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How to cite

CORNU, Philippe, ISAKOV, Dusan. The Optimal Strategy of the Initial Bidder in Takeorver Contests: Theoy and Empirical Evidence. 2000

This publication URL: https://archive-ouverte.unige.ch/unige:5865

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The Optimal Strategy of the Initial Bidder in Takeover Contests: Theory and Empirical Evidence

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January 2000

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We are grateful to Chao Chen, Daniel McConaughy, Jennifer Juergens, and to participants at the 1998 FMA Conference in Chicago, the workshop participants at California State University Northridge and University of Geneva for their helpful comments and suggestions. The views and opinions expressed in this paper are those of the authors only. All remaining errors and omissions are our responsibility.

Résumé
Cet article analyse le comportement optimal de l'acquéreur initial lors d'une offre publique d'achat. Dans le modèle théorique, l'acquéreur a le choix entre proposer un prix élevé ou un prix faible. Les deux types d'offre peuvent conduire a une surenchère de la part d'un concurrent. Le modèle inclut des coûts d'information ainsi que des coûts liés à l'enchère proprement dite. Les stratégies optimales sont spécifiées selon un modèle d'équilibre bayésien parfait. Il découle du modèle que l'acquéreur initial a intérêt a fixer un prix initial élevé afin de dissuader de potentiels concurrents. Les implications empiriques du modèle sont analysées sur un échantillon d'acquisitions américaines sur la période 1990-1995. Entre autres résultats, on trouve que le la relation entre le niveau de la prime offerte et le degré de surenchère change selon que l'OPA est amicale ou hostile.

Abstract
This paper investigates the optimal bidding strategy for the initial bidder in takeover contests. In the theoretical model, the initial bidder has the choice between making a low or a high preemptive initial bid. Both types of bids can lead to a competitive auction process among bidders, and both information and bidding costs are included in the analysis. Optimal strategies are specified following the Perfect Bayesian Equilibrium. The model predicts notably that the optimal strategy for the initial bidder is to make a high preemptive initial bid. This strategy deters potential bidders to compete for the same target. The empirical implications of the theoretical model are then examined on US data over the period 1990-1995. Among other results, the relation between the level of bid premiums and the degree of competition is found to be dependent on the type of offer, i.e. hostile or friendly.

1. Introduction

To determine the amount of the initial bid to launch a takeover, the first bidder has to take into account three considerations. First, the bid has to be accepted by the target shareholders. This condition rises two types of problems. The *free rider* problem, pointed out by Grossman and Hart (1980), may occur when shareholders are atomistic and consider that their decision has no impact on the outcome of the takeover. In this case, shareholders are tempted not to submit their shares to free-ride on the increase in value resulting from the takeover, thus causing the takeover bid to fail. One manner to avoid such problem is to launch a takeover on the totality of the target stocks. The *lemons* problem, formulated by Hansen (1987), may occur when the target has a proprietary information on his own value: the target shareholders accept to sell their stocks only if the bid is higher than the value of the target firm. To avoid the lemons problem, the bidder can offer stock exchange as medium of payment, to make the bid contingent on the success of the acquisition. If the bidder has a proprietary information on his own value too, a double lemons problem arises because the bidder will not offer stock exchange payment when the target underestimates the value of bidder stocks. Thus, the bidder proposes stock exchange payment only if the bidder stocks are overvalued by the target. Aware of this problem, the target should never accept a stock exchange offer.

A second consideration that has to be taken into account by the first bidder is that the acquisition of the target firm must be profitable for him. This condition requires that the bidder has a fair estimation of the target value. In other words, the bid should never be higher than the target value for the bidder. This condition, if satisfied, rules out the hubris hypothesis mentioned by Roll (1986), where the bidder pays too much for his acquisition due to over-optimism.

A third consideration is that the initial bid should deter other potential bidders to enter the competition, to avoid expensive auction processes among bidders.[1] The model hereafter supposes that the first two conditions are met. The initial bid is accepted by the target shareholders, because the bid is supposed higher than the reservation price of the target shareholders. And the acquisition is profitable for the initial bidder, because the initial bidder is supposed to get costly information to have a fair estimation of the target value. The focus of this paper is on the third condition, i.e. on the deterring role of the initial bid.

Two conflicting hypotheses may be formulated regarding the impact of the initial bid on the decision of the potential bidder to compete or not. First, the signaling hypothesis states that when the first bidder makes a low initial bid, the first bidder sends the message that he has a low expected value of the target. The potential bidder has thus a strong incentive to enter the competition. Conversely, when the first bidder makes a high initial bid, then the message sent is that the first bidder has a high expected value of the target, i.e. the first bidder will probably compete if the potential bidder overbids. The high initial bid is thus a strong deterrent for the potential bidder not to enter the competition. Second, the efficiency hypothesis supposes that when the first bidder makes a low initial bid, the target value is properly assessed by the market. The bid premium corresponds then to the idiosyncratic gains to the first bidder, and the potential bidder has no incentive to enter the competition. Conversely, when the first bidder makes a high initial bid, the target value is supposed to be strongly undervalued by the market. In this case, the potential bidder has a strong incentive to enter the competition.

Fishman (1988) presents a model where the potential bidder has no private information concerning the target value. There is no uncertainty regarding the outcome of the bid: when the first bidder makes a low initial bid, the potential bidder enters the competition, whereas when the first bidder makes a high initial bid, the potential bidder does not enter the competition. Fishman (1988) supposes the auction process to be costless for the bidders, once the initial information costs paid. He provides a rationale for the first bidder to make a high initial bid, rather than making a low initial bid and raising it in case of competition among bidders. Hirshleifer and Png (1989) propose a model similar to Fishman (1988) with the difference that they include a bidding cost for each overbid when an auction process occurs. They show that, contrary to Fishman (1988), the price paid with a high initial bid may be higher than the price resulting from an auction process, because bidding costs may deter potential bidders with low synergy to enter the competition. Khanna (1997) presents a model where the first bidder always

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[1] Walkling and Edmister (1985), Bradley, Desai and Kim (1988), Berkovitch and Narayanan (1990) and De, Fedenia and Triantis (1996) show that competition among bidders is costly to the shareholders of the acquiring firm.

makes a preemptive initial bid. However, the preemptive initial bid may be followed by competition among bidders. Khanna (1997) shows that, when target management is permitted to resist, the optimal strategy for the first bidder remains to make a high initial bid.

The aim of this paper is to determine the optimal bidding strategy for the initial bidder that deters potential bidders to compete for the same target. The model below takes into account both initial information costs and bidding costs associated to an auction process. Contrary to Giammarino and Heinkel (1986), Fishman (1988), and Hirshleifer and Png (1989), the impact of a particular type of initial bid on the decision made by potential bidders to compete or not is uncertain. Both low initial bids and high preemptive initial bids may be followed by a competitive auction process among bidders. Moreover, contrary to Khanna (1997), the initial bid is not restricted to high preemptive bids only. The first bidder has the choice between making a low initial bid or a high initial bid. The deterring role of the initial bid depends on the beliefs of potential bidders regarding the first bidder's type. More precisely, potential bidders believe that when the initial bid is higher than a given threshold, the probability that the first bidder is of high type is higher than the probability that the first bidder is of low type, and conversely.

This paper is divided in five sections: the following section specifies the theoretical model and its assumptions, the third section presents the equilibrium solutions, the fourth section provides an empirical analysis of the model on the US market and the last section summarizes the paper.

2. Model

The assumptions of the model below are the following. First, there are two potential bidders i, $i = \{1,2\}$. The second (potential) bidder does not systematically overbid: whether there is a competition or not is endogenously determined by the model. Second, the aim of the bidder and target management is to maximize the wealth of their respective shareholders, to rule out agency conflicts. Moreover, the takeover is on all target equities, to avoid the free rider problem. Third, all agents (i.e. bidder and target shareholders) are risk neutral, to find equilibrium solutions following the Perfect Bayesian Equilibrium. Finally, both bidders and the target have private information on the profitability of the acquisition. This last assumption states that there is asymmetry of information between bidders and targets. The model distinguishes between, first, the bidder i expectation of the target value to bidder i, $E_i(\tilde{V}_i)$, on which bidder i bases his bid, second, the target expectation of its own value and, third, the real value of the target to bidder i, V_i, used to determine the real payoffs for each strategy. To avoid the lemons problem, the real value of the target is unknown *ex ante*, even for the target management. Finally, the target value to bidder i, V_i, includes the idiosyncratic gains resulting from the takeover to bidder i.

The proceeding is the following: at date 0, bidder 1 observes the reservation price of the target, V_0, which is set to the pre-bid market value of the target, and decides whether or not to launch a takeover. If bidder 1 decides to launch a takeover, he spends k_1 to get more information and offers the amount b_1. At date 1, bidder 2 observes b_1 and decides whether or not to compete. If bidder 2 decides to compete, he spends k_2 to get more information and offers b_2. Afterwards, an auction process may (or not) follow until one bidder remains with the highest bid. For each overbid, bidder i spends c_i as bidding costs.

To describe more formally the takeover proceeding, the following notation is used. The target value to bidder 1 and bidder 2 (i.e. including synergy specific to bidder i) is noted V_i, $\forall i = \{1,2\}$. The target value for bidder 1 and bidder 2 are positively correlated, but the expected payoff to bidder 2 is decreasing in V_1. This is necessary for bidder 1 to have an incentive to signal that he has a high valuation of the target, in order to deter competition. Let $F_i(\cdot)$ be the cumulative distribution function of $\tilde{V}_i$, and let $f_i(\cdot)$ be the density function of $\tilde{V}_i$. The density function, $f_i(V_i)$, is strictly positive on the interval $[\underline{V},\overline{V}]$, where $\underline{V} < V_0 < \overline{V}$ and zero elsewhere. These functions are common knowledge. The expected value of the target without investigation is negative, i.e. $E_1(\tilde{V}_1)$, $E_2(\tilde{V}_2) < 0$, so bidder i has to get costly information before launching a takeover. *Nature* draws bidder 1 type, q, from a set of possible types, Θ, such that $q \in \Theta = \{q^\lambda, q^h\}$, where q^λ means that bidder 1 has a low expected value of the target, $E_1^\lambda(\tilde{V}_1)$, and q^h

means that bidder 1 has a high expected value of the target, $E_1^h(\tilde{V}_1)$.[2] Nature draws the type of bidder 1 (λ or h) with a known probability set to 0.5 hereafter,[3] and the expected value of the target for bidder 2 is higher than for low-bidder 1 and lower than for high-bidder 1. In other terms, $E_1^{\lambda}(\tilde{V}_1) < E_2(\tilde{V}_2) < E_1^h(\tilde{V}_1)$.[4]

The problem for bidder 1 is to deter bidder 2 to overbid, by sending a preemptive message through his initial bid, to acquire the target at a bargaining price. So bidder 1 takes into account the reaction that bidder 2 will have to the initial offer made by bidder 1 in choosing the appropriate type of bid to launch the takeover. In other words, the bid made by bidder *i* depends on bidder 1 type and bidder *j* action, $b_i \equiv b_i(q, a_j)$, $\forall i \neq j$. Moreover, the bid offered by bidder *i* is strictly lower than the target value to bidder *i*, $b_i < E_i(\tilde{V}_i)$.

There is bid threshold, b^*, observable by all such that if the initial bid price is lower, $b_1 < b^*$, the probability of an auction is high, because bidder 2 considers that bidder 1 type is low with a high probability. Conversely, if the initial bid price is higher than the bid threshold, $b_1 > b^*$, the probability of an auction is low, because bidder 2 considers that bidder 1 type is low with a low probability. The different levels of the initial bid made by bidder 1 are summarized in Figure 1, where:

$$b^{\lambda} \in B^{\lambda} = \left\{ b_1 \middle| V_0 < b_1 \leq b^* \right\},\ b^h \in B^h = \left\{ b_1 \middle| b^* < b_1 \leq E_2(\tilde{V}_2) \right\},\ b^w \in B^w = \left\{ b_1 \middle| E_2(\tilde{V}_2) < b_1 \leq E_1^h(\tilde{V}_1) \right\}$$

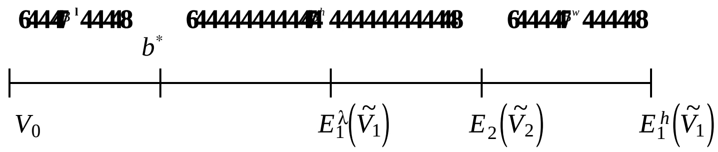

Figure 1
Levels of initial bid for bidder 1

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[2] *Ex ante,* $E_1^{\lambda}(\tilde{V}_1)$ and $E_1^h(\tilde{V}_1)$ reflect the incentive for bidder 1 to acquire the target. *Ex post,* the target value to bidder 1 is equal to V_1, whatever the bidder 1 type is.

[3] Bidder 1 knows already his own type before playing. However, he has also to know the probability distribution on Nature move in order to anticipate bidder 2 reaction to bidder 1 message.

[4] It is supposed implicitly that bidder 2 type is common knowledge for bidder 1, because bidder 1 knows is own type and bidder 1 type is defined by comparison with bidder 2 type. In other words, the expected value of the target for bidder 1 is high or low with respect to the expected value of the target for bidder 2.

Bidder 1 has the choice between three different levels of initial bid. If bidder 1 chooses to offer b^{λ}, the probability of an auction is high because bidder 2 believes that, having observed b^{λ}, the probability $m(\cdot)$ that bidder 1 type is low is higher than the probability that bidder 1 type is high, i.e. $m(q^{\lambda} \mid b^{\lambda}) > m(q^{h} \mid b^{\lambda})$. Conversely, if bidder 1 offers b^{h}, the probability of deterring is high because bidder 2 believes that, having observed b^{h}, the probability that bidder 1 type is high is higher than the probability that bidder 1 type is low, i.e. $m(q^{h} \mid b^{h}) > m(q^{\lambda} \mid b^{h})$. Finally, if bidder 1 offers b^{w}, there is no competition and bidder 1 acquires the target with certainty, because b^{w} is higher than the expected value of the target for bidder 2.

Knowing his own type, bidder 1 chooses an action, a_1 among the set of possible initial bid, A_1, such that $a_1 \in A_1 = B^{l} \cup B^{h}$. The bid b^{w} is not considered as an alternative action for bidder 1 in the model, because offering b^{w} is the most expensive choice for bidder 1 and the result is known with certainty. The action a_1 represents a message regarding bidder 1 type, sent by bidder 1 to his potential opponents. Having observed bidder 1 action, bidder 2 chooses an action, a_2, among the set of possible actions, A_2, such that $a_2 \in A_2 = \{0,1\}$, where $a_2 = 0$ means that bidder 2 does not overbid and $a_2 = 1$ means that bidder 2 does overbid. If bidder 2 enters the competition, bidder 1 does (resp. does not) overbid if he is high (resp. low) and bidder 2 continues to overbid, once entered in an auction process. If bidder 1 type is low, bidder 2 wins the competition with a higher bid than bidder 1 offer. If bidder 1 type is high, bidder 1 wins the auction and pays one plus $b_2^{\max} \equiv E_2(\tilde{V}_2) - k_2 - nc_2$ for the target, where n is the number of bidder 2 overbids during the auction process. The bid $b_2^{\max}$ corresponds to the maximum price offered by bidder 2, since in this case, the profit to bidder 2 is null. The auction process is resumed by the auction result, i.e. the highest bid for which the transaction is concluded. The target accepts the offer with the highest value if it is above a known reservation price, V_0.

Ex ante, the outcome for the bidders is uncertain for two reasons: first, the equilibrium solutions are contingent on both bidder strategy and, second, the real value of the target is unknown, given an equilibrium solution. The bidders have *common knowledge* on the entire structure of the game. If this assumption is satisfied, no bidder has interest to play differently from the equilibrium strategy, and the equilibrium provided by the game becomes a valid prediction of what will happen.

The aim of bidder i is to maximize his own payoff, p_i, depending on bidder 1 type and action and on bidder 2 action, $p_i \equiv p_i(q, a_1, a_2)$. The *ex post* payoffs obtained by the final purchaser immediately after the acquisition are described below. Bidder 1 payoffs are the following:

$$p_1(\cdot, b^\lambda, 0) = V_1 - b_1^\lambda(\cdot, 0) - k_1 \tag{1a}$$

$$p_1(\cdot, b^h, 0) = V_1 - b_1^h(\cdot, 0) - k_1 \tag{1b}$$

$$p_1(q^\lambda, \cdot, 1) = -k_1 \tag{1c}$$

$$p_1(q^h, \cdot, 1) = V_1 - [b_2^{\max} + 1] - k_1 - (n+1)c_1 \tag{1d}$$

Bidder 2 payoffs are described below:

$$p_2(\cdot, \cdot, 0) = 0 \tag{2a}$$

$$p_2(q^\lambda, b_1^\lambda, 1) = V_2 - [b_1^\lambda(q^\lambda, 1) + 1] - k_2 \tag{2b}$$

$$p_2(q^\lambda, b_1^h, 1) = V_2 - [b_1^h(q^\lambda, 1) + 1] - k_2 \tag{2c}$$

$$p_2(q^h, \cdot, 1) = -k_2 - nc_2 \tag{2d}$$

An important feature of the model is that the initial bid made by bidder 1 is deterring or not following the probability estimated by bidder 2 that bidder 1 is of a particular type, after having observed bidder 1 action. The bidder 2 beliefs that bidder 1 type is low, given the observed initial bid made by bidder 1, is denoted $p \equiv m(q^\lambda | b^\lambda)$ if bidder 1 offers b^λ and $q \equiv m(q^\lambda | b^h)$ if bidder 1 offers b^h. So, b^λ deters bidder 2 to enter the competition if $E[\tilde{p}_2(a_2 = 1 | b^\lambda)] < E[\tilde{p}_2(a_2 = 0 | b^\lambda)]$, i.e. if $p[\tilde{V}_2 - b_1^\lambda(q^\lambda, 1) - 1 - k_2] + (1-p) \quad [-k_2 - nc_2] < 0$, or in other words, if bidder 2 believes that bidder 1 type is low with a probability such that:

$$p < \frac{k_2 + nc_2}{\widetilde{V}_2 - b_1^{\lambda}(q^{\lambda},1) - 1 + nc_2}. \tag{3}$$

Similarly, b^h is deterring if $E[\widetilde{p}_2(a_2 = 1 | b^h)] < E[\widetilde{p}_2(a_2 = 0 | b^h)]$, i.e. if $q[\widetilde{V}_2 - b_1^h(q^{\lambda},1) - 1 - k_2] + (1-q)[-k_2 - nc_2] < 0$ or in other words, if bidder 2 believes that bidder 1 type is high with a probability such that:

$$q < \frac{k_2 + nc_2}{\widetilde{V}_2 - b_1^h(q^{\lambda},1) - 1 + nc_2}. \tag{4}$$

As $b_1^{\lambda}(q^{\lambda},1) < b_1^h(q^{\lambda},1)$, the expression on the right side of inequality (3) is lower than the expression on the right side of (4). The condition (3) is therefore more restrictive than condition (4) and, as a consequence, b^{λ} is less deterring than b^h.

3. Equilibrium

The equilibrium strategies are defined by the Perfect Baysian Equilibrium (PBE) requirements for a signaling game. The following notation is used: $r(q)$ denotes bidder 2 prior beliefs (before the game begins) about bidder 1 type, and $m(q | a_1)$ denotes the posterior probability distribution describing bidder 2 belief about which types q could have sent any observed message a_1 from A_1. For each q in Θ, we have $m(q | a_1) \geq 0$ and $\sum_{q\in\Theta} m(q | a_1) = 1$. Finally, $s_1(a_1 | q)$ denotes bidder 1 pure strategy, prescribing an action a_1 for each type q, and $s_2(a_2 | a_1)$ denotes bidder 2 pure strategy, prescribing an action a_2 for each action a_1.

The equilibrium is analyzed for pooling and separating pure strategies.[5] To find an equilibrium, it is supposed technically that:

$$V_2 - b_1^h(q^{\lambda},1) - 1 - k_2 = \left| -k_2 - nc_2 \right|, \tag{5}$$

[5] It is supposed that no decision maker chooses randomly the strategy he will make. Therefore, the analysis of the equilibrium is restricted to pure strategies only.

i.e. bidder 2 profit when low-type bidder 1 makes a high bid is equal to the costs that bidder 2 incurs if he competes against a high-type bidder 1. So, bidder 2 action depends only on the bidder 2 beliefs regarding bidder 1 type given b^h. It follows from (5) that:

$$\frac{k_2 + nc_2}{V_2 - b_1^h(q^\lambda,1) - 1 + nc_2} = 0.5 \quad \text{and} \tag{6}$$

$$V_2 - b_1^\lambda\left(q^\lambda,1\right) - 1 - k_2 > \left|-k_2 - nc_2\right| . \tag{7}$$

The equilibrium strategy for bidder 1 is denoted $s_1^*(a_1 \mid q) = (a_1', a_1'')$, where a_1' and a_1'' are bidder 1 actions when his type is low and high respectively. The equilibrium strategy for bidder 2 is denoted $s_2^*(a_2 \mid a_1) = (a_2', a_2'')$, where a_2' and a_2'' are bidder 2 actions when bidder 1 initial bid is low and high respectively. The equilibrium strategies are described in proposition 1.

Proposition 1 (i) *There exists a PBE.*

(ii) *If* (σ_1^*, σ_2^*) *constitutes a PBE, then*

E1

$s_1^*(a_1 \mid q) = (b^\lambda, b^\lambda)$

$s_2^*(a_2 \mid a_1) = (1,1)$ if $p > 0.5$, $q \geq \dfrac{k_2 + nc_2}{V_2 - b_1^h(q^\lambda,1) - 1 + nc_2}$. (8a)

E2

$s_1^*(a_1 \mid q) = (b^h, b^h)$

$s_2^*(a_2 \mid a_1) = (1,0)$ if $q < 0.5$, $p \geq \dfrac{k_2 + nc_2}{V_2 - b_1^\lambda(q^\lambda,1) - 1 + nc_2}$. (8b)

E3

$s_1^*(a_1 \mid q) = (b^h, b^\lambda)$

$s_2^*(a_2 \mid a_1) = (1,0)$ if $p = 0$, $q = 1$. (8c)

Proof: *See the Appendix.*

In equilibrium E1, both bidder 1 type makes a low initial bid, b^λ, and neither b^λ nor b^h are deterring following bidder 2 beliefs p and q. So bidder 2 enters the competition whatever bidder 1 action is. In equilibrium E2, both bidder 1 type makes a high initial bid, b^h, and bidder 2 enters the competition if he observes b^λ and does not compete if he observes b^h, given his beliefs. Finally in equilibrium E3, bidder 1 makes a high initial bid if he is of low type and makes a low initial bid if he is of high type. Bidder 2 does not compete if he observes b^λ and competes if he observes b^h, given his beliefs. However, the unique equilibrium satisfying the bidder 2 most intuitive beliefs that $q \equiv m(q^\lambda | b^h) < p \equiv m(q^\lambda | b^\lambda)$ and $q < 0.5 < p$ is the second pooling equilibrium E2.

The expected payoffs to bidder 1 and 2, following the equilibrium strategies are described below.

E1 $$E(\tilde{p}_1) = E\left\{(1-p)(\tilde{V}_1 - b_2^{\max} - 1 - (n+1)c_1) - k_1 \middle| p > 0.5, q \leq \frac{k_2 + nc_2}{\tilde{V}_2 - b_1^h(q^\lambda,1) - 1 + nc_2}\right\} \quad (9a)$$

$$E(\tilde{p}_2) = E\left\{p\left[\tilde{V}_2 - b_1^\lambda(q^\lambda,1) - 1\right] + (1-p)(-nc_2) - k_2 \middle| p > 0.5, q \leq \frac{k_2 + nc_2}{\tilde{V}_2 - b_1^h(q^\lambda,1) - 1 + nc_2}\right\} \quad (9b)$$

E2 $$E(\tilde{p}_1) = E\left\{\tilde{V}_1 - b_1^h(\cdot,0) - k_1 \middle| q < 0.5, p \geq \frac{k_2 + nc_2}{\tilde{V}_2 - b_1^\lambda(q^\lambda,1) - 1 + nc_2}\right\} \quad (9c)$$

$$E(\tilde{\pi}_2) = 0 \quad (9d)$$

E3 $$E(\tilde{p}_1) = \frac{1}{2}E\left\{q\left[\tilde{V}_1 - b_1^h(\cdot,0) - k_1\right] + (1-p)\left[\tilde{V}_1 - b_2^{\max} - 1 - k_1 - (n+1)c_1\right] \middle| p = 0, q = 1\right\} \quad (9e)$$

$$E(\tilde{p}_2) = \frac{1}{2}(1-p)(-k_2 - nc_2) \quad (9f)$$

Both equilibrium that includes a low initial bid, b^λ, in its optimal strategy (i.e. equilibrium E1 and E3) yields a lower expected payoff than the expected payoff resulting from a pooling equilibrium on a high initial bid, b^h (i.e. equilibrium E2). Bidder 1 should therefore make high initial bids only, whatever bidder 1 type is. Overall, the most credible equilibrium strategy following bidder 2 beliefs, which is to make a high preemptive initial bid, is also the most profitable for bidder 1. This result gives support to the signaling hypothesis.

The existence of initial information costs, k_i, and bidding costs, c_i, leads to the following implications.

Implication 1 *The higher the information and bidding costs are, the lower the highest bid is.*

This follows from the definition of $b_i^{max}(\cdot)$. Contrary to Hirshleifer and Png (1989)– who argue that if a bidder accepts to incur bidding costs, this signals that he is of high-type and may deter competition– the bidding costs are not deterring *per se.*

Implication 2 *In an auction process, the payoff to the high-type bidder 1 is higher (lower) when bidder 2 bidding costs are higher (lower) than bidder 1.*

This follows from Implication 1 and bidder 1 payoff (1d). In raising, the bidding costs lower the bidder 2 maximum bid. So, if $c_2 > c_1$ $(c_2 < c_1)$, the decrease of the final bid made by bidder 2 is higher (lower) than the increase of bidder 1 costs.

4. Empirical analysis

The initial sample covers all the takeover attempts that occurred during the period 1990 to 1995, as listed in *Mergerstat Review*, with an offered price of USD 100 millions or higher. The initial sample includes 684 takeovers attempts, successful or not. For an acquisition to be listed in the *Mergerstat Review*, both the offered price and the target's net earnings have to be available. Statutory mergers are not included in the roster. Finally, the *Wall Street Journal Index* has been used to complete the missing information for each transaction. The number and the total value of announced takeovers over the period 1990-1995 are reported in Table 1 and Figure 2.

Table 1
Announced takeovers over the period 1990-1995

	Total value (USD billions)	Frequency
1990	76	87
1991	33	64
1992	29	62

1993	83	95
1994	120	165
1995	243	211
Total	584	684

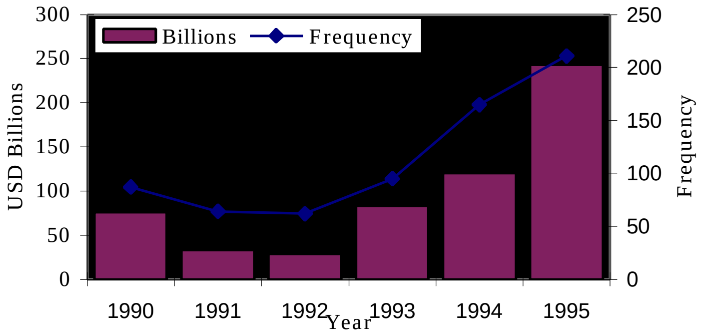

Figure 2
Trends in takeovers: 1990-1995

The beginning of the nineties is characterized by a contraction of the takeover market, probably due to the recession that was prevailing during that period. From 1992 to 1995 though, the trend is inverted: the number of takeovers and the total value of announced takeovers increase continuously, as the economic recovery becomes stronger. The takeover activity in 1995 is the highest over the last 20 years, both in terms of number of transactions and total value of takeovers.[6]

To be included in the final sample used to conduct the empirical analysis presented below, the following informations are required for each takeover attempts: the announcement year, the buyer's and target's country, the target's industry and sales, the method of payment, the premium and the PE ratio offered, the purchase price to book value (stockholder's equity) ratio, whether the attempt is successful, whether there is competition among bidders, and whether the bid is hostile or friendly. All these variables are defined hereafter. The final sample that includes the takeover cases meeting all these criteria is reduced to 273 takeovers. The target's line of business is classified into the 50 *Mergerstat Review* industry category. The variables used to conduct the empirical analysis are the followings:

[6] Cf. *Mergerstat Review*, 1995.

INDUST	The target's industry category. The Top 10 industry by number of transactions only is reported individually. The other industries are gathered into the category "Other". The takeovers belonging to the Top 10 industry represent 70.3% of the sample.
YEAR	The announcement year. The year corresponds to the year of the announcement of the takeover, even if the transaction is pending on December 31.
SUCCES	The success of the takeover attempt (dichotomous variable). The possible values are "Yes" or "No".
BUYCOU	The country of the buyer (dichotomous variable). The possible values are "U.S." or "Foreign".
TARCOU	The country of the target (dichotomous variable). The possible values are "U.S." or "Foreign".
COMPET	Whether there is a competition among bidders for the same target (dichotomous variable). The possible values are "Yes" or "No".
HOSTIL	Whether the offer is hostile (dichotomous variable). The possible values are "Yes" or "No".
SALES	The target's most recent annual sales available at the time of the takeover announcement (in USD million). The target's sales are defined as low, medium, or high if they belong to the lowest third of the sales included in the sample (i.e. to the percentile below 33.3%, or below USD 258.3 million), to the middle third (i.e. between 33.3% and 66.6%, or between USD 258.3 and USD 1,383.3 million), or to the highest third (i.e. above 66.6%, or above USD 1,383.3 million) respectively. When the target's industry is "Banking & Finance", the target's assets are reported instead.
PRICE	The total price offered (in USD million). The price offered for a target is defined as low, medium, or high if it belongs to the percentile below 33.3% (i.e. below USD 238.0 million), between 33.3% and 66.6% (i.e. between USD 238.0 and USD 772.7 million), or above 66.6% (i.e. above USD 772.7 million) respectively.

METPAY The method of payment. The method of payment may be by : "Cash", "Debt", "Stock", or "Mixed". In the sample used to conduct the empirical analysis (where N=273 takeovers), no takeover has been launched with a debt offer (in the initial sample including 684 takeovers, two cases only are reported). Therefore, the value "Debt" for the variable METPAY is not reported in the analysis below.

PE The price to earnings ratio offered. The PE is based on the publicly traded target's latest 12 months (trailing) earnings available at the time of the announcement date. For privately held targets and divestitures, the PE offered is based on the target's most recent annual earnings available at the time of announcement. The PE offered for a target is defined as low, medium, or high if it belongs to the percentile below 33.3% (i.e. below 17.3x), between 33.3% and 66.6% (i.e. between 17.3x and 28.7x), or above 66.6% (i.e. above 28.7x) respectively.

PREMIU The premium offered (in percent). The premium offered is the difference between the price offered per target's stock with the target's stock market value five business days before the announcement date, in percent. The premium offered for a target is defined as low, medium, or high if it belongs to the percentile below 33.3% (i.e. below 21.8%), between 33.3% and 66.6% (i.e. between 21.8% and 39.9%), or above 66.6% (i.e. above 39.9%) respectively.

MULTIP The multiple of book. The multiple of book is the purchase price to book value (stockholder's equity) ratio, for the latest available fiscal year at the time of announcement. The multiple of book offered for a target is defined as low, medium, or high if that multiple of book belongs to the percentile below 33.3% (i.e. below 2.3x), between 33.3% and 66.6% (i.e. between 2.3x and 4.3x), or above 66.6% (i.e. above 4.3x) respectively.

Finally, more than 97% of the takeovers included in the sample are acquisitions of a public traded company– the other category are Divestiture, Acquisition of a privately owned company, and Acquisition of a foreign based company. Besides, more than 96% of the sample concern acquisitions of 100% of the target's equity.

The characteristics of the final sample (*N*=273) are presented in Table 2 and 3. Cash offers represent more than a quarter of the takeovers in the sample, whereas more than half of the takeovers are launched with a stock offer. Again, there is no debt offer in the final sample. Nearly 13% of the takeovers are subject to competition from other bidders, and more than 12% are hostile offers. A large majority of the takeovers are successful (85.7%), and are launched by a U.S. bidder (88.3%) over a U.S. target firm (99.6%). The year 1992 counts the lowest number of takeover attempts in the sample: one case only satisfying the criteria used to build the final sample is reported. The industry that reported by far the most numerous cases of takeover attempt is the Banking & finance industry: alone, it provides more than a quarter of the takeovers included in the sample. Finally, by construction, the takeovers of the sample are splitted in thirds, into the categories Low, Medium or High for the variables SALES, PRICE, PREMIU, PE, and MULTIP.

Table 2
Characteristics of the sample

Variable	Value	Frequency	Percent
METPAY	Cash	72	26.4
	Stock	142	52.0
	Mixed	59	21.6
COMPET	Yes	35	12.8
	No	238	87.2
HOSTIL	Yes	33	12.1
	No	240	87.9
SUCCES	Yes	234	85.7
	No	39	14.3
BUYCOU	U.S. buyer	241	88.3
	Foreign buyer	32	11.7
TARCOU	U.S. target	272	99.6
	Foreign target	1	0.4
YEAR	1990	36	13.2
	1991	20	7.3
	1992	1	0.4
	1993	52	19.0
	1994	67	24.5
	1995	97	35.5
INDUST	Banking & finance	71	26.0
	Insurance	21	7.7
	Computer software, supplies	18	6.6
	Drugs, Medical supplies	16	5.9
	Retail	15	5.5
	Health services	14	5.1
	Electric, gas, water & sanitary	13	4.8

Office & computer hardware	8	2.9
Wholesale & distribution	8	2.9
Leisure & entertainment	8	2.9
Other	81	29.7

Table 3
Characteristics of the price, premium, P/E, multiple of book offered, and target's sales

	Mean	Std. Deviat	Min.	Max.	Percentiles 25	50	75
PRICE	1,121.9	2,066.6	100.0	19,000.0	195.0	390.6	1,143.3
PREMIU	33.5	26.6	-63.8	138.0	17.1	29.4	45.8
PE	27.0	17.7	1.1	150.0	15.8	22.0	32.7
MULTIP	5.7	13.3	0.4	132.9	2.0	3.0	5.5
SALES	2,847.8	9,752.5	7.8	114,038.0	173.4	617.0	1,773.4

The average bid price reported in Table 3 is around USD 1,100 million, but this mean may be misleading as bid prices have a large dispersion: they range from USD 100 million to USD 19,000 million. The median is around USD 390 million only, and the three fourth of the sample are composed of bid prices of roughly USD 1,100 million and below. The premiums have a much less wide dispersion than the prices: they range from -63.8% to 138%. The mean and the median are around 30% and three fourth of the sample include takeovers with a premium below 46%. The PE offered range from 1.1x to 150.0x, averaging 27.0x. The multiples of book offered average 5.7x, whereas for half of the takeovers included in the sample, the bidder pays three times or less the book value of the target stockholder equity to acquire the target. Finally, the target sales have a very wide dispersion: they range from USD 7.8 million to USD 114,038.0 million. The median is USD 617.0 million and three fourth of the sample concern acquisitions of target firms with USD 1,800 million sales or below.

Table 4 reports that the proportion of cash offers increases with the premium: 25.0% of the cash offers are launched with a low premium, whereas this percentage raises to 43.1% for high premiums. Cash offers are thus more often associated with high premiums than with any other level of premium.

The higher percentage (42.9%) of the takeovers incurring a competition follows a high premium, and conversely, the lowest percentage (22.9%) of the takeovers incurring a competition follows a low premium. In other words, the percentage of having a competition is 8.8% when the offered premium is low, and this percentage raises to 16.5% after a high bid premium. Launching a takeover with a high premium does not seem to deter other potential bidders to compete. This finding contradicts the conclusions reached in the theoretical part.

Table 4

Cross-tabulations between the premium offered and the other variables.

Variable	Value	Premium offered (PREMIU) Low (%)	Medium (%)	High (%)	Chi-square	df	Asymp. sig. (2-sided)
METPAY	Cash	25.0	31.9	43.1	6.653[a]	4	0.155
	Stock	38.0	31.0	31.0			
	Mixed	32.2	40.7	27.1			
COMPET	Yes	22.9	34.3	42.9	2.425[a]	2	0.297
	No	34.9	33.2	31.9			
HOSTIL	Yes	9.1	30.3	60.6	15.098[a]	2	0.001**
	No	36.7	33.8	29.6			
SUCCES	Yes	34.6	33.8	31.6	2.333[a]	2	0.311
	No	25.6	30.8	43.6			
BUYCOU	U.S. buyer	33.6	35.3	31.1	5.381[a]	2	0.068
	Foreign buyer	31.3	18.8	50.0			
TARCOU	U.S. target	33.5	33.5	33.0	2.007[b]	2	0.367
	Foreign target	0.0	0.0	100.0			
YEAR	1990	27.8	41.7	30.6	6.441[c]	10	0.777
	1991	30.0	25.0	45.0			
	1992	100.0	0.0	0.0			
	1993	32.7	34.6	32.7			
	1994	31.3	29.9	38.8			
	1995	37.1	34.0	28.9			
INDUST	Banking & finance	39.4	32.4	28.2	17.284[d]	20	0.634
	Insurance	28.6	47.6	23.8			
	Computer soft...	22.2	33.3	44.4			
	Drugs, medic. sup	43.8	25.0	31.3			
	Retail	46.7	26.7	26.7			
	Health services	28.6	57.1	14.3			
	Electric, gas...)	23.0	38.5	38.5			
	Computer hard...	25.0	37.5	37.5			
	Wholesale & distribut.	25.0	37.5	37.5			
	Leisure & entertainmt.	50.0	37.5	12.5			
	Other	29.6	27.2	43.2			
SALES	Low	33.0	33.0	34.1	0.725[a]	4	0.948
	Medium	34.1	30.8	35.2			
	High	33.0	36.3	30.8			
PRICE	Low	36.3	29.7	34.1	2.110[a]	4	0.716
	Medium	35.2	35.2	29.7			
	High	28.6	35.2	36.3			
PE	Low	38.3	31.9	29.8	2.640[a]	4	0.620
	Medium	29.5	31.8	38.6			
	High	31.9	36.3	31.9			
MULTIP	Low	43.6	29.8	26.6	8.277[a]	4	0.082
	Medium	24.7	34.8	40.4			
	High	31.1	35.6	33.3			

** Significant at α=0.01 level. [a] 0 cells (0%) have expected count less than 5.
[b] 3 cells (50.0%) have expected count less than 5. The minimum expected count is 0.33.
[c] 3 cells (16.7%) have expected count less than 5. The minimum expected count is 0.33.
[d] 15 cells (45.5%) have expected count less than 5. The minimum expected count is 2.67.The percentage of hostile offers increases drastically with the bid premium. In other words, in accordance with the common sense, higher bid premiums are more often offered in hostile takeovers than in friendly takeovers.

The percentage of successful takeovers is negatively related to the bid premium: 34.6% of the successful takeovers follow a low premium, whereas 31.6% only follow a high premium. This finding is probably due to the fact that higher premiums are associated with hostile takeovers and competition among bidders, resulting in a lower percentage of successful offers.

Half of the foreign buyers launch their takeovers with a high bid premium, and all the foreign targets are offered a high premium.

In accordance with the intuition, the proportion of takeovers launched with a low premium increases with an economy in recession (as for the beginning of the nineties) and decreases with an expanding economy (except in 1995).

The computer software industry is the sector having the highest percentage of takeovers offering a high premium. This is certainly due to the high expectation of growth in a high-tech sector.

The percentage of takeovers with a high offered price is positively related to the level of the bid premium. In other words, the larger the takeover is (in terms of offered prices), the higher the bid premium is.

Finally, the percentage of the takeovers with a low PE and a low multiple to book ratio is negatively related to the level of the bid premium. In other terms, the takeovers launched with a low PE and multiple are also logically offered a low bid premium.

To test the null hypothesis of independence between the variable PREMIU and the other variables, the Chi-square statistics are reported in Table 4. The only strongly significant rejection of the null hypothesis occurs for the relationship between HOSTIL and PREMIU. To further analyze the impact of the variables HOSTIL and COMPET on the other variables, the cross-tabulations between these two variables and the others are reported in Tables 5 and 6.[7]

Table 5 reports that 25.0% of the cash offers are hostile, whereas this percentage drops to 3.5% only for the stock offers. As a result, 34.3% of the competitive offers are hostile, and this percentage falls to 8.8% for non-competitive offers. In other terms, 36.4% of the hostile takeovers incur a competition, whereas 9.6% only of the friendly takeovers incur a competition. Again, all

[7] The cross-tabulations between the variables HOSTIL and COMPET and the variables BUYCOU, TARCOU, INDUST and YEAR have not been reported in Table 5 and 6 in order to save space. The results are available upon request to the authors.

these relationship are strongly significant. Table 5 reports also a strong relationship between HOSTIL and SUCCES: when the offer is hostile, the percentage of being successful is much lower (7.7%) than when the offer is friendly (92.3%). Finally, the percentage of hostile offers increases drastically and significantly with the price and the bid premium offered. In other words, large takeovers (i.e. with a high purchase price) are more hostile than small takeovers, and hostile takeovers result in higher bid premiums than friendly takeovers.

Table 5
Cross-tabulations between HOSTIL and the other variables.

Variable	Value	Hostile offer (HOSTIL) Yes (%)	No (%)	Chi-square	df	Asymp. sig. (2-sided)
METPAY	Cash	25.0	75.0	22.415[a]	2	0.000**
	Stock	3.5	96.5			
	Mixed	16.9	83.1			
COMPET	Yes	34.3	65.7	18.615[b]	1	0.000**
	No	8.8	91.2			
SUCCES	Yes	7.7	92.3	29.782[b]	1	0.000**
	No	38.5	61.5			
SALES	Low	5.5	94.5	8.893[a]	2	0.012*
	Medium	11.0	89.0			
	High	19.8	90.2			
PRICE	Low	3.3	96.7	17.373[a]	2	0.000**
	Medium	9.9	90.1			
	High	23.1	76.9			
PREMIU	Low	3.3	96.7	15.098[a]	2	0.001**
	Medium	11.0	89.0			
	High	22.0	78.0			
PE	Low	13.8	86.2	4.063[a]	2	0.131
	Medium	15.9	84.1			
	High	6.6	93.4			
MULTIP	Low	10.6	89.4	1.666[a]	2	0.435
	Medium	15.7	84.3			
	High	10.0	90.0			

[a] 0 cells (0%) have expected count less than 5. [b] 1 cell (25.0%) has expected count less than 5.
** Significant at α=0.01 level. * Significant at α=0.05 level.

The strong relationships between COMPET and the variables METPAY and HOSTIL have already been discussed above. Table 6 reports also a strongly significant dependence between COMPET and SUCCES: when there is a competition among bidders for the same target, the percentage of success is only 9.0%, whereas this percentage raises to 91.0% when there is no competitive bidding. The initial bidder has thus a strong incentive to deter other potential bidders to enter the competition for the same target. Finally, Table 6 reports a strongly significant relationship between COMPET and the variables PRICE and MULTIP, but no trend between these variables is clearly defined.

Table 6

Cross-tabulations between COMPET and the other variables.

Variable	Value	Competition (COMPET) Yes (%)	Competition (COMPET) No (%)	Chi-square	df	Asymp. sig. (2-sided)
METPAY	Cash	22.2	77.8	10.249[a]	2	0.006**
	Stock	7.0	93.0			
	Mixed	15.3	84.7			
HOSTIL	Yes	36.4	63.6	18.615[b]	1	0.000**
	No	9.6	90.4			
SUCCES	Yes	9.0	91.0	21.679[a]	1	0.000**
	No	35.9	64.1			
SALES	Low	5.5	94.5	6.751[a]	2	0.034*
	Medium	15.4	84.6			
	High	17.6	82.4			
PRICE	Low	7.7	92.3	15.797[a]	2	0.000**
	Medium	6.6	93.4			
	High	24.2	75.8			
PREMIU	Low	8.8	91.2	2.425[a]	2	0.297
	Medium	13.2	86.8			
	High	16.5	83.5			
PE	Low	11.7	88.3	2.210[a]	2	0.331
	Medium	17.0	83.0			
	High	9.9	90.1			
MULTIP	Low	10.6	89.4	9.241[a]	2	0.010**
	Medium	21.3	78.7			
	High	6.7	93.3			

[a] 0 cells (0%) have expected count less than 5. [b] 1 cell (25.0%) has expected count less than 5.
** Significant at α=0.01 level. * Significant at α=0.05 level.

The probability of a takeover incurring a competition depending on the level of the bid premium is investigated with a multinomial Logit model. The polytomous explanatory variable is PREMIU (with the possible values: Low, Medium, or High), and the dichotomous response variable is COMPET. The expected number of offers incurring a competition with the level of bid premium i is denoted m_{i1}, and the expected number of offers incurring no competition with the level of bid premium i is denoted m_{i0}, where $i \in \{L,M,H\}$ represents respectively the index for a Low, Medium, or High bid premium. The Logit model is the following:

$$\ln\left(\frac{m_{i1}}{m_{i0}}\right) = l + d_i \qquad \forall\ i \in \{L,M,H\} \tag{10}$$

where l is the baseline term, and d is the term due to the level of bid premium chosen. The equivalent loglinear model is described by equation (11).

$$\ln(m_{ij}) = \alpha_i + \beta_j + \gamma_{ij} \qquad \forall\ i \in \{L,M,H\},\ j=0,1 \qquad (11)$$

where α_i is the main-effects term of the variable PREMIU i, β_j is the main-effects term of the variable COMPET, γ_{ij} is the interaction term between PREMIU and COMPET, j = 1 is the index for an offer incurring a competition and j = 0 is the index for an offer without competition.[8]

Table 7

General Loglinear Model: $\ln(m_{ij}) = \alpha_i + \beta_j + \gamma_{ij}$, $\forall\ i \in \{L,M,H\}$ **and** $j = 0,1$.

Parameter [b]	Estimate	SE	Z-value	Asymptotic 95% CI Lower	Upper
α_L	2.079	[a]	[a]	[a]	[a]
α_M	2.485	[a]	[a]	[a]	[a]
α_H	2.708	[a]	[a]	[a]	[a]
β_0	1.623	0.283	5.74	1.07	2.18
γ_{L0}	0.717	0.466	1.54	–0.20	1.63
γ_{M0}	0.262	0.419	0.62	–0.56	1.08

[a] Constants are not parameters under multinomial assumption. Therefore, standard errors are not calculated.

[b] The redundant parameters are not reported in table 13, as they are set to zero.

Table 8

Logit Model: $\ln(m_{i1}/m_{i0}) = \lambda + \delta_i$, $\forall\ i \in \{C,S,M\}$.

λ	δ_L	δ_M	δ_H
–1.623	–0.717	–0.262	0.000

The results of the loglinear model (11) and Logit model (10) are reported in Tables 7 and 8 respectively. The estimated odds of having a competition among bidders after a particular bid premium are the following:

$$\frac{m_{L1}}{m_{L0}} = e^{\lambda+\delta_L} = e^{-2.340} = 0.096 \qquad (12a)$$

$$\frac{m_{M1}}{m_{M0}} = e^{\lambda+\delta_M} = e^{-1.885} = 0.152 \qquad (12b)$$

$$\frac{m_{H1}}{m_{H0}} = e^{\lambda+\delta_H} = e^{-1.623} = 0.197 \qquad (12c)$$

[8] The comparison of equations (9) and (10) gives $\lambda = (\beta_1 - \beta_0)$ and $\delta_i = (\gamma_{i1} - \gamma_{i0})$.

The highest odds to have a competition follow a high bid premium, whereas the lowest odds to have a competition follow a low bid premium. Finally, it is 2.1 times (0.197/ 0.096) more probable to have a competition after a high bid premium than after a low bid premium.

As high bid premiums appear to be intrinsically associated with hostile offers, the question turns to be: when the initial bidder decides to launch a hostile takeover, which level of bid premium is the most deterring for other bidders to enter the competition ?

Table 9
Cross-tabulations among hostile bids between COMPET and PREMIU.

Variable	Value	Competition (COMPET) Yes (%)	No (%)	Chi-square	df	Asymp. sig. (2-sided)
PREMIU	Low	27.3	72.7	0.573[a]	2	0.751
	Medium	37.5	62.5			
	High	29.0	71.0			

[a] 1 cell (16.7%) has expected count less than 5. The minimum expected count is 3.50.

Table 9 reports the results of the cross-tabulations between the variables PREMIU and COMPET, for hostile takeovers only. From Table 9, the results found previously are partially inverted: for hostile offers, the percentage of having a competition after a high bid premium (29.0%) is lower than after a medium bid premium (37.5%), but remains higher than with a low bid premium (27.3%). Moreover, the null hypothesis of independence between PREMIU and COMPET can not be rejected. To conclude, no overwhelming deterring effect resulting from the level of the bid premium is reported empirically. However friendly takeovers may not follow the same logic as our model as they may not require to have a strategic behaviour to deter potential competition. An analysis of hostile takeovers shows that making a high bid premium to launch a takeover seems to be more deterring than a medium premium, which (weakly) confirms the conclusions reached in the theoretical part, but less deterring than a low bid premium. Finally, it remains that the lack of a strong evidence regarding the deterring effect of the level of the bid premium may be due to the small size of the sample.

5. Conclusion

The optimal bidding strategy for the initial bidder in takeover contests is investigated. The initial bidder has the choice between making a low or a high preemptive initial bid. Both types of bid can lead to a competitive auction process among bidders. The deterring role of the initial bid depends on the beliefs of the potential bidder regarding the first bidder type. Moreover, both information and bidding costs are included in the analysis. The equilibrium strategies are specified following the Perfect Baysian Equilibrium requirements. The model predicts notably that the best strategy for the initial bidder is to make a high preemptive initial bid, independently of the expected value of the target for the initial bidder. This strategy deters potential bidders to compete for the same target.

Empirically, it is found that competition follows more often high initial bids than low initial bids, because high initial bids are inherently related to hostile offers which, in turn, are strongly related to competitive bidding. In controlling for hostile takeovers, competition among bidders follows more often medium offers rather than low or high bids. This is probably due to the fact that medium offers send a troubled message to the market participants. Our theoretical model is therefore only weakly confirmed by the empirical results. The sample used in this study is however relatively small and more empirical work is needed before definitive conclusions about the validity of the model can be drawn.

Appendix

(i) In any finite game– i.e. any game with a finite number of players, types and possible moves– there exists a PBE.[9]

(ii) Equilibrium E1.

Suppose there exists a pooling equilibrium where bidder 1 plays $(b^{\lambda}, b^{\lambda})$, then the bidder 2 belief $(p, 1-p)$ at this information set is determined by Bayes' rule and bidder 1 action: $p > 0.5$. Given this belief, bidder 2 best response following b^{λ} is to enter the competition, i.e. $a_2 = 1$, which yields the payoffs $V_1 - b_2^{\max} - 1 - (n+1)c_1 - k_1$ and $-k_1$ when bidder 1 type is low and high, respectively. To determine whether both bidder 1 type are willing to choose b^{λ}, we need to specify how would react bidder 2 to b^h. If bidder 2 chooses $a_2 = 0$ after observing b^h, the payoff for both bidder 1 type is $V_1 - b_1^h(\cdot,0) - k_1$, which is more profitable than $V_1 - b_2^{\max} - 1 - (n+1)c_1 - k_1$ and $-k_1$. If bidder 2 chooses $a_2 = 1$ after observing b^h, low-type bidder 1 payoff is $-k_1$ and high-type bidder 1 payoff is $V_1 - b_2^{\max} - 1 \ -(n+1)c_1 - k_1$, which is not higher than $V_1 - b_2^{\max} - 1 - (n+1)c_1 - k_1$ and $-k_1$. Finally, we have to consider the bidder 2 beliefs at the information set corresponding to the second period, and the optimality for bidder 2 to choose the action $a_2 = 1$ when observing the messages b^h, given his beliefs. It is optimal for bidder 2 to play $a_2 = 1$ having observed b^h, if its expected payoff resulting from $a_2 = 1$ is higher than the expected payoff resulting from $a_2 = 0$, given b^h. So, it is optimal for bidder 2 to play $a_2 = 1$ having observed b^h if:

$$q \geq \frac{k_2 + nc_2}{V_2 - b_1^h(q^{\lambda}, 1) - 1 + nc_2}.$$

To summarize, we have shown that:

$$s_1^*(a_1 | q) = (b^{\lambda}, b^{\lambda})$$

$$s_2^*(a_2 | a_1) = (1,1)$$

[9] See Gibbons (1992).

constitute a pooling PBE if $p > 0.5$, and $q \geq \dfrac{k_2 + nc_2}{V_2 - b_1^h(q^\lambda,1) - 1 + nc_2}$.

Equilibrium E2.

It is possible to apply the same line of argument just described above to show that in equilibrium E2,

$$s_1^*(a_1 \mid q) = (b^h, b^h)$$

$$s_2^*(a_2 \mid a_1) = (1,0)$$

constitute a pooling PBE if $q < 0.5$, and $p \geq \dfrac{k_2 + nc_2}{V_2 - b_1^\lambda(q^\lambda,1) - 1 + nc_2}$.

Equilibrium E3.

Suppose there exists a separating equilibrium where bidder 1 plays (b^h, b^λ), then both bidder 2 beliefs at these information sets are determined by Bayes'rule and the bidder 1 actions: $q = 1$, $p = 0$. Given these beliefs, bidder 2 best responses are $a_2 = 1$ if bidder 2 observes b^h and $a_2 = 0$ if bidder 2 observes b^λ, which results in the following payoffs for bidder 1: $-k_1$ and $V_1 - b_1^\lambda(\cdot,0) - k_1$ if bidder 1 plays b^h or b^λ respectively. If one of bidder 1 type decides to play differently from (b^h, b^λ) given bidder 2 beliefs, he will reach a lower (or equal) payoff. Therefore,

$$s_1^*(a_1 \mid q) = (b^h, b^\lambda)$$

$$s_2^*(a_2 \mid a_1) = (1,0) \qquad \text{if } p = 0,\ q = 1.$$

constitute a separating PBE in equilibrium E3.

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