No 475

JULY 2021

CefES

Center for European Studies

PAPER SERIES

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DIPARTIMENTO DI ECONOMIA, METODI QUANTITATIVI E STRATEGIA DI IMPRESA

UNIVERSITA' DEGLI STUDI DI MILANO BICOCCA

It takes two to tango: Interlockings and Partial Equity Ownership

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This version: 19th July 2021

Abstract

We study the relation between the acquisition of a partial equity ownership and interlocking directorates among rival companies. Partial equity ownership between rivals in the product market is convenient, even in the case of passive participation, since, by internalizing competition, it raises the profits of both companies. The price of the acquisition, however, is affected by the marginal cost of the target company. When this cost is private information, the bidder has to elicit the true value of the equity stake from the target through a proper design of the offer in the context of asymmetric information. One possible alternative is for the bidder to propose an interlocking directorate to observe the private cost: to achieve this goal, the bidder has to convince the target to host one of his executives on the board. We build a novel framework to analyze the choice to interlock together with the acquisition of a minority equity stake and study when the two events are observed at the equilibrium. We suggest that interlocking directorates may be ancillary to a minority acquisition when the value of the target is private information.

JEL classification: D4 (Market Structure and Pricing); G3 (Corporate Finance and Governance); L2 (Firm Objectives, Organization and Behavior).

Keywords: Interlocking Directorates; Partial Equity Ownership; Information; Oligopoly.

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1 Introduction

Interlocking directorates and partial equity ownership are widespread phenomena among competitors in the marketplace.

In Europe more than 10% of the companies share the same executives and this percentage raises to 19% among the largest EU companies (see van Veen and Kratzer, 2011; Heemskerk, 2013). Interlocking directorates among companies have been widely investigated within the literature of management and sociology, suggesting that resource-seeking, monitoring, reducing market uncertainty, internalizing potential conflicts and assessing human capital are the reasons for building strategic alliances and ties (see *e.g.* Lamb and Roundy, 2016). Companies through interlocks may gather private information and therefore gain competitive advantages (see *e.g.* Larcker and Tayan, 2010). It is also common to observe partial equity ownership among rival companies worldwide, when the control remains in the hands of the target company: for instance, in the acquisition of non-voting stocks by Gilette in Wilkinson Sword in 1989, in the acquisition by Microsoft of about 7% of the non-voting stock in Apple in 1997, in the passive investment by TCI in Time Warner in 1999 or the acquisition of minority stock holdings of 25% by Ryanair in Air Lingus in 2006, rising to 29.8% in 2008 (see Gilo, 2000; Ezrachi and Gilo, 2006; OECD, 2008).

Although interlocking directorates and cross-ownerships are considered an equivalent form of ties between companies, from the antitrust perspective, they play a different role. Khanna and Thomas (2009) show that these two ties improve the synchronicity of companies' stock prices, however with different intensities. This evidence leaves unexplained their difference. In the present paper, we study interlocking directorates and partial equity ownership together as we believe they are intertwined aspects of the same business strategy, although each of them plays a specific role. In particular, we believe that interlocking directorates are ancillary to partial acquisitions. This intuition finds support in the empirical evidence showing that partial acquisitions are more likely among companies directly connected through interlocking directorates at the time of the deal (see Stuart and Yim, 2010; Renneboog and Zhao, 2014). Also, the price paid in the acquisition is significantly lower when the interlocking director comes from the acquiring company, since interlocking directorates reduce the asymmetry of information between the two companies. "*Having a board connection between two firms may improve information flow and communication between the firms, and increase each firm's knowledge and understanding of the other firm's operations and corporate culture.... The information advantage may also affect the takeover premium and hence the transaction price of the deal. This is because acquirers with a board connection to the target may enjoy a bargaining advantage in deal negotiations due to their private information about the target firm relative to outside bidders with no connection to the target.*" (Cai and Seviril, 2012, p.327).

We consider the acquisition of a minority equity stake between rivals in the product market. We restrict our analysis to passive ownership, that is, when the target does not transfer any control over its strategic variables, contrary to what happens in full mergers. Even in this case, the two companies gain from the deal since they internalize the effect of their actions on the profits, thus softening competition (see, for instance, the empirical evidence in Nain and Wang, 2018). In our framework, we assume that the bidder does not know the marginal cost of the target and thus, might benefit from reducing the asymmetry of information when bidding. Through an interlocking, the external director observes the marginal cost of the target company. Interlocking may become, therefore, instrumental to the corporate deal. For the interlocking to occur, however, the target company has to accept hosting the executive of the future acquiring company on its board. The choice to interlock is the outcome of the strategic interaction between the two companies in the context of imperfect information. When interlocking, the bidder gains accuracy to design a proper bid. The target company agrees to open its board and, as a result, discloses its private information only when this leads to more favorable terms in the acquisition. We discuss the characteristics of the equilibrium in which interlocking directorates and partial equity ownership coexist.

We model a three-stage game: in the first stage, the bidder and the target might agree on the interlocking, in the second stage the bidder makes an offer to acquire a non-controlling block in the target company and finally, the two companies compete *à la* Cournot in the product market. To anticipate our results, we show that depending upon the level of efficiency of the target company, the bidder will succeed in having one of his executives sitting on the board of the target, before launching the bid. Without interlocking, the bidder, facing adverse selection, cannot condition the deal to the true type (either efficient or inefficient) of the target company. Hence, the bidder will offer a higher price to acquire the stake to induce truth-telling by the inefficient target. When deciding to host one of the directors of the acquiring company, the target company discloses its marginal cost. While the efficient type gains from disclosure in the product market, the inefficient type has to give up the rent of asymmetric information. Hence, only the efficient target accepts the interlocking, while the inefficient does not. The paper shows how the proposal to interlock can be used as a screening device in the market for corporate control between two rival companies. In this respect, interlocking can be interpreted as a preliminary step in the acquisition of a minority equity stake.

It is well known that interlocking ties undermine the independence of board decisions,[1] facilitate the extraction of private benefits to the detriment of minority shareholders and reduce competition in the product market. We suggest that, when observing interlocking and partial equity ownership in association, it is not simply the consequence of a quest for minority representation once the acquisition is completed. We believe that the interlocking tie is ancillary to the corporate deal, in line with the empirical evidence. Interlocking is the result of a strategy to gain information on the target company to reduce the cost of the acquisition, where the crucial element driving the interlocking decision is information acquisition. This result might have implications for the antitrust analysis where interlocking ties and partial equity ownership are considered equivalent, as they raise the risk of collusive agreements in the product market (see Petersen, 2016). Adding to this concern, we point to the fact that interlocking may not only limit competition in the product market, but more importantly, it has consequences on the market for corporate control.

The structure of the paper is the following. After discussing the literature in section 2, we present the setup of the model in section 3. Section 4 solves the competition in the product market, while in section 5 we analyze the terms of the acquisition deal. In section 6 we solve for the choice to interlock and provide the Perfect Bayesian equilibrium for each possible initial beliefs. Section 7 concludes the paper.

[1] See Adams (2017) for the many instances in which a board's decisions are not independent.

2 Related Literature

The paper is related to different strands of the literature.

A first group of papers analyzes the effects of interlocking directorates (ID), from the sociological and managerial literature following Mizruchi (1996). Some papers suggest that ID reduce the information gap between companies and that the informative spillovers sourcing from those ties may benefit managerial practices (see *e.g.* Loderer and Peyer, 2002; Ozmel et al., 2013; Lamb and Roundy, 2016; Mazzola et al., 2016). To the best of our knowledge, there are no theoretical models on the strategic reasons why companies form ID, except Battaggion and Cerasi (2020) that model the choice to interlock between rival companies. Conversely, this paper argues not only that interlocking comes from a strategic decision of the two companies, but that it is instrumental to the bidder of a minority block-holding to gain private information on the target company.

Another relevant group of papers studies the effect of partial equity ownership (PEO) in oligopoly models. Among these, Reynolds and Snapp (1986) and Flath (1991) study a model with quantity competition, while Shalegia and Spiegel (2012) a model with price competition. They all show that PEO softens competition in equilibrium. Ezrachi and Gilo (2006) analyzes the relation between PEO and the incentive to collude, while Jovanovic and Wey (2014) consider PEO as a preliminary step in the direction of a full merger. Our paper shares the same results on product market competition. In particular, focusing on static models with Cournot competition, the acquisition of a non-controlling block in the rival, raises the profits of all companies by internalizing the strategic externality caused by competition. However, since we are not focusing on collusion, we restrict our analysis to a static game and to the acquisition of a partial equity stake. Liu et al.(2018) analyze a model where firms competing *à la* Cournot with PEO face adverse selection due to private information about their marginal costs, a framework similar to our paper. They show that both firms prefer at the equilibrium information sharing. In our paper, the existence of benefits from PEO is the motivation as to why the bidder launches the acquisition of a stake in the rival company. We aim to study the asymmetry of information in the deal and how the ID helps in overcoming it by letting the bidder observe the true value of the target company. Notice that in our model, for the ID to succeed, the target company must be willing to host the director of the rival company.

We are also close to the literature on takeovers when the bidder does not know the intrinsic value of the target company. Typically, this literature assumes a contest among bidders who directly address the shareholders of the company. We simplify the analysis of the market for corporate control, as we assume there are no dispersed shareholders of the target company nor other bidders interested in participating in the acquisition. Our framework is similar to Schnitzer (1996), who studies the conditions by which a raider may decide to launch a friendly takeover when the value of the target is private information.

Finally, the paper is related to the empirical evidence on the acquisitions of companies (see *e.g.* Renneboog and Zhao, 2014; Stuart and Yim, 2010; Chikh and Filbien, 2011; Cai and Seviril, 2012) as it uncovers a role for ID in the market of corporate control. This literature, although mainly empirical, it provides the ground on which we measure our theoretical predictions.

3 Setup

Assume a simple market structure where two firms, 1 and 2, sell an homogeneous good. The demand for the product is:

$$P(q_1, q_2) = 1 - q_1 - q_2$$

Each company's marginal cost of production can take only two values $\tilde{c}_k \triangleq \{c^L, c^H\}$ with $k = 1, 2$. The two marginal costs are independently drawn from the same support $\tilde{c}_k \in (0, 1]$. The marginal cost captures the level of efficiency of each company, with $c_k^H > c_k^L$. While the marginal cost of company 1 is common knowledge (to simplify the analysis), the marginal cost of company 2 is private information. Company 1 forms beliefs about the level of efficiency of the rival, assigning probability $\Pr\{c_2 = c^L\} \equiv \mu$ with $\mu \in [0, 1]$.

Company 1 holds a minority equity stake $\sigma \in [0, \overline{\sigma}]$ into company 2, with $\overline{\sigma} = 0.5$. With this minority shareholding, company 1 chooses quantity q_1 to maximize its consolidated profit, that is, individual profit plus the value of the share of profits in company 2. We will focus only on passive partial ownership, that is, we assume that company 1 does not control the quantity of the rival, which is set by company 2 alone. Still, having an equity stake in the rival allows to soften competition, so that both companies enjoy greater profits. This explains why company 2 might be willing to tender an equity stake to company 1.

To acquire a share of company 2, company 1 has to make an offer (bid); we assume the bidder has full bargaining power. Since the bidder (she) does not observe the degree of efficiency of the target (he), she might end up paying an excessive price for this minority stake. One possible way for the bidder to reduce the uncertainty is to propose an interlocking directorate to the target company. If company 2 hosts an executive of company 1, it will disclose (assuming full disclosure) the marginal cost to the rival. However, for this agreement to take place the target company has to accept.

The timing of the game is the following:

- $t = 0$: company 1 proposes an interlocking to company 2; company 2 decides whether to accept to host an executive of the rival on its board;
- $t = 1$: in the market for corporate control, company 1 (the bidder) offers B (the bid) to acquire a minority stake $\sigma \leq \overline{\sigma}$ into company 2 (the target);
- $t = 2$: the two companies compete in quantities in the product market.

For a given stake $\sigma \leq \overline{\sigma}$, the consolidated profits of the two companies are given by:

$$V_1(\sigma, q_1, q_2) \equiv \pi_1(q_1, q_2) + \sigma\pi_2(q_1, q_2) \tag{1}$$

$$V_2(\sigma, q_1, q_2) \equiv (1 - \sigma)\pi_2(q_1, q_2) \tag{2}$$

where π_1 and π_2 are the individual profits of the two companies.

The game is solved by backward induction using the concept of Bayesian Perfect Equilibrium. First, we solve for the equilibrium quantities in the product market, then for the optimal bid B and stake $\sigma \leq \overline{\sigma}$ in the market for corporate control and finally for the choice to interlock.

4 Product Market

In this section we analyze the last stage of the game, where the two companies compete in quantities. We assume that company 1 owns an exogenous stake $\sigma \leq \overline{\sigma}$ into company 2. We postpone to section 5 the choice of this optimal stake. In what follows, we derive the equilibrium in the product market in the only two possible cases:

- both companies agree on the interlocking and marginal costs are common knowledge (all equilibrium variables are denoted by ID);
- without interlocking, company 1 does not observe the marginal cost of company 2 (all equilibrium variables are denoted by N).

4.1 Interlocking

In this case, company 1 observes the marginal cost of the rival and chooses quantity q_1 by maximizing the consolidated profit in (1), while company 2 chooses quantity q_2 by maximizing its profit in (2).

Lemma 1 *At the equilibrium the individual profits when company 2 hosts a director of company 1 on its board, are:*

$$\pi_1^{ID}(\sigma|c_1^i, c_2^j) = q_1^{ID}(\sigma|c_1^i, c_2^j)\left[q_2^{ID}(\sigma|c_1^i, c_2^j) - (c_1^i - c_2^j)\right] \tag{3}$$

and

$$\pi_2^{ID}(\sigma|c_1^i, c_2^j) = q_2^{ID}(\sigma|c_1^i, c_2^j)^2 \tag{4}$$

where $\{i, j\}$ can be either L or H.

Proof. (See A.1 in the Appendix). ■

When σ increases, both equilibrium quantities rise as competition becomes softer: when company 1 owns a stake in company 2, it internalizes the effect of increasing its quantity on the profit of the rival. This effect can be measured directly through an increase in σ in the equilibrium quantities (see equations (13) and (14) in Appendix A.1). Notice also that the individual profit of company 1 in (3) is affected by the difference in the efficiency of the two companies: if company 2 is more efficient than the rival, company 1 will limit its production at the equilibrium since it gains more by letting the efficient rival to produce, gaining from the larger rival's profit.

4.2 No interlocking

Assume now that company 1 does not interlock with company 2. In this case company 1 does not observe the marginal cost of the rival, since it is private information. Therefore company 1 chooses its quantity q_1 by maximizing the consolidated profit in (1), without observing the quantity set by company 2. On the contrary, company 2 chooses its quantity by maximizing the consolidated profit in (2) observing the marginal cost of the rival.

Lemma 2 *At the equilibrium, without the interlocking, the individual expected profits are:*

$$\pi_1^N(\sigma|c_1^i, c_2^j, \mu) = q_1^N(\sigma|c_1^i, c_2^j, \mu)\left[q_2^N(\sigma|c_1^i, c_2^j, \mu) - (c_1^i - c_2^j)\right] \tag{5}$$

and

$$\pi_2^N(\sigma|c_1^i, c_2^j, \mu) = q_2^N(\sigma|c_1^i, c_2^j, \mu)^2 \tag{6}$$

where $\{i, j\}$ *can be either* L *or* H*.*

Proof. (See A.2 in the Appendix). ■

5 Market for corporate control

In the market for corporate control company 1 (the bidder) launches a bid B to acquire a minority stake into company 2 (the target). In exchange, the target promises a share $\sigma \leq \overline{\sigma}$ of his profits to the bidder.

5.1 Interlocking

Through the interlocking the bidder observes the marginal cost of the rival, hence she will condition the offer to the target's type.

The bidder offers a contract (σ_{ij}, B_{ij}), i.e. acquisition price and equity stake, that solves the following program:

$$\begin{cases} \quad \max \quad & V_1^{ID}(\sigma_{ij}|c_1^i, c_2^j) - B_{ij} \\ s.t. \quad (IR_2) & V_2^{ID}(\sigma_{ij}|c_1^i, c_2^j) + B_{ij} \geq V_2^{ID}(0|c_1^i, c_2^j) \end{cases}$$

where i refers to the type of company 1, while j to the type of company 2. Given that the bidder has full bargaining power, the (IR_2) is saturated.

Proposition 3 *When the bidder (company* 1*) interlocks with the target (company* 2*), the deal at the equilibrium is:*

$$\sigma_{ij}^{ID} = \min\left\{\frac{4c_1^i - 5c_2^j + 1}{2c_1^i - 3c_2^j + 1}, \overline{\sigma}\right\} \geq 0 \tag{7}$$

$$B_{ij}^{ID} = \frac{\sigma_{ij}^{ID}(3 + \sigma_{ij}^{ID})}{(3 - \sigma_{ij}^{ID})^2}\left[q_2^{ID}(0|c_1^i, c_2^j)\right]^2 \tag{8}$$

where $\{i, j\}$ *can be either* L *or* H*.*

Proof. (See A.3 in the Appendix). ■

Each bidder's type offers a contract to each type of target company. The following proposition defines the equilibrium bids and stakes as function of the efficiency levels of the target.

Proposition 4 *The bidder is willing to bid more and acquire a larger stake, the more efficient is the target:*

$$B_{iL}^{ID} > B_{iH}^{ID} \quad \text{and} \quad \sigma_{iL}^{ID} > \sigma_{iH}^{ID}$$

where i *can be either L or H.*

Proof. (See A.4 in the Appendix). ■

There are two reasons why the bidder wants to acquire a greater stake if the target is efficient. The first is that PEO softens competition between rivals since the acquirer internalizes the effect of a change of her own quantity on the profit of the rival. Given that profits are larger with one of the two rivals holding a PEO, both firms benefit. The second reason has to do with the difference in the degrees of efficiency between the two companies: if the rival is more efficient, the bidder may recover the loss from reducing her quantity and gaining from the larger profit of the target.

5.2 No interlocking

In this case the bidder does not observe the marginal cost of the target and faces the risk of adverse selection. With asymmetric information, the inefficient target will pretend to be the efficient one, since the share of the efficient target is valued more than that of the inefficient target. Hence, the bidder has to offer a menu of contracts to elicit the true value of the target and to prevent the inefficient type to mimic the efficient one. As it is usual in these class of models, the two binding constraints are the participation constraint of the efficient type, (IR_{2L}), and the incentive compatibility constraint of the inefficient type, (IC_{2H}).

Company 1 solves the following program:

$$\begin{cases} \max & \mu\left[V_1^N(\sigma_{iL}|c_1^i,c_2^L,\mu)-B_{iL}\right]+(1-\mu)\left[V_1^N(\sigma_{iH}|c_1^i,c_2^H,\mu)-B_{iH}\right] \\ s.t. \quad (IR_{2L}) & V_2^N(\sigma_{iL}|c_1^i,c_2^L,\mu)+B_{iL}\geq V_2^N(0|c_1^i,c_2^L,\mu) \\ \quad\quad (IC_{2H}) & V_2^N(\sigma_{iH}|c_1^i,c_2^H,\mu)+B_{iH}\geq V_2^N(\sigma_{iL}|c_1^i,c_2^H,\mu)+B_{iL} \end{cases}$$

where i can be either L or H.

From the two binding constraints, we derive the two bids:

$$B_{iL}^N(\mu)=V_2^N(0|c_1^i,c_2^L,\mu)-V_2^N(\sigma_{iL}^N|c_1^i,c_2^L,\mu) \tag{9}$$

$$B_{iH}^N(\mu)=B_{iL}^N(\mu)+V_2^N(\sigma_{iL}|c_1^i,c_2^H,\mu)-V_2^N(\sigma_{iH}|c_1^i,c_2^H,\mu) \tag{10}$$

The two bids reflect the distortion induced by the asymmetry of information. The efficient target is left at his reservation value as in the interlocking case (although the reservation value contains now an expected term since the bidder does not know the marginal cost of the target). The inefficient target instead earns a rent to induce his truth-telling: the gain compensates him for the loss incurred, being the inefficient target, when tendering σ_{iL}^N instead of σ_{iH}^N.

Hereafter, we assume $c^H=c$ and $c^L=0$. Moreover, to avoid negative quantities at the equilibrium[2] we add the following **Assumption 1**, that is $c\in(0,\frac{1}{2}]$.

In the next proposition we derive the solution.

[2]For the lowest quantity to be non negative, we need $q_1^{ID}(0|c_1^H,c_2^L)=q_2^{ID}(0|c_1^L,c_2^H)=\dfrac{(1-2c)}{3}\geq 0$.

Proposition 5 *Without interlocking the optimal contract is:*

- *pooling when $\mu = \frac{1}{2}$: the bidder offers a single contract regardless the type of the target;*
- *separating for all $\mu \in [0, 1]$ but $\mu \neq \frac{1}{2}$: the bidder offers two contracts $\{\sigma_{iL}^{N}(\mu), B_{iL}^{N}(\mu)\}$ and $\{\sigma_{iH}^{N}(\mu), B_{iH}^{N}(\mu)\}$ where the type of the bidder i can be either L or H.*

Proof. (See A.5 in the Appendix). ■

Without interlocking, the bidder, not knowing the efficiency level of the target, offers a pair of contracts based on her beliefs. When the bidder attaches the same probability to face a low-cost and high-cost target, she offers a unique contract to the two types. Otherwise, the bidder offers a contract to select between low and high-cost targets.

6 Choice to interlock

In this section, we analyze the choice to interlock at stage $t = 0$. The bidder, anticipating the outcome in the market for corporate control, may propose an interlocking to the target. After the proposal, the target decides whether to accept, thus opening his board to a director of the bidder. When the offer is rejected, the marginal cost of the target remains private information, while if accepted, the bidder observes the marginal cost of the rival. Recall that the bidder decides whether to interlock without knowing the target's type, while the target when deciding knows all marginal costs.

Let's focus first on the bidder's choice and then on the choice of the target. The expected profit of the bidder in the case of interlocking at the equilibrium is:

$$EV_1^{ID}(.|c_1^i, \mu) \equiv \mu \left\{ V_1(\sigma_{iL}^{ID}|c_1^i, c_2^L) - B_{iL}^{ID} \right\} + (1-\mu) \left\{ V_1(\sigma_{iH}^{ID}|c_1^i, c_2^H) - B_{iH}^{ID} \right\} \tag{11}$$

where i can be either L or H and for brevity we define $EV_1^{ID}(.|c_1^i, \mu) \equiv EV_1^{ID}(\sigma_{ij}^{ID}|c_1^i, c_2^j)$.

Without interlocking, the expected profit of the bidder is instead:

$$EV_1^{N}(.|c_1^i, \mu) \equiv \mu \left\{ V_1(\sigma_{iL}^{N}|c_1^i, c_2^L, \mu) - B_{iL}^{N}(\mu) \right\} + (1-\mu) \left\{ V_1(\sigma_{iH}^{N}|c_1^i, c_2^H, \mu) - B_{iH}^{N}(\mu) \right\} \tag{12}$$

where i can be either L or H and $EV_1^{N}(.|c_1^i, \mu) \equiv EV_1^{N}(\sigma_{ij}^{N}|c_1^i, c_2^j, \mu)$.

To establish whether the bidder has incentive to propose the interlock we have to check which of the two expected profits, (11) or (12), is greater at the equilibrium. The following Proposition states our result.

Proposition 6 *For $c \in (0, \frac{1}{2}]$ and $\mu \in (0, 1]$, the bidder always prefers to interlock, since*

$$EV_1^{ID}(.|c_1^i, \mu) - EV_1^{N}(.|c_1^i.\mu) > 0$$

where i can be either L or H.

Proof. (See A.6 in the Appendix). ■

Provided that the bidder always proposes the interlocking, will the target accept hosting a director of the rival on his board? In the next proposition we derive the best reply of the target.

Proposition 7 *For any belief $\mu \in (0,1]$ and for all possible bidder's type,*

- *a target of type L accepts the proposal;*
- *a target of type H rejects the proposal.*

Proof. (See A.7 in the Appendix). ■

Proposition 7 proves that only the efficient target accepts to host a director of the bidder. The inefficient target will never accept to host a director of the bidder, since he benefits from the asymmetry of information in the equilibrium without interlocking. The bidder instead, regardless of her type, will always prefer the interlocking, as it reduces the uncertainty about the type of the target.

This result shows that interlocking may be beneficial as a screening device for the bidder when planning to acquire a minority equity stake in a rival company.

6.1 Equilibrium

We can now solve the game for the sub-game perfect Bayesian equilibrium.

Proposition 8 *For any belief $\mu \in \left(\frac{1}{2}, 1\right]$:*

- *if the target is efficient, there is interlocking at the equilibrium:*
  - *a bidder of type L acquires a stake $\sigma_{LL}^{ID} = 0.5$ and pays B_{LL}^{ID},*
  - *a bidder of type H acquires a stake $\sigma_{HL}^{ID} = 0.5$ and pays B_{HL}^{ID}.*
- *If the target is inefficient, there is no interlocking at the equilibrium:*
  - *a bidder of type L acquires a stake $\sigma_{LH}^{N}(\mu, c) = \min\left\{\frac{1-c(5+\mu)}{1-c(3-\mu)}, 0.5\right\}$ and pays B_{LH}^{N},*
  - *a bidder of type H acquires a stake $\sigma_{HH}^{N}(\mu, c) = \min\left\{\frac{1-c(1+\mu)}{1-c(1-\mu)}, 0.5\right\}$ and pays B_{HH}^{N}.*

Proof. The proof follows from the equilibrium shares and from Propositions 6 and 7. ■

The above Proposition shows that the interlocking occurs at the equilibrium only when the target is efficient, regardless of the type of the bidder. With the interlocking, the bidder succeeds in acquiring the largest possible share, i.e. $\overline{\sigma} = 0.5$. This result proves that under specific conditions the interlocking is observed at the equilibrium together with PEO. Notice that the association between ID and PEO reveals information about the level of efficiency of the two companies involved in the acquisition.

Corollary 9 *By refusing to host the executive of the rival company, the inefficient target is able to retain a greater share of his equity, that is $\sigma_{LH}^{N}(\mu, c) \leq \sigma_{LH}^{ID}(c)$ and $\sigma_{HH}^{N}(\mu, c) \leq \sigma_{HH}^{ID}(c)$ for any belief $\mu \in \left(\frac{1}{2}, 1\right]$.*

Proof. (See A.8 in the Appendix). ■

As for the bids, we are able to rank them in the special case of the pooling solution.

Corollary 10 *In the pooling solution ($\mu = \frac{1}{2}$):*

- *the inefficient bidder pays a lower bid in the interlocking case for* $c \leq 0.4$*, since* $B_{HL}^{N} > B_{HL}^{ID}$.
- *the efficient bidder pays a lower bid in the interlocking case for* $c \leq 0.12$*, since* $B_{LL}^{N} > B_{LL}^{ID}$*; otherwise* $B_{LL}^{N} < B_{LL}^{ID}$.

Proof. (See A.9 in the Appendix). ■

The corollary implies that the inefficient bidder, when interlocking, may save money by paying a lower bid for a sensible range of values of c. In case the bidder is efficient, instead, this range is very small. As c increases, the efficient bidder becomes reluctant to buy a share without knowing the target. Therefore she will offer a bid which is lower than in the case of interlocking, not to risk to buy an inefficient target.

7 Conclusions

In this paper, we study interlocking as a mechanism to screen the target in a partial equity acquisition among rival companies. Before the acquisition, when the level of efficiency of the rival is private information, the bidder might ask to interlock to elicit information about the true level of efficiency of the target. We show that the efficient target has indeed incentive to accept, therefore disclosing his type. In contrast, the inefficient target rejects the interlocking to extract a rent from the bidder. However, by rejecting the interlocking the inefficient target reveals his type. When there is asymmetric information, ID might be an important preliminary step in the acquisition affecting the terms of the deal. We show that, without interlocking, the bidder acquires a smaller share compared to the case with interlocking. Furthermore, regardless of the type of bidder, the price paid without interlocking is almost always higher, due to a lower accuracy in the evaluation of the target.

Our results contribute to the ongoing knowledge in two dimensions. On the one hand, our model provides a theoretical justification for the empirical association between ID and PEO. On the other hand, it points to interesting implications for the antitrust analysis. From the antitrust perspective, ID and PEO are considered almost equivalent ties, with a potential for collusive agreements in the product market. In contrast, we suggest that ID are the result of a strategy to reduce the cost of the acquisition. More precisely, interlocking may reduce competition in the market for corporate control since the bidder benefits from accessing private information about the target company and excluding other potential bidders from the acquisition. We leave it for future research to consider the antitrust implications of interlocking for the market of corporate control. In this respect, we see this paper as a first contribution to shed light on the role of interlocking in limiting competition both in the product market and in the market for corporate control.

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Declarations of interest: none

A Appendix

A.1 Proof of Lemma 1

By solving for the Nash equilibrium we derive the following equilibrium quantities:

$$q_1^{ID}(\sigma|c_1^i, c_2^j) = \frac{(1-\sigma) + (1+\sigma)c_2^j - 2c_1^i}{3-\sigma} = \frac{1}{3-\sigma}\left[3q_1^{ID}(0|c_1^i, c_2^j) + \sigma(c_2^j - 1)\right] \tag{13}$$

$$q_2^{ID}(\sigma|c_1^i, c_2^j) = \frac{1 + c_1^i - 2c_2^j}{3-\sigma} = \frac{1}{3-\sigma}\left[3q_2^{ID}(0|c_1^i, c_2^j)\right] \tag{14}$$

and the equilibrium price

$$P^{ID}(\sigma|c_1^i, c_2^j) = 1 - q_1^{ID}(\sigma|c_1^i, c_2^j) - q_2^{ID}(\sigma|c_1^i, c_2^j) = \frac{1 + c_1^i + (1+\sigma)c_2^j}{3-\sigma} \tag{15}$$

where $q_1^{ID}(0|c_1^i, c_2^j)$ and $q_2^{ID}(0|c_1^i, c_2^j)$ are the equilibrium quantities of the standard Cournot case, that is when $\sigma = 0$. Substituting the equilibrium price and quantities into the definition of each company's individual profits we derive the result. □

A.2 Proof of Proposition 2

By solving for the Nash equilibrium we derive the following equilibrium quantities:

$$\begin{aligned} q_1^N(\sigma|c_1^i, c_2^j, \mu) &= \tfrac{1}{3-\sigma}\left[3q_1^{ID}(0|c_1^i, c_2^j) - (1-\sigma)E(c_2|\mu) - (c_2^j + \sigma)\right] \\ q_2^N(\sigma|c_1^i, c_2^j, \mu) &= \tfrac{1}{3-\sigma}\left[3q_2^{ID}(0|c_1^i, c_2^j) + \tfrac{1}{2}(1+\sigma)(c_2^j - E(c_2|\mu))\right] \end{aligned} \tag{16}$$

and the equilibrium price

$$P^N(\sigma|c_1^i, c_2^j, \mu) = \frac{1}{3-\sigma}[1 + c_1^i + \frac{(3-\sigma)}{2}c_2^j - \frac{(1+\sigma)}{2}E(c_2|\mu)]$$

with $E(c_2|\mu) = \mu c_2^L + (1-\mu)c_2^H$. Substituting the equilibrium quantities and price into the definition of individual profits we derive the result. Notice that when $E(c_2|\mu) = c_2^j$ we are back at the equilibrium values of the quantities with interlocking. □

A.3 Proof of Proposition 3.

Given that company 1 has full bargaining power, the (IR_2) is binding. We obtain the expression of the bid as a function of σ_{ij}:

$$B_{ij} = \pi_2^{ID}(0|c_1^i, c_2^j) - (1-\sigma_{ij})\pi_2^{ID}(\sigma_{ij}|c_1^i, c_2^j) =$$

$$q_2^{ID}(0|c_1^i, c_2^j)^2 - (1-\sigma_{ij})q_2^{ID}(0|c_1^i, c_2^j)^2\left[\tfrac{3}{3-\sigma_{ij}}\right]^2 = \tfrac{\sigma_{ij}(\sigma_{ij}+3)}{(3-\sigma_{ij})^2}q_2^{ID}(0|c_1^i, c_2^j)^2$$

Substituting the expression of the bid in the payoff, we derive:

$$V_1^{ID}(\sigma_{ij}|c_1^i,c_2^j) - B_{ij} = \pi_1^{ID}(\sigma_{ij}|c_1^i,c_2^j) + \pi_2^{ID}(\sigma_{ij}|c_1^i,c_2^j) - \pi_2^{ID}(0|c_1^i,c_2^j) =$$

$$q_1^{ID}(0|c_1^i,c_2^j)^2 - \tfrac{\sigma_{ij}}{3-\sigma_{ij}}\left[q_1^{ID}(0|c_1^i,c_2^j) - \tfrac{3(2-\sigma_{ij})}{3-\sigma_{ij}}q_2^{ID}(0|c_1^i,c_2^j)\right]q_2^{ID}(0|c_1^i,c_2^j)$$

Now we can take the derivative w.r.t. σ_{ij} and obtain the following FOC:

$$\frac{3}{(3-\sigma_{ij})^2}\left[-q_1^{ID}(0|c_1^i,c_2^j) + q_2^{ID}(0|c_1^i,c_2^j)\frac{2(3-2\sigma_{ij})}{3-\sigma_{ij}}\right]q_2^{ID}(0|c_1^i,c_2^j) = 0$$

from which the optimal stake is:

$$\sigma_{ij}^{ID}(c_1^i,c_2^j) = \frac{6q_2^{ID}(0|c_1^i,c_2^j) - 3q_1^{ID}(0|c_1^i,c_2^j)}{4q_2^{ID}(0|c_1^i,c_2^j) - q_1^{ID}(0|c_1^i,c_2^j)} \tag{17}$$

Substituting the equilibrium quantities in the Cournot case with $\sigma = 0$, we obtain the result. Finally, the optimal bid is:

$$B_{ij}^{ID}(c_1^i,c_2^j) = \frac{\sigma_{ij}^{ID}(3+\sigma_{ij}^{ID})}{(3-\sigma_{ij}^{ID})^2}q_2^{ID}(0|c_1^i,c_2^j)^2 \tag{18}$$

and substituting the equilibrium quantities in (13) and (14) and the optimal stake in (17), we may derive an expression of the optimal bid as a function of marginal costs alone. □

A.4 Proof of Proposition 4

First, notice that:

$$\frac{\partial\sigma_{ij}^{ID}}{\partial c_2^j} = \frac{2(c_1^i-1)}{(2c_1^i-3c_2^j+1)^2} \leq 0$$

For a given c_1^i, it follows that $\sigma_{iL}^{ID} > \sigma_{iH}^{ID}$. Notice also that a less efficient bidder (higher c_1) will acquire a smaller share, since $\frac{\partial\sigma_{ij}^{ID}}{\partial c_1^i} < 0$. Second, from the definition of the optimal bid in (8) we can derive that:

$$\frac{\partial B_{ij}^{ID}}{\partial\sigma_{ij}^{ID}} = \frac{9(1+\sigma_{ij}^{ID})}{(3-\sigma_{ij}^{ID})^3}\left[q_2^{ID}(0|c_1^i,c_2^j)\right]^2 \geq 0$$

We can easily conclude that $B_{iL}^{ID} > B_{iH}^{ID}$. □

A.5 Proof of Proposition 5

Substituting the two bids from (9) and (10) into the objective function, we derive the relaxed optimization problem:

$$\begin{aligned}\max_{\sigma_{iL},\sigma_{iH}} \quad & \mu\left[V_1^N(\sigma_{iL}|c_1^i,c_2^L,\mu) + V_2^N(\sigma_{iL}|c_1^i,c_2^L,\mu)\right] - V_2^N(0|c_1^i,c_2^L,\mu)+ \\ & +(1-\mu)\left\{[V_1^N(\sigma_{iH}|c_1^i,c_2^H,\mu) + V_2^N(\sigma_{iH}|c_1^i,c_2^H,\mu)] + \left[V_2^N(\sigma_{iL}|c_1^i,c_2^L,\mu) - V_2^N(\sigma_{iL}|c_1^i,c_2^H,\mu)\right]\right\}\end{aligned} \tag{19}$$

Since $V_1^N + V_2^N = \pi_1^N + \pi_2^N$ from (1) and (2) we can rewrite the objective function as:

$$\mu\left[\pi_1^N(\sigma_{iL}|c_1^i, c_2^L, \mu) + \pi_2^N(\sigma_{iL}|c_1^i, c_2^L, \mu)\right] - \pi_2^N(0|c_1^i, c_2^L, \mu)+$$

$$+(1-\mu)\left\{\left[\pi_1^N(\sigma_{iH}|c_1^i, c_2^H, \mu) + \pi_2^N(\sigma_{iH}|c_1^i, c_2^H, \mu)\right] + (1-\sigma_{iL})\left[\pi_2^N(\sigma_{iL}|c_1^i, c_2^L, \mu) - \pi_2^N(\sigma_{iL}|c_1^i, c_2^H, \mu)\right]\right\} \tag{20}$$

The first order condition with respect to σ_{iH} is given by:

$$(FOC_H): \quad (1-\mu)\frac{\partial}{\partial \sigma_{iH}}\left[\pi_1^N(\sigma_{iH}|c_1^i, c_2^H, \mu) + \pi_2^N(\sigma_{iH}|c_1^i, c_2^H, \mu)\right] = 0 \tag{21}$$

Substituting the equilibrium quantities from (16) and solving we obtain the optimal stake:

- when the bidder is efficient ($c_1^L = 0$)

$$\sigma_{LH}^N(\mu, c) = \frac{1 - c(5+\mu)}{1 - c(3-\mu)} \tag{22}$$

- when the bidder is inefficient ($c_1^H = c$)

$$\sigma_{HH}^N(\mu, c) = \frac{1 - c(1+\mu)}{1 - c(1-\mu)} \tag{23}$$

Analogously, the first order condition with respect to σ_{iL} is given by:

$$\begin{gathered}(FOC_L):\ \mu\tfrac{\partial}{\partial \sigma_{iL}}\left[\pi_1^N(\sigma_{iL}|c_1^i, c_2^L, \mu) + \pi_2^N(\sigma_{iL}|c_1^i, c_2^L, \mu)\right] + \\ +(1-\mu)\tfrac{\partial}{\partial \sigma_{iL}}\left\{(1-\sigma_{iL})\left[\pi_2^N(\sigma_{iL}|c_1^i, c_2^H, \mu) - \pi_2^N(\sigma_{iL}|c_1^i, c_2^L, \mu)\right]\right\} = 0\end{gathered} \tag{24}$$

where the first term is equivalent to the term in FOC_H. We have two cases:

- when the bidder is efficient ($c_1^L = 0$):

$$\begin{gathered}\mu\tfrac{[1-2c(1-\mu)]}{(3-\sigma_{LL}^N)^3}[1 + c(1-\mu) - \sigma_{LL}^N(1 - c + c\mu)] + \\ -\tfrac{c(1-\mu)}{4(3-\sigma_{LL}^N)^2}[8(1-c) + (1-2\mu)c(1 - 6\sigma_{LL}^N + (\sigma_{LL}^N)^2] = 0\end{gathered} \tag{25}$$

- when the bidder is inefficient ($c_1^H = c$):

$$\begin{gathered}\mu\tfrac{[1-c+2c\mu)]}{(3-\sigma_{HL}^N)^3}[1 + 5c - c\mu - \sigma_{HL}^N(1 + c + c\mu)] + \\ -\tfrac{c(1-\mu)}{4(3-\sigma_{HL}^N)^2}[8 + (1-2\mu)c(1 - 6\sigma_{HL}^N + (\sigma_{HL}^N)^2] = 0\end{gathered} \tag{26}$$

In both cases we find an implicit solution of σ_{LL}^N (respectively, σ_{HL}^N) as a function of μ and c. Notice that when $\mu = \frac{1}{2}$ we are back to the solution of the previous FOC_H. This means that in this special case we have a pooling solution, namely $\sigma_{LL}^N(\mu = \frac{1}{2}) = \sigma_{LH}^N(\mu = \frac{1}{2})$ (respectively, $\sigma_{HL}^N(\mu = \frac{1}{2}) = \sigma_{HH}^N(\mu = \frac{1}{2})$). $\square$

A.6 Proof of Proposition 6.

We can rewrite (11) as follows:

$$EV_1^{ID}(.|c_1^i,\mu)=\mu\left[q_1^{ID}(0|c_1^i,c_2^L)^2-\frac{\sigma_{iL}^{ID}}{1-\sigma_{iL}^{ID}}q_1^{ID}(0|c_1^i,c_2^L)q_2^{ID}(0|c_1^i,c_2^L)+\frac{3\sigma_{iL}^{ID}(2-\sigma_{iL}^{ID})}{(1-\sigma_{iL}^{ID})(3-\sigma_{iL}^{ID})}q_2^{ID}(0|c_1^i,c_2^L)^2\right]$$

$$+(1-\mu)\left[q_1^{ID}(0|c_1^i,c_2^H)^2-\frac{\sigma_{iH}^{ID}}{1-\sigma_{iH}^{ID}}q_1^{ID}(0|c_1^i,c_2^H)q_2^{ID}(0|c_1^i,c_2^H)+\frac{3\sigma_{iH}^{ID}(2-\sigma_{iH}^{ID})}{(1-\sigma_{iH}^{ID})(3-\sigma_{iH}^{ID})}q_2^{ID}(0|c_1^i,c_2^H)^2\right] \tag{27}$$

while (12) can be rewritten as follows:

$$EV_1^N(.|c_1^i,\mu)=\mu\left\{q_1^N(\sigma_{iL}^N|c_1^i,c_2^L,\mu)\left[q_2^N(\sigma_{iL}^N|c_1^i,c_2^L,\mu)+(c_2^L-c_1^i)\right]+q_2^N(\sigma_{iL}^N|c_1^i,c_2^L,\mu)^2\right\}$$

$$-q_2^N(0|c_1^i,c_2^L,\mu)^2+(1-\mu)\left\{q_1^N(\sigma_{iH}^N|c_1^i,c_2^H,\mu)\left[q_2^N(\sigma_{iH}^N|c_1^i,c_2^H,\mu)+(c_2^H-c_1^i)\right]+q_2^N(\sigma_{iH}^N|c_1^i,c_2^H,\mu)^2\right\}$$

$$+(1-\mu)(1-\sigma_{iL}^N)\left[q_2^N(\sigma_{iL}^N|c_1^i,c_2^L,\mu)^2-q_2^N(\sigma_{iL}^N|c_1^ic_2^H,\mu)^2\right] \tag{28}$$

We distinguish two cases according to the type of bidder. Define $F_i(.|c_1^i,\mu)$ the difference between (27) and (28), where i can be L or H. We are able to prove that this difference is always positive for all admissible values $c\in(0,\frac{1}{2}]$, $\mu\in\left(\frac{1}{2},1\right)$ and for each type of bidder. The strategy of the proof is to show that the difference is positive for $\mu=\frac{1}{2}$ and $\mu=1$ and that moreover, it is increasing in $\mu\in(0,1)$.

- Assume the bidder is efficient ($c_1^L=0$):

For each value of μ, we substitute the equilibrium quantities from (13), (14) and (16) into the two expected profits in (27) and (28). The difference between the two expected profits when $\mu=1/2$ (black line in Figure 1) is:

$$F_L\left(.|c_1^L=0,\mu=\frac{1}{2}\right)=\frac{1}{720c}\left(-1085c^3+670c^2-12c+10\right)$$

The difference when $\mu=1$ (dashed line in Figure 1) is:

$$F_L\left(.|c_1^L=0,\mu=1\right)=-\frac{1}{1800c}\left(1150c^3-1325c^2+12c-25\right)$$

It is immediate to see that $F_L\left(.|c_1^L=0,\mu\right)>0$ in these two cases.

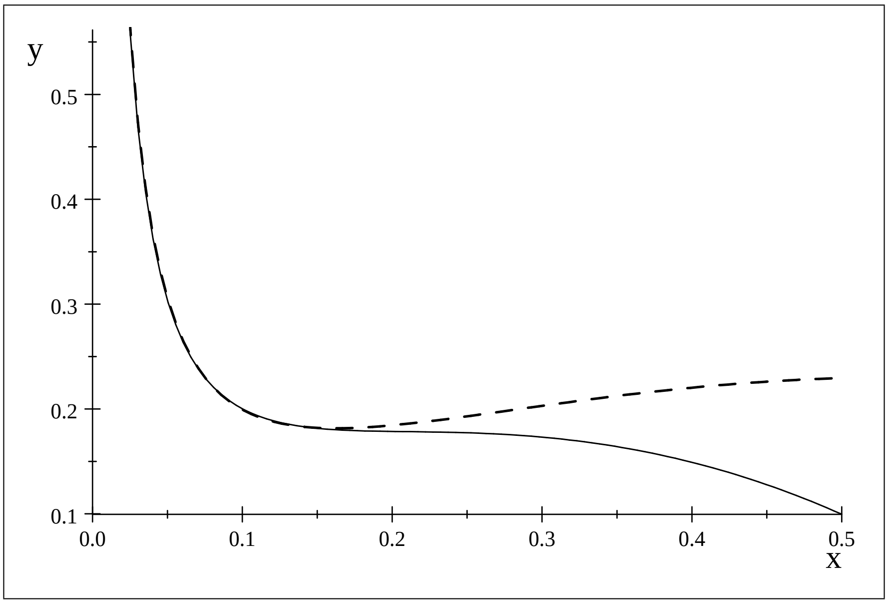

Figure 1

- Assume firm 1 is inefficient ($c_1^H = c$):

As in the previous case, we define the difference between the two profits (27) and (28) as $F_H\left(.|c_1^H = c, \mu\right)$ when $\mu = \frac{1}{2}$ and $\mu = 1$. In Figure 2 we plot the difference when $\mu = 1/2$ (black line) and when $\mu = 1$ (dashed line). Again, it is immediate to see that $F_H\left(.|c_1^H = c, \mu\right) > 0$ when either $\mu = \frac{1}{2}$ or $\mu = 1$.

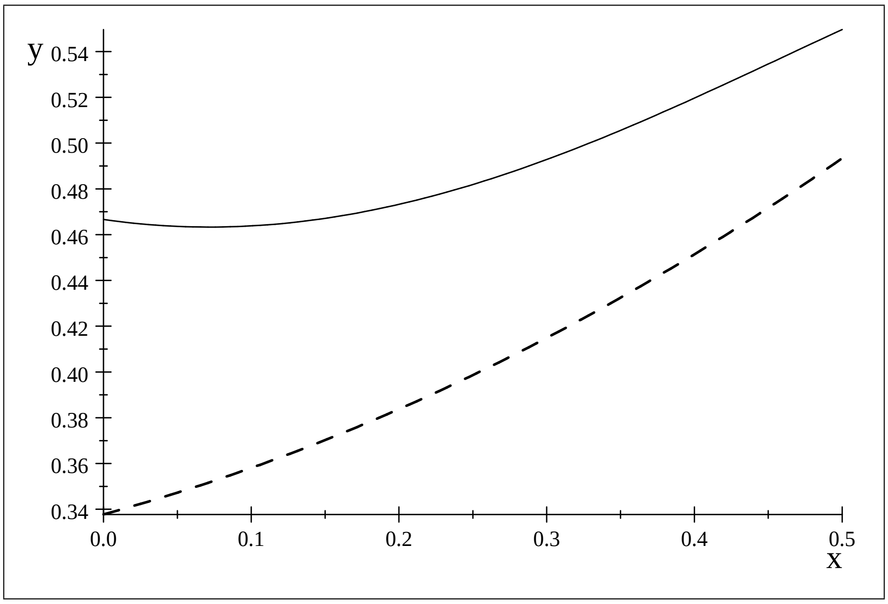

Figure 2

Now, we show that the differences $F_L\left(.|c_1^L, \mu\right)$ and $F_H\left(.|c_1^H, \mu\right)$ are increasing in $\mu \in (0, 1)$.

We define the derivative of $F_L\left(.|c_1^L, \mu\right)$ with respect to μ as $N_L\left(c, \mu, \sigma_{LL}^N(\mu, c), \sigma_{LH}^N(\mu, c)\right) = \frac{\partial F_L\left(.|c_1^L, \mu\right)}{\partial \mu}$. Plotting the implicit graph of $N_L(\cdot)$, we obtain:

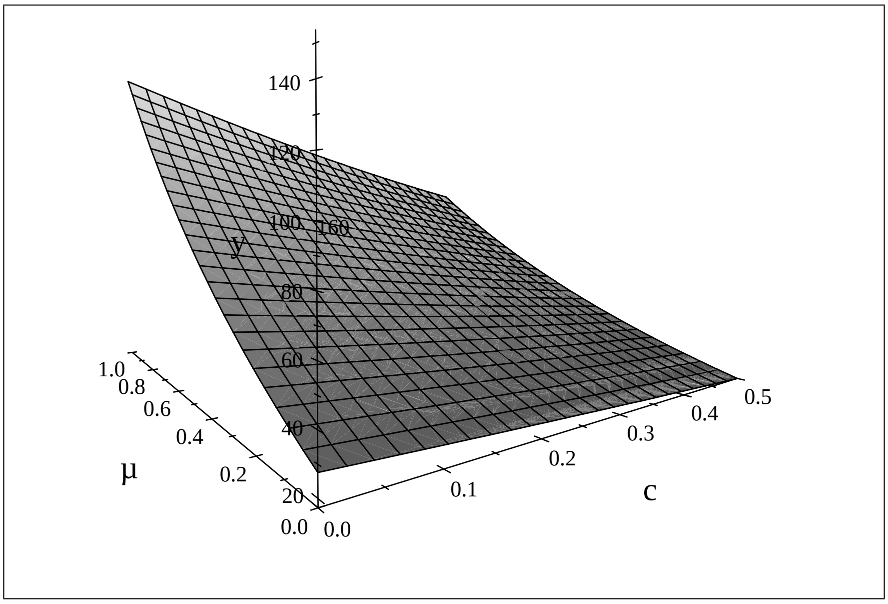

Figure 3

which is always positive for $\mu \in (0,1)$ and $c \in (0,0.5]$. Therefore $N_L\left(c,\mu,\sigma^N_{LL}(\mu,c),\sigma^N_{LH}(\mu,c)\right) = \frac{\partial F_L\left(.|c_1^L,\mu\right)}{\partial\mu} > 0$.

Analogously, we define $N_H\left(c,\mu,\sigma^N_{HL}(\mu,c),\sigma^N_{HH}(c,\mu)\right) = \frac{\partial F_H\left(.|c_1^H,\mu\right)}{\partial\mu}$. Plotting the implicit graph $N_H(\cdot)$, we obtain:

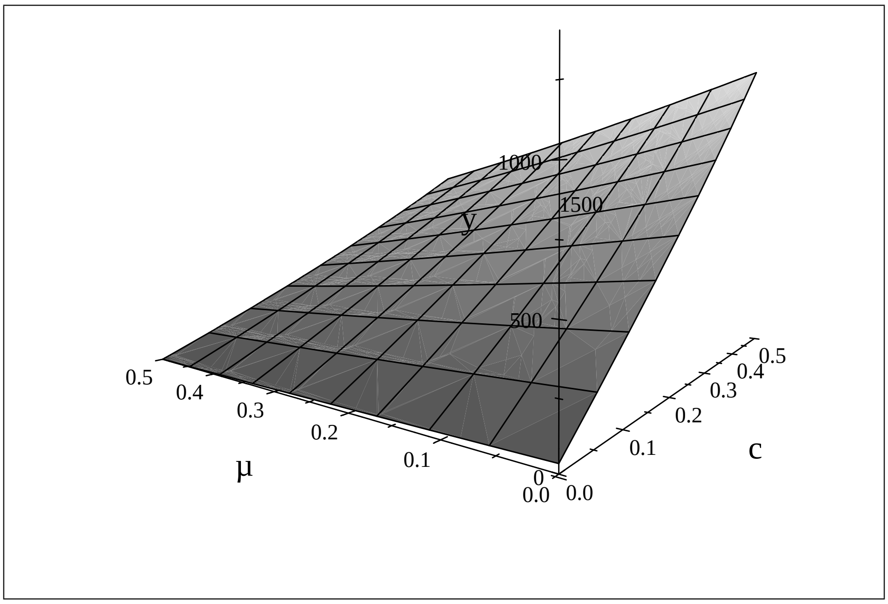

Figure 4

which is always positive for $\mu \in (0,1)$ and $c \in (0,0.5]$. Therefore $N_H\left(c,\mu,\sigma^N_{HL}(\mu,c),\sigma^N_{HH}(c,\mu)\right) = \frac{\partial F_H\left(.|c_1^H,\mu\right)}{\partial\mu} > 0$. $\square$

A.7 Proof of Proposition 7

For a generic type i of company 1, we need to check whether the payoff of the two types of company 2 when accepting the interlocking is greater than without interlocking.

- Assume that company 2 is efficient. When company 2 (target) accepts the interlock, his payoff is given by the RHS of the binding constraint (IR_2) in the equilibrium with interlocking:

$$V_2^{ID}(\sigma_{iL}^{ID}|c_1^i, c_2^L) + B_{iL}^{ID} = V_2^{ID}(0|c_1^i, c_2^L)$$

while when it refuses the interlock, his payoff is given by the RHS of the binding constraint (IR_{2L}) in the equilibrium without interlocking:

$$V_2^N(\sigma_{iL}^N|c_1^i, c_2^L, \mu) + B_{iL}^N(\mu) = V_2^N(0|c_1^i, c_2^L, \mu)$$

If the RHS in the interlocking case is greater, it means that the efficient target accepts the invitation to interlock. We compare the two RHS:

$$\begin{aligned} &V_2^{ID}(0|c_1^i, c_2^L) - V_2^N(0|c_1^i, c_2^L, \mu) = \pi_2^{ID}(0|c_1^i, c_2^L) - \pi_2^N(0|c_1^i, c_2^L, \mu) = \\ &q_2^{ID}(0|c_1^i, c_2^L)^2 - q_2^N(0|c_1^i, c_2^L, \mu)^2 = q_2^{ID}(0|c_1^i, c_2^L)^2 - \left[q_2^{ID}(0|c_1^i, c_2^L) - \tfrac{1}{6}E(c_2|\mu)\right]^2 \end{aligned} \tag{29}$$

which becomes:

$$\frac{1}{3}E(c_2|\mu)\left[q_2^{ID}(0|c_1^i, c_2^L) - \frac{1}{12}E(c_2|\mu)\right] = \frac{(1-\mu)c}{3}\left[\frac{1+c_1^i}{3} - \frac{c(1-\mu)}{12}\right] \geq 0 \quad \forall c_1^i, \mu$$

- Assume that company 2 is inefficient. When company 2 (target) accepts the interlock, his payoff is given by the RHS of the binding constraint (IR_2) in the equilibrium with interlocking:

$$V_2^{ID}(\sigma_{iH}^{ID}|c_1^i, c_2^H) + B_{iH}^{ID} = V_2^{ID}(0|c_1^i, c_2^H)$$

while when it refuses the interlock, his payoff is larger than the RHS, which is the lower bound to its payoff, as we can see from (IR_{2H}) in the equilibrium without interlocking:

$$V_2^N(\sigma_{iH}^N|c_1^i, c_2^H, \mu) + B_{iH}^N(\mu) > V_2^N(0|c_1^i, c_2^H, \mu)$$

We can prove that

$$V_2^N(0|c_1^i, c_2^H, \mu) - V_2^{ID}(0|c_1^i, c_2^H) = \frac{1}{3}(c_2^H - E(c_2|\mu))\left[\frac{1}{12}(c_2^H - E(c_2|\mu)) + q_2^{ID}(0|c_1^i, c_2^H)\right] \geq 0$$

since c_2^H is always greater than $E(c_2|\mu)$. Therefore it can never be that:

$$V_2^{ID}(0|c_1^i, c_2^H) > V_2^N(0|c_1^i, c_2^H, \mu)$$

Hence, we can conclude that company 2 when of type H rejects the invitation, regardless the type of company 1. □

A.8 Proof of Corollary 9

For $\mu \in \left(\frac{1}{2}, 1\right)$ we can prove that:

- $\sigma^N_{LH}(\mu, c) = \min\left\{\frac{1-c(5+\mu)}{1-c(3-\mu)}, 0.5\right\} \leq \sigma^{ID}_{LH}(c) = \min\left\{\frac{1-c5}{1-c3}, 0.5\right\}$;
- $\sigma^N_{HH}(\mu, c) = \min\left\{\frac{1-c(1+\mu)}{1-c(1-\mu)}, 0.5\right\} \leq \sigma^{ID}_{HH}(c) = \min\left\{\frac{1-c}{1-c}, 0.5\right\}$.□

A.9 Proof of Corollary 10

For $\mu = \frac{1}{2}$, bids are:

$$B^{ID}(\sigma^{ID}_{LL}|c^L_1, c^L_2) = \frac{7}{225}$$

$$B^{ID}(\sigma^{ID}_{HL}|c^H_1, c^L_2) = \frac{7}{225}c^2 + \frac{14}{225}c + \frac{7}{225}$$

and, given $\sigma^N_{LL} = \sigma^N_{LH}$ and $\sigma^N_{HL} = \sigma^N_{HH}$,

$$B^N(\sigma^N_{LL}\left|c^L_1, c^L_2\right.) = \frac{1}{720c - 288}\left(869c^3 - 906c^2 + 312c - 32\right) = B^N(\sigma^N_{LH}\left|c^L_1, c^H_2\right.)$$

$$B^N(\sigma^N_{HL}\left|c^H_1, c^L_2\right.) = \frac{1}{144\,(c-2)}\left(9c^3 + 6c^2 + 40c - 32\right) = B^N(\sigma^N_{HH}\left|c^H_1, c^H_2\right.)$$

Consider first the case firm 1 is inefficient, we plot $B^{ID}(\sigma^{ID}_{HL}|c^H_1, c^L_2)$ (continuous line) and $B^N(\sigma^N_{HL}\left|c^H_1, c^L_2\right.)$ (dashed line) in Figure 5,

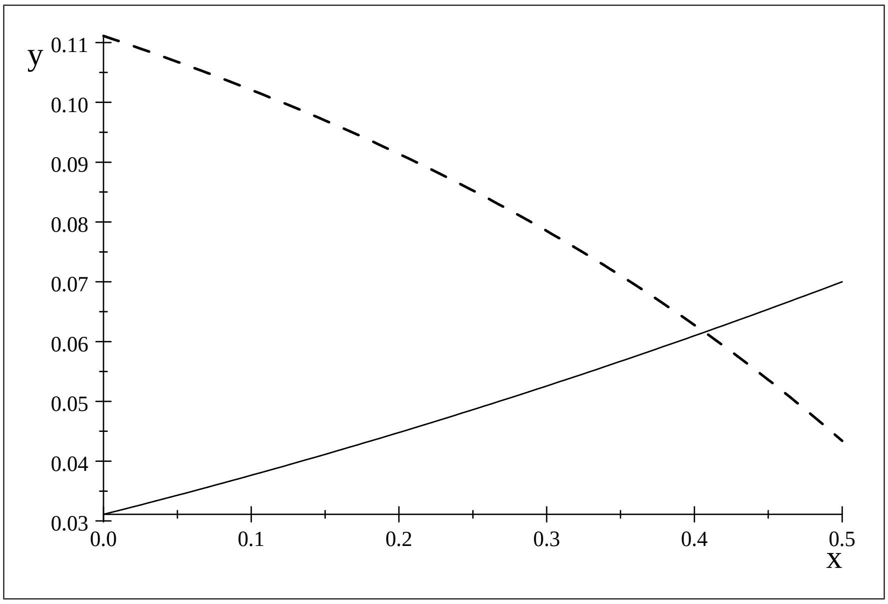

Figure 5

While in the case of the efficient firm 1, we plot $B^{ID}(\sigma^{ID}_{LL}|c^L_1, c^L_2)$ (continuous line) and $B^N(\sigma^N_{LL}\left|c^L_1, c^L_2\right.)$(dashed line) in Figure 6,

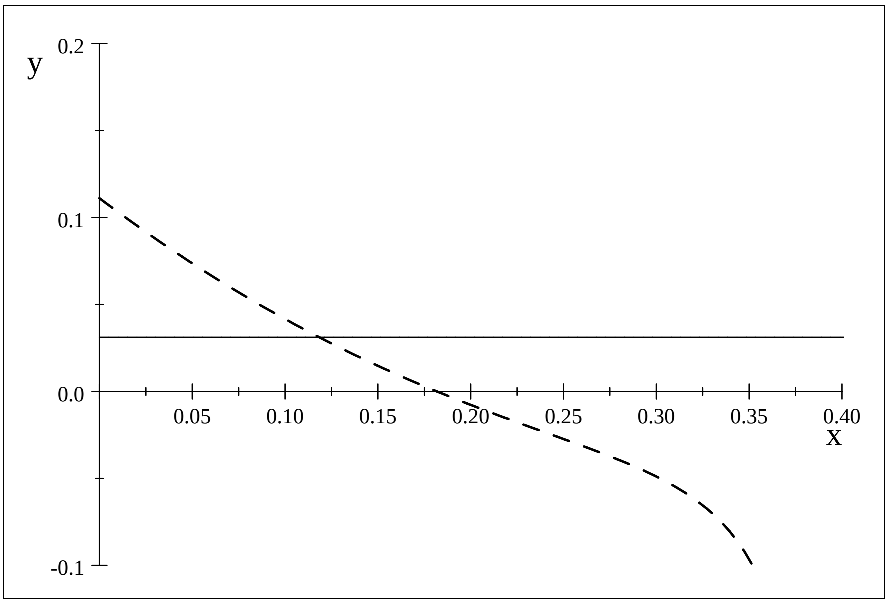

Figure 6