionisation structure neutral in relation to overall efficiency (i.e. social welfare becomes the same under decentralised and centralised unionisation).[1]

Up to now, however, the literature on unionised oligopolies has devoted no attention to the effects of unionisation on social welfare when firms can strategically manipulate production capacity (i.e. choosing over- or under-capacity). Such a latter issue has been extensively treated as a sequential game of "capacity then quantity" (e.g. Spence, 1977; Dixit, 1980; Tirole, 1988; Basu and Singh, 1990) showing that firms generally maintain over-capacity in order to lead their rivals to reduce output.[23] Analysing if this still applies when firms' production costs are set by unions and, particularly, how alternative unionisation structures differently affect final social outcomes in such a framework is obviously relevant to the concerns of labour economics and industrial organization, as well as to provide new insights to the debate on the desirability of alternative unionisation regimes.

In order to fill up that gap in the literature, we analyse a three-stage duopoly game: at the first stage, each firm chooses its production capacity; at the second stage, unions (that can be decentralised or centralised) set wages; at the third stage, each firm decides its optimal (profit-maximising) output. In particular, the contribution we aim to provide is twofold. From one hand, extending the literature

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[1] While Fanti and Meccheri (2013) concentrate on "sales delegation" contracts, Meccheri and Fanti (forthcoming) compare the results of alternative managerial delegation contracts in the presence of centralised unionisation.

[2] Another important reason for holding idle capacity, highlighted by this literature, is to deter market entry (see, also, Brander and Spencer, 1983; Bulow et al., 1985; Horiba and Tsutsui, 2000). We will not consider market entry in this paper, deferring to future research the study of such an issue in our framework.

[3] Several extensions to a non-pure oligopoly, such as to a situation in which profit-maximising firms compete with labour-managed firms, to mixed oligopolies, or in the presence of managerial delegation lead to more various results, depending on the modelling environment (e.g. Stewart, 1991; Zhang, 1993; Haruna, 1996; Wen and Sasaki, 2001; Nishimori and Ogawa, 2004; Lu and Poddar, 2005; Ogawa, 2006; Bárcena-Ruiz and Garzón, 2007; Tomaru et al., 2009; Fernández-Ruiz, 2012).

on unionised oligopoly – so far focused on firms' competition in the product market – to the case in which firms strategically compete also on capacities, and investigating the role of alternative unionisation structures in such a context . On the other hand, analysing under unionisation the robustness of the conventional result by the literature of dynamic (strategic) capacity choice, namely investing in over-capacity represents a strategic incentive for firms, despite its cost-inefficiency.

Our main results can be summarised as follows. Firstly, under unionisation (no matter whether decentralised or centralised) firms choose *under*-capacity unless unions are extremely oriented towards employment. This is because under-capacity also leads to relatively less employment, hence it acts as a device for firms to dampen unions' wage claims. Moreover, such result also implies that a given value for the union's employment-wage preference mix does exist, for which capacity choice efficiency is restored. More generally, decentralised unionisation is more "capacity choice-efficient" than non-unionisation only when unions are distinctly oriented towards wages or towards employment. Instead, a centralised unionisation structure always (that is, irrespective of the union's orientation towards wages or employment) outperforms non-unionisation and it is also preferable to decentralised unionisation unless unions are strongly oriented towards employment. We show that this relates to the fact that the central union's wage claims are less responsive to the level of capacity chosen by firms. Furthermore, we also highlight how wage-aggressiveness by unions contributes to reduce the "distortion" caused by the strategic incentive for firms towards over-capacity.

In relation to the comparison between alternative unionisation structures in terms of welfare outcomes, we show that, while profits are, as intuitive, always higher under decentralised unionisation, both consumer surplus and overall welfare can be, rather counter-intuitively, higher under a centralised structure. In particular, this actually applies, for consumer surplus, when unions are strongly oriented towards employment, and, for social welfare, unless unions

are extremely oriented towards employment or sufficiently oriented towards wages. These represent novel results since, due to the fact that a central union fixes a higher wage, output (consumer surplus) and welfare as a whole are generally larger in a decentralised structure. We point out how our unconventional results strongly relate to the interplay between the unions' role in setting wages and the strategic capacity choice by firms.

Finally, we also extend the basic framework with homogeneous goods and quantity competition in order to assess the robustness of the results summarised above, as well as to provide a better qualification of them. Most notably, introducing product differentiation and price competition into the analysis enlarges the range of situations, in which centralised unionisation outperforms a decentralised structure in terms of both capacity choice-efficiency and welfare outcomes.

The remaining part of the paper is organised as follows. In Section II., we introduce the basic model and present results of the benchmark case without unions. Section III. introduces unions into the analysis; we derive the equilibrium outcomes of the three-stage game with both decentralised (firm-specific) and centralised (wide-industry) union(s), discussing the main results concerning capacity choice. In Section IV., we analyse and compare alternative unionisation structures in terms of welfare outcomes. Section V. extends the basic framework (based on homogeneous products and Cournot competition) by considering also product differentiation and competition in prices. Finally, Section VI. concludes, while further details are relegated to the final Appendix.

II.   Model

We consider a duopolistic Cournot market for a single homogeneous product, with inverse demand given by:

$$p = 1 - Q \tag{1}$$

where p denotes price and Q is the sum of firms' output ($Q = q_1 + q_2$).[4] We also assume that firms have identical cost functions and following an established literature (e.g. Vives, 1986) we assume that, in relation the generic firm i ($i, j = 1, 2, i \neq j$), it takes the following form:

$$C_i = w_i l_i + (x_i - q_i)^2 \qquad (2)$$

where w_i is the per-worker wage (with $w_i < 1$), l_i is the employment level of the firm i and x_i is its production capacity, hence ($x_i - q_i$) represents the (positive or negative) "excess capacity". Particularly, under this cost function, it is easy to see that the long-run average cost is minimised when quantity equals production capacity, hence both over-capacity and under-capacity are "inefficient". Accordingly, the firm i's profits are defined as follows:

$$\pi_i = (1 - Q)q_i - w_i l_i - (x_i - q_i)^2. \qquad (3)$$

Moreover, we assume that both firms produce according to a standard production function with constant returns to labour, $q_i = l_i$, and following the unionised oligopolies literature, where the monopoly union model is widely adopted (e.g. Brekke 2004; Haucap and Wey 2004; Lommerud et al. 2005), we consider a situation in which wages are monopolistically chosen by union(s). Specifically, we consider the following three-stage game: in the first stage, each firm chooses its production capacity; in the second stage, unions choose wages; in the third stage, each firm chooses its output level. Figure 1 summarises the timing of events.

Particularly, in relation to the second stage, we analyse two alternative scenarios: i) unionisation is decentralised, hence two firm-specific unions choose wages for their own employees (firms); ii) unionisation is centralised, hence an industry-wide union chooses an uniform wage for all employees (firms) in the industry. This will permit us to compare the performances of those alternative

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[4]Notice that the more general inverse demand $p' = a - bQ'$ can be obtained from this normalised model simply by fixing $p = p'/a$ and $Q = (b/a)Q'$.
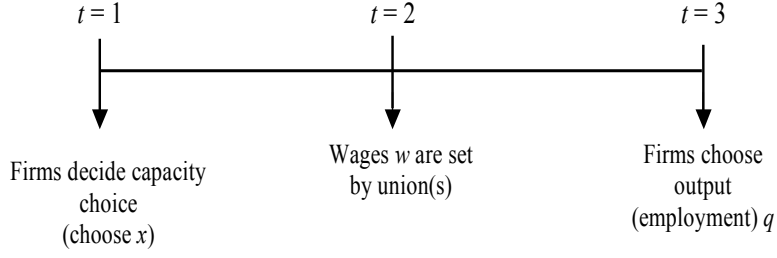
Figure 1: Timing

unionisation structures in relation to incentives for firms in choosing production capacity.

As usual, to look for a subgame perfect equilibrium, we solve the game backwards. At the third stage (the market game), firms choose output to maximise (3). In relation to the generic firm i, the first-order condition for profit maximisation leads to the firm's reaction function as:

$$q_i(q_j) = \frac{1 - w_i - q_j - 2x_i}{4} \tag{4}$$

and from (4), by substituting for the corresponding expression for the firm j, we get the equilibrium output by firm i, for given wages and production capacities:

$$q_i(\mathbf{w}, \mathbf{x}) = \frac{3 - 4w_i + w_j + 8x_i - 2x_j}{15}. \tag{5}$$

with $\mathbf{w} = (w_1, w_2)$ and $\mathbf{x} = (x_1, x_2)$.

II.A.   A benchmark case: capacity choice without unionisation

For following comparisons and discussion, it can be useful to recall equilibrium outcomes without unionisation. In this benchmark case, two only stages apply: in the first stage, each firm chooses its production capacity; in the second stage, each firm chooses its output level, given firms' production capacities.

Without loss of generality, let normalise to zero the exogenous wage for (non-unionised) workers, i.e. $w_i = w_j = 0$. By substituting (5) and the corresponding for firm j in (3), and maximising with respect to x_i drives to the following reaction function in capacity space:

$$x_i(x_j) = \frac{48 - 32x_j}{97} \tag{6}$$

which, in turn, leads to the following (symmetric) equilibrium choice of capacity and output:

$$x = \frac{16}{43}; \quad q = \frac{15}{43}. \tag{7}$$

From (7), the following remark can be stated.

Remark 1 *When wages are exogenously given, firms always choose over-capacity.*

III. Capacity choice under unionisation

III.A. Decentralised unionisation

In the presence of labour (monopoly) unions, the latter set wages at the second stage of the game (see Figure 1). Specifically, when unionisation is decentralised, firm-specific (symmetric) unions simultaneously fix wages for their own workers. We consider that unions have weighted preferences over wage and employment (e.g. Pencavel, 1984, 1985; Dowrick and Spencer, 1994) and, in particular, the utility of the firm i's union is given by the following general Stone-Geary utility function:

$$V_i = w_i^{\theta} l_i^{1-\theta} \tag{8}$$

where $\theta \in (0,1)$ is the relative weight placed by unions on wages with respect to employment. In particular, for $\theta > (<)\ 0.5$ unions have preferences relatively more wage-oriented (employment-oriented),

while $\theta = 0.5$ refers to the special case of total wage bill-maximising unions.[5]

Unions maximise their objective functions with respect to wages, taking firms' output decision into account. Substituting (5) in (8) and maximising with respect to w_i, we get:

$$w_i(w_j) = \frac{\theta(3 + w_j + 8x_i - 2x_j)}{4} \tag{9}$$

which defines the sub-game perfect best-reply function in wages of the union-firm pair i, under the assumption of a non-cooperative Cournot-Nash equilibrium in the product market. Solving the system composed by (9) and its counterpart for j, we get the sub-game perfect equilibrium wage, for given capacity choices x_i and x_j:

$$w_i(\mathbf{x}) = \frac{\theta^2(3 - 2x_i + 8x_j) + \theta(12 + 32x_i - 8x_j)}{16 - \theta^2} \tag{10}$$

and, by substituting (10) in (5) and (3), we get output and profit as a function of the capacity choices. At the first stage, firms simultaneously choose capacity to maximise their own profits, which leads to the following reaction function for the firm i:

$$x_i(x_j) =$$

$$\frac{64\left[192 - 348\theta + 117\theta^2 + 42\theta^3 - 3\theta^4 - (128 - 392\theta + 408\theta^2 - 152\theta^3 + 8\theta^4)x_j\right]}{24832 + 69632\theta - 48288\theta^2 + 4352\theta^3 + 97\theta^4} \tag{11}$$

and, in symmetric equilibrium, we get:

$$x^{DU} = \frac{64(16 - 33\theta + 18\theta^2 - \theta^3)}{2752 + 3024\theta - 2604\theta^2 + 203\theta^3} \tag{12}$$

$$q^{DU} = \frac{60(16 - 16\theta - \theta^2 + \theta^3)}{2752 + 3024\theta - 2604\theta^2 + 203\theta^3} \tag{13}$$

where the superscript DU recalls that they are obtained under decentralised unionisation.

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[5] A more general expression for the unions' utility function would be $V_i = (w_i - \overline{w})^\theta l_i^{1-\theta}$, which also includes the workers' reservation wage $\overline{w}$. Since our results would not change qualitatively, in order to streamline the exposition somewhat, we omit $\overline{w}$ (that can be thought as normalised to zero, such as the exogenous wage of Section II.A.).

Now, by exploiting (12) and (13), we determine the choice of the (positive or negative) excess capacity, which, interestingly, depends on the union's preference parameter.

Result 1 *Under decentralised unionisation, firms choose under-capacity unless unions are extremely oriented towards employment. When θ is extremely low, they choose instead over-capacity.*

Proof. By using (12) and (13), we get that, for $\theta \in (0, 1)$:

$$x^{DU} - q^{DU} =$$

$$\frac{4(16 - 288\theta + 303\theta^2 - 31\theta^3)}{2752 + 3024\theta - 2604\theta^2 + 203\theta^3} \gtreqless 0 \Leftrightarrow \theta \lesseqgtr \frac{136 - 60\sqrt{5}}{31} = 0.0592. \tag{14}$$

■

By defining as "capacity inefficiency" the absolute value of the excess capacity, by numerical comparison between equilibrium excess capacity in the benchmark (without unions) case and (14), we also get:[6]

$$\begin{cases} |x - q| > |x^{DU} - q^{DU}| & \text{if } \theta < 0.1384 \text{ and } \theta > 0.8997 \\ |x - q| < |x^{DU} - q^{DU}| & \text{otherwise} \end{cases} \tag{15}$$

hence, the following result can be stated in relation to the comparison between capacity-efficiency under decentralised unionisation and the case without unions.

Result 2 *When unions are distinctly oriented towards wages or towards employment, firms are more "capacity-efficient" under decentralised unionisation than in the case without unionisation.*

Figure 2 provides a graphical proof of Result 2 (as well as of Result 1). In particular, it displays the behaviour of $(x^{DU} - q^{DU})$ (red line) and compares it with that of $(x - q)$ (black line). Notice that,

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[6]All the numerical results and the graphical proofs that follow are derived in MAPLE (programs available from the authors upon request).
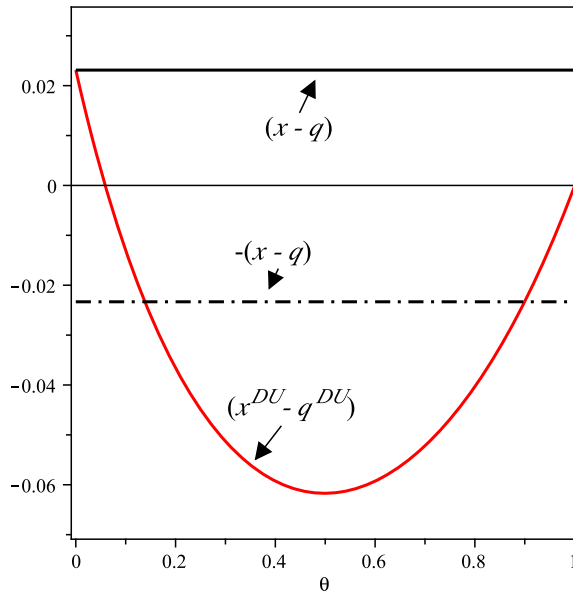
Figure 2: Excess capacity: decentralised unionisation vs. non-unionisation

in order to provide a clear-cut comparison of capacity-efficiency under the two alternative regimes, the excess capacity for the case without unionisation, which is always positive, is "mirrored" also with negative sign (dotted-dashed curve). Clearly, for a given θ value, capacity inefficiency is larger when the curve is farther from the x-axis.

Particularly, in line with Result 2, Figure 2 shows that, for intermediate values of θ, the non-unionisation regime is more capacity-efficient than decentralised unionisation, while the reverse holds true for extreme values of θ. Moreover, it is worth remarking that, while in the non-unionised case there is always capacity-inefficiency, under decentralised unions a recover of efficiency in capacity choice does exist for a given value of the unions' preferences parameter (that is, $\theta = 0.0592$).

The reason why unionisation reduces inefficiency, or even restores capacity-efficiency, lies in the mutual interaction between the two distortions in the labour and the product markets, respectively: the market power of unions induces firms to reduce the strategic use of the excess capacity because a higher capacity would mean higher

employment which, in turn, would strengthen the wage claim. In particular, there also exists a critical level of "wage-orientation" of unions such that the two distortions cancel each other out, as above shown.

III.B. Centralised unionisation

Now we consider the case of centralised unionisation. A monopoly industry-wide union chooses a single wage for all workers in the industry ($w_i = w_j = w$) to maximise:[7]

$$V = w^\theta (l_i + l_j)^{1-\theta}. \tag{16}$$

By substituting (5) and the corresponding equation of firm j (with $w_i = w_j = w$) in (16) and maximising with respect to w, we get:

$$w(\mathbf{x}) = \theta(1 + x_i + x_j). \tag{17}$$

Again, by substituting (17) in (5) and (3), we get output and profit as a function of the capacity choices. Firms simultaneously choose capacity at the first stage to maximise their own profits, which leads to the following reaction function for the firm i:

$$x_i(x_j) = \frac{2\left[24 - 33\theta + 9\theta^2 - (16 + 18\theta - 9\theta^2)x_j\right]}{97 + 96\theta - 18\theta^2} \tag{18}$$

and, in symmetric equilibrium, we get:

$$x^{CU} = \frac{2(8 - 11\theta + 3\theta^2)}{43 + 44\theta - 12\theta^2} \tag{19}$$

$$q^{CU} = \frac{15(1 - \theta)}{43 + 44\theta - 12\theta^2} \tag{20}$$

where the superscript CU recalls that they are obtained with a central union.

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[7]Clearly, since there is only one union, we do not need to use an index anymore to denote it.
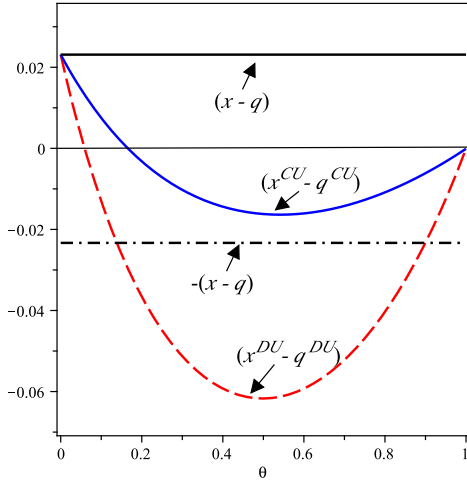
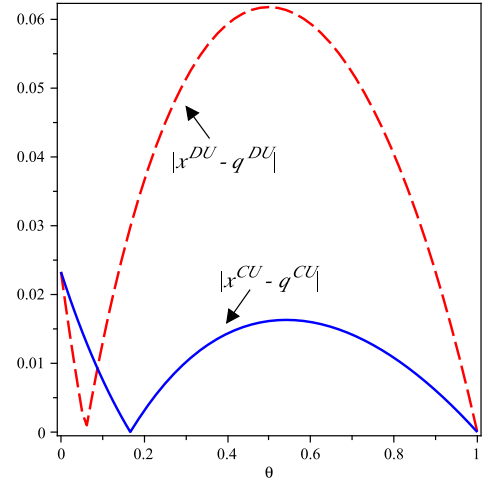Figure 3: Excess capacity: centralised, decentralised and non-unionisation

Figure 4: Excess capacity (absolute values): decentralised vs. centralised unionisation

Result 3 *Under centralised unionisation, firms choose under-capacity unless union is sufficiently oriented towards employment. When θ is sufficiently low, they choose instead over-capacity.*

Proof. By using (19) and (20), we get that, for $\theta \in (0,1)$:

$$x^{CU} - q^{CU} =$$

$$\frac{1 - 7\theta + 6\theta^2}{43 + 44\theta - 12\theta^2} \gtreqless 0 \Leftrightarrow \theta \lesseqgtr \frac{1}{6} = 0.1667. \qquad (21)$$

∎

Result 4 *Firms are always more "capacity-efficient" under centralised unionisation than in the case without unionisation. That is, the following always applies:*

$$|x^{CU} - q^{CU}| < |x - q| \quad \text{for any} \ \ \theta \in (0,1).$$

Figure 3 provides a graphical proof of Result 4. Furthermore, it also compares the behaviour of the excess capacity under centralised unionisation (blue line) and decentralised unionisation (red dashed line), showing that, unless unions are very strongly oriented towards employment, a centralised structure leads to a more efficient outcome (this appears even more clearly in Figure 4, in which

excess capacity behaviour under alternative unionisation structure is plotted in absolute value).

In particular, by numerical comparison between (14) and (21), we get:

$$|x^{DU} - q^{DU}| > |x^{CU} - q^{CU}| \quad \text{if} \ \ \theta > 0.0876 \qquad (22)$$

and the following result can be stated.

Result 5 *Generally, firms are more "capacity-efficient" under centralised unionisation than under decentralised unionisation. Indeed, the reverse only applies when unions are very strongly oriented towards employment.*

By concluding this section, the economic intuition behind the above findings is worth remarking. Firstly, notice that, regardless of the unionisation structure, the higher the capacity chosen by firms, the higher the wage set by the union(s). Indeed, taking (10) and (17) into account, we get:

$$\frac{\partial w(\mathbf{x})}{\partial x_i}\bigg|^{DU} = \frac{2\theta(16 - \theta)}{16 - \theta^2} > 0 \quad \text{for any} \ \ \theta \in (0, 1) \qquad (23)$$

$$\frac{\partial w(\mathbf{x})}{\partial x_i}\bigg|^{CU} = \theta > 0 \quad \text{for any} \ \ \theta \in (0, 1). \qquad (24)$$

Hence, in order to dampen wage claims, firms will choose a lower level of capacity than in the absence of unionisation. This implies that, although unionisation leads to a higher wage and lower output, the reduction in production capacity chosen by firms is generally larger than the decrease of output, so resulting in under-capacity.

Secondly, when, from one hand, unions only care about employment (i.e. $\theta \to 0$), wages are *de facto* exogenous hence, regardless of the unionisation structure, equilibrium outcomes (including capacity choice) parallel those of the benchmark case without unions. On the other hand, different unionisation structures lead to the same

results also when $\theta \to 1$.[8] In particular, when unions tend to be only oriented towards wages, excess capacity is zero irrespective of the unions' structure, which means that the negative (with respect to profit) "wage effect" of increasing capacity exactly offsets the standard positive "competition effect", highlighted by the received literature on strategic capacity choice.

Moreover, by means of a simple comparison between (23) and (24), it is possible to verify that $(\partial w(\mathbf{x})/\partial x_i)|^{DU}$ is always greater than $(\partial w(\mathbf{x})/\partial x_i)|^{CU}$:[9] the wage under centralised unionisation is more sensitive to the level of capacity with respect to that fixed by firm-specific unions. In other words, firms may obtain a given reduction of wages with a lower cut of production capacity when unions are centralised. This explains why, unless θ tends to zero or to one, the production capacity chosen by firms under centralised unionisation is always higher, hence under-capacity is lower, than in a decentralised structure.

IV. Welfare results under alternative unionisation structures: a comparison

In this section, starting from the equilibrium outcomes above obtained, we perform a welfare analysis. This will also permit to assess whether the conventional wisdom that decentralised unions should be welfare-preferred still applies to a duopolistic setting with (strategic) capacity choice.

In particular, by using (3), (10), (12), (13) and (17), (19), (20), we get that equilibrium wage and profit under alternative unionisation structures are given by, respectively:

$$w^{DU} = \frac{225\theta(16 - \theta^2)}{2752 + 3024\theta - 2604\theta^2 + 203\theta^3} \tag{25}$$

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[8]From (10) and (17), it is easy to check that in (symmetric) equilibrium with $x_i = x_j$, wages are the same under centralised and decentralised unionisation when $\theta \to 1$ (see also (25) and (27) below).

[9]This simply derives by noting in (23) that $2(16 - \theta)/(16 - \theta^2) > 1$ for any $\theta \in (0, 1)$.

$$\pi^{DU} = \frac{32(24832 + 19968\theta - 162720\theta^2 + 170560\theta^3 - 56895\theta^4 + 4158\theta^5 + 97\theta^6)}{(2752 + 3024\theta - 2604\theta^2 + 203\theta^3)^2} \quad (26)$$

and

$$w^{CU} = \frac{75\theta}{43 + 44\theta - 12\theta^2} \quad (27)$$

$$\pi^{CU} = \frac{2(97 - 98\theta - 113\theta^2 + 132\theta^3 - 18\theta^4)}{(43 + 44\theta - 12\theta^2)^2}. \quad (28)$$

Furthermore, by considering that consumer surplus is $CS = 2q^2$ and overall welfare is $SW = 2\pi + 2wl + CS$,[10] we get that:

$$SW^{DU} = \frac{8(429056 + 562944\theta - 1964160\theta^2 + 1314080\theta^3 - 375060\theta^4 + 34839\theta^5 - 1699\theta^6)}{(2752 + 3024\theta - 2604\theta^2 + 203\theta^3)^2}$$

$$\quad (29)$$

$$SW^{CU} = \frac{2(419 + 479\theta - 1126\theta^2 + 264\theta^3 - 36\theta^4)}{(43 + 44\theta - 12\theta^2)^2} \quad (30)$$

and the following results can be stated:

Result 6 (welfare comparisons) *By comparing equilibrium outcomes under alternative unionisation structures, the following results apply:*

- *firms' profits are always higher under decentralised unionisation than under centralised unionisation;*

- *unless unions are strongly oriented towards wages, total wage bill is higher under centralised unionisation than under decentralised unionisation. Instead, the reverse holds when $\theta > 0.7090$;*

- *unless unions are strongly oriented towards employment, consumer surplus is higher under decentralised unionisation than under centralised unionisation. In particular, the reverse holds when $\theta < 0.1287$;*

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[10]Notice that we use the total wage bill instead of union utility in the welfare function. In this choice we follow many others in the literature (e.g. Brander and Spencer, 1988; Mezzetti and Dinopoulos, 1991; Zhao, 2001) and this can be explained by the fact that unions' members are also final good consumers. Alternatively, since in our case the wage bill also corresponds to the union's rent (reservation wage is normalised to zero), the latter can be considered as a part of the producer surplus (Bughin and Vannini, 1995).
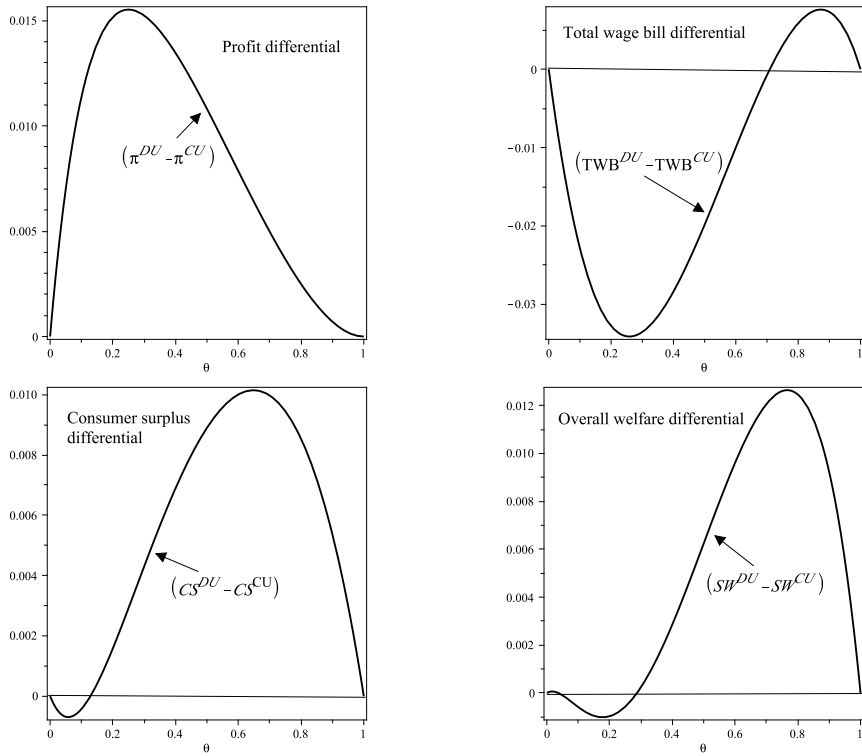
Figure 5: Decentralised vs. centralised unionisation: welfare comparisons

- *social welfare as a whole is higher under centralised unionisation unless unions are extremely oriented towards employment or sufficiently oriented towards wages, that is for $0.037 < \theta < 0.2873$. Otherwise, it is higher under decentralised unionisation.*

Figure 5 provides a graphical proof of Result 6, which economic intuition can be explained as follows. Firstly, notice that, although cost-inefficiency linked to excess capacity is generally higher with firm-specific unions, the standard result that profits are larger under decentralised unionisation is always confirmed. This means that larger excess-capacity costs under decentralised unionisation are more than offset by the higher wages fixed by a central union. However, for reasons that have already been discussed, the profit differential in favour of firm-specific unions tends to reduce rapidly as θ increases.

On the other side, unless unions are not too much wage-aggressive, the total wage bill is always higher with a central union. Moreover, if

unions are strongly employment-oriented, also the consumer surplus is higher under centralised unionisation. The latter is a novel result since, due to the fact that a central union sets a higher wage than firm-specific unions, resulting output (hence consumer surplus) is generally lower in the former unionisation structure.[11] This unconventional finding strongly relates here to the role played by capacity choice. Indeed, since under centralised unionisation firms choose higher capacity to dampen the union's (higher) wage claims (and taking into account that when θ is low, excess capacity is positive), they also increase output to reduce cost-inefficiency due to excess capacity. Thus there exists a range, for which unions are properly employment-oriented, where consumer surplus and total wage bill differentials (in favour of centralised unionisation) together prevail on profit differential (in favour of decentralised unionisation) and, as a consequence, social welfare as a whole is actually higher in a centralised structure.

V.   *Extensions*

In what follows we aim at testing the robustness of the above results, as well as at better qualifying them. In particular, we extend the basic framework by introducing product differentiation and price competition into the analysis.

V.A.   Product differentiation

Firms still compete in a Cournot framework but with differentiated products and we assume that each firm i is faced with the following (inverse) demand function, which replaces (1) in the analysis:

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[11]In Fanti and Meccheri (2013), it is established an "irrelevance result" in the presence of managerial delegation (i.e. firms' owners delegate output decisions to managers), according to which consumer surplus (and overall welfare) does not depend on the unions' structure. However, the (strict) preference by consumers and society for a centralised wage setting structure is not established.

$$p_i = 1 - q_i - cq_j \qquad (31)$$

where $c \in (-1, 1)$ represents the degree of product differentiation. Specifically when $-1 < c < 0$ products are complements (the higher $|c|$, the higher the degree of complementarity), for $0 < c < 1$ products are substitutes (the higher c, the higher the degree of substitutability), while for $c = 0$ they are independent.

In this context, in the non-unionised case, by paralleling the analysis of Section II.A., we get that the excess capacity is given by:

$$x_D - q_D = \frac{c^2}{32 + 16c - 4c^2 - c^3} \qquad (32)$$

where the subscript D refers to the differentiated products case. (32) implies that firms choose over-capacity unless products are independent. Clearly, in the latter case, since the product markets are completely separated, there is no advantage for firms to manipulate capacity strategically, hence excess-capacity is null.

Instead, under alternative unionisation structures, the following outcomes apply in equilibrium:[12]

$$x_D^{DU} - q_D^{DU} = -\frac{4 \left[16c^2 - (256 + 32c^2)\theta + (256 + 48c^2 - c^4)\theta^2 - (32c^2 - c^4)\theta^3 \right]}{Y} \qquad (33)$$

and

$$x_D^{CU} - q_D^{CU} = \frac{c^2 - (8 - 2c + c^2)\theta + (8 - 2c)\theta^2}{Z} \qquad (34)$$

where $Y = 64c^3 + 256c^2 - 1024c - 2048 - (64c^3 + 128c^2 + 16c^4 - c^6 - 4c^5)\theta^3 + (64c^3 + 512c^2 - 16c^4 - 4c^5 + 2048)\theta^2 - (16c^4 + 64c^3 - 1024c - 128c^2 + 4096)\theta$ and $Z = c^3 + 4c^2 - 16c - 32 + (16 - 4c)\theta^2 - (48 - 4c)\theta$.

From (33) and (34) the following result can be stated.

Result 7 *Under both decentralised and centralised unionisation, firms choose under-capacity unless unions are sufficiently oriented towards employment (i.e. unless θ is sufficiently low). Moreover, the lower the degree of product differentiation (that is, the lower $|c|$), the lower*

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[12]See Appendix A.1 for their analytical derivations.

the value of θ above which firms choose under-capacity. In particular, when products are independent ($c = 0$), firms choose under-capacity for any θ.

Proof. By using (33), we get:

$$x_D^{DU} - q_D^{DU} \gtreqless 0 \Leftrightarrow \theta \lesseqgtr \overline{\theta}_D^{DU} \equiv \frac{4\left[32 + 2c^2 - \sqrt{1024 + 128c^2 - 28c^4 + c^6}\right]}{c^2(32 - c^2)}. \tag{35}$$

Moreover, by differentiating $\overline{\theta}_D^{DU}$ with respect to c, we get:

$$d(\overline{\theta}_D^{DU})/dc =$$

$$\frac{4\left[65536 - 384c^4 + 24c^6 - c^8 - (2048 - 128c^2 - 4c^4)\sqrt{1024 + 128c^2 - 28c^4 + c^6}\right]}{c^3(32 - c^2)^2\sqrt{1024 + 128c^2 - 28c^4 + c^6}}. \tag{36}$$

In particular, notice that $\overline{\theta}_D^{DU}$ is positive except when $c = 0$, for which is zero. Hence, in such a case $\theta > \overline{\theta}_D^{DU}$ for any $\theta \in (0, 1)$, implying that firms always choose under-capacity.

Similarly, by using (34), we get:

$$x_D^{CU} - q_D^{CU} \gtreqless 0 \Leftrightarrow \theta \lesseqgtr \overline{\theta}_D^{CU} \equiv \frac{c^2}{2(4 - c)}. \tag{37}$$

By differentiating $\overline{\theta}_D^{CU}$ with respect to c, we get:

$$\frac{d(\overline{\theta}_D^{CU})}{dc} = \frac{c(8 - c)}{2(4 - c)^2} \tag{38}$$

hence, also under centralised unionisation $\overline{\theta}_D^{CU} = 0$ for $c = 0$ and, in such a case, firms always choose under-capacity irrespective of θ. ∎

Figures 6 and 7 below provide a graphical illustration of Result 7. In particular, according to the unionisation regime, all the couples θ-c that lie above the threshold values $\overline{\theta}_D^{DU}$ or $\overline{\theta}_D^{CU}$ (grey areas) are those for which firms choose under-capacity.
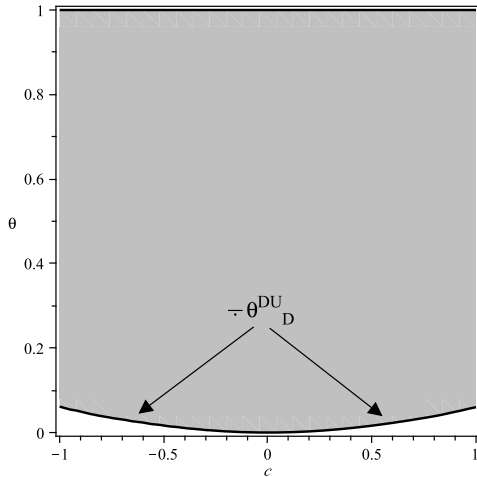
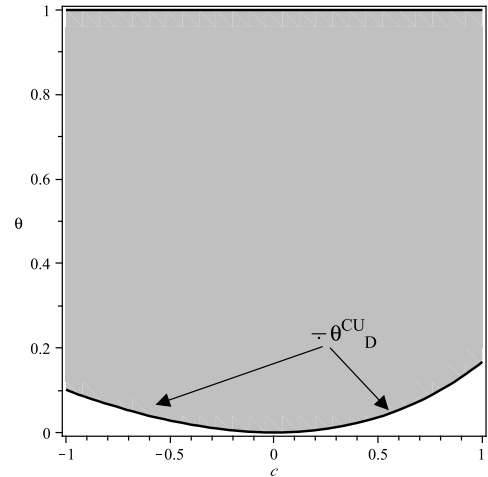Figure 6: Excess capacity threshold under decentralised unionisation

Figure 7: Excess capacity threshold under centralised unionisation

From the above figures, it is also worth noting that a sort of "asymmetry" between unionisation regimes does exist for extreme values of c. Indeed, while under decentralised unionisation the critical threshold for θ is the same irrespective of the fact that goods are perfect substitutes or complements, under centralised unionisation under-capacity is more likely to apply when goods are perfect complements than perfect substitutes.[13]

Figure 8, instead, provides graphical evidence on the capacity choice behaviour under alternative unionisation structures (including non-unionisation) for different degrees of product differentiation. Clearly, since under non-unionisation the excess capacity is zero for $c = 0$, such regime generally becomes more capacity-efficient than unionisation as products tend to be more independent. Notice, however, that even when products are scarcely related (e.g. $c = \pm 0.5$), unionisation outperforms non-unionisation when unions are strongly oriented towards employment or towards wages.

Furthermore, in relation to the comparison of alternative unionisation structures (decentralised vs. centralised), Result 5 (obtained with homogenous products) is largely confirmed, except for the special case with $c = 0$, in which centralised unionisation is *always* (i.e.

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[13]Specifically, we get that $\overline{\theta}_D^{DU}|_{c=1} = \overline{\theta}_D^{DU}|_{c=-1} = 0.0592$, while $\overline{\theta}_D^{CU}|_{c=1} = 0.1667 > 0.1 = \overline{\theta}_D^{CU}|_{c=-1}$.
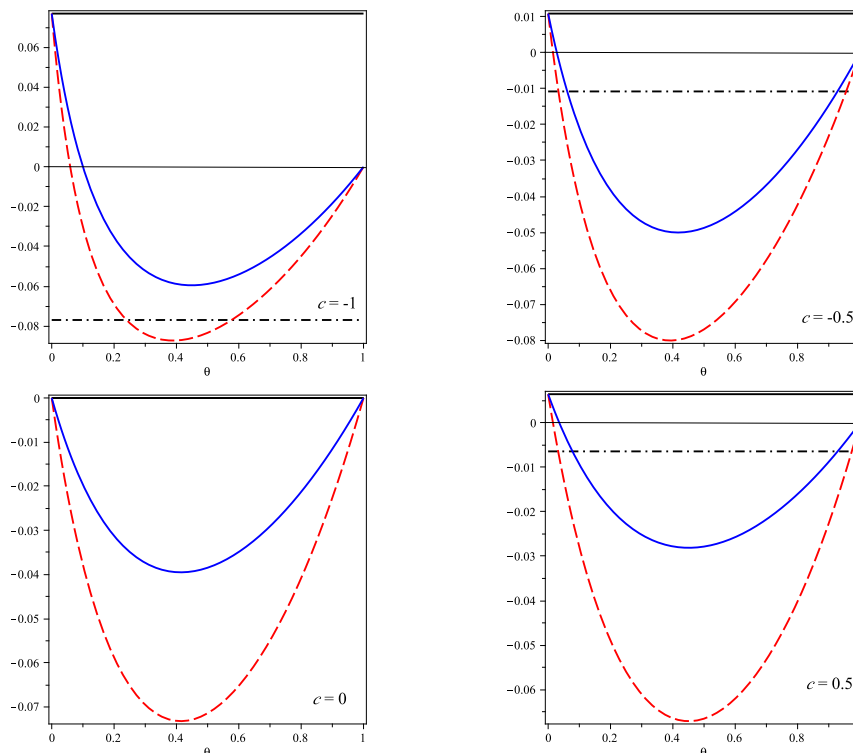
Figure 8: Excess capacity behaviour with selected values of product differentiation

for any θ) more efficient than a decentralised structure.

Finally, Figure 9 shows for which combinations of θ and c, a decentralised unionisation structure outperforms a centralised structure (white area), and *viceversa* (grey area), in terms of welfare outcomes. In particular, according to the figure, the following results can be highlighted:

- irrespective of the degree of unions' attitude towards wages or employment, firms' profits are higher under decentralised (centralised) unionisation when products are substitutes (complements);

- total wage bill is higher under centralised unionisation unless: i) products are substitutes *and* unions are strongly oriented towards wages; or ii) products are sufficiently complements *and* unions are strongly oriented towards employment;
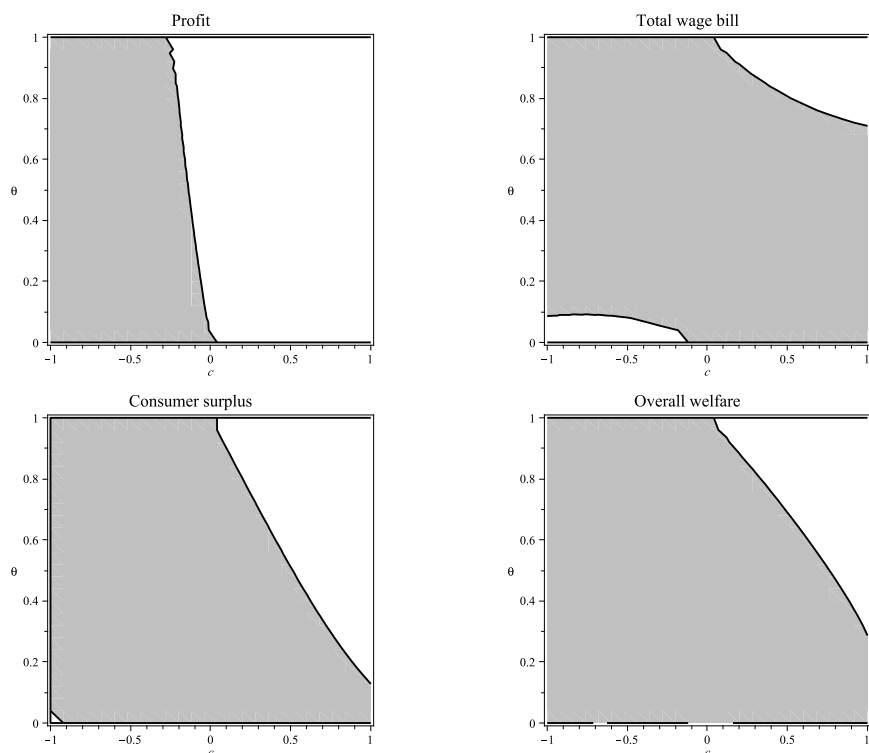
Figure 9: Decentralised vs. centralised unionisation: welfare comparisons with product differentiation

- generally, consumer surplus[14] is higher under centralised unionisation; the reverse only applies if products are substitutes and unions are sufficiently oriented towards wages, or in the special case in which products are (near-)perfect complements and unions are (near-)completely oriented towards employment;

- also social welfare is generally higher under centralised unionisation. In particular, the conventional wisdom that decentralised unions are welfare-preferred only applies when product are substitutes and unions are sufficiently oriented towards wages or in the special case with perfect substitutes and extremely oriented towards employment unions (see Result 6).

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[14]Recall that in this framework with product differentiation, consumer surplus is $CS = (1 + c)q^2$.

V.B. Price competition

Now, we consider a model of differentiated duopoly where firms compete in prices, i.e. a Bertrand model. From (31) and its counterpart for firm j, we can write firm i's product demand as:

$$q_i = \frac{1 - p_i - c(1 - p_j)}{1 - c^2} \tag{39}$$

and, by standard analysis, we obtain that the excess capacity in the non-unionised case is:

$$x_B - q_B = -\frac{c^2(3 - c^2)}{32 + 16c - 28c^2 - 9c^3 + 9c^4 + c^5 - c^6} \tag{40}$$

where the subscript B refers to the Bertrand case. As expected, the result obtained under quantity competition is reversed when firms compete in prices: unless products are independent (for which excess capacity is null), firms always choose under-capacity.
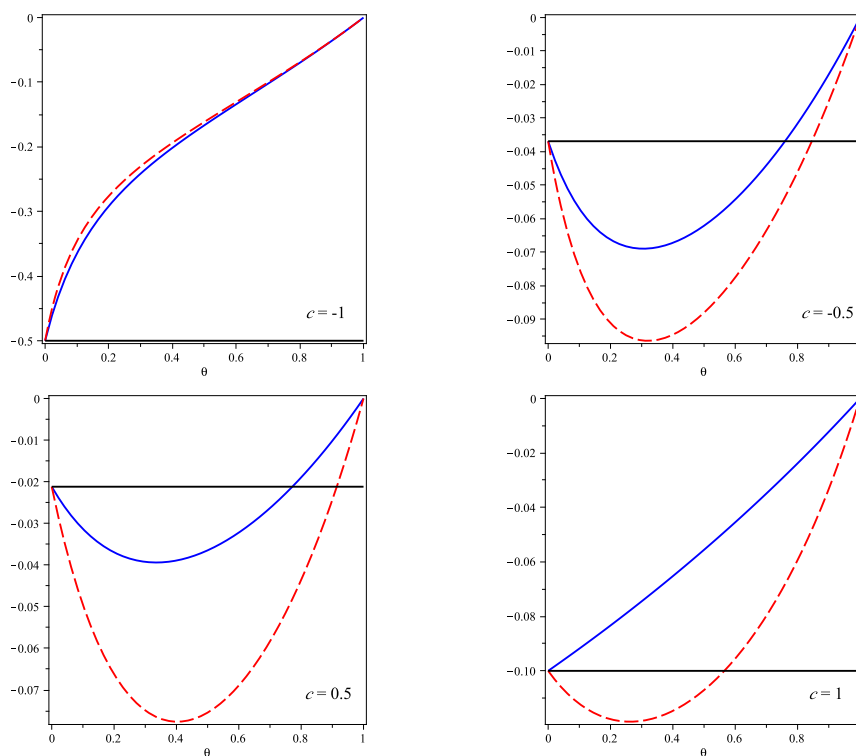

Figure 10: Excess capacity with selected values of c under price competition

Due to numerical complexity, the formal results with price competition relative to the unionised cases are rather unmanageable, thus their study is performed by means of graphical analyses.[15] In particular, Figure 10 shows, under alternative unionisation structures, the excess capacity behaviour according to θ, for selected values of the degree of product differentiation. Firstly, notice that, under price competition, firms always opt for under-capacity regardless of the unionisation structure. Moreover, the following results are worth remarking:

- when products tend to be perfect complements $(c \rightarrow -1)$, unionisation is always (i.e. for any θ) more capacity-efficient than non-unionisation. Moreover, under unionisation, "cost inefficiency" monotonically decreases as θ increases (unions become more wage-oriented), and the performance of alternative unions' structure is approximately the same (decentralised unionisation marginally outperforms a centralised union structure);

- while non-unionisation is always more cost-efficient when products are independent $(c = 0)$, unionisation can outperform non-unionisation for any $-1 < c < 1$, but this actually occurs only when unions are strongly oriented towards wages;

- unless when products are (near-)perfect complements $(c \rightarrow -1)$, from the cost-efficiency viewpoint, centralised unionisation is always better than decentralised unionisation. Moreover, in the special case of (near-)perfect substitutes $(c \rightarrow 1)$, centralised unionisation always outperforms non-unionisation too.

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[15]In Appendix A.2 we provide the preliminary results, which are needed to derive (computer-assisted) the excess capacity and the other welfare outcomes for this case.
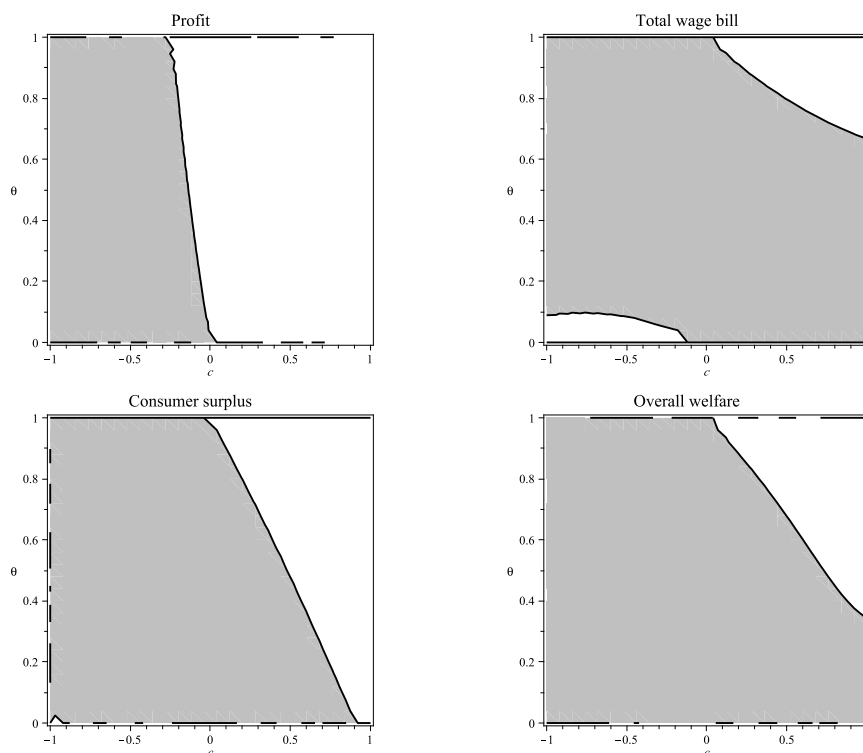
Figure 11: Decentralised vs. centralised unionisation: welfare comparisons with price competition

Finally, Figure 11 shows welfare comparisons between decentralised and centralised unionisation for different combinations of θ and c (recall that in the white area decentralised unionisation outperforms centralised unionisation, *viceversa* in the grey area). From the figure, it clearly arises as qualitative results obtained under quantity competition, described in Section V.A., are fully confirmed, hence they prove to be robust with respect to the mode of competition in the product market.[16]

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[16]The only slight difference with the quantity competition case that can be remarked refers to the consumer surplus. Indeed, when products tend to be perfect substitutes and firms compete in prices, consumer surplus is always (that is, for any θ) higher under decentralised unionisation. Instead, when firms compete in quantities, this applies only if θ is sufficiently high.

VI. Conclusion

In this paper, we have studied how unionisation structures that differ in the degree of wage setting centralisation interplay with the strategic choice of production capacity by firms, and how this affects product market and welfare outcomes. Our findings have shown that under unionisation firms generally opt for under-capacity, in sharp contrast with the traditional choice of over-capacity. This is due to the fact that, in the presence of unionisation, the "distortions" in the labour market (the "wage effect") and the product market (the standard "strategic capacity-choice effect") operate one against another, and (generally) the former prevails on the latter.

Furthermore, the capacity choice by firms is generally (i.e. unless unions are strongly oriented towards employment) more efficient under centralised unionisation than in a decentralised structure. Relative to more general welfare outcomes, we have pointed out that, while profits are always higher under decentralised unionisation, both consumer surplus and overall welfare can be higher under a centralised structure. In particular, this actually applies, for consumer surplus, when unions are strongly oriented towards employment, and, for social welfare, unless unions are extremely oriented towards employment or sufficiently oriented towards wages. Moreover, introducing product differentiation and price competition into the analysis enlarges the range of situations, in which centralised unionisation outperforms a decentralised structure.

These represent novel results since, due to the fact that a central union fixes a higher wage, the conventional belief would be that output (consumer surplus) and welfare as a whole are generally larger in a decentralised structure. Instead, our (unconventional) results, that strongly relate to the interaction between the unions' role in setting wages and the strategic capacity choice by firms, shed new light on the issue of which unionisation structure is more desirable from a welfare viewpoint and, in particular, provide a reason against the dominant wisdom that a decentralised structure is generally preferable.

Future research directed to further extend our model can be carried out along possible different lines. For instance, we have adopted a framework in which unions set wages after than firms have chosen capacity choice. This can be rationalised by the fact that, at least in the short-medium run, production capacity is generally an irreversible choice (i.e. modifying production capacity entails very large costs for firms), while changing workers' wages can be done more frequently. Nevertheless, considering also an alternative scenario, where the timing of moves relative to capacity choice and wage setting is reversed, deserves a future research. Furthermore, also market entry and union(s)-firms bargaining in determining wages are worth investigating in our framework. Notice, however, that in relation to wage bargaining, while we have to leave the final answers to further research, some preliminary intuitions could arise from this work by recalling that the monopoly union model, considered in this paper, represents a special case of the bargaining model where unions have all the bargaining power. On the other hand, the benchmark (without unions) model corresponds to the case with firms having all the bargaining power in determining wages. Hence, this suggests that in a more general bargaining model, the under-capacity result generally obtained here with unions (which contrasts with the over-capacity result of the benchmark case) should apply, provided that unions' bargaining power *vis-à-vis* firms is sufficiently large.

Appendix

A.1 Product differentiation

Decentralised unionisation   Under decentralised unionisation, product differentiation and quantity competition, in stage 3, the firm i maximises (3) with respect to q_i, taking (31) into account. In this case, the corresponding equation for (5) (equilibrium output for given wages and capacities) is:

$$q_i(\mathbf{w}, \mathbf{x}) = \frac{4(1 - w_i + 2x_i) - c(1 - w_j + 2x_j)}{16 - c^2}. \qquad \text{(A1)}$$

At the second stage, unions choose wages to maximise (8), taking (A1) into account, which leads to the following sub-game perfect equilibrium wage, for given capacities:

$$w_i(\mathbf{x}) = \frac{\theta \left[16 + 32x_i - 4c(1 + 2x_j) + \theta[4c(1 + 2x_j) - c^2(1 + 2x_i)]\right]}{16 - \theta^2 c^2}. \qquad \text{(A2)}$$

At the first stage, firms choose capacity to maximise their own profits taking (A1) and (A2) into account, which leads to the following symmetric equilibrium outcomes:

$$x_D^{DU} = \frac{64 \left[(32 + c^2)\theta - (16 + 2c^2)\theta^2 + c^2\theta^3 - 16\right]}{Y} \qquad \text{(A3)}$$

$$q_D^{DU} = \frac{4 \left[16c^2 + (256 - 16c^2)\theta + (16c^2 - c^4)\theta^2 - (16c^2 - c^4)\theta^3 - 256\right]}{Y} \qquad \text{(A4)}$$

where Y is defined in the main text. Finally, by substituting back, we get the following (equilibrium) result for wages:

$$w_D^{DU} = \frac{\theta \left[512c^2 - 16c^4 + (256c^2 - 32c^4 + c^6)\theta^2 - 4096\right]}{Y} \qquad \text{(A5)}$$

as well as the other welfare outcomes (profits, total wage bill, consumer surplus and overall welfare) that underlie Figure 9.[17]

Centralised unionisation   Under centralised unionisation, product differentiation and quantity competition, in stage 3, the firm i's output choice clearly parallels that relative to the decentralised unions case, hence equilibrium output, for given wages and capacities, is given by (A1) with $w_i = w_j = w$.

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[17]Due to their numerical complexity (lenght), they are not reported here. All the results that, for sake of space, are not explicitly showed are derivable by those here presented and, however, are available from the authors upon request.

At the second stage, the central union chooses w to maximise (16) taking (A1) into account, which leads to the following equilibrium wage, for given capacities:

$$w(\mathbf{x}) = \theta(1 + x_i + x_j). \qquad \text{(A6)}$$

At the first stage, firms choose capacity to maximise their own profits taking (A1) and (A6) into account, which leads to the following symmetric equilibrium outcomes:

$$x_D^{CU} = \frac{2\left[(12 - c)\theta - (4 - c)\theta^2 - 8\right]}{Z} \qquad \text{(A7)}$$

$$q_D^{CU} = \frac{(c^2 - 16)(1 - \theta)}{Z} \qquad \text{(A8)}$$

where Z is defined in the main text. Finally, by substituting back, we get the following equilibrium wage:

$$w_D^{CU} = \frac{\theta(c^3 + 4c^2 - 16c - 64)}{Z} \qquad \text{(A9)}$$

as well as the other welfare outcomes that underlie Figure 9.

A.2 Price competition

Decentralised unionisation   Under decentralised unionisation and price competition, in stage 3, firm i, taking (39) into account, maximises (3) with respect to p_i. This leads to the following equilibrium price, for given wages and capacities:

$$p_i(\mathbf{w}, \mathbf{x}) = \frac{12 - 7c^2 + c^4 + (2 - c^2)(2w_i - 4x_i) - (3c - c^3)(1 - w_j + 2x_j)}{16 - 9c^2 + c^4} \qquad \text{(A10)}$$

and, considering (39), equilibrium output, for given wages and capacities:

$$q_i(\mathbf{w}, \mathbf{x}) = \frac{(4 - c^2)(1 + w_i + 2x_i) - c(1 - w_j + 2x_j)}{16 - 9c^2 + c^4}. \qquad \text{(A11)}$$

In stage 2, the unions maximise (8) taking (A11) into account, which leads to the following equilibrium wage, for given capacities:

$$w_i(\mathbf{x}) = \frac{\theta\left[(16 + c^4 - 8c^2 + \theta c^2)(1 + 2x_i) + (c^3 - 4c - \theta c^3 + 4\theta c)(1 + 2x_j)\right]}{16 + c^4 - 8c^2 - \theta^2 c^2}.$$
(A12)

At the first stage, the analysis proceeds as in the previous sections. Particularly, firms make capacity choices to maximise their own profits taking (A11) and (A12) into account, which then leads to the following symmetric equilibrium values for production capacity and output, respectively (the subscript B refers to the Bertrand case):

$$x_B^{DU} = -\frac{2\left[\begin{array}{c} c^{10}(1 + \theta^2 - 2\theta) - c^8(18 + \theta^3 + 16\theta^2 - 35\theta) \\ +2c^6(64 + 5\theta^3 + 54\theta^2 - 123\theta) - 32c^4(14 + \theta^3 + 12\theta^2 - 27\theta) \\ +32c^2(24 + \theta^3 + 22\theta^2 - 47\theta) - 512\theta^2 + 1024\theta - 512 \end{array}\right]}{\left[\begin{array}{c} c^{12} + c^{11}(\theta - 1) + c^{10}(3\theta^2 - 9\theta - 21) + c^9(21 - \theta^3 + \theta^2 - 21\theta) + c^8(184 - 3\theta^3 - 47\theta^2 + 157\theta) \\ +c^7(13\theta^3 - 13\theta^2 + 172\theta - 172) + c^6(328\theta^2 - 1088\theta - 864) + c^5(688 - 52\theta^3 + 52\theta^2 - 688\theta) \\ +c^4(2304 - 112\theta^3 - 1264\theta^2 + 3728\theta) + c^3(31\theta^6 + 64\theta^3 + 64\theta^2 + 1344\theta - 1344) \\ +c^2(2560\theta^2 - 6272\theta - 3328) + c(1024 - 1024\theta) - 2048\theta^2 + 4096\theta + 2048 \end{array}\right]}$$
(A13)

$$q_B^{DU} = \frac{\left[\begin{array}{c} (c^{10} - 1024)(\theta - 1) + c^8(21 - \theta^3 + \theta^2 - 21\theta) + c^6(13\theta^3 - 13\theta^2 + 172\theta - 172) \\ +c^4(688 - 52\theta^3 + 52\theta^2 - 688\theta + 688) + c^2(64\theta^3 - 64\theta^2 + 1344\theta - 134) \end{array}\right]}{\left[\begin{array}{c} c^{12} + c^{11}(\theta - 1) + c^{10}(3\theta^2 - 9\theta - 21) + c^9(21 - \theta^3 + \theta^2 - 21\theta) + c^8(184 - 3\theta^3 - 47\theta^2 + 157\theta) \\ +c^7(13\theta^3 - 13\theta^2 + 172\theta - 172) + c^6(328\theta^2 - 1088\theta - 864) + c^5(688 - 52\theta^3 + 52\theta^2 - 688\theta) \\ +c^4(2304 - 112\theta^3 - 1264\theta^2 + 3728\theta) + c^3(31\theta^6 + 64\theta^3 + 64\theta^2 + 1344\theta - 1344) \\ +c^2(2560\theta^2 - 6272\theta - 3328) + c(1024 - 1024\theta) - 2048\theta^2 + 4096\theta + 2048 \end{array}\right]}$$
(A14)

from which equilibrium values for excess capacity, wages and the other welfare outcomes that underlie Figures 10 and 11 are obtained.

Centralised unionisation Under centralised unionisation and price competition, in stage 3, the firm i's choice relative to the price, as before, parallels that relative to the decentralised unions case and equilibrium price and output, for given wages and capacities, are given by (A10) and (A11), respectively, with $w_i = w_j = w$.

At the second stage, the central union chooses w to maximise (16) taking (A11) into account, which leads to the following equilibrium

wage, for given capacities:

$$w(\mathbf{x}) = \theta(1 + x_i + x_j).^{18} \qquad (\text{A15})$$

At the first stage, firms choose capacity to maximise their own profits taking (A11) and (A15) into account, which leads to the following symmetric equilibrium outcomes:

$$x_B^{CU} = \frac{(8 + c^4 - 6c^2)(3\theta - \theta^2 - 2) + (c^3 - 2c)(\theta - \theta^2)}{\begin{bmatrix} c^6 - c^5 - 6\theta c^4 + 2\theta^2 c^4 - 9c^4 - 2\theta c^3 + 2\theta^2 c^3 + 9c^3 + 36\theta c^2 \\ +28c^2 - 12\theta^2 c^2 - 4\theta^2 c + 4\theta c - 16c + 16\theta^2 - 48\theta - 32 \end{bmatrix}} \qquad (\text{A16})$$

$$q_B^{CU} = \frac{(9c^2 - c^4 - 16)(1 - \theta)}{\begin{bmatrix} c^6 - c^5 - 6\theta c^4 + 2\theta^2 c^4 - 9c^4 - 2\theta c^3 + 2\theta^2 c^3 + 9c^3 + 36\theta c^2 \\ +28c^2 - 12\theta^2 c^2 - 4\theta^2 c + 4\theta c - 16c + 16\theta^2 - 48\theta - 32 \end{bmatrix}} \qquad (\text{A17})$$

from which equilibrium values for excess capacity, wages and the other welfare outcomes that underlie Figures 10 and 11 are obtained.

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[18]From (17), (A6) and (A12), it is possible to note that the (central) union's choice *at this stage* (as a function of capacity choices by firms) is the same independently by the degree of product substitutability (differentiation) and by fact that firms compete in quantities or in prices. However, since equilibrium capacity changes according to the degree of product differentiation and the competition regime, the (symmetric) sub-game perfect equilibrium wage also is different. This implies that the well-known "wage rigidity result" by Dhillon and Petrakis (2001) does not apply to our three-stage game.

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