Similar Bidders in Takeover Contests*

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Abstract
When bidders in a corporate takeover have related resources and post-acquisition strategies, their valuations of a target are likely to be interdependent. This paper analyzes a theoretical model and a laboratory experiment of sequential-entry takeover contests in which similar acquirers have correlated private valuations. Increased similarity between bidders has two effects on equilibrium bidding strategies. On the one hand, informational externalities of early bids from similar rivals induce participation in the contest. On the other hand, a bidding competition between similar bidders makes participation less attractive. The model predicts that expected acquisition prices and the probability of multiple-bidder contests are the highest for intermediately similar bidders. Our laboratory experiments indicate overbidding and excessive participation compared to the equilibrium. Accounting for acquirers’ additional utility of winning, the experiments support the theory.

JEL codes: G34, D44, D03
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1. Introduction

Returns in mergers and acquisitions for acquirer and target not only depend on the value that is created, but also on acquisition premium that is paid. Empirical research indicates that, overall, acquisitions do create value (Andrade, Mitchell and Stafford, 2001; Bargeron, Schlingemann, Stulz, and Zutter, 2008; Betton, Eckbo, and Thorburn, 2008) but gains accrue mostly to targets. Acquiring firms’ returns are, on average, close to zero and exhibit large variation (Stulz, Walkling, and Song, 1990; Leeth, and Borg, 2000; Fuller, Netter, and Stegemoller, 2002; Moeller, Schlingemann, and Stulz, 2005; Betton, Eckbo, and Thorburn, 2008). Taken together, the evidence suggests that acquisition prices are determinative for the division of takeover surplus.

The underlying causes of this variation in prices and returns have been subject to continuous scrutiny in the empirical literature. Surprisingly, the level of competition as measured by the number of bidders does not seem to explain this variation (Boone and Mulherin (2008)). However, characteristics of buyers do appear to be successful in explaining returns.

Guided by this evidence, we develop a takeover contest model in which the characteristics of potential acquirers matter and affect the intensity of competition. We want to take into account that potential acquirers can be similar or dissimilar because they may have very similar or very unique resources, capabilities, and post-acquisition strategies. More specifically, we analyze a model of two potential bidders that sequentially may enter a takeover contest. If the bidders are similar, their private values of a target are correlated. After observing the initial bid, the second bidder may decide to pay an entry cost to learn its valuation and to participate in the contest. Entering takeover contests is costly since

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1 Boone and Mulherin (2008) use an extensive data set on potential bidders and control for the endogeneity between returns and the level of competition. Some earlier studies using less detailed data sets show either no significant relation (Kale, Kini, and Ryan, 2003; Betton, Eckbo, and Thorburn, 2008) or mixed results (Schwert, 2000).

2 Moeller, Schlingemann, and Stulz (2004, 2005) find that the size of the bidder is responsible for a large portion of variation in returns. Acquirers with more uncertain growth prospects gain less in acquisitions (Moeller, Schlingemann, and Stulz 2007). Furthermore, the premiums paid to targets depend significantly on the public status of acquirers and whether acquirers are operating firms or private equity funds (Bargeron, Schlingemann, Stulz, and Zutter 2008). Among operating firms, acquirer returns depend on the strategic objectives of acquiring firms (such as vertical integration, horizontal integration, or diversification) (Walker, 2000).
information on target value requires due diligence costs such as fees for consultants, lawyers and investment bankers. The first bidder may offer a high (preemptive) bid in an attempt to deter the competing firm from entering. Alternatively, a low (accommodating) offer by the first bidder may induce entry by the second bidder and start a competitive auction. The signaling effect of an opening offer depends critically on the similarity between bidders.

The interdependence of bidders’ valuations has two opposing effects on contest participation. On the one hand, a bid from a bidder that is similar creates a greater informational externality and thereby encourages entry by a rival. On the other hand, if bidders are more closely related, the bidding contest is expected to be more competitive. The resulting high prices reduce expected payoffs from participation and thus discourage entry. We show that neither of the effects is dominant but their relative strengths depend on the level of similarity and radically affect bidding strategies, price, and bidders’ participation. Our analysis provides several important new insights and implications.

First, conditional on observing a takeover, the probability of single-bidder acquisitions and multiple-bidder contests varies in similarity between potential bidders. Multiple-bidder contests are most likely between intermediately similar competitors, due to the strength of informational externalities of initial bids that attracts followers. Initial bids from very similar bidders promise an even higher expected target value, but also indicate a fierce bidding competition. As a result, single-bidder contests are expected mostly between dissimilar (when informational externalities are low) and very similar competitors (when potential competition is high).

Second, expected prices for targets demonstrate an inverted U-shape in the level of bidder similarity. This pattern applies for prices in both single-bidder acquisitions and in multiple-bidder contests. The initial bid embeds informational externalities that signal value, making it attractive for competitors to enter. In single-bidder acquisitions, this means that high preemptive bids are required to deter a competitor that shares some of the sources of value. However, if bidders become very similar, the competition effect on prices starts to dominate informational externalities, and deterrence is possible with a relatively low preemptive bid. When multiple-bidder contests occur, competitive bidding yields higher
prices when rivals are more similar. However, when rivals are almost equals, the initial bidder will accommodate only if its valuation is low, but this means that the expected price in the contest will be low as well.

Third, our analysis indicates that in an environment with interdependent values, the similarity of potential bidders is an important measure of competition intensity. Targets’ returns are higher in single-bidder acquisitions than in multiple-bidder contests for any given level of similarity because a premium is required to preempt a rival. However, this does not necessarily imply that empirical data should demonstrate higher target returns in single-bidder acquisitions. As discussed above, multiple-bidder contests are most likely at intermediate levels of similarity at which expected prices are the highest. Conversely, single-bidder acquisitions are most likely at very low and very high levels of similarity when expected prices are lower. This implies that, in a cross-section of acquisitions, the relation between the number of bidders and target returns may show either sign if the level of similarity is not controlled for.

Since potential bidders that are preempted are hard to observe in historical field data, we employ a laboratory experiment to test our theoretical predictions and to validate the model. The experimental design replicates the model specification. Two groups of subjects play the roles of first or second bidder in a company auction. Their valuations are correlated with a correlation coefficient called “similarity level”. The first bidder chooses her first bid and the second bidder can decide to enter or not depending on the first bid and the similarity level. In this way, we collect data about preemptive bidding behavior and conditional entry decisions.

The experimental results support the main insights of the model. High first bids deter second bidders from entering. The proportion of single bidder contests demonstrates a non-monotonic pattern in similarity levels, as predicted. However, preemptive first bids exhibit a monotonic increasing relation with similarity levels, rather than the predicted inverted U-shape. Our explanation for this discrepancy between the model and experimental behavior is the utility of winning hypothesis, which states that the pure fact of winning can bring the winning bidder an additional utility (besides actual payoff). In corporate acquisitions, utility of winning manifests in agency conflicts that lead to empire-building and
managerial entrenchment. The first bidder with utility of winning is willing to pay a high preemptive bid to secure winning and the second bidder with utility of winning is difficult to be deterred, which reinforces high preemptive bids. Utility of winning has a particularly strong effect on preemptive bids in contests between very similar bidders, which are the most competitive. By adding utility of winning to our model, we get a new predicted equilibrium, which includes a non-monotonic preemption proportion and a monotonic acquisition price. The improvement in fit between theory and experiment findings indicates that the utility of winning can play a role in shaping bidding strategies.

This paper is related to the literature on sequential bidding in takeover contests initiated by Fishman (1988). With sequential entry, there is information externality from initial bids. Hence, a high first bid, which signals a high value of initial bidders for the target, can deter competition. Others have extended this model in various directions. Fishman (1989) shows that the medium of exchange can be a supplementary tool for preemption in addition to a high bid. Chowdhry and Nanda (1993) claim that issuing debt commits the bidder to overbidding, which can be preemptive. Burkart (1995), Singh (1998), Bulow, Huang and Klemperer (1999), and Ravid and Spiegel (1999) study overbidding induced by toeholds. Hirshleifer and Png (1989), Daniel and Hirshleifer (1998) explore takeovers from the perspective of efficiency, and find that, although preemption reduces competition, it may raise expected social welfare if bidding is costly. Che and Lewis (2007) apply the preemption model to a policy analysis of lockups, and discuss how lockups affect competition levels and allocation efficiency. Bulow and Klemperer (2009) compare simultaneous auctions and sequential-entry takeover contests and rationalize the target’s preference for auctions rather than for sequential bidding by showing how preemptive bids transfer surplus from sellers to buyers. The model presented here differs from all these papers in that it investigates the impact of similarity between bidders on equilibrium bids, participation, and returns by assuming private correlated values. Our experiment is the first direct test in a controlled environment of the underling model of sequential-entry takeover contrasts.

The remainder of the article is organized as follows. In Section 2, we describe our model of a sequential-entry takeover contest. Section 3 analyzes bidding and participation strategies and presents the
equilibrium. Section 4 discusses empirical implications of the model. Section 5 describes the experiment design. Section 6 presents the experimental results and a behavioral extension of the model. Finally, we conclude in Section 7.

2. A model of takeover contests

2.1. Bidders and target values

Two potential bidders, firms A and B, compete to acquire a target. The private values of the target for the two bidders are allowed to be interdependent. The valuation of firm \( i \) is denoted by \( v_i \), \( i = A, B \).

Both valuations are drawn from normal distributions with equal means, \( v_0 \), standard deviations, \( \sigma \), and are correlated with coefficient \( \rho \geq 0 \). \( f_i \) and \( F_i \) denote probability density and cumulative distribution functions of \( v_i \). Below we use the notation \( \tilde{v}_i \) and \( \bar{v}_i \) for the random values and \( v_A \) and \( v_B \) for their realizations to clarify the distinction. The bidders know the distributions of both values, but can observe the realizations of their own values after conducting costly valuation and cannot directly observe the value realizations of the opponent. The value of the target without a takeover is equal to \( v_0 \). This means that uninformed bidders expect neither to create nor to destroy value in the takeover. The target accepts any offer at or above \( v_0 \).

We model the interdependence of values using non-negative correlation instead of the commonly-used affiliation, mostly because correlation is easier to understand for the subjects in our experiment.\(^4\) It is important to understand how to interpret different levels of the correlation coefficient. The correlation between bidders’ valuations reflects the degree of similarity of the rival bidders’ resources, capabilities,

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\(^3\) Our focus on the single-bidder and two-bidder contests should be not seen as very limiting as few contests have more than two bidders. Bradley, Desai, and Han (1988) report only eight instances of more than two public bidders in their sample of 286 contests. The number of potential bidders may be higher, but Boone and Mulherin (2008), who also identify potential bidders that did not publicly place a bid, provide evidence that our assumption is close to reality in most situations. They show that the average number of potential buyers (those signing confidentiality agreements to access non-public information about the target) is 3.14 (median 1), of private-bid bidders is 1.24 (median 1) and of public-bid bidders is 1.12 (median 1). The low numbers also indicate that it should be relatively easy for firms to identify other potential buyers.

\(^4\) Note that affiliation is a subset of positive correlation.
and post-acquisition strategies. More specifically, we have the following examples in mind. Private equity funds often have very similar post-acquisition strategies and therefore likely to face high correlation between valuations. For example, in leveraged buyouts, the added value is mainly generated by tax shields, high managerial participation, improved monitoring stemming from concentrated ownership and the disciplining effect of leverage. These value drivers are relatively homogenous and can be obtained by a number of capable investors. Strategic buyers are more heterogeneous as they may have built up unique assets and are likely to create unique synergies that depend on the bidders’ assets and resources and their match with the target. Clearly, in some such cases the correlation may be positive and high (e.g., two industry competitors competing for a horizontal merger with a third firm), but in other situations it can be much lower (e.g., an industry leader aiming at horizontal integration and industry consolidation competing against an industry supplier aiming at limiting bargaining power). Zero correlation can be expected if two bidders derive values from a completely different match of resources or industry forces, for example, a hostile bidder with an asset-stripping strategy and a strategic bidder valuing the target as a going concern.

2.2. Bidding and payoffs

We consider the following bidding contest. First, bidder A finds a potential target that is suitable for acquisition. Following Fishman (1989), we assume that there are few potential targets so that it is not profitable for acquirers to perform costly due diligence on random firms. Bidder A pays entry cost $c_A$ to get informed on its private valuation $v_A$ of the target. Next, if $v_A$ exceeds the seller’s reservation price, $v_0$, then bidder A places an initial offer $b$. If bidder A does not place a bid, the contest is over, as bidder B does not know the potential target. After observing $b$, bidder B decides whether to enter the contest and to learn its valuation $v_B$ of the target. We denote bidder B’s decision by $e_B \in \{0,1\}$, where $e_B = 0$ indicates that bidder B does not enter the contest and $e_B = 1$ indicates that bidder B pays entry cost $c_B$. 
and learns $v_B$. Finally, if bidder $B$ enters, the price is determined by an English auction. This means that the bidder with the highest valuation wins the auction and pays the value of the losing bidder.

Entry is assumed to be costly. The entry costs of both bidders include due diligence costs required to learn the value of the target in acquisition. This includes fees to consultants and investment bankers but also other costs such as disclosure costs, financing fees, or opportunity cost of management time. In effect, we assume that a bidder can participate in the takeover contest only if it pays the entry cost.

We simplify the analysis and assume that the entry cost of bidder $A$, $c_A$, is sufficiently low so that bidder $A$ always performs due diligence if it identifies a potential target. Because the game is degenerate if bidder $A$ does not place a bid, it is with little loss of generality.

In the game after bidder $A$’s entry, we derive equilibrium decisions of bidder $A$ to place the initial bid and of bidder $B$ to enter the takeover contest. This signaling game can have multiple equilibriums. We focus on the perfect Bayesian equilibrium that is most profitable for bidder $A$. This is equivalent to selecting the perfect sequential equilibrium or the one satisfying the credibility refinement.\(^5\)

With this game specification, we can determine the bidders’ payoffs contingent on their valuations and actions. Denote by $\pi_i(v_A, v_B, b, e_B)$ the payoff of bidder $i$ as a function of $v_A, v_B, b, \text{ and } e_B$. The payoff function of bidder $A$, if it places a bid, can be written as

$$\pi_A(v_A, v_B, b, 0) = v_A - b - c_A;$$

$$\pi_A(v_A, v_B, b, 1) = \begin{cases} v_A - b - c_A & \text{if } v_B \leq b \\ v_A - v_B - c_A & \text{if } b < v_B \leq v_A \\ -c_A & \text{if } v_B > v_A. \end{cases}\quad(1)$$

Upon winning the contest, bidder $A$ receives the payoff equal to its valuation of the target $v_A$ minus the price paid and minus the entry cost. Note that in an English auction mechanism, the winning bidder pays the value of the losing bidder, so the price paid by winning bidder $A$ if $b < v_B \leq v_A$ is $v_B$. Bidder $A$ loses the contest if $v_B > v_A$ and its payoff is then just $-c_A$. Similarly, bidder $B$’s payoffs are the following:

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\(^5\) The equilibrium selection follows Fishman (1988). See also Che and Lewis (2007) and Bulow and Klemperer (2009, footnotes 11 and 21) for a more detailed discussion.
\[
\begin{align*}
\pi_B(v_A, v_B, b, 0) &= 0; \\
\pi_B(v_A, v_B, b, 1) &= \begin{cases} 
-c_B & \text{if } v_B \leq v_A \\
-\frac{v_B - v_A - c_B}{2} & \text{if } v_B > v_A.
\end{cases}
\end{align*}
\]

(2)

2.3. Informational externalities and competition

We take a first look at the influence of bidder A’s offer on bidder B’s beliefs and payoff. An important observation is that the expected payoff may either increase or decrease in the level of similarity between the valuations. Intuition suggests that there are two effects due to correlated valuations. First, if valuations are dependent, then the second bidder can infer some information about its own value of the target from the first offer. Second, if both bidders enter the contest, the level of similarity will affect the competitiveness of the contest and the price paid by the winning bidder. We refer to the former effect as the informational externality effect and to the latter as the competition effect.

Suppose now that bidder A’s strategy of is fully revealing. From observing a bid \(b\), bidder B can exactly infer the realization of bidder A’s value \(v_A\). In other words, we assume here that bidder A’s strategy is separating and each valuation realization stipulates a different bid. Because \(v_A\) and \(v_B\) are correlated, information about the realization of \(v_A\) affects the posterior distribution of \(v_B\). Given bidder A’s value \(v_A\), the posterior distribution of the value of bidder B is again normal with probability density function denoted by \(f_{B|A}\). The expected value is updated to

\[
\mu_{B|A} = \mathbb{E}[v_B | v_A] = \rho v_A + (1 - \rho)v_o.
\]

(3)

It follows from (3) that the informational externality effect of increasing \(\rho\) on bidder B’s expected value is positive for all \(\rho\) as long as \(v_A > v_o\). Because bidder A places a bid only if \(v_A\) exceeds \(v_o\), the informational externality effect encourages bidder B to participate and bidder B is better off with a correlation with bidder A that is as high as possible.

The posterior standard deviation of \(v_B\) is updated to \(\sigma_{B|A} = \sigma \sqrt{1 - \rho^2}\). It is the largest at \(\rho = 0\) and decreases as the value of \(\rho\) increases. The posterior standard deviation is related to the competition effect
and it works through the expected payoff that bidder B obtains from entering the contest. If bidder B knows the realization of $v_A$, this payoff is given by

$$E[p_B(v_A, \bar{v}_B, b, 1)] = -\int_{v_A}^{\bar{v}_B} c_B f_{v_B|A}(v)dv + \int_{v_A}^{1} (v - v_A - c_B) f_{v_B|A}(v)dv$$

$$= \sigma \sqrt{1 - \rho^2} \phi(z_A) - z_A (1 - \Phi(z_A)) - c_B,$$

where $z_A = (v_A - \mu_{v_B|A}) / \sigma_{v_B|A}$, and $\phi$ and $\Phi$ denote probability density and cumulative distribution functions of the standard normal distribution.

To isolate the competition effect, we set $v_A = v_0$, at which the informational externality effect is absent. Taking the derivative of (4) with respect to $\rho$, we obtain

$$-\rho \sigma \sqrt{1 - \rho^2} / \sqrt{2\pi}.$$

The sign of this expression—reflecting the competition effect of similarity—is negative if $\rho > 0$. When taking into account only the competition effect, bidder B prefers the correlation to be equal to zero. Intuitively, if both bidders enter the contest and their valuations are not dispersed, then they outbid each other to the point that the expected price paid by the winning bidder is close to its value. In other words, given the mean of its valuation, bidder B prefers to have the highest variance. The effect is caused by the convexity of bidder B’s payoff function in its valuation of the target, so that a higher posterior variance $\sigma^2_{v_B|A}$ leads to higher expected payoffs.

With the assumption of this subsection that $v_A$ is observable, neither the informational externality effect nor the competition effect dominates for all levels of similarity. The derivate of the expected payoff of bidder B from entering (given in (4)) with respect to $\rho$ includes both effects and is given by

$$\frac{\sigma}{\sqrt{1 - \rho^2}} \left[-\rho \phi(z_A) + (1 - \rho)z_A (1 - \Phi(z_A))\right].$$
It is easy to establish that this expression is positive for relatively small positive $\rho$ (the positive informational externality effect dominates the negative competition effect), and is negative for large positive $\rho$ (the negative competition effect dominates the positive informational externality effect).

The preceding discussion clearly conveys the intuition for the two effects of similarity, but the separating strategy of bidder A that fully reveals its valuation cannot be sustained by an equilibrium. The next section analyzes strategies of both bidders that can form equilibrium.

### 3. Bidders’ strategies and equilibrium

#### 3.1. Bidder A: to preempt or to accommodate

We restrict our attention to cut-off pure strategies in which bidder A with valuations within a certain set places a specified bid. These strategies are intuitive and have a clear interpretation in our bidding game: preemption and accommodation. With a preemptive bid, the expected payoff for the second bidder is sufficiently low so that it is deterred from entering. An accommodating bid does not attempt to limit participation of the follower. If bidder A preempts with a bid $b$, its expected payoff is given by

$$E[\pi_A(v_A, \bar{v}_B, b, 0)] = v_A - b - c_A.$$  \hspace{1cm} (7)

If bidder A accommodates, it cannot gain anything from bidding above the reservation value, so its bid is equal to $v_0$ and its expected payoff is

$$E[\pi_A(v_A, \bar{v}_B, v_0, 1)] = \int_{v_A}^{v_0} \pi_A(v_A, v, v_0, 1) f_{\bar{v}_B}(v) dv = \int_{v_A}^{v_0} (v_A - v - c_A) f_{\bar{v}_B}(v) dv$$

$$+ \int_{v_A}^{v_0} (v_A - v - c_A) f_{\bar{v}_B}(v) dv + \int_{v_A}^{v_0} -c_A f_{\bar{v}_B}(v) dv$$

$$= \sigma \sqrt{1 - \rho^2} \left[ \phi(z_A) - \phi(z_0) + z_A \Phi(z_A) - z_0 \Phi(z_0) \right] - c_A,$$  \hspace{1cm} (8)

where $z_A = (v_A - \mu_{\bar{v}_B}) / \sigma_{\bar{v}_B}$ and $z_0 = (v_0 - \mu_{\bar{v}_B}) / \sigma_{\bar{v}_B}$.

Bidder A will be willing to preempt with a bid $b$ if the expected payoff from preemption exceeds or equals the expected payoff from accommodation, that is if
Figure 1. Preemptive bid $\bar{b}(v_A)$ and bidder A’s payoffs for $\rho \geq 0$. “Acc > Pre” denotes that the expected payoff from the accommodating strategy exceeds the expected payoff from the preemptive strategy with bid $b$. “Pre > Acc” denotes that the expected payoff from the preemptive strategy with bid $b$ exceeds the expected payoff from the accommodating strategy.

\[
V(v_A, b) = E[\pi_A(v_A, \bar{v}_B, b, 0)] - E[\pi_A(v_A, \bar{v}_B, v_0, 1)] \geq 0. \quad (9)
\]

Conversely, if $V(v_A, b) < 0$, then bidder A is better off with accommodation. Denote by $\bar{b}(v_A)$ the maximum bid that bidder A with value $v_A$ is willing to offer to preempt bidder B. This means that with a bid at $\bar{b}(v_A)$, the condition in (9) holds in equality. Substituting (7) and (8) into (9), we obtain that

\[
\bar{b}(v_A) = v_A - \sigma \sqrt{1 - \rho^2} [\phi(z_\phi) - \phi(z_0) + z_A \Phi(z_A) - z_0 \Phi(z_0)]. \quad (10)
\]

For a given preemptive bid $b$, bidder A’s incentive for accommodation or preemption depends on the realized value of $v_A$. If $b \leq \bar{b}(v_A)$, then the expected payoff from preemption is larger than that from accommodation, and the opposite relation holds if $b > \bar{b}(v_A)$. In the Appendix we prove that the following result holds given that $\rho \geq 0$.

**Lemma 1.** $\bar{b}(v_A)$ increases in $v_A \geq v_0$. 

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The implication of the lemma is illustrated in Figure 1 and is that for a given preemptive bid $b$, such that $\bar{b}(\nu) = b$, bidder A with valuation larger than or equal to $\nu$ prefers to preempt rather than to accommodate. This observation justifies our focus on cut-off accommodation and preemption strategies of bidder A.

3.2. Bidder B: to participate or to stay out

We consider here bidder B’s expected payoff when bidder A uses a cut-off strategy. Suppose a bid $b$ is chosen if the realized valuation of bidder A lies in between some $\nu$ and $\bar{\nu}$. Denote by $W(\nu, \bar{\nu})$ bidder B’s expected payoff if it decides to enter the contest (as long as bid $b$ is lower than $\nu$, which is the case in equilibrium, this value depends only on the implied valuations of bidder A, not on the bid itself). Then

$$W(\nu, \bar{\nu}) = \frac{1}{F_A(\bar{\nu}) - F_A(\nu)} \int_{\nu}^{\bar{\nu}} E[\pi_A(v_A, \bar{\nu}, b, 1)] f_A(v_A) dv_A. \tag{11}$$

Bidder B is deterred by the set of bidder A with valuations in $(\nu, \bar{\nu})$ if $W(\nu, \bar{\nu}) \leq 0$. If this is the case, then bidder B’s payoff from entering falls below its payoff from staying out, which is equal to zero.

From Section 3.1 we know that for $\rho \geq 0$, bidder A’s incentives to preempt increase in its own valuation. Therefore bidder A uses a preemptive strategy if its valuations are above some $\nu$. A preemptive strategy works only if it implies that bidder B does not enter, that is, that the expected payoff of bidder B from entering $W$ is non-positive. The following lemma shows that the cheapest such strategies (with $W$ equal to zero) are unique.

Lemma 2. There exists at most one $\nu \geq \nu_0$ that solves $W(\nu, \infty) = 0$.

For the case of $\rho \geq 0$, let us define $\nu_L$ such that $W(\nu_L, \infty) = 0$. $\nu_L$ is the lowest value such that information that $\nu_A \geq \nu_L$ deters bidder B from the contest.
The incentives of bidder B to enter are influenced by the informational externality and competition effects. If the negative effects of similarity dominate, bidder B may easily be deterred. In particular, in some cases, bidder B may be deterred by information that \( v_A \) exceeds the reservation value, \( v_A \geq v_0 \), inferred from observing bidder A placing any bid. The following lemma specifies when this is the case.

**Lemma 3.** Let \( R = \sqrt{2\pi c_A}/\sigma \) and assume that \( 2R < 1 \). If bidder B believes that \( v_A \geq v_0 \), then bidder B does not enter the contest whenever \( \rho < \rho_1 = R - \sqrt{1-2R} \) or \( \rho > \rho_2 = R + \sqrt{1-2R} \).

We assume from now on that \( 2R < 1 \) to focus on interesting cases. If this condition is not satisfied, then bidder B does not participate after a bid from A for any possible value of \( \rho \). Lemma 3 states that if bidder B’s only information is that bidder A’s valuation exceeds the reservation price \( v_0 \), it may still be sufficient as a deterrent if the valuations are interdependent with a low correlation coefficient, \( \rho < \rho_1 \), or if the valuations are strongly positively correlated, \( \rho > \rho_2 \). Intuitively, a high value of \( v_A \) together with a low correlation promises a low expected value of \( v_B \). For example, consider the extreme case with \( \rho = -1 \). Then \( v_A > v_0 \) implies \( v_B < v_0 \) and bidder B makes sure losses with any positive entry cost. On the other hand, a high value of \( v_A \) with a high correlation leaves little profit to be earned in the subsequent auction, because values of both bidders are expected to be similar. At the extreme point as \( \rho = 1 \), \( v_B \) is equal to \( v_A \) with probability one, and after entry the price paid is equal to the value, which leaves no profit. At very low and very high correlation, expected payoffs do not compensate the entry cost. We note that for positive \( c_A \) and \( 2R < 1 \), both \( \rho_1 \) and \( \rho_2 \) are inside the domain for a correlation coefficient and are such that \(-1 < \rho_1 < 0.5 < \rho_2 < 1\).

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6 The condition is a result of the requirement that \( W(v_0, \infty) \) is positive at least for some values of \( \rho \).
3.3. Equilibrium

Equilibrium strategies (in the game after A enters) consists of bidder A’s initial bidding strategy $b$ and bidder B’s entry strategy $e_b$. In the previous subsections, we outlined the derivation of the strategies in the signaling equilibrium involving the most profitable outcome for bidder A. These strategies can be interpreted as accommodation with a bid at the reservation price that induces entry of the competitor, as preemption with a bid at a premium over the reservation price that deters the other contestant, and, in some cases, as a deterring bid that, while low at the reservation price, effectively deters the competitor.

For example, in the case of the preemptive outcome, the equilibrium is constructed as follows. We have shown that there is a threshold $v_L$ such that bidder A with $v_A \geq v_L$ places a preemptive bid and deters bidder B. For this bid not to be imitated by bidder types with $v_A < v_L$, it must be at least $b(v_L)$. Bidder A with valuations $v_A < v_L$ cannot match this bid and offers the lowest price $v_0$ which invites the second bidder. These results are gathered in the following proposition.  

**Proposition 4.** In the game after bidder A enters, there exists equilibrium $(b^*, e^*_b)$ in cut-off strategies with the following properties. If $v_A \geq v_0$, then bidder A places a bid and there are two cases.

1. If $0 \leq \rho < \rho_1$, then

\[
b^* (v_A) = \begin{cases} 
  b(v_L) & \text{if } v_A \geq v_L \\
  v_0 & \text{if } v_0 \leq v_A < v_L,
\end{cases}
\]

\[
e^*_b (b) = \begin{cases} 
  1 & \text{if } b < b(v_L) \\
  0 & \text{if } b = b(v_L);
\end{cases}
\]

2. If $\rho \geq \rho_2$, then $b^* (v_A) = v_0$ and $e^*_b (b) = 0$.

---

\[\text{For transparency, Proposition 4 is stated for the case } \rho_1 < 0. \text{ Using Lemma 3, it holds if } R < \sqrt{2} - 1. \text{ The proposition can be adapted to the other case in the obvious way.}\]
Figure 2. Equilibrium strategies in the bidding game (with bidder A participating) for various correlations $\rho$ and bidder A’s valuations $v_A$. The figure on the left presents the case of $\rho \leq 0$ and the one on the right presents the case of $\rho > 0$. Regions 1-4 specify qualitatively different strategy pairs.

Figure 2 presents how the equilibrium strategies depend on the level of correlation between the valuations. There are four possible scenarios depending on the correlation $\rho$ and the first bidder’s valuation $v_A$. In Region 1 at intermediate levels of correlation, bidder A preempts bidder B with a high bid. If the correlation is positive then this happens for sufficiently high values $v_A$ such that $v_A \geq v_B$. In Region 2 at intermediate levels of correlation and at low valuations (but above $v_0$), bidder A accommodates. With increasing correlation, the accommodation strategy is first supported by increasing valuations (preemption is difficult due to the informational externality effect). Then with increasing correlation, preemption becomes easier (due to the competition effect) and accommodation is used only by bidder A with relatively low values.\(^8\) In Region 3, the bidders are so similar that it does not pay for bidder B to engage in costly participation in the contest. In Region 4, the bidders are so dissimilar that if the target is sufficiently attractive for the initial bidder to place a bid, then bidder B’s expected payoff is not sufficient to participate.

\(^8\) See the Appendix for a proof that $v$ is always non-monotonic in $\rho$, increasing for small correlation and decreasing for high correlation.
4. Implications of the theory

Similarity between bidders generates the trade-off between the informational externality of the initial bid and the intensity of competition. The interaction of these two forces leads to a non-monotonic relationship of the correlation coefficient on acquisition strategies and returns. Figure 3 presents numerical comparative statics with respect to the correlation coefficient between bidders’ valuations. Other exogenous parameters are set at $\sigma = 20$, $c_g = 2$, and $v_0 = 50$. These parameters are later used in our experiments. Figures 3.A and 3.B plot the expected prices paid for the target in single-bidders contests and multiple-bidder contests. Contingent on observing a single-bidder contest, the offered price has an inverted U-shape in the similarity with the potential competitor. Similarly, contingent on observing a two-bidder contest, the expected price paid by the winning bidder has an inverted U-shape in the similarity between bidders. The non-monotonic effect of similarity on target returns is driven by the fact that low bids may deter competition if the potential competitors are very similar or very dissimilar. It should be noted that in what is meant here as multiple-bidder contests, there could only be one official bid observed, if the second bidder’s value turned out to be below the reservation price after due diligence. But in such contests there are more potential acquirers that participate in earlier stages of the contests (by, for example, signing confidentiality agreements to access non-public information about the target).

Figures 3.C and 3.D present the probabilities of observing either a single-bidder contest or a multiple-bidder contest conditional on observing a takeover. The probability of single-bidder contests is non-monotonic and has a U-shape. The complementing probability of two-bidder contests is then also non-monotonic and has an inverted U-shape. The two-bidder contests are mostly observed at intermediate positive correlation. The intuition is that it is most difficult to deter the second bidder at these levels of correlation, and only the highest valuations of the first bidder can serve as an effective deterrent.

The expected final price in two-bidder contests is lower that the preemptive bid in single-bidder acquisitions for any given correlation. This is because accommodating bids are offered by bidder A only
Figure 3. Non-monotonic effects of correlation $\rho$. The figures show the preemptive bid (A), the expected price paid in a two-bidder contest (B), the probability of preemption (C) and of two-bidder contests (D) for different levels of the correlation coefficient between the bidders’ valuations. All the values are calculated for $\sigma = 20$, $c_B = 2$, and $v_o = 50$.

when it has a relatively low valuation or when it expects weak competition. However, two-bidder contests are most likely when the expected prices in two-bidder contests are high, and single-bidder contests are most likely when the prices in single-bidder contests are low. This may explain why empirical evidence of the effects of competition measured by the number of bidders on target returns is inconclusive and frequently demonstrates a puzzling lack of any significant relation. The analysis indicates that the effect of the number of bidders should be controlled for the level of similarity.
5. The experimental setup

The theoretical predictions of the model are difficult to test empirically using historical acquisition data. First, as is usual with field data, many relevant factors change simultaneously making clean comparative static tests difficult. Second, more specifically to our theory, information about competing bidders is available in multi-bidder contests. However, in single-bidder contests, the identity of preempted bidders, and so their similarity with acquirers, is not readily observable by researchers. A laboratory experiment is a suitable methodology that allows us to test the theory on human behavior in a controlled environment. We design a computerized experiment in which we recreate the exact setting of the model. In different treatments, we change only the level of interdependence between bidders’ valuations and keep all other variables constant.

It should be noted that the behavior observed in the laboratory often deviates from theoretical predictions even in simple auctions [see Kagel (1995) for a survey]. People demonstrate systematic biases that may intensify some predicted forces and weaken others. The aim here is to verify if people respond to the key tradeoffs in our theory. As such, a laboratory test is a first and important step to validate the relevance of our theoretical predictions to corporate environments.9

5.1. Treatments and hypotheses

The parameters in the experiment are chosen to replicate a takeover opportunity with uncertain value and with sufficient potential profits to make the investment attractive. The mean target value is set at \( v_0 = 50 \), the standard deviation of the bidders’ valuation, \( \sigma \), equals 20, and the entry cost, \( c \), equals 2. When there is no rival, this parameter setting leads to an expected payoff of about 30 to a bidder if she enters. With competing bidders, the expected payoff of the initial bidder will vary depending on the intensity of competition and the strategies bidders adopt.

9 Several other papers also use experiments to test corporate takeovers theories, e.g., Kale and Noe (1997), Croson, Gomes, McGinn and Nöth (2004), Gillette and Noe (2006), and Kogan and Morgan (2010).
Table 1. Theoretical predictions in the three treatments.

Single-bidder contests denotes the proportion of contests in which bidder B does not participate; Price in single-bidder contests denotes the level of the first bid that deters bidder B from entering (preemptive bid); Price in two-bidder contests denotes the average price in cases where bidder B enters; and Preemption value denotes the level of the first bidder valuation above which she decides to place a preemptive bid. The numbers are rounded to integer values.

<table>
<thead>
<tr>
<th>Similarity treatment</th>
<th>Single-bidder contests</th>
<th>Price in single-bidder contests</th>
<th>Price in two-bidder contests</th>
<th>Preemption value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>66%</td>
<td>53</td>
<td>51</td>
<td>58</td>
</tr>
<tr>
<td>Intermediate</td>
<td>30%</td>
<td>60</td>
<td>54</td>
<td>69</td>
</tr>
<tr>
<td>High</td>
<td>70%</td>
<td>56</td>
<td>53</td>
<td>58</td>
</tr>
</tbody>
</table>

*Based on the generated data used in this experiment. The predictions based on the exact theoretical distribution are 67%, 34%, and 67% for Low, Intermediate and High treatments, respectively.

We set up three treatments that differ in the level of correlation between bidders’ valuations. The correlations are 0, 0.5, and 0.95. These levels are sufficiently different to represent three typical takeover contests. In the low similarity treatment (with correlation equal to 0), bidders’ valuations are independent. This is as in the standard Fishman (1988) model and we interpret this case as a contest between a strategic bidder and a financial bidder. The intermediate similarity treatment (with correlation equal to 0.5) represents the case of two strategic bidders. The high similarity treatment (with correlation equal to 0.95) represents the case in which bidders’ valuation are highly dependent with each other as in bidding between two financial bidders.

The three treatments generate qualitatively distinctive equilibrium strategies. Table 1 reports the theoretical predictions for equilibrium strategies and outcomes. At low similarity, the minimum bid that can preempt bidder B is 53 and when bidder A’s value is above 58, she chooses to offer this preemptive bid. This implies that single-bidder contests are expected in 66% of observed takeovers and that the average price in two-bidder contests is about 51. At intermediate similarity, bidder A makes a preemptive bid equal to 60 when her value is above 69 and the proportion of single-bidder contests is significantly lower at 30%, while prices in two-bidder contests are higher at 54. At high similarity, the proportion of single-bidder contests increases to 70%, bidder A will make a preemptive bid of 56 when her value is above 58, and the average price in two-bidder contests decreases slightly to 53. The model predicts a non-
monotonic pattern in the proportion of single-bidder contests and acquisition prices. This leads to three testable hypotheses.\textsuperscript{10}

**Hypothesis 1.** The proportion of single-bidder contests is higher in the low and high treatments than in the intermediate treatment.

**Hypothesis 2.** Acquisition prices in single-bidder contests in the low and high similarity treatments are lower than in the intermediate treatment.

**Hypothesis 3.** Acquisition prices in two-bidder contests in the low and high similarity treatments are lower than in the intermediate treatment.

### 5.2. Experiment implementation

We carried out the experiment in the Erasmus Behavioural Lab (EBL) with subjects that are master-level students in economics and finance. 36 subjects took part in the experiment in two identical sessions with different subjects: 20 in a first session and 16 in a second session.

In each session, the bidding game was repeated in 30 rounds. Additionally, the subjects first played six unpaid practice rounds to learn the experimental setup and the game. Our experiment comprised 540 rounds in total. At the beginning of each session, participants were randomly assigned to play a role throughout the entire session: either "first bidder" or "second bidder". Each first bidder was randomly paired with a second bidder in each round to avoid learning bidder characteristics. This was aimed to facilitate the perception of a series of one-shot games.

\textsuperscript{10} We do not specify a separate hypothesis for preemption values. First, preemption values used by bidder A are not directly observable in the experiment. Second, in the theory, preemption values measure the same behavior as the proportion of single-bidder contests. The proportion of single-bidder contests is the proportion of bidder A’s distribution that falls above preemption value.
The sequence of the game was as follows. At the beginning, both bidders were informed about the level of their similarity. The first bidder was assigned her valuation of the target and the entry fee was deducted from her account. Next, she submitted her bid. After observing the first bid and similarity level, the second bidder chose whether to enter or not. If she entered, the entry fee was deducted from her current account and her valuation of the target was revealed. Then the outcome of the auction was automatically determined by an English auction – the bidder with the highest valuation bought the target for the second highest bid. If instead the second bidder chose not to enter, the game ended and the first bidder bought the target with her first bid.

Each bidder’s valuation of the target was private information. The similarity level and the distribution of bidders’ valuations were known to both bidders. It was also known that the target would not sell below a reservation price of 50. In every round, the first bidder was assigned a new random valuation drawn from normal distribution with a mean of 50 and a standard deviation of 20 truncated at the mean. The first bidder’s valuation is truncated and is above 50, because otherwise no contest is initiated. The value for the second bidder was drawn from a (non-truncated) normal distribution with a mean of 50 and a standard deviation of 20. The second bidder’s valuation was correlated with the first bidder’s valuation with a correlation coefficient equal to the similarity level. To ensure that participants understood the distribution of bidders’ valuations and their interdependent nature, numerical examples were given for different similarity levels.

Each pair of bidders in each round was assigned with a new similarity level drawn from the set \{0, 0.5, 0.95\} with equal probability. To control learning across different similarity levels, the similarity level sequence was arranged in a random order. The experimental sessions lasted about two hours and the final payoffs in the experiment were determined by the performance of the participants and by their roles. The accumulated payoffs were recorded by points they earned or lost, with a conversion rate of €1 for every

---

11 The second highest bid is defined as the second highest value in \{the first bidder’s valuation, the second bidder’s valuation, the first bid\}.
12 Alternatively, we could have used full normal distribution and removed half of the rounds which involved no actions and had no information.
13 We refer to the online appendix for the experiment instructions.
20 points. Because of the entry fee, the bidders that lost an auction incurred a net loss. To prevent bankruptcy, each bidder was given 60 initial points, which was just sufficient to cover the entire entry fee if she bid in every round. Furthermore, the second bidders were given an additional fixed payment of €5 to compensate for their disadvantaged initial position compared to the first bidders. The range of actual earnings paid to the first bidder was €5.90-€17.00, with a mean of €9.00; the range of actual earnings paid to the second bidder was €7.70-€10.90, with a mean of €9.00.

6. Experimental results

We start with an overview of aggregate bidder behavior in different treatments. Table 2 presents descriptive statistics of the results. Panel A shows that the first bid in the single-bidder contests is higher than that in the two-bidder contests. The differences are highly significant in all treatments. We take this finding as reassurance that first bids can be preemptive and most subjects were responding sensibly within our experiment.

Panel B of Table 2 provides some support to the theoretical predictions for the proposed effects of similarity between bidders. The proportion of single-bidder contests is moderately lower in the intermediate similarity treatment compared to the low similarity treatment, while the percentage of single-bidder contests in the high similarity treatment is significantly higher than that in the intermediate treatment. The U-shape across the three treatments is line with Hypothesis 1. The mean price paid in single-bidder contests is lower in the low treatment than in the intermediate treatment (significant at the 10% level), which is consistent with Hypothesis 2. The mean price paid in the high similarity treatment is higher than in the intermediate treatment, at odds with Hypothesis 2; the difference is, however, not significant.

6.1. H1: proportion of single-bidder contests

The second bidder knows only the first bid and the similarity level before she decides whether to
Table 2. Descriptive statistics of the experimental results.
Statistics are calculated from 540 experimental observations. In Panel A, the data are split in two depending on the number of bidders active in the contest. Columns report the percentage of the two types of contests (Proportion) and the mean of the first bids (First bid) and prices across the three treatments. The last two columns present the difference in first bids across the two types of contests and t-test values for differences between means. Panel B reports the results of t-tests for differences between means of the proportion of and prices paid in two types of contests across the three treatments. Parentheses report number of observations or standard error.

Panel A: statistics for each contest outcome

<table>
<thead>
<tr>
<th>Similarity treatment</th>
<th>Single-bidder contests</th>
<th>Two-bidder contests</th>
<th>First bid difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proportion</td>
<td>First bid (Price)</td>
<td>Proportion</td>
</tr>
<tr>
<td>Low</td>
<td>27%</td>
<td>56.00</td>
<td>73%</td>
</tr>
<tr>
<td></td>
<td>(N=132)</td>
<td>(0.93)</td>
<td>(N=48)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>22%</td>
<td>58.79</td>
<td>78%</td>
</tr>
<tr>
<td></td>
<td>(N=141)</td>
<td>(1.28)</td>
<td>(N=39)</td>
</tr>
<tr>
<td>High</td>
<td>39%</td>
<td>60.80</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>(N=110)</td>
<td>(1.42)</td>
<td>(N=70)</td>
</tr>
</tbody>
</table>

Panel B: differences between treatments

<table>
<thead>
<tr>
<th>Comparison pair</th>
<th>Proportion of single-bidder contests</th>
<th>Price in single-bidder contests</th>
<th>Price in two-bidder contests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low – Intermediate</td>
<td>5% (4.5%)</td>
<td>Mean</td>
<td>1.11</td>
</tr>
<tr>
<td>High – Intermediate</td>
<td>17%*** (4.8%)</td>
<td>Mean</td>
<td>3.56</td>
</tr>
</tbody>
</table>

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

participate in the contest. To explain the binary participation decision in a regression analysis, we use these two variables as explanatory variables. Furthermore, considering that the participation decision may also be affected by individual characteristics, we adopt a random-effect probit regression with an individual specific term included in the disturbance. Specifically, we estimate the following model:

\[
y'_p = \gamma_0 + \gamma_1 \text{FirstBid}_j + \gamma_2 \text{Low}_t + \gamma_3 \text{High}_t + \eta_j + \epsilon_y
\]

\[
y_p = \begin{cases} 
1 & \text{if } y'_p \geq 0 \\
0 & \text{if } y'_p < 0 
\end{cases}
\]

where \(y'_p\) is a latent variable, and \(y_p\) is the observed participation decision of the \(j^{th}\) second bidder in round \(t\) (with 1 denoting participation and 0 non-participation). Variable \(\text{FirstBid}_j\) is the first bid of the first
The second bidder’s participation decision. Regression is done on all experimental data, with a sample size equal to 540. The dependent variable takes a value 1 if the second bidder participates in the contest and 0 otherwise. FirstBid is the first bid of the first bidder. Low and High are dummies for the similarity treatments. The second column reports estimated coefficients and the third column reports standard errors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \gamma )</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-4.55***</td>
<td>0.61</td>
</tr>
<tr>
<td>FirstBid</td>
<td>0.06***</td>
<td>0.01</td>
</tr>
<tr>
<td>Low</td>
<td>0.31*</td>
<td>0.17</td>
</tr>
<tr>
<td>High</td>
<td>0.52***</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

The second bidder’s participation decision. Regression is done on all experimental data, with a sample size equal to 540. The dependent variable takes a value 1 if the second bidder participates in the contest and 0 otherwise. FirstBid is the first bid of the first bidder. Low and High are dummies for the similarity treatments. The second column reports estimated coefficients and the third column reports standard errors.

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Standard error</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-4.55***</td>
<td>0.61</td>
</tr>
<tr>
<td>FirstBid</td>
<td>0.06***</td>
<td>0.01</td>
</tr>
<tr>
<td>Low</td>
<td>0.31*</td>
<td>0.17</td>
</tr>
<tr>
<td>High</td>
<td>0.52***</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Variables \( Low_t \) and \( High_t \) are two dummies that stand for the low similarity and the high similarity treatments, respectively. We take intermediate similarity as a reference treatment. If the proportion of preemption indeed exhibits a U-shape, both \( \gamma_2 \) and \( \gamma_3 \) are expected to be positive. Finally, \( \eta_j \) is an individual random effect of subject \( j \) and \( \epsilon_{jt} \) is a residual error term; both are assumed to be normally distributed with a mean zero.

Estimation results are presented in Table 3. The positive sign of the coefficient of FirstBid confirms that the probability of successful preemption is increasing in the first bid. Furthermore, the positive signs of the coefficients of Low and High indicate that the probabilities of being preempted in the low and high similarity treatments are higher than in the intermediate similarity treatment. All the estimates are significant at the 1% level, except for the coefficient of Low significant at the 10% level. Therefore, the response of the second bidder is consistent with Hypothesis 1. It seems that the second bidders respond to the tradeoff between similarity effects. Low information externality in the low similarity treatment apparently discourages the second bidder from entering. The strong competition effect in the high similarity treatment can also be discouraging. On the contrary, the second bidder is less likely to be preempted in intermediate treatment because the information externality is relatively large while the competition is not very high.
Table 4. Linear regression on prices in single-bidder contests.

Only data in single-bidder contests are included, with a sample size equal to 157 observations. The dependent variable is the price paid for the target in single-bidder contests. Low and High are dummies for the similarity treatments. The second column reports estimated coefficients and the third column reports standard errors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>54.894***</td>
<td>0.633</td>
</tr>
<tr>
<td>Low</td>
<td>-1.367*</td>
<td>0.727</td>
</tr>
<tr>
<td>High</td>
<td>2.886***</td>
<td>0.728</td>
</tr>
</tbody>
</table>

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

6.2. H2: prices in single-bidder contests

According to Hypothesis 2, the intermediate treatment should facilitate the highest prices in single-bidder contests. Prices in single-bidder contests are equal to the first bidder’s preemptive bids. To check whether the first bidder’s strategy follows the prediction, we use observations with single-bidder contests and run a simple panel data regression with random effects of the following form:

$$Price_{ijt} = \beta_0 + \beta_1 Low_i + \beta_2 High_i + v_{ij} + \varepsilon_{ijt}.$$ 

Dependent variable $Price_{ijt}$ is equal to the acquisition price in single-bidder contests in round $t$. As before, variables $Low_i$ and $High_i$ are indicators for the low similarity and the high similarity treatments. Variable $v_{ij}$ is an individual random effect of the group consisting of $i^{th}$ first bidder and $j^{th}$ second bidder assumed normal with a mean of 0.

According to Hypothesis 2, both $\beta_1$ and $\beta_2$ are expected to be negative. The estimation results are reported in Table 4. $\beta_1$ is negative and significant at the 10% level. $\beta_2$ is significantly positive at the 1% level. The first bids in preempted contests are thus monotonically increasing in the similarity level. This implies that the experimental data are consistent with the comparative statics prediction of Hypothesis 2 between the low and intermediate treatments, but not between the intermediate and high treatments.

Recall that Hypothesis 1 found a clear confirmation in the data. This means that with increasing
Table 5. Linear regression on prices in two-bidder contests.

Only data in two-bidder contests are analyzed, which include 383 observations. The dependent variable is the price paid for the target in two-bidder contests. *Low* and *High* are dummies for the similarity treatments. The second column reports estimated coefficients and the third column reports standard errors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\theta$</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>57.801***</td>
<td>0.719</td>
</tr>
<tr>
<td>Low</td>
<td>-1.809*</td>
<td>1.008</td>
</tr>
<tr>
<td>High</td>
<td>4.033***</td>
<td>1.061</td>
</tr>
</tbody>
</table>

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

similarity from intermediate to high levels, the second bidder decreases her participation in the contest. However, in spite of what the theory suggests, the first bidder is either willing or is forced by the (expected) behavior of the second bidder to offer a higher preemptive bid to ensure low participation in the high similarity treatment.

6.3. **H3: prices in two-bidder contests**

The next step is to check prices in two-bidder contests. According to Hypothesis 3, the intermediate treatment boasts the highest average price compared to low and high treatments. To test it, we run a similar regression as above, but the dependent variable changes to prices in two-bidder contests. Regression is done on observations with two-bidder contests and with the following form:

$$Price_{ijt} = \theta_0 + \theta_1 Low_{i} + \theta_2 High_{i} + v_{ij} + \epsilon_{ijt}$$

$Price_{ijt}$ denotes prices in two-bidder contests, and $Low_i$ and $High_i$ are two similarity indicators. Again, we control an individual random effect of group $ij$, $v_{ij}$, assumed normal with a mean of 0.

As Hypothesis 3 predicts that price in two-bidder contests in low and high treatment are lower than in intermediate treatment, both $\theta_1$ and $\theta_2$ are expected to be negative. Regression results in Table 5 provide only partial support to this prediction. $\theta_1$ is negative at 10% significance level, while $\theta_2$ is significantly positive. Instead of a non-monotonic pattern, the prices in two-bidder contests increases monotonically in similarity, which is similar to the relation we found in the prices in single-bidder contests.
6.4. Overbidding and utility of winning

A quantitative comparison of the theoretical predictions and experimental data (see Tables 1 and 2) shows higher rates of contest participation in all experimental treatments and higher acquisition prices in high similarity treatments. This indicates that we observe some type of overbidding behavior in both bidders. While such behavior is not accounted for by our rational model with standard preferences, overbidding in auction experiments has been widely documented (Cox, Smith, and Walker, 1988; Goeree, Holt, and Palfrey, 2002).

A common and successful explanation for overbidding in auction experiments is the utility of winning hypothesis. Utility of winning refers to situations in which bidders enjoy extra utility when they win an auction and take this into account when making their decision. It has been repeatedly shown to play an important role, especially in private-value auctions (Cox et al., 1988; Goeree et al., 2002; Cooper and Fang, 2008).

We explore how utility of winning changes our predictions and if these new predictions can achieve a better match with the experimental data. Utility of winning transforms the bidders’ utility conditional on winning. The extent of utility when winning may be related to the magnitude of the payoff. In other words, the higher the payoff, the stronger the positive feeling of winning. Accordingly, we revise the utility of bidder $i$ to

$$ U_i = \begin{cases} m\pi_i & \text{if } i \text{ wins} \\ \pi_i & \text{if } i \text{ loses} \end{cases} $$

(12)

where $m$ is a multiplier denoting a utility that will amplify the utility in winning cases by $m$ times.\(^{15}\)

\(^{14}\) Besides utility of winning, we also checked other explanations for overbidding, such as loss aversion, over-optimism and excessive entry of the second bidder. However, these alternative explanations fail to provide a better fit than utility of winning. Furthermore, these behavioral factors cannot explain co-existence of a non-monotonic proportion of single-bidder contests and monotonic preemptive bids.

\(^{15}\) We also tried a specification of a constant utility of winning, as used in Goeree et al. (2002), i.e., $U_i = \pi_i(\text{win}) + w$, where constant $w$ denotes additional utility brought by winning. This payoff insensitive model produces a similar result as the specification in (12) but with a bit higher prediction error (156). To make the discussion concise, we report only the model with a proportional utility of winning.
Table 6. Theoretical predictions of the model extended with utility of winning.

*Single-bidder contests* denotes the proportion of contests in which bidder B does not participate; *Price in single-bidder contests* denotes the level of the first bid that deters bidder B from entering (preemptive bid); and *Price in two-bidder contests* denotes the average price in contests where bidder B participates. The numbers are rounded to integer values. To make it comparable with the experimental results, the theoretical proportion of single-bidder contests is calculated with the randomly generated data used in this experiment. The utility of winning parameter, \( m \), is estimated by minimizing the sum of squared errors between the predicted participation decision and the actual participation decisions in the data.

<table>
<thead>
<tr>
<th>Similarity treatment</th>
<th>Single-bidder contests</th>
<th>Price in single-bidder contests</th>
<th>Price in two-bidder contests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>58%</td>
<td>54</td>
<td>51</td>
</tr>
<tr>
<td>Intermediate</td>
<td>20%</td>
<td>61</td>
<td>55</td>
</tr>
<tr>
<td>High</td>
<td>29%</td>
<td>68</td>
<td>58</td>
</tr>
</tbody>
</table>

Estimated parameters \( m = 1.22 \)

<table>
<thead>
<tr>
<th>Sum of squared errors in the baseline model</th>
<th>153</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of squared errors</td>
<td>179</td>
</tr>
</tbody>
</table>

\(^{a}\) Based on the generated data used in this experiment.

Optimal strategies of both bidders can be solved for any value of \( m \). We estimate \( m \) at a level that is most consistent with the observed behavior in the experiment. For each \( m \), we calculate the predicted preemptive bid \( b_k \) in the three treatments, \( k = \text{low}, \text{intermediate}, \text{high} \). The second bidder’s predicted response in treatment \( k \) is to enter if the first bid is below \( b_k \) and not to enter if the first bid is above \( b_k \). A prediction error is defined as the difference between actual entry decisions and predicted ones (entry equals to 1 and non-entry equals to 0). By minimizing the sum of squared prediction errors across a grid over \( m \), we get the estimate of \( m \) (this simple procedure follows Levine and Palfrey (2007)).

The estimated parameters and new predictions are reported in Table 6. Compared to the previous predictions with the baseline model, the fit in entry decision is improved. In the baseline model, entry decisions in 179 observations are different from the theoretical prediction; while in the model with utility of winning this prediction error is reduced by 26.\(^{16}\) \( m \) is estimated at 1.22. This implies that when a bidder wins, the utility experienced is 22% higher than the nominal payoff. The value of parameter clearly

---

\(^{16}\) By estimating preemptive bid \( b_k \) that best explains the second bidder’s entry decisions in the data regardless of the theoretical predictions, we achieve a prediction error of 134. Taking this into consideration, a reduction of 26 can be viewed as sizable improvement.
Winning probability of each bidder

Figure 4. Winning probabilities of each bidder conditional on the second bidder’s entry. The probability is calculated from the generated data used in the experiment assuming that the second bidder always enters.

larger than one is indicative of the existence of utility of winning. Notably, the new predictions have the same comparative statics as those found in the data. The proportion of single-bidder contests exhibits a U-shape (as in the baseline model), while the acquisition prices are now increasing in the similarity level. Utility of winning improved the fit by altering predictions in those areas where the baseline model had problems explaining the data, i.e., in the high similarity treatment and more for preemptive bid and prices in two-bidder contests than for participation rates.

To understand the role of utility of winning, we need to address two questions. Why does utility of winning alter the predicted strategies mostly in the high similarity treatment? Figure 4 plots the probability of winning for each bidder conditional on the second bidder’s entry. The chance that the first bidder (the second bidder) wins decreases (increases) in similarity. Hence, utility of winning brings two effects to the bidders’ incentives. First, to secure winning, the first bidder is willing to offer a high preemptive bid especially in the high treatment. Second, to have a chance of winning, the second bidder is especially willing to enter in the high treatment. Both effects imply that utility of winning will affect

---

17 We also estimated $m_i$ separately for each subject. The estimation ranges from 0.28 to 3.89, with a mean of 2.09. The median is 1.99 and the standard deviation is 0.91. All but three estimations are larger than 1, again supporting the utility of winning hypothesis.
bidding and entry strategies mostly at high similarity. The next question to address is: Why is the acquisition price more affected by utility of winning than the entry decision? For the entry decision, a high participation rate of the second bidder is mitigated by the first bidder’s willingness to offer a higher preemptive price. On the contrary, these two effects reinforce each other while affecting acquisition prices in the presence of utility of winning. Both the first bidder’s willingness to invest more in deterrence and the second bidder’s stronger reluctance to be preempted will drive up prices in single-bidder contests (preemptive bid). Furthermore, a high participation rate strengthens a competition effect, which leads to the highest prices in two-bidder contests in the high similarity treatment.

To summarize, we find evidence indicating that utility of winning may play a role in bidding strategies. However, it remains a question whether this finding can be generalized to explain the high takeover premium observed outside the laboratory environment. The stakes in the experiment are much smaller than in corporate takeovers and subjects visiting a laboratory may be particularly prone to pursue winning. CEO’s of acquisitive companies, however, are likely to have other and also strong impulses to chase acquisitions for extra non-pecuniary utility. The main reason is that managers operate under agency conflicts. If, apart from value creation, there is additional utility of winning in acquisitions, then managers internalize the majority of the utility but their share in value creation or destruction is at most partial. This means that the decision makers’ incentives are skewed from value creation towards utility of winning. This observation is consistent with a large body of empirical evidence that documents that corporate acquisitions are, to a large degree, driven by managers’ empire building incentives and managerial entrenchment (e.g., Lang, Stulz, and Walkling, 1991; Masulis, Wang, and Xie, 2007).

7. Conclusions

This paper has shown that interdependence (or similarity) in bidders’ private valuations has significant effects on the strategies and outcomes in sequential-entry takeover contests. With interdependent valuations, the initial bid not only conveys information about the first bidder’s valuation but also about other potential bidders’ valuations. Besides this information externality, similarity levels
indicate the intensity of bidding competition if both bidders enter the contest. The information externality and the intensity of competition determine the chances of preemption and equilibrium acquisition prices. Our theory for takeover contests predicts that the information externality effect dominates at low levels of similarity and the competition effect dominates at high levels of similarly. The interplay of these two forces generates a non-monotonic effect of similarity: the proportion of multiple-bidder versus single-bidder contests and the level of acquisition prices are the highest at intermediate levels of similarity.

To verify whether these predictions hold, we carried out a controlled laboratory experiment. Subjects participated in three treatments that differed in the level of interdependence between valuations. The comparative statics prediction with respect to the proportion of single-bidder contests is strongly supported by the data. The effect of similarity on acquisition prices finds only partial support. We further find that the bidders in the experiment tend to overbid and excessively participate. By extending the takeover model with utility of winning, a standard explanation of overbidding, we can support all the comparative statics found in the data. Overall, these results indicate that subjects reacted strategically to the effects of information externality and competition intensity in the way predicted by the theory. We suggest that overbidding and utility of winning found in the laboratory have parallels in the corporate world in forms of empire building tendencies and managerial entrenchment.

Our findings on the differences between takeover contests with different similarity levels between bidders can be summarized as follows. Contests between dissimilar potential acquirers (e.g., a strategic bidder against a financial bidder) have low prices and are relatively often single-bidder contests. Contests between intermediately similar bidders (e.g., two strategic bidders) generate high prices and are frequently competitive with two bidders placing bids. Contests in which potential acquirers are very similar (e.g., two financial bidders) have high prices and are seldom with more than one bidder.

In conclusion, this paper reveals a strong influence of bidders’ similarity on takeover strategies. The theory and the experiment imply that, in addition to the number of bidders, the similarity in bidders’ characteristics is an important measure of competition intensity which should be accounted for in empirical studies of returns in takeovers.
Appendix. Proofs

**Proof of Lemma 1:** Taking the derivative of (10) with respect to $v_A$ we obtain

\[
\begin{aligned}
\tilde{B}'(v_A) &= 1 - \Phi(z_0) - \left(1 - \rho\right)\left(\Phi(z_A) - \Phi(z_0)\right) \\
&\geq 1 - \Phi(z_0) - \left(\Phi(z_A) - \Phi(z_0)\right) = 1 - \Phi(z_A) \geq 0.
\end{aligned}
\]  

(13)

In the first inequality we use that $z_A \geq z_0$ and $\rho \geq 0$. \(\square\)

**Proof of Lemma 2:** Let $v \in \{v : W(v, \infty) = 0\}$. We will show that $v$ is unique if it exists. By (11) $W(v, \infty) = 0$ is equivalent to

\[
\left\{ \int_{\bar{\nu}} E[\pi_B(v_A, \bar{v}_B, b, l)] f(v_A) dv_A = 0. \right. \tag{14}
\]

Note that $E[\pi_B(v_A, \bar{v}_B, b, l)]$ (given in (4)) is negative for large $v_A$, $E[\pi_B(\infty, \bar{v}_B, b, l)] = -c_B < 0$. Since $f(v_A)$ is always positive, $E[\pi_B(v_A, \bar{v}_B, b, l)]$ must be positive for some $v_A \geq v$, for the root $v$ in (14) to exist. Because $E[\pi_B(v_A, \bar{v}_B, b, l)]$ is decreasing in $v_A$:

\[
\frac{\partial E[\pi_B(v_A, \bar{v}_B, b, l)]}{\partial v_A} = \sigma \sqrt{1 - \rho^2} \left[-z_A f(z_A) - 1 + \Phi(z_A) + z_A f(z_A)\right] \frac{dz_A}{dv_A}
\]

\[
= \sigma \sqrt{1 - \rho^2} \left[\Phi(z_A) - 1\right] \frac{(1 - \rho)}{\sigma_B l} \leq 0,
\]

it must be then that

\[
E[\pi_B(v, \bar{v}_B, b, l)] > 0. \tag{15}
\]

Suppose now that $v$ exists so that (15) holds. Then the derivative of $W(v, \infty)$ with respect to $v$ evaluated at $v$ is negative:
\[ \frac{d}{dv} W(v, \infty) \bigg|_{v_0} = \frac{f(v)}{1 - F(v)} E\left[ \pi_b(v_A, v_b, b, 1) \right] f(v_A) dv_A - \frac{f(v)}{1 - F(v)} E\left[ \pi_b(v, v_b, b, 1) \right] \]
\[ = \frac{f(v)}{1 - F(v)} \left( W(v, \infty) - E\left[ \pi_b(v, v_b, b, 1) \right] \right) \]
\[ = -\frac{f(v)}{1 - F(v)} E\left[ \pi_b(v, v_b, b, 1) \right] < 0. \]

Since \( W(v, \infty) \) is a continuous function, it follows that it must have at most one root. Therefore the solution to \( W(v, \infty) = 0 \) is unique if it exists.

**Proof of Lemma 3:** We will use the following integrals for some constants \( m, \ n, \) and \( h \):

\[
\int_{-\infty}^{\infty} \phi(hx)\phi(x) dx = \frac{\Phi(Hn) - \Phi(Hm)}{H\sqrt{2\pi}},
\]
\[
\int_{-\infty}^{\infty} x\Phi(hx)\phi(x) dx = \frac{n}{H\sqrt{2\pi}} \left( \Phi(Hn) - \Phi(Hm) \right) + \phi(m)\Phi(hm) - \phi(n)\Phi(hm),
\]

where \( H = \sqrt{1 + h^2} \). Then

\[ W(v, \overline{v}) = \frac{1}{F_A(\overline{v}) - F_A(v)} \left[ E\left[ \pi_b(v_A, v_b, b, 1) \right] f_A(v_A) dv_A \right] \]
\[ = \frac{1}{F_A(\overline{v}) - F_A(v)} \left[ \sigma \left[ \frac{1}{1 - \rho^2} \left( \Phi(z_A) - z_A(1 - \Phi(z_A)) \right) - c_b \right] f_A(v_A) dv_A \right] \]
\[ = \frac{\sigma - \sigma \rho}{\Phi(\overline{v}) - \Phi(v)} \left[ \frac{H}{H\sqrt{2\pi}} \left( \Phi(H\overline{y}) - \Phi(H\gamma) \right) - \phi(\overline{y})(1 - \Phi(H\gamma)) + \phi(\overline{y})(1 - \Phi(H\overline{y})) \right] - c_b, \]

where \( \gamma = (v - v_0) / \sigma, \overline{y} = (\overline{v} - v_0) / \sigma, h = (1 - \rho) / \sqrt{1 - \rho^2} \) and \( H = \sqrt{1 + h^2} \). In the second line of (17) we use (4) and the third line follows from (16).

If bidder A’s valuation is above \( v_0 \), then bidder B’s expected payoff from entering is equal to

\[ W(v_0, \infty) = \frac{1}{\sqrt{2\pi}} \left[ \sigma \sqrt{2(1 - \rho)} - \sigma (1 - \rho) \right] - c_b. \]
The expression follows from (17). Bidder B does not enter if \( W(v_o, \infty) \leq 0 \). Solving this quadratic inequality for \( \rho \), yields \( \rho_1 \) and \( \rho_2 \) given in the proposition. They exist and are distinct under the assumption that \( 2R < 1 \).

\[ \square \]

**Proof of the non-monotonic shape of \( v \) in \( \rho \):** We show that \( v \) increases in \( \rho \) at low \( \rho \) and decreases in \( \rho \) at high \( \rho \). Since \( v \) is defined by \( W(v, \infty) = 0 \), we have that \( \frac{dv}{d\rho} = -\frac{\partial W}{\partial \rho}/\frac{\partial W}{\partial v} \). As shown in the proof of Lemma 2, \( \frac{\partial W}{\partial v} \) is negative, so \( \frac{dv}{d\rho} \) has the same sign as \( \frac{\partial W}{\partial \rho} \). Differentiating (17), we obtain

\[
\frac{\partial W(v, \infty)}{\partial \rho} = -\frac{\sigma}{1 - \Phi(y)} \left[ \frac{H}{2h\sqrt{2\pi}} \left( 1 - \Phi(Hy) \right) - \phi(y) \left( 1 - \Phi(hy) \right) \right]. \tag{18}
\]

Suppose first that \( \rho_1 \geq 0 \). Then the lowest \( \rho \) that supports preemption is \( \rho_1 \). At \( \rho = \rho_1 \), \( v = v_o \) and so \( \overline{y} = 0 \). We have

\[
\left. \frac{\partial W(v, \infty)}{\partial \rho} \right|_{\rho = \rho_1} = \frac{\sigma}{\sqrt{2\pi}} \frac{\sqrt{2(1 - \rho_1)} - 1}{\sqrt{2(1 - \rho)}} > 0.
\]

The inequality holds because \( \rho_1 < 0.5 \) and thus \( 2(1 - \rho_1) > 1 \).

Suppose next that \( \rho_1 < 0 \). Then preemption is possible at \( \rho = 0 \). At \( \rho = 0 \), \( v > v_0 \) and so \( \overline{y} > 0 \). When \( \rho = 0 \), \( h = 1 \) and \( H = \sqrt{2} \), and (18) becomes

\[
\left. \frac{\partial W(v, \infty)}{\partial \rho} \right|_{\rho = 0} = \frac{\sigma}{1 - \Phi(y)} \left[ \phi(y) \left( 1 - \Phi(y) \right) - \frac{1}{2\sqrt{\pi}} \left( 1 - \Phi(\sqrt{2} y) \right) \right].
\]

which has the same sign as \( G(\overline{y}) \), where

\[
G(\overline{y}) = \phi(\overline{y}) \left( 1 - \Phi(\overline{y}) \right) - \frac{1}{2\sqrt{\pi}} \left( 1 - \Phi(\sqrt{2} \overline{y}) \right).
\]

Because \( \overline{y} > 0 \),
\[ G'(y) = -\frac{y}{\sqrt{2\pi}}\phi(y)\left(1 - \Phi(y)\right) - \phi^2(y) + \frac{\phi(\sqrt{2}y)}{\sqrt{2\pi}} = -\frac{y}{\sqrt{2\pi}}\phi(y)\left(1 - \Phi(y)\right) < 0. \]

In addition, \( G(0) = 1/(2\sqrt{2\pi}) - 1/(4\sqrt{\pi}) > 0 \) and \( G(\infty) \to 0^+ \). It follows that sign of function \( G(y) \) is always positive, which means that \( \partial W / \partial \rho \big|_{\rho=0} \) is positive. The signs of the derivatives at \( \rho = \rho_1 \) (if \( \rho_1 \geq 0 \)) and \( \rho = 0 \) (if \( \rho_1 < 0 \)) show that the preemptive value first increases in similarity level.

The highest \( \rho \) that supports preemption is \( \rho_2 \). At \( \rho = \rho_2 \),

\[ \frac{\partial W(v_0, \infty)}{\partial \rho} \bigg|_{\rho=\rho_2} = \frac{\sigma}{\sqrt{2\pi}} \frac{\sqrt{2(1-\rho_2)} - 1}{\sqrt{2(1-\rho_2)}} < 0. \]

The sign is negative because \( 2(1-\rho_2) > 1 \). This shows that the preemptive value \( y \) decreases in \( \rho \) at high \( \rho \).
References


Online Appendix (Not for Publication)

INSTRUCTIONS FOR THE FIRST BIDDER

Welcome to this economic experiment. Please follow the instructions carefully. If you make good decisions, you can earn a considerable amount of money.

I. STRUCTURE OF THE GAME

The game will be repeated in thirty rounds. In each round, two bidders are coupled. One participant plays the role of FIRST BIDDER, the other of SECOND BIDDER. Your role is always FIRST BIDDER. For each round, you may face a different second bidder. You will never learn with whom you were matched.

In each round, you will have a chance to buy a target. At the beginning of a round, you will be assigned your value of the target. This value is a random number that is above 50 (50 is included). Only you will observe this value, but both you and the second bidder know its distribution. The second bidder’s private value of the target is uncertain. However, both you and the second bidder will know the DISTRIBUTION of the second bidder’s value and the SIMILARITY between your valuations.

Your decision is to choose a FIRST BID. The second bidder will be informed about this bid, and based on this information he/she will decide whether to COMPETE with you or NOT. When the second bidder makes this decision, he/she still does not know his/her value of the target.

If the second bidder decides to compete, the buyer of the target and the price paid is set as follows. The target is sold to the bidder with the higher value. If the second bidder’s value is larger than the first bid, the price paid by the buyer is the value of the bidder with the lower value; if your first bid is higher than the second bidder’s value, the price is the first bid. If the second bidder decides not to compete, you get the target at the price of the first bid. You make profit if you succeed in acquiring the target but not paying too much (that is, if the price you pay is less than your value of the target).

At the beginning of each round, an entry fee of 2 points will be deducted from your current account. The target will not be sold at any price less than its reservation value equal to 50 points.

II. EXAMPLE

– First stage: you will learn the similarity and your valuation for this round. With this information, you choose the first bid for the target. The first bid should be no less than 50 and no more than your value. For example, you may see the following screen:

```
Round 1
The similarity is 0 for this round, and your value is 64.
2 points as an entry fee has been deducted from your account.
Please submit your FIRST BID here.

Note: This round is for practice, your performance in this period will have no impact on your final monetary payment.
```

– Second stage: the second bidder will be informed about the first bid. Then he/she decides whether to COMPETE or NOT. For example, if the first bid is 50, then he/she will see:

```
```
If he/she chooses to compete, the entry fee, 2 points, will be deducted from his/her current points. Then, his/her value of the target will be revealed. After that, the system will automatically assign the buyer as the one with the highest value. If the values of bidders are equal, one of you will buy the target by probability 1/2.

• If the second bidder chooses not to compete, then you will buy the target at the price of the first bid.
  – At the end of each round, the result (the values of the bidders, the buyer, and your payoff) will be displayed in a table at the bottom of the window.

In each round you can earn or lose points. Your earnings depend on your and the second bidder’s decisions. In addition, at the beginning of this experiment, you will have 60 points as initial capital. The payoff in each round is calculated as in the table below. The conversion ratio between points and euro is 20:1. If you earn 400 points in total, your payoff in cash will be 400/20 = €20.

<table>
<thead>
<tr>
<th>The second bidder’s action:</th>
<th>Compete</th>
<th>Not compete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buyer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You</td>
<td>The second bidder</td>
<td>You</td>
</tr>
<tr>
<td>Your payoff:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your value</td>
<td>Price</td>
<td>First bid</td>
</tr>
<tr>
<td>– Entry fee</td>
<td>– Entry fee</td>
<td>– Entry fee</td>
</tr>
</tbody>
</table>

In the above example (similarity = 0, and the first bid is 50), if the second bidder chooses to compete and his/her value is 53, you become the buyer and buy the target for the price 53, then your payoff is 9 points (= 64 – 53 – 2). If the second bidder chooses to compete and his/her value is 78, the second bidder becomes the buyer and buys the target, and then your payoff is -2 points. If the second bidder chooses not to compete, then you buy the target for the price 50 and your payoff is 12 points (= 64 – 50 – 2).

III. CHOOSING THE FIRST BID
At the time both you and the second bidder make the decisions, neither of you knows the value of the target to the second bidder. This means that the expected outcome of the game, that is who buys the target and the price paid, will depend on the distribution of your values and the similarity between them. All the information below about the distributions is known also to the second bidder.

THE FIRST BIDDER’S VALUE
Your value is a random value above 50 points (50 is included). The figure following shows the distribution of your value.
The figure reveals that your value around 50 is most likely and the probability decreases with larger values. The area below the curve can be used to obtain the probability that your value falls in a particular range. For example, the probability that your value is in between 50 and 63 is about 50% (on average in 50 of the 100 cases). The table provides further information.

The first bidder’s value

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>has a mean of</td>
<td>66</td>
</tr>
<tr>
<td>in 50% of the cases is</td>
<td>between 50 and 63</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>between 50 and 73</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>between 50 and 89</td>
</tr>
</tbody>
</table>

SIMILARITY AND THE SECOND BIDDER’S VALUE

The second bidder’s value is different from yours, but there is some connection between your value and his/hers. This is expressed by the level of SIMILARITY. This level can be either 0, 0.5 or 0.95. The larger the similarity, the more similar the second bidder’s value and yours are.

Below we give some examples when the level of your valuation is 50, 63, 73, and 89, respectively. These levels are the cut-off points of examples in the previous section “THE FIRST BIDDER’S VALUE.”

– If similarity = 0, no matter what your value, the frequency of the second bidder’s valuation is the same. The following figure and table present its distribution. You can find that the distribution of the second bidder’s value is centered around its mean, 50.

If similarity = 0, the second bidder’s value is independent of your value and

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>has a mean of</td>
<td>50</td>
</tr>
<tr>
<td>in 50% of the cases is</td>
<td>between 37 and 63</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>between 27 and 73</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>between 11 and 89</td>
</tr>
</tbody>
</table>

– If similarity = 0.5 the distributions display a similar shape. However, the two values are now expected to be fairly similar. This means that the higher your value, the larger the mean of second bidder’s value is. In addition, given your
valuation, the second bidder’s valuation has a smaller variance than in the case of similarity = 0.

<table>
<thead>
<tr>
<th>Similarity = 0.5 and your value is 50, the second bidder’s value</th>
<th>Similarity = 0.5 and your value is 63, the second bidder’s value</th>
</tr>
</thead>
<tbody>
<tr>
<td>has a mean of</td>
<td>has a mean of</td>
</tr>
<tr>
<td>50</td>
<td>56.5</td>
</tr>
<tr>
<td>in 50% of the cases is</td>
<td>in 50% of the cases is</td>
</tr>
<tr>
<td>between 38 and 62</td>
<td>between 45 and 68</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>in 75% of the cases is</td>
</tr>
<tr>
<td>between 30 and 70</td>
<td>between 37 and 76</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>in 95% of the cases is</td>
</tr>
<tr>
<td>between 16 and 84</td>
<td>between 23 and 90</td>
</tr>
</tbody>
</table>

If similarity = 0.5 and your value is 73, the second bidder’s value:

<table>
<thead>
<tr>
<th>has a mean of</th>
<th>61.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>in 50% of the cases is</td>
<td>between 50 and 73</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>between 42 and 81</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>between 28 and 95</td>
</tr>
</tbody>
</table>

If similarity = 0.95, the two values are expected to be very similar. The higher your value, the larger the mean of second bidder’s value is. In addition, given your valuation, the second bidder’s valuation has the smallest variances in this case.

<table>
<thead>
<tr>
<th>Similarity = 0.95 and your value is 50, the second bidder’s value</th>
<th>Similarity = 0.95 and your value is 63, the second bidder’s value</th>
</tr>
</thead>
<tbody>
<tr>
<td>has a mean of</td>
<td>has a mean of</td>
</tr>
<tr>
<td>50</td>
<td>62.5</td>
</tr>
<tr>
<td>in 50% of the cases is</td>
<td>in 50% of the cases is</td>
</tr>
<tr>
<td>between 46 and 54</td>
<td>between 58 and 67</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>in 75% of the cases is</td>
</tr>
<tr>
<td>between 43 and 57</td>
<td>between 55 and 70</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>in 95% of the cases is</td>
</tr>
<tr>
<td>between 38 and 62</td>
<td>between 50 and 70</td>
</tr>
</tbody>
</table>

If similarity = 0.95 and your value is 73, the second bidder’s value:

<table>
<thead>
<tr>
<th>has a mean of</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td>in 50% of the cases is</td>
<td>between 68 and 76</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>between 65 and 79</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>between 60 and 84</td>
</tr>
</tbody>
</table>

If similarity = 0.95 and your value is 89, the second bidder’s value:

<table>
<thead>
<tr>
<th>has a mean of</th>
<th>87</th>
</tr>
</thead>
<tbody>
<tr>
<td>in 50% of the cases is</td>
<td>between 83 and 91</td>
</tr>
<tr>
<td>in 75% of the cases is</td>
<td>between 80 and 94</td>
</tr>
<tr>
<td>in 95% of the cases is</td>
<td>between 75 and 99</td>
</tr>
</tbody>
</table>

For the participants with knowledge of statistics: your value is drawn from a normal distribution with mean 50 and standard deviation 20 truncated at 50 (that is, the value is restricted to be above 50). The second bidder’s value is drawn from another normal distribution also with mean 50 and standard deviation 20, and this normal distribution has a correlation coefficient equal to “similarity” with your value. It is necessary that you are familiar with these notions; it only matters that you understand how often different realizations of your value occur, and what the relation between two bidders’ valuation is.