Strategic and Financial Bidders in Takeover Auctions*

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Abstract

We propose a structural model of takeover auctions that allows for asymmetries between strategic and financial bidders. Using hand-collected data on the number of bidders, their types and bids, we estimate the model to recover valuations of participating bidders. We find that strategic and financial bidders differ along multiple dimensions: (i) they value targets with different observable characteristics; (ii) valuations of financial bidders are affected more by aggregate economic conditions; (iii) strategic bidders are more heterogeneous than financial bidders both within and across auctions; (iv) strategic bidders typically value targets more, but some mature underperforming targets are valued more by financial bidders.

Keywords: mergers and acquisitions, strategic bidders, financial bidders, takeover auctions

JEL Classification Numbers: D44, G32, G34

The market for corporate control is one of the largest corporate markets. In 2007 alone, the value of M&A transactions in the United States was staggering \$4.8 trillion. While some takeovers proceed as negotiations of a target with a single acquirer, around 50% of takeovers face competition among several potential acquirers.[1] It is therefore important to understand how bidders compete against each other, in particular, whether there are systematic differences among them. Both academic and business literatures, as well as targets themselves, recognize two major groups of bidders: strategic and financial. In a nutshell, strategic bidders are usually companies in a related type of business (e.g., a competitor, a customer or a supplier). They look for targets that offer long-term operational synergies and plan to integrate such targets into their own business. In contrast, financial bidders, such as private equity firms and divisions of investment banks, seek for financial synergies as well as for undervalued companies with a potential to improve operations. After the acquisition, a financial bidder treats the target as a part of its financial portfolio and sells it once exit opportunities become sufficiently good.

Theoretical literature on auctions implies that bidder asymmetry can be an extremely important factor that affects creation of value and distribution of substantial revenues in the multi-trillion market for takeovers. Yet despite their recognized importance in the business literature,[2] the differences between strategic and financial bidders remain relatively unexplored. An important obstacle is the lack of data on potential acquirers of the target. A researcher typically observes only the outcome of the takeover: the identities of the acquirer and the target and the payment of the acquirer to the shareholders of the target. These data alone are insufficient to understand how different types of bidders value the target as a group due to the sample selection problem. A premium paid by an acquirer is not just the payment of the bidder with *the highest* valuation in each auction, but also depends on the number

[1] See Boone and Mulherin (2006). Even though public competing bids are rare, a more detailed analysis of deal backgrounds reveals substantial competition via non-public bids.

[2] E.g., see "Who has the advantage: strategic buyers or private equity funds?" by Mark E. Thompson and Michael O'Brien in *Financier Worldwide*'s November 2005 issue and "Selling to a strategic or financial buyer" by Rebecca Pomering in *Financial Advisor*'s May 2006 issue.

of other potential strategic and financial acquirers and their valuations, which are usually unobserved by researchers. In this paper, we circumvent this problem by using a manually collected dataset of takeover auctions that includes data on all participating bidders and their bids rather than only data on the eventual acquirers. Coupled with robust structural assumptions on the bidding behavior, these data allows us to estimate and compare the differences in valuations (i.e. maximum willingness to pay for the target) of strategic and financial bidders. We show that there exist considerable differences between valuations strategic and financial bidders in four dimensions: (i) they value targets with different observable characteristics; (ii) valuations of financial but not strategic bidders are affected by aggregate economic conditions; (iii) strategic bidders are more heterogeneous than financial bidders both within each auction and across auctions; (iv) strategic bidders typically value targets more, but these exists a subset of mature underperforming targets that are valued more by an average financial bidder. Our results suggest that bidder asymmetries are extremely important in understanding the takeover market.

To study strategic and financial bidders, we follow Boone and Mulherin (2006, 2007) and manually collect the data from SEC deal backgrounds. We identify all cash-only takeovers that are in the form of auctions.[3] For these takeovers, we study the whole takeover process and identify the numbers and, if recorded, types (strategic and financial) of bidders that signed confidentiality agreements and thereby got access to private information about the target. For these bidders, which we call "potential bidders," we collect the data on whether each of them made informal indications of interest, formal bids; and, finally, the identity of the winner, which ultimately acquired the target. Our final sample consists of 349 takeover auctions that were completed between 2000 and 2008.

Having collected the data on participating bidders, we move on to estimate their intrinsic valuations. The major challenge with such estimation is the need to impose the structure on the bidding behavior. In other words, one has to specify reasonable assumptions about the mapping of bidder valuations into the observed takeover outcomes: the identity of the

[3]We discuss the reasons for focusing on cash auctions in Section III.A, and the selection issues in Section VI.C.

acquirer, its payment, and the losers' bids. A caveat here is that all existing models of takeovers and, more generally, English auctions rely on rather restrictive assumptions, which are inconsistent with the typical "free-form" nature of takeover auctions. For example, the assumption that takeovers proceed as "button" auctions with a continuously increasing price, as in the seminal work by Milgrom and Weber (1982), is inconsistent with the observed jump bids and re-entries, which are common features of takeover auctions[4]. While these features can be separately explained by many different models (e.g., Fishman (1988, 1989), Avery (1996), Daniel and Hirshleifer (1998)), there is no consensus about which model of auction, if any, fits the observed data best. Because of this, rather than committing to a particular model, our identification relies on the restrictions coming from three intuitive assumptions that are consistent with a large variety of bidding patterns in English auctions:

Assumption 1. Bidders do not bid more than they are willing to pay.

Assumption 2. Bidders do not allow an opponent to win at a price they are willing to beat.

Assumption 3. Bidders do not make informal non-committing bids, if their valuation is below the value of the target under its current management.

As shown in Haile and Tamer (2003), these assumptions can be used to build lower and upper bounds on the bidders' valuations.[5] To obtain point estimates, we combine Assumptions 1–3 with assumptions about the structure of the bidders' valuations. Specifically, we assume that each bidder's valuation is a combination of the observable component, which depends on the observed characteristics of the target, and the unobservable private component. While the observable component is common for all bidders of the same type (strategic or financial), the unobservable components are different across bidders and measure the heterogeneity of their valuations within their group. Imposing these assumptions allows us to obtain point estimates of the valuation functions: the sensitivities of the average valuations of strategic and financial bidders to the observable characteristics of the target and the economy and

[4]See also Chowdhry and Nanda (1993), Bulow, Huang and Klemperer (1999), Povel and Singh (2010), who model takeover contests as "button" auctions.

[5]In fact, Haile and Tamer (2003) show that the bounds on the bidders' valuations can be obtained under Assumptions 1 and 2 only. Unlike their setting, informal bids are common in takeover auctions, which under Assumption 3 allows to obtain tighter bounds, making the estimated valuations more precise.

the variances of the unobservable components. Importantly, our empirical strategy allows for potential differences between financial and strategic bidders but does not impose them at the model specification stage.

We show that there are fundamental differences in how strategic and financial bidders value the companies. First, strategic and financial bidders value the target companies in systematically different ways. On average, strategic but not financial bidders are willing to pay higher premiums relative to market values for smaller targets that have substantial internal cash reserves and that undertake significant research and development activities. In contrast, financial bidders are willing to pay higher premiums for companies that underperform, which is reflected in substantial negative cash flows, but are insensitive to such target characteristics as size, q-ratio, and research and development expenses. Second, valuations of strategic and financial bidders react differently to changes in the economic environment. While valuations of strategic bidders seem to be unaffected by those, financial bidders appear to be willing to pay higher premiums (relative to the market values) for targets after a period of low market returns and when the costs of borrowing are lower.

Perhaps the most striking evidence of difference between strategic and financial bidders, however, is in the sources of heterogeneity of their valuations. Valuations of financial bidders are to a large extent explained by observable factors, captured by the information about the targets available from the market and financial statements. In contrast, valuations of strategic bidders are less tied to publicly observable characteristics: their unobserved component of valuations is almost twice more important than that of financial bidders. This finding suggests a stark difference in heterogeneity of strategic and financial bidders. Financial bidders appear to be similar to each other and rather exchangeable from the target's point of view: they generate similar value in an auction based on objective characteristics. Each strategic bidder, however, is unique and can potentially generate substantial value.

Valuations of strategic bidders are typically higher than those of financial bidders. An average strategic bidder is willing to pay a premium of 16.7% to the market value of the target, while the same number for an average financial bidder is 11.7%. However, the relation between valuations changes substantially with the characteristics of the target and the economic environment. In particular, perhaps contrary to common belief that strategic bidders always value targets more because only they can create synergies, we find a subset of mature underperforming targets that are on average valued more by financial bidders. For such targets, it is financial bidders that seem to generate higher synergies because of their ability to completely overhaul the target firm's operations.

In addition to practical considerations outlined above, our estimation results have two important implications for modeling takeovers as auctions. First, strategic and financial bidders appear to be different from each other, so models that allow for bidder asymmetries are likely to be more appropriate to settings in which financial and strategic bidders compete against each other. Asymmetry between bidders is an important feature, because it can lead to different equilibria of standard auctions as well as to different implications for the efficiency and optimality of auction designs.[6] Second, our results add to the debate about the use of private versus common value paradigms in the theoretical modeling of takeovers. They suggest that the choice is likely to depend on the setting. If strategic bidders are the dominant participants in the market, as in the models in which mergers are driven by industry concentration, then the use of private values is more valid. In contrast, if financial bidders are the important participants in the market, as in the models in which acquisitions are driven by the underperformance of the target's current management, then the public common values setting may be more appropriate.

Because our structural approach recovers distributions of bidders' valuations (or, in other words, their maximum willingness to pay) for target companies, it allows us to study acquirers' winning slack, i.e., how much the acquirers underpay relative to their expected valuations. While financial acquirers usually pay close to their maximums, keeping on average 7.3% of their maximum willingness to pay, strategic acquirers tend to have a substantial winning slack, which averages 14.9% of their maximum willingness to pay. Given that acquisitions by strategic bidders generate acquirer's abnormal returns that are close to zero (e.g., Betton, Eckbo, and Thorburn (2008a)), our result suggests either a significant stock market anticipation of

[6]For example, see Klemperer (1998), Maskin and Riley (2000), and Krishna (2003) for models of auctions with various forms of bidder asymmetries, and Bulow, Huang, and Klemperer (1999) and Povel and Singh (2006) for the applications to the takeover market.

acquisition activity by strategic bidders or substantial private benefits of their managers, consistent with empirical evidence on merger-induced CEO compensation (Grinstein and Hribar (2004), Harford and Li (2007)).

Our paper is related to two strands of literature. First, it is related to empirical literature on mergers and acquisitions that studies competition among multiple bidders in takeover contests. Boone and Mulherin (2007) analyze 400 takeovers for large public U.S. companies and show that approximately half of them can be classified as auctions given a substantial competition on the pre-public takeover stage. We follow their methodology to identify auctions. Our sample is different, because it covers a more recent period and a broader range of companies. In addition, we differentiate between strategic and financial bidders. In addition, to the extent that strategic bidders are more likely to be public firms than financial bidders, our paper is related to Bargeron et al. (2008) who examine the difference in announcement returns for targets acquired by public and private companies and to Betton, Eckbo, and Thorburn (2008b) who study the public versus private bidders' choices between mergers and takeover contests. Second, our paper is related to the literature on structural estimation of English auctions (see, e.g., Paarsch (1997), Athey and Haile (2002), Haile and Tamer (2003), Brendstrup and Paarsch (2006)). Specifically, we follow the approach by Haile and Tamer (2003) and impose intuitive restrictions on the bidding process instead of specifying a complete model of the auction. Our empirical methodology is different from Haile and Tamer (2003) in three important ways. First, we add the third assumption, while Haile and Tamer (2003) focus on only the first two assumptions. Intuitively, informal non-committing bids are common in takeover auctions, and the willingness of a bidder to submit even an informal bid is likely to be informative about its valuation. Second, our methodology considers bidders of two types, while Haile and Tamer (2003) consider ex-ante identical bidders. Finally, Haile and Tamer (2003) use nonparametric estimation techniques to construct the bounds on the distributions of the valuations. Because we are more interested in point estimates, we make the parametric assumption about bidders' valuations.

The remainder of the paper is organized in the following way. Section I describes the process and timing of events of a typical takeover auction. Section II describes the assumptions that link the informal and formal bids to the bidders' valuations, which are defined as their maximum willingness to pay. The section continues with the description of the estimation procedure. Section III presents data and summary statistics. Section IV reports the estimates of the model, discusses their significance and intuition, and discusses the role of major assumptions of our empirical strategy. Section V characterizes the model-implied distribution of takeover gains between targets and acquirers and relates it to earlier empirical findings. Section VI discusses approach validity and reports various robustness checks. Finally, Section VII concludes.

I Institutional Background

Before proceeding to setting up the model and estimation procedure, we describe how a takeover auction is usually conducted. The process of a typical takeover auction, shown on Figure 1, has been described by Boone and Mulherin (2006, 2007) and studied theoretically by Hansen (2001). It usually starts when the firm (typically, its board of directors) analyzes strategic alternatives and decides that the best alternative is to sell itself to a potential buyer. After this, the firm hires an investment bank, which examines potential strategic and financial buyers and presents a list of potentially interested parties to the firm. The firm and its investment bank contact the parties who in their view might be interested in acquiring the company. The interested potential bidders sign confidentiality agreements upon which they receive access to non-public information about the target. After studying this information, some of the potential bidders submit preliminary bids in several rounds. The bids at this stage are non-binding in the sense that bidders do not commit to them and frequently renegotiate them in the future. After several rounds of preliminary bids, the selling firm and its investment bank ask a smaller number of most interested bidders to submit final round bids. Upon receiving the final round bids, the firm negotiates with the bidders and sometimes raises the price. The final round bids are usually formal, and the takeover agreement is usually signed soon after receiving the final round bids (in many cases, within 2-3 days). Sometimes, the target accepts a formal offer from a bidder even beyond the final round deadline if it is sufficiently high. Before the first takeover agreement is signed, the takeover process is private in the sense that potential bidders and their bids are not publicly announced. In the rest of the paper we refer to the preliminary non-binding bids as informal bids and to the final round bids and public bids after the takeover agreement is signed as formal bids unless it is stated explicitly that the final round bid is subject to additional due diligence or approval of financing.

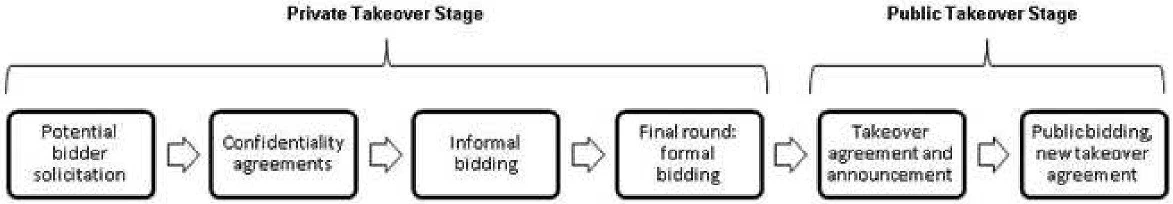

Figure 1: Timing of the Takeover Auction Process

While this structure of takeover auctions is most similar to an "English" or "oral ascending bid" auction, in which the target lets the bidders offer higher prices until only one of them remains, wins the asset and pays according to her offer, an important characteristic of takeover auctions is their informal structure. There are several aspects in which takeover auctions differ from English auctions typically studied in the literature. First, usually there are several rounds of informal bids. The exact number of rounds is not predetermined, and bidders do not commit to their informal bids, often decreasing them in the subsequent rounds. Second, exits and reentries of bidders are common: in many cases bidders stop contacting with the seller saying that they are no longer interested in the transaction, but later they reappear with better offers. Finally, jump bids and negotiations between the selling firm and potential bidders are common. Given these peculiarities, it is difficult to come up with a formal model that will be close to the true process of takeover auctions. We address this issue in our empirical strategy.

II Model Specification

Having described the process of a typical takeover auction, we now turn to a structural model of bidding in a takeover auction. Given the free-form structure of a typical takeover auction, our goal is to avoid significant abstractions and at the same time put sufficient structure in order to be able to estimate valuations of bidders.

II.A Strategic and Financial Bidders

Consider auction for target i. Suppose that the auction has N_i potential bidders. Potential bidders are defined as those parties solicited by the seller that agreed to sign confidentiality agreements and thereby obtained access to non-public information about the target. Each bidder belongs to one of the two categories, strategic and financial, denoted by letters s and f, respectively. Let $t_{i,j} \in \{s, f\}$ denote the type of bidder j in the auction for target i.

After observing non-public information about the target, each potential bidder learns her valuation, which is defined as the maximum amount that the bidder is willing to pay to acquire the target. We assume that valuation of bidder j is given by

$$V_{i,j} = M_i \exp\left\{X_i' \beta_{t_{i,j}} + \varepsilon_{i,j}\right\}. \tag{1}$$

Here, M_i refers to the value of the target under its current management, and $\exp\left\{X_i'\beta_{t_{i,j}} + \varepsilon_{i,j}\right\}$ refers to the bidder-specific premium (or discount, if it is below one). The premium of each bidder is the sum of a public common component, $X_i'\beta_{t_{i,j}}$, which is the same to all bidders of a particular category (financial or strategic), and a private component, which is specific to each bidder. The public common component captures common factors that affect attractiveness of the target for all bidders. It depends on the vector of publicly observable characteristics of the target and current aggregate economic conditions, X_i. Because strategic and financial bidders may value different characteristics of the firm, the common components may be different between the two classes of bidders: β_s may not be equal to β_f. The private component captures such factors as synergy and suitability of the target for each potential acquirer. We assume that ε_{ij} is distributed according to $F_s(\cdot)$, if the bidder is strategic, and $F_f(\cdot)$, if the bidder is financial. We make an assumption that $F_s(\cdot)$ and $F_f(\cdot)$ are independent Normal distributions with zero means and variances σ_s^2 and σ_f^2, respectively. Section VI presents robustness checks and discussions of this and the rest of assumptions.

For notational simplicity, we normalize bidders' valuations by market values of the targets:

$$\log v_{i,j} \equiv \log\left(\frac{V_{i,j}}{M_i}\right) = X_i' \beta_{t_{i,j}} + \varepsilon_{i,j}. \tag{2}$$

Two important points are to be made about valuations of strategic and financial bidders. First, our estimation strategy treats bidders' valuations as parameters that are observable to the bidders, but unobservable to the researcher. This allows us to avoid making assumptions about the exact sources of valuations. Specifically, valuations can come not only from synergy, but also from private benefits of control, and our approach allows us to estimate the valuations without making any specific assumptions about the structure of private benefits. Second, the form of valuations (1) implies that there are three potential sources of differences between financial and strategic bidders. Strategic and financial bidders are different either because they value different characteristics of the target companies, because their valuations respond differently to change in aggregate economic conditions, or because the importance of private components of valuations is different. The first two effects are captured by the potential differences between β_s and β_f. The third effect is captured by the potential difference between σ_s and σ_f. Importantly, while the model allows for differences between strategic and financial bidders, it does not impose them ex ante: all bidders are treated equally, and we let the data determine whether strategic and financial bidders are different.

II.B Bidding Behavior

The potential bidders compete in an English auction with otherwise no observable rules. The bidder who offers the highest price for the target wins the auction and acquires the target. Because jump bids are prevalent in mergers and acquisitions (Betton and Eckbo (2000)), a famous "button" model of an English auction (Milgrom and Weber (1982)), in which each bidder continuously confirms her participation by holding a button and exits the auction once it releases the button, is misspecified.

Instead of committing to interpretation of bids implied by any particular model, we rely on an incomplete model of English auctions consisting of three simple and reasonable assumptions:

Assumption 1. *Bidders do not bid more than they are willing to pay.*

Assumption 2. *Bidders do not allow an opponent to win at a price they are willing to beat.*

Assumption 3. *Bidders do not make informal non-committing bids, if their valuation is below the value of the target under its current management.*

Assumptions 1 and 2 come from Haile and Tamer (2003) who deal with nonparametric estimation of homogeneous bidders' valuations in English auctions without clearly identifiable rules. Their motivation is straightforward. Because, independently of the underlying structure of the auction, every formal bid is potentially a winning bid, it is irrational for a bidder to bid more than her valuation. This motivates Assumption 1. Assumption 2 means that as long as there is a chance of winning the auction and paying below the valuation, a rational bidder will take this opportunity.[7] In takeover auctions, targets typically let potential bidders, whose current bids are below the highest bid, know that there is a bidder with a better offer.[8] Thus, bidders have the opportunity to respond to the current highest bid. Given this, Assumption 2 means that a bidder does not miss this opportunity, if she can make a positive surplus. Finally, Assumption 3 is natural in the context of takeover auctions. If a rational bidder completed due diligence and learned that she values the target below its market value under the current management, she would not continue to invest time and resources and submit either formal or

[7]Without loss of generality, "rational" bidders in this paper include bidders with behavioral values for the target (i.e., bidders can be overoptimistic about the target), as long as such bidders do not overbid above their behavioral valuations and will want to outbid anyone who is about to win an auction at a lower price.

[8]The bidders are at least informed whether they are currently in front of the competition or are currently losing. Oftentimes, the target also informs the bidders about the exact or approximate value of the current highest bid.

informal bids, simply because the target's shareholders would not agree to sell the company at a price below its market value under the current management.

These restrictions on bidding strategies allow for a large variety of bidding patterns observed in takeover auctions. For example, unlike the "button" model, they are compatible with jump bidding, bidders re-entering the takeover process, and bidders not bidding at all, which are common features of takeover auctions. In addition, the implied ranking of bids does not necessarily map one-to-one with the ranking of bidders' valuations, except for the winning bidder, who must be the bidder with the highest valuation.

II.C Estimation Strategy

Consider auction i. Let $b_{i,j}$ denote the highest bid submitted by bidder j during the takeover process in auction i and let $t_{i,j}$ denote the bidder's type (s or f). If bidder j submits only an informal bid, then, consistent with Assumption 3, we can set $b_{i,j} = M_i$, where M_i is the target i's value under the current management. If the bidder does not submit any bid, then $b_{i,j} = 0$.

Without loss of generality, we sort bidders within each auction in the descending order by their highest bid: $b_{i,1} \geq b_{i,2} \geq ... \geq b_{i,N_i}$. The first bidder is then the winner. We need to write the likelihood of auction i's outcome given the realization of bids $b_i = (b_{i,1}, b_{i,2}, ..., b_{i,N_i})'$, types $t_i = (t_{i,1}, t_{i,2}, ..., t_{i,N_i})'$, and model parameters $\theta = (\beta_S, \beta_F, \sigma_S^2, \sigma_F^2)'$. There are several events which constitute this likelihood. As an example, we only provide the expression for the likelihood of one of the events; the rest are provided in Section II.A of Appendix B:

1. Bidder 1 *submits formal bid* $b_{i,1}$ and *wins*. By Assumption 1, the likelihood of this event is

$$l_{i,1}(v_{i,1}|X_i, b_{i,1}, t_{i,1}; \theta) = \mathbb{P}\{b_{i,1} \leq v_{i,1}|X_i, t_{i,1}; \theta\} = 1 - \Phi\left(\frac{\log \frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,1}}}{\sigma_{t_{i,1}}}\right), \quad (3)$$

   where $\Phi(\cdot)$ is the c.d.f. of the standard Normal distribution.

2. Bidder $j > 1$ *submits formal bid* $b_{i,j}$ and *loses* to bidder 1.

3. Bidder $j > 1$ *submits informal bid* of any size and *loses* to bidder 1.

4. Bidder $j > 1$ *does not submit any bid.*[9]

Because the identity of the winning bidder is public information, we always now whether bidder 1 is strategic or financial. However, the types of losing bidders are not always provided in the takeover deal backgrounds and thus are not always known by us. To deal with non-observability of some losing bidder types, we use a two-step estimation procedure, whose details are outlined in Sections II.B and II.C of Appendix B. On the first step, we estimate probability $\mathbb{P}\{t_{i,j}|Z_i;\gamma\}$ that a losing bidder's unobservable type is $t_{i,j} \in \{s, f\}$ from the observable data Z_i which contains target and economy characteristics X_i and outcomes of the auction (winning bid, winning bidder's type, and the total number of bidders). On the second step, the *expected* likelihood $\mathbb{E}\left[l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j};\theta)\right]$ of the event is calculated as the weighted sum of the likelihoods conditional on type $t_{i,j}$, with probability weights of each $t_{i,j}$ given by the first-step estimate.

By independence of the bidders' private components of valuations, the likelihood function for auction i can be written as

$$L_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i;\theta) = \prod_{j=1}^{N_i} \mathbb{E}\left[l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j};\theta) \mid t_{i,j}\right] \qquad (4)$$

where $N_{s,i}$, $N_{f,i}$, and $N_{u,i}$ are correspondingly the number of strategic, financial bidders, and bidders with unobservable type, such that $N_{s,i} + N_{f,i} + N_{u,i} = N_i$.

Let $\mathfrak{L}_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i;\theta) = \log L_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i;\theta)$. Define $b = (b_1, b_2, ..., b_I)'$ and $t = (t_1, t_2, ..., t_I)'$. Also, define N_s, N_f, N_u to be the sum of the corresponding number of bidder types across all auctions. The complete likelihood function of the model is given by

$$\begin{aligned}
\mathfrak{L}(v|N_s, N_f, N_u, X, b, t;\theta) &= \frac{1}{\sum_{i=1}^{I} N_i} \sum_{i=1}^{I} \mathfrak{L}_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i;\theta) \\
&= \frac{1}{\sum_{i=1}^{I} N_i} \sum_{i=1}^{I} \sum_{j=1}^{N_i} \mathbb{E}\left[\log l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j};\theta)|t_{i,j}\right] \qquad (5)
\end{aligned}$$

[9] Almost always, the bidder does not inform the target about the reason for not submitting a bid. However, in several cases in our sample, a bidder who does not submit a bid informs the target that this is because her valuation is below the company's market value m_i. We differentiate between these two groups during the estimation. Section II.A of Appendix B provides the details.

The estimates are obtained by maximizing (5) with respect to the parameter set θ. The additional details of the analytical properties and numerical implementation of the above maximum likelihood method are given in Sections II.A–II.D of Appendix B. In Appendix C, we use simulations to examine performance of the estimator, compare it to a number of alternatives, and argue that it performs consistently well at recovering valuation parameters.

III Data and Summary Statistics

III.A Data Description

We analyze a sample of corporate takeovers announced and completed in the period from January 1, 2000[10] to September 6, 2008 (the most recent data entry at the moment of data collection). The sample comes from mergers and acquisitions database of the Securities Data Corporation (SDC). We require that targets and bidders satisfy the following set of conditions:

- The target is a publicly traded non-financial (SIC codes 6000-6999 excluded) US company;
- Bidders seek 100% of target shares;
- Winning bids are made in cash only;
- The deal is not a spin-off, recap, self-tender, exchange offer, repurchase, minority stake purchase, acquisition of remaining interest, privatization;
- The deal is an auction. We define the deal as a negotiation if only one potential bidder signs a confidentiality agreement and as an auction if two or more potential bidders sign confidentiality agreements;
- Final deal value is included in the database;

[10]Before 2000, detailed information on the composition of competition was rarely provided in deal backgrounds; whenever it was provided, the pool of competitors was more often divided into public and private bidders rather than strategic and financial bidders. Although private bidders are more likely to be financial bidders, the absence of a one-to-one correspondence and lower overall quality prevent us from using older data.

- Deal backgrounds are available in the SDC.

Whenever the last two requirements are not satisfied, we try to complement the data using other sources (EDGAR filings on the SEC, MergerMetrics).

There are two important constraints that we impose on the deal in order to include it in our sample. First, we focus on cash-only deals because in this case the value of the deal is known with certainty. Our estimation strategy requires knowledge of the target's value of the winning bid in order to recover valuation bounds of all bidders. If the winning bid is in securities, its cash value depends on the unobservable characteristics of the bidder and thus cannot be reliably compared to cash-only deals or to other bids in securities, without imposing a realistic model of security pricing and observing identities and characteristics of all auction participants.[11] We discuss the difficulties with using data on non-cash bids in more detail in Appendix D and the potential selection effect in Section VI.[12] Second, we focus on takeovers in the form of auctions. There are two reasons for this. First, if a takeover is a negotiation with a single bidder, its outcome depends on expected competition should the bidder's offer be rejected. Because this expected competition is not observed, including negotiations in the sample is not feasible. Second, the quality of a significant share of deal backgrounds which are classified as negotiations is low: these deal backgrounds are significantly shorter and include less information on the takeover process. Because of this, it may be the case that a substantial portion of deals classified as negotiations are actually auctions with missing information on losing bidders. These two reasons prevent us from including negotiations in the sample.[13]

[11] This approach would require the set of auctions in which the identities of all bidders are known; the number of such auctions is however extremely small. Modeling and estimation of auctions with non-cash bids using available data is, however, an interesting and challenging direction of future research.

[12] An even safer approach would be to eliminate all auctions with at least one non-cash bid. Note, however, that a non-cash losing bid provides information about valuation of only this bidder, while a non-cash winning bid provides information about valuations of all bidders in the auction. Thus, a non-cash losing bid introduces a considerably smaller econometric problem than a non-cash winning bid. The downside of eliminating auctions with any non-cash bids is the reduction in the sample size: the number of non-cash bids in actions won by a cash bid is small (typically, zero or one) but, for example, even one non-cash bid in an auction with 25 bidders would force us to eliminate all 25 bidders from the sample. Given that our sample is 349 auctions, this is an important concern. As a consequence, we left auctions in which there exist non-cash losing bids in the sample. As a robustness check, we estimated the model using more relaxed assumptions on the lower bounds on losing bidders' valuations if they bid in stock and found similar results.

[13] Boone and Mulherin (2007) show that roughly half of takeovers in their sample (which is tilted towards larger targets and thus likely underestimates the share of auctions) are in the form of auctions and that there

The background documents allow us to manually collect the information on potential bidders in each auction. We define potential bidders as bidders who signed a confidentiality agreement with the target, thereby obtaining access to confidential data and learning their valuations. For each takeover i, we collect the total number of bidders N_i, the number of bidders that are known to be financial bidders $N_{f,i}$, and the number of bidders that are known to be strategic bidders $N_{s,i}$. The identities of $N_i - N_{s,i} - N_{f,i}$ bidders are unknown, and we use this fact in our estimation procedure.

After signing a confidentiality agreement, a potential bidder can drop out of the auction, submit only a non-binding offer (to which we refer as an "informal bid"), or submit a binding offer in the final round of the auction (to which we refer as a "formal bid"). Sometimes bidders submit competitive bids publicly after the announcement of the takeover; we also refer to these bids as "formal bids." Both informal and formal bids define the lower bound of valuation of the bidder: a formal bid contains all the information of an informal bid by the same bidder, and the highest formal bid contains all the information of any other formal or informal bids by the same bidder. Therefore, in our estimation we only use the highest formal bid whenever a bidder submits multiple informal and formal bids.

Appendix A provides an example of a typical takeover auction. It contains extracts from the SEC deal background which we use to collect the data for our estimation. Manor Care, a target in the healthcare industry, decided at the meeting of the board of directors on April 10, 2007 to explore strategic opportunities to enhance shareholder value, possibly through the potential sale of itself. Over the course of the next several weeks, JP Morgan, the investment bank of Manor Care, contacted 48 potential bidders, 23 of which (2 strategic and 21 financial bidders) signed confidentiality agreements and thereby received access to non-public information about the company. 2 strategic and 8 financial bidders made informal offers during several rounds of informal bidding, and 2 bidders, one strategic and one financial, made formal offers at the end of the process. The eventual acquirer, Carlyle, a financial bidder, made an offer of $67 per share and won the auction. The other bidder that submitted a formal bid offered $65 and lost the auction. On July 2, 2007, Manor Care and Carlyle issued a joint press

is no significant difference in wealth effects between auctions and negotiations.

release announcing the deal. The data we collect from this auction consists of the number of potential bidders that signed confidentiality agreements, their types, the binary indicator whether each bidder submitted a bid (formal or informal), and her formal bid, if any.

Following other empirical research on mergers and acquisitions, we collect data on the market values of the targets[14] *(i)* four weeks prior to the day of the takeover announcement and *(ii)* one day prior to the day of any press release that states that the company is for sale or is exploring strategic alternatives (only if the press release occurred no more than a year before the takeover).[15] Whenever there is a press release, we use *(ii)* as a measure of variable M_i in the model; in the other cases, we use *(i)* as a measure of M_i.[16]

Characteristics of the targets come from the quarterly COMPUSTAT database. We collect and construct the following objective target characteristics: firm size defined as the book value of the target's total assets, market leverage, q-ratio, cash flow over the last four quarters, cash, and short-term investments, R&D expenses, intangible assets (all measured as percentage of the target's book value). Economy-wide variables are the market return, defined as the cumulative return on the S&P 500 index in the past 12 months, and the credit spread, defined as the rate on Moody's Baa bonds closest from the past to the date at which the snapshot of the market value was taken, minus the rate on 10-year Treasury bonds of the same date.

We use assumptions standard in corporate finance literature to filter out unreasonable values of exogenous variables that are likely to be accounting mistakes. Specifically, we remove observations with market leverage below 0 and above 100 percent, q-ratio in excess of 10, cash flow in excess of 10, negative cash stock. In addition, we remove eight instances in which the ratio of the winning bid to the target's value under the current management $b_{i,1}/M_i$ is below 1, and two instances in which it is above 4. The latter cases are clearly outliers; the former cases (all except one auction) correspond to takeovers in which the auction process did not proceed

[14]Whenever the target has dual-class stock (6 cases) or stock split during the time after the snapshot of the market price is taken but before the takeover announcement (2 cases), we compute the market value to be the weighted average of dual-class stock prices or the proportion of the price before the stock split.

[15]A press release occurred for 100 out of 349 targets. In almost all cases it substantially increased the market value of the target.

[16]As a robustness check, we also calculate M_i as the market value 3 months prior to the day of the takeover announcement. The results using this measure are discussed in Section VI.

"by the book," most often because time constraints prohibited the target from soliciting the highest offer: either the target was in deep distress or its large shareholder influenced the immediate sale of the company at a low price. After applying all of the above filters, we are left with 349 takeover auctions and 4365 potential bidders.

III.B Summary Statistics

Table I shows bidder participation in the full sample of auctions, as well as in the auctions won by strategic versus financial bidders, and across 11 industries defined as in Fama and French (1997).[17] On average, an auction won by a financial bidder attracts approximately 6 more participants. The type of a bidder is known for approximately 45% of bidders. On average, financial bidders participate in takeover auctions more often but win less often (in approximately 40% of the cases). An auction won by a strategic bidder has more observed strategic potential bidders, while an auction won by a financial bidder has more observed financial potential bidders. The winning bid paid when a strategic bidder wins the auction is on average 9.9 percentage points higher than the winning bid paid when a financial bidder wins the auction: 46.4% vs. 36.5%. To the extent that strategic bidders are more likely to be public firms, this result is consistent with the findings of Bargeron et al. (2008), who show that the targets' announcement returns are higher for targets that were acquired by public rather than private acquirers. But because the level and composition of competition is different in auctions won by different types of bidders, we cannot draw any conclusions about valuations of strategic and financial bidders.

Approximately 40% of auctions in the sample are for targets that belong to "Business Equipment" industry, which includes business and computer services and software companies. The two other industries with the highest number of takeover auctions are "Wholesale, Retail" and "Healthcare, Medical, etc.," with each accounting for approximately 13–14% of the sample. Auctions in "Chemicals," "Business Equipment," and "Healthcare, Medical, etc." industries have in average a relatively small number of bidders. On the other hand, for the

[17] The "Finance" industry from the standard twelve-industry classification does not contain any firms due its exclusion from the sample of targets.

latter two industries the composition of competition is skewed towards strategic bidders and the winning bid is relatively large, which suggests that these targets are especially valued by strategic competitors.

Table II complements Table I by presenting the descriptive statistics of target's characteristics in the full sample of auctions, as well as in samples of auctions won by strategic versus financial bidders, and across 11 industries. An average size of the target is \$654 million; the sample in total accounts for \$228 billion worth of transactions. On average, financial bidders tend to win in auctions for larger companies (the average size is \$1,168 million) with higher recent cash flows that also have higher leverage ratios. Strategic bidders end up acquiring targets with higher q-ratios, R&D expenditures, and more cash and short-term investments on the balance sheet. The magnitudes of two target characteristics, leverage and cash + short-term investments, markedly differ from the COMPUSTAT averages. This is not surprising given the composition of our sample: approximately 53% of it are firms from "Business Equipment" and "Healthcare, Medical, etc." industries. Table II shows that these are growth firms that, consistent with the prior research, are more likely to have low leverage and large cash balances.

Table III presents descriptive statistics of bids made by strategic and financial bidders, as well as by bidders whose types we do not observe. An average auction has between 12 and 13 potential bidders who sign confidentiality agreements. These numbers are higher than those in Boone and Mulherin (2006, 2007), likely because their sample includes only auctions for large targets which are less competitive on average, while we consider auctions for all public companies. Approximately one third of bidders makes informal bids, and an average auction contains approximately 4 informal and 1.36 formal bids. Strategic bidders are much more likely to submit either informal or formal bid. This result can work in support of the hypothesis that valuations of strategic bidders have either higher mean or higher variance but can also be driven by the difference in sensitivities to objective valuation characteristics of the target. Consistent with Table I, the average of all, including losing, formal bids is higher for strategic bidders (the difference is 11.2%). 33 formal bids in our sample were impossible to classify as belonging to any type of bidder. These bids appear to be higher than the average of formal bids made by both strategic and financial bidders. However, due to a small number of these unclassified bids, these statistics are not meaningful.

IV Estimation Results

IV.A Recovering Types of Bidders with Missing Information

On the first step, we need to recover the probabilities that bidders, whose types we do not observe, are either strategic or financial in order to use this information as input when estimating our model of valuations. For this purpose, as described in Section II.C, we estimate equation

$$\mathbb{P}\left(t_{i,j}=s|Z_i\right)=\Gamma\left(Z_i'\gamma\right),\ j>1. \tag{6}$$

Equation (6) determines the probability with which a losing bidder j in an auction for target i is strategic or financial as a function of the observable characteristics of the target, economic environment at the moment of the takeover, and the outcomes of the auction. Because the type of the winning bidder is always public information, to avoid selection bias we estimate Equation (6) only on the sample of losing bidders. Assuming that in auctions for similar targets that have similar outcomes, losing bidders whose types are unknown are not different from losing bidders whose types are known, we conclude that the estimate reflects the probability that a losing bidder of an unknown type is strategic. Specifically, a bidder with unobserved type is strategic with probability $\Gamma\left(Z_i'\hat{\gamma}\right)$ and financial with probability $1-\Gamma\left(Z_i'\hat{\gamma}\right)$, where $\hat{\gamma}$ is the vector of estimates.

Table IV reports the results of the binary Logit model, which we use to estimate Equation (6).[18] Table IV shows that most observable characteristics of the target, economic environment, and the auction are significant determinants of the probability that an unobserved bidder is strategic. For example, a bidder with unobserved type is more likely to be strategic if the auction has a lower number of participating bidders and the winner is a strategic bidder.

[18] In the first specification, vector Z_i contains X_i and auction outcomes; in the second one, Z_i is updated with industry fixed effects following the five-industry classification by Fama and French (1997). We have also estimated (6) using Probit model and obtained very similar results.

IV.B Valuations of Strategic and Financial Bidders

We now have recovered probabilities that bidders with unobserved types are either strategic or financial. Following the empirical strategy outlined in Section II.C of Appendix B, we estimate the parameters of the model of valuation, β_s, β_f, σ_s, σ_f, using maximum likelihood. The results are reported in Table V.

Before proceeding to the discussion of the estimation results, it is important to mention two caveats. First, our methodology allows us to see *if* and *how* valuations of strategic and financial bidders are different. However, we do not attempt to provide an exact answer *why* valuations of strategic and financial bidders are different. To answer this question, a researcher should go even further and carefully model valuations themselves according to the theory that is tested. We only discuss a number of different theories that are consistent with our findings, without committing our interpretation to any single one. Second, note that according to the model of valuations in (2), a positive (negative) coefficient does not mean that a bidder values (discounts) targets with this characteristic. Instead, it means that a bidder values targets with this characteristic in a different way than the market. Indeed, if all bidders valued all characteristics in the same way as the market does, then all coefficients would be zero: $\beta_s = \beta_f = 0$.

Table V shows the results of the valuation model for different specifications of strategic and financial bidders' valuations. Model I illustrates the most basic comparison of the valuations of two groups of bidders. Valuations of strategic bidders (with the mean and the median above the market, correspondingly, by 16.28% and 11.96%) appear to be typically higher than those of financial bidders (with the mean and the median above the market, correspondingly, by 5.84% and 4.39%)[19] and more dispersed. Model II presents our main specification: it includes objective characteristics of the target firms and economy-wide variables in the model of valuations. In order to see whether sensitivity of bidders' valuations to objective characteristics in targets is driven by industry effects or not, Model III expands Model II to include industry

[19] To obtain these numbers from Table V note that if $\log v_j = \beta + \sigma u_j$ and u_j are i.i.d. standard Normal, then the median and the mean valuations are equal to $\exp(\beta)$ and $\exp(\beta + 0.5\sigma^2)$

dummies following the 5-industry classification by Fama-French (1997).[20]

It is helpful to organize the discussion of our results around four main points: (i) bidders' valuations and observable characteristics of the targets; (ii) bidders' valuations and aggregate economic conditions; (iii) importance of observable vs. unobservable components of bidders' valuations; (iv) general comparison of magnitudes of bidders' valuations. Finally, we compare our results to results obtained using a "naive" empirical approach, which simply regresses takeover premiums paid by strategic and financial bidders on characteristics of the target and economy-wide variables.

Bidders' valuations and observable characteristics of the targets

The results in Table V suggest that strategic and financial bidders seem to value targets with different observable characteristics. The coefficient for size is significantly negative for strategic bidders, suggesting that strategic bidders, on average, are willing to pay a lower premium for larger companies. In contrast, the corresponding coefficient is insignificantly different from zero and almost zero in the magnitude for financial bidders. This result suggests that while size is an important determinant of valuations of strategic bidders, it does not seem to affect valuations of financial bidders. This can happen when synergies from mergers of two operating companies have decreasing returns to scale, while an increase in efficiency due to an acquisition by a financial bidder is multiplicative. If this is the case, strategic bidders are willing to pay systematically lower premia (percentage-wise) for acquiring the target. In contrast, the maximum willingness to pay of financial bidders will be percentage-wise independent of the size of the target. Alternative interpretations are financial constraints of strategic bidders, which make it more difficult to pay a higher premium for a larger target,[21] and concavity of the private benefits of managers of strategic bidders.

The coefficients for leverage and leverage squared suggest that the target's leverage has an inverted U-shaped effect on the valuations of both strategic and financial bidders. According

[20] In Model III we follow the 5-industry classification instead of the 11-industry classification because many industries in the 11-industry classification have few observations in our sample, as evident from Table I.

[21] If this is the case, then in the extended dataset, which includes auctions won (mainly by strategic bidders) in stock and combinations of cash and stock, the coefficient will likely become smaller in absolute value and lose its significance.

to Model II, a marginal increase in leverage increases the valuation of a strategic (financial) bidder, if the leverage is below 41.35% (45.99%), and decreases the valuation, if it is above this amount. One potential explanation for this effect is that bidders value reasonable leverage in targets more than the market because an acquisition helps lift the target's dynamic debt overhang, described by Hennessy (2004). On the other hand, high leverage increases default risk of the merged company (especially if the target and the acquirer are subject to the same risks, as is often the case for strategic bidders) and is thus undesirable. While the shape of the effects of leverage on valuations is similar for strategic and financial bidders, their magnitudes are different: The effect of leverage on valuations of strategic bidders is approximately 2.5 times greater than on valuations of financial bidders.[22] This result means that strategic bidders appear to be more sensitive to the leverage of the target firm than financial bidders.

The coefficients for q-ratio are close to zero and statistically insignificant for both strategic and financial bidders, suggesting that neither type of bidders has systematic preferences for growth versus value targets that are not accounted for in the other characteristics. At the same time, the coefficient for research and development expenses is significantly positive for strategic bidders and insignificant for financial bidders. This is consistent with the idea that synergies between a strategic acquirer and a target often arise from a combination of their expertise in research and development activity. For example, this is likely to be the case for pharmaceutical and technology companies. In contrast, because financial bidders are likely to improve efficiency of general operations of the firm, it is not surprising that they do not appear to value research and development activity in a different way from the market.

The coefficient for cash flow is significantly negative and high in magnitude for financial bidders, suggesting that they value targets with lower cash flows more than the market. At the same time, the coefficient is significant but much lower in magnitude for strategic bidders in Model II and is insignificant in Model III. This is consistent with the idea that financial but not strategic bidders are good at improving the operations of underperforming companies.

[22]Note, however, that the difference between the two coefficients is insignificant for both *Leverage* and $Leverage^2$, and also the null hypothesis that both coefficients for *Leverage* and $Leverage^2$ are simultaneously the same for strategic and financial bidders is not rejected: for example, the p-value of the Wald test in Model II is 23.52%.

Intuitively, firms with lower cash flow are likely to be firms that underperform under the current management. As a result, the potential to improve operations is likely to be higher for firms with lower cash flows. Therefore, financial bidders are eager to pay higher premiums relative to the market value for firms with lower cash flows. These results are consistent with a view of takeovers as mechanisms of improving the operational efficiency of the target company (e.g., Grossman and Hart (1980)).[23]

The coefficient for cash is significantly positive for strategic but not financial bidders. Given that the value of \$1 must be equal to \$1, this result is surprising. We propose three hypotheses why this can be the case. The first hypothesis is that cash reserves can potentially capture future investment (especially, R&D) opportunities that are not accounted for in the q-ratio and the current R&D expenses (see, e.g., Erickson and Whited (2000, 2006)). Then, a positive coefficient on the cash variable means that the bidder is willing to pay more for R&D opportunities, which the target cannot realize itself and which therefore are not reflected fully in the value under the current management. The second hypothesis is related to the manager's ability to divert cash. If the manager diverts cash of the target, then the market will not value the target's cash one-to-one, because not all cash will be used for the firm's purposes. In this context, the positive coefficient for cash does not mean that the bidder is willing to pay more than one-to-one for target's cash but rather that she values cash more than it is valued by the market under the current management. Finally, the coefficient for cash loses its statistical significance in Model III suggesting that the positive effect of cash in Model II may be driven by industry-specific levels of cash holdings. As such, cash can potentially capture investment opportunities or target manager's cash diversion abilities that are industry-specific.

One potential critique of Model II's results is that some bidders might be buying targets in particular industries rather than targets with particular stand-alone characteristics. As a consequence, significant coefficients may capture this industry effect. For example, strategic bidders might be interested in targets from more R&D intensive industries, or industries with small firms rather than in more R&D intensive or smaller firms per se. To check this, Model

[23] In the unreported results, we also include ROE as a measure of firm profitability. When ROE is used as a replacement for cash flow, we find very similar results. When ROE is used together with cash flow, the results are not meaningful because of multicollinearity between these two variables.

III studies the determinants of valuations in presence of industry fixed effects which substitute the generic constant term. Table V shows that all significant coefficients of Model II, except cash and cash flows for strategic bidders, remain significant in Model III, suggesting that bidders indeed seem to value specific targets.[24]

In the unreported results, we also include ownership characteristics of the target (percentage of the target owned by insiders and percentage of the target owned by institutional investors) and measures of industry concentration (market share of 4 or 20 largest firms in the industry, obtained from U.S. Census Bureau) into the valuation model. We do not find statistical significance of any of these characteristics for either strategic or financial bidders.

Bidders' valuations and aggregate economic conditions

The results in Table V suggest that the parameters of the economic environment at the time of the takeover have different effects on valuations of strategic and financial bidders. While we find no evidence of importance of economy-wide variables for valuations of strategic bidders, valuations of financial bidders appear to be significantly affected by aggregate economic conditions. We account for two variables of the economic environment, the return on S&P 500 in the 12 months preceding the takeover and the credit spread at the time of the takeover. The first variable captures the difference in valuations in booms versus recessions. The second variable captures the importance of the costs of financing. While estimates of coefficients for strategic bidders are insignificant, both coefficients are significant for financial bidders. The coefficient for market return is significantly negative, suggesting that financial bidders are willing to pay higher premiums to the market values after a period of low market returns. The coefficient for credit spread is also significantly negative. Because a financial bidder typically finances acquisition through debt, her maximum willingness to pay is determined as a difference between the additional value that it can realize through a reorganization of the target company and the costs associated with borrowing the funds to finance the acquisition. The credit spread is likely to be a good measure of the financial bidder's costs of borrowing:

[24]We omit estimated industry effects in the table for brevity, yet most of them are significant, suggesting some industry-specific heterogeneity not accounted for by target and economy characteristics. This extra heterogeneity, however, is not large enough to substantially affect our estimates of private valuation magnitudes.

if the default premium in the market goes up, the costs of borrowing for the financial bidders goes up as well. Thus, a higher credit spread in the economy reduces the maximum willingness to pay for financial bidders. This result is in line with recent findings of Axelson et al. (2010) that both buyout leverage and buyout pricing are negatively related to the market-wide credit risk premium of leveraged loans at the time of the buyout.

Importance of observed vs. unobserved components for bidders' valuations

The results in Table V suggest that the importance of unobserved components of valuations is substantially different for strategic and financial bidders. According to Model II, we find that the average impact of a private component of the valuation is about 15% of the market value for financial bidders and about 26% for strategic bidders.[25] This striking difference is virtually unaffected by adding industry dummies in the valuation model. This result suggests that valuations of financial bidders are closely tied to the objective characteristics of the target, while valuations of strategic bidders are mostly based on whether a particular target is a good fit for a particular strategic bidder, which is not reflected in the objective characteristics of the target.

This difference has two implications. First, it suggests that due diligence is likely to be more important for strategic bidders than for financial bidders. If private components of valuations are revealed in the course of due diligence, the empirical results imply that due diligence changes the willingness to pay of a strategic bidder and a financial bidder by, on average, 26% and 15% of the market value of the target, respectively. Second, the result adds to the debate on the use of "private value" versus "common value" valuation concepts in the theoretical modeling of takeovers. This is not the most important concern in models like ours, in which the common component is known to the bidders before the auction takes place (the "public common value" framework). But this question can be especially important for models, in which the common component is revealed in the course of auction, which could

[25] Because valuations of bidders are log-normally distributed, conditional on publicly observable characteristics of the target, their conditional standard deviations are equal to $\sqrt{e^{\sigma_t^2}-1}$, $t \in \{S, F\}$. For the base model, this implies the conditional standard deviation of $\sqrt{e^{0.258^2}-1} = 26.24\%$ for valuations of strategic bidders and $\sqrt{e^{0.153^2}-1} = 15.39\%$ for valuations of financial bidders.

lead to phenomena (such as the winner's curse) that could not occur in the models of private values. Our results suggest that the use of a particular framework depends on whether the setting under question requires the focus on strategic or financial bidders. If strategic bidders are the dominant participants in the market, then the use of private values is more valid, and vice versa.

Comparison of magnitudes of bidders' valuations

To shed light on the magnitude of the bidders' valuations of targets with different characteristics and at times of different economic conditions, Table VI presents the effects of the change in each factor on the valuations of strategic and financial bidders from 10%-th to 90%-th quantile of the sample distribution, using estimation results of Model II. Valuations of strategic bidders are most sensitive to the target's size, leverage, cash holdings, and R&D expenses. Valuations of financial bidders are most sensitive to the target's leverage and cash flows. Valuations of financial but not strategic bidders are also sensitive to whether the takeover occurs in boom or in recession. Our estimation results suggest the following evolution of merger activity over the business cycle. Valuations of strategic bidders are relatively persistent over time. However, valuations of financial bidders are not: they go up in periods of cheap debt and, especially, after periods of low market returns.

Overall, these results suggest that strategic bidders typically value targets more than financial bidders. This is consistent with the common belief that strategic bidders can realize synergies from the acquisition that financial bidders cannot. However, perhaps contrary to the common intuition that strategic bidders always value targets more, we find that there exists a subsample of targets that are valued more on average by financial bidders. Intuitively, despite the presence of substantial synergies, strategic bidders are at a comparative disadvantage at performing a major overhaul of large mature targets that with low cash flows and R&D (especially following a period of low market returns), but this is exactly the kind of job at which financial bidders excel.

Comparison with results of takeover premiums regressions

We complete the discussion of Table V with the comparison of our results to results obtained using a "naive" empirical approach of regressing takeover premiums on the target's characteristics and the economy-wide variables. The "naive" approach assumes that valuations of strategic (financial) bidders are approximately equal to takeover premiums paid by strategic (financial) bidders in their acquisitions and runs OLS of takeover premiums on two subsamples: acquisitions by strategic bidders and acquisitions by financial bidders. The results of this exercise are presented on the right panel of Table V.[26] As discussed earlier, this "naive" approach is not an appropriate way to compare strategic and financial bidders because of the selection problem: it selects data only on winning bidders, which are bidders with the highest valuations out of all participating bidders. Because the types of winning bidders and takeover premiums are results of competitive decision making, higher takeover premiums alone provide little information about average valuations when their endogenous determination is not taken into account.

Table V shows that our results are drastically different from the results obtained using the "naive" approach. First, if one mistakenly assumed that winning bids made by strategic and financial acquirers were equal to average valuations of these two bidder types, then one would conclude that there is little evidence that valuations of the two types of bidders are different: all coefficients are not statistically different for bidders of the two types and most of them appear to be of similar magnitudes. The most striking difference is in the role of unobserved components of valuations. From the results of the "naive" approach, there would not seem to be any meaningful difference between the importance of unobserved valuation components of the two bidder types. However, as our results suggest, this is not the case: for example, according to Model II, the average impact of a private component of the valuation is 15% of the market value for financial bidders and 26% for strategic bidders.

Second, one would mistakenly conclude that some variables affect valuations of strategic

[26]In order to make these results comparable to prior literature that deals with the analysis of determinants of takeover premiums, we present results that are based on the sample of winning bids. We have also run the same regressions on the sample of all formal bids and obtained very similar results. In addition, we have used targets' announcement returns instead of takeover premiums and obtained very similar results. Finally, we have tried to add the logarithm of the number of potential bidders to the set of explanatory variables in order to somewhat control for omitted data, and obtained largely unaffected results.

(financial) bidders. The most striking difference is in the effect of past market return. Results of the OLS regression show that takeover premiums of both strategic and financial bidders decrease following a period of high market return. At the same time, our results show that only valuations of financial bidders decrease following a period of high market return. This implies that past performance of the stock market affects takeover premiums paid by strategic bidders only through their effect on the level of competition among bidders. Because valuations of financial bidders go up following a period of low market returns, strategic bidders face an increased competition from financial bidders. As a result, when a strategic bidder wins the auction, she pays a higher price for the target, even though the average valuation of strategic bidders stays the same. In a similar vein, one would mistakenly conclude that there is no evidence that strategic bidders value targets with high R&D expenses more.[27]

V Distribution of Takeover Gains between Targets and Acquirers

A question of utmost importance for M&A practitioners and academic researchers is how the surplus from takeovers is split between the acquirer and the target. Most of the existing literature addresses this question by looking at the returns to the acquirer and the target upon the takeover announcement. The common conclusion is that returns to targets are large and positive, while returns to acquirers are close to zero and sometimes even negative.[28] These results seem to suggest that most if not all gains from takeovers are accrued to targets. Apart from a well-known concern that expectation of acquisition activity is already incorporated in the acquirer's stock price,[29] this approach does not allow to evaluate gains to private acquirers,

[27]As in Section III.A of Appendix B, we have also estimated the "button" model of takeover auctions. The results, omitted here for brevity, are not supportive of the "button" model: most coefficient estimates are substantially different, and some lose or gain significance as compared to the baseline model. Most strikingly, the misspecified model predicts an inverse relation between the importance of unobserved valuation components for strategic and financial bidders.

[28]See, e.g., Jarrell, Brickley, and Netter (1988) for early evidence and Andrade, Mitchell, and Stafford (2001) and Betton, Eckbo, and Thorburn (2008a) for recent updates.

[29]See Betton, Eckbo, and Thorburn (2008a) for a discussion, and Song and Walkling (2000, 2008) and Fuller, Netter, and Stegemoller (2002) for approaches to deal with this problem. McCardle and Viswanathan

which comprise a significant group of strategic bidders and a vast majority of financial bidders. Because our empirical strategy is aimed at estimating valuations of all bidders and does not use data on acquirer's stock price, it allows us to address these concerns.

To analyze the distribution of takeover gains between targets and acquirers, we compare the observed winning bids with the expected valuations of the winning bidders, conditional on the characteristics of the target, the economy-wide variables, and the outcome of the auction[30]:

$$\mathbb{E}\left[v_i^{(1)}|X_i, b_i^1, t_i^1\right] = \mathbb{E}\left[v_i^{(1)}|X_i, v_i^{(1)} \geq b_i^1, v_i^{(2)} \leq b_i^1, t_i^1\right]. \tag{7}$$

By properties of order statistics, (7) can be computed as the expectation of a random variable distributed according to a lognormal distribution with parameters $X_i'\beta_{t_i^1}$ and $\sigma^2_{t_i^1}$, truncated at b_i^1 from below. We use the estimation results of Model II to compute the estimates of the expected valuations of the winning bidders, $E\hat{v}_i^{(1)}$, for each takeover auction i in the sample. This gives us the estimate of each acquirer's maximum willingness to pay for the target. By comparing it with the actual winning bid for each takeover, we are able to quantify the "winning slack" of the winning bidder.

Figure 2 plots the distribution of the ratio of the winning bid to the estimate of the expected valuation of the winning bidder for the samples of takeovers undertaken by strategic and financial acquirers. Strategic acquirers pay between 65.5% and 92.9% (on average, 85.1%) of their expected maximum willingness to pay. Financial acquirers pay between 84.7% and 97.9% (on average, 92.7%) of their expected maximum willingness to pay. These results have two implications. First, it appears that financial bidders often pay close to their maximum willingness to pay when acquiring the target. If a financial bidder's valuation corresponds to the present value of future proceeds from selling the reorganized company, discounted according to the appropriate cost of capital, this result suggests that financial bidders are able to generate returns only slightly above the required return. This interpretation is in line with the finding of Kaplan and Schoar (2005) that average LBO fund returns (net of fees) are

(1994), Jovanovic and Braguinsky (2004), and Morellec and Zhdanov (2005) develop models in which returns to acquirers can be negative, even though acquirers obtain positive gains from takeovers.

[30] Number of strategic bidders, number of financial bidders, type of the winning bidder, and size of the winning bid.

slightly below the S&P 500 return.

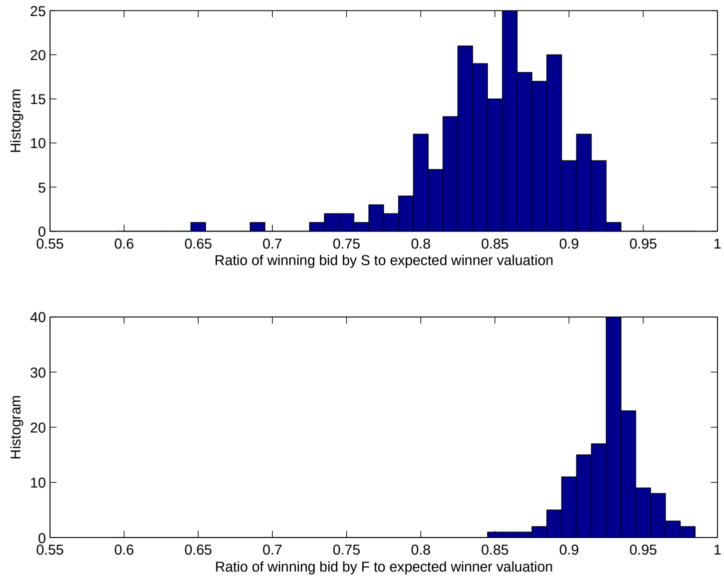

Figure 2: Distribution of the winning slack. The figure shows the distribution of 1-*Winning Slack*, which is defined as the ratio of the winning bid to the ex-post mean of valuation by the winner, conditional on the observable winning bid. Higher winning slack corresponds to lower effective competition in an auction and to higher ability of the winner to pay more if stronger competition arises or target characteristics change adversely.

Second, unlike financial acquirers, strategic acquirers appear to have substantial winning slack, underpaying, on average, 14.92% of their maximum willingness to pay (or, equivalently, 24.7% of the target's pre-takeover market price). Not only do strategic acquirers pay, on average, higher premiums than financial acquirers, but also the maximum premiums that they are willing to pay are considerably higher. If valuations of strategic acquirers were solely defined by potential synergies from the acquisition and there were no anticipation of the takeover, we would expect to obtain the acquirer's announcement returns of approximately 3%.[31] This finding contrasts with the evidence of approximately zero acquirer's announcement returns in takeovers. The difference between these findings is due to two reasons. First, future

[31] Under these assumptions, the acquirer's abnormal return would be the difference between its maximum willingness to pay and the price paid, multiplied by the relative size of the target. Given that the median size of a target is around 12% of the size of the acquirer in the sample of acquisitions of public U.S. companies by public U.S. companies (Andrade, Mitchell, and Stafford (2001)), the implied announcement return is around $0.12 \times 24.7\% \approx 3\%$.

acquisition activity is likely to be captured in the acquirer's stock price, before the acquisition occurs. For example, Song and Walkling (2008) find that the average acquirer's returns are significantly positive at 0.69% for the sample of acquisitions that were the first in the industry in the last 12 months, which are arguably unanticipated. However, because this number is significantly below 3%, the anticipation effect alone is unlikely to explain the absence of the acquirer's announcement return. The second factor that potentially can capture the difference is the private benefits of control. If managers of strategic bidders obtained private benefits from undertaking acquisitions, then their maximum willingness to pay for the target would be above the price at which the acquirer shareholders' gains from the acquisition are zero.[32] As a result, strategic bidders would be willing to overpay for targets, which would lead to a substantial winning slack that is not reflected in the their shareholders' wealth.

VI Approach Validity

In this section, we examine validity of our empirical approach. First, we study the overall fit of the model. Second, we present several robustness checks, in which we relax each of the identification assumptions and re-estimate the model of valuations. Finally, we discuss other potential concerns with the results such as the effects of sample selection.

VI.A Overall Performance of the Model

Table VII examines the fit of the model.[33] We use the estimates of Model II to simulate valuations and outcomes of $34,900$ of takeover auctions (100 simulated auctions for each target

[32]The private benefits of managers could be due to empire building (Jensen (1986)) or effects on compensation through M&A bonuses and future stock and option grants. Grinstein and Hribar (2004) find that M&A bonuses paid to the acquirers' CEOs are unrelated to the deal performance, suggesting that managerial power is an important driver of acquisitions. Studying post-merger compensation of bidders' CEOs, Harford and Li (2007) find that CEOs' pay and wealth are sensitive to positive stock performance following a merger and not sensitive to negative stock performance.

[33]Because we use all the bids, not only the winning bids, in our estimation, the intrinsic valuations of bidders are estimated more precisely. However, the fit of the winning bid alone implied by the model might diverge from that observed in the data, if the losing bids carry a substantially different information than the winning bids. Therefore, the fit of the model can be checked by looking at whether simulations of the model produce auction outcomes that closely resemble the data.

in the sample). More specifically, for each auction we simulate the types of the uninformed bidders using the estimates of the Logit model in Table IV and valuations of all participating bidders using the estimates of the valuations model in Table V. Then, for each simulated auction we determine its outcome: the type of the winning bidder and the takeover premium. By Assumptions 1–3, the type of the winning bidder is equal to the type of the bidder with the highest valuation. The takeover premium is not uniquely determined, because our identification assumptions imply only bounds on it. The lower bound on the winning bid (normalized by the value of the target under the current management) is the maximum of the second highest bidder's valuation among all participants and 1:

$$\text{Winning Bid LB}_i = \max\left[v_i^{(2)}, 1\right], \tag{8}$$

where $v_i^{(j)}$ denotes the j^{th} highest valuation in simulated auction i. The winning bid must be above the second highest valuation by Assumption 2, as otherwise the bidder with the second highest valuation would be willing to beat the winner's offer. In addition, the winning bid must be above 1, as otherwise the shareholders of the target are better off not selling the company at all. The upper bound on the winning bid is the valuation of the winning bidder, which is the highest bidder's valuation among all participants:

$$\text{Winning Bid UB}_i = v_i^{(1)}. \tag{9}$$

The winning bid must be below the winner's valuation by Assumption 1, as otherwise the winner would pay more than she is willing to. Having recorded the outcomes of the simulated auctions, we compare their summary statistics (presented in Table VII) with the corresponding sample values presented in Table I.

Table VII shows that the simulations produce outcomes that are similar to what we observe in the data. Strategic bidders win auctions more often than financial bidders, despite the fact that a typical auction has more financial bidders than strategic bidders. As in the data, there are fewer bidders in takeovers won by strategic bidders than in takeovers won by financial bidders: 11.7 versus 14.5 bidders on average compared to 9.9 versus 16.5 bidders in the data. The average winning premium in the data is within the bounds for the samples of all auctions and auctions won by strategic bidders, and slightly above the upper bound in auctions won by financial bidders.[34] Precisely, the model predicts the average target premium in takeover auctions to be between 30.2% and 52.4%, which is consistent with the observed average takeover premium of 42.5%. For the sample of takeovers undertaken by strategic (financial) acquirers, the model predicts the average takeover premium to be between 32.9% and 59.1% (23.5% and 35.5%), while the sample average takeover premium in the data is 46.4% (36.5%).

Thus, we conclude that the model performs reasonably well at capturing the takeover outcomes observed in the data. Note that our estimation procedure relied on all bids rather than only winning bids, so the fact that simulations produce takeover outcomes that are similar to what we observe in the data is not trivially because we use the winning bids when estimating the valuations.

VI.B Robustness Checks

Our estimation results are based on four important assumptions: Assumptions 1 - 3 and normality of distribution of private components of valuations. While Assumption 1 must hold in all auctions by the definition of the maximum willingness to pay, the other assumptions may be violated in some contexts. To see whether the estimation results are robust to the identification assumptions, we alter them one-by-one and re-estimate Model II.

First, we alter Assumption 2. If submitting a bid is costly, a bidder may choose to let the opponent to win at a price she is willing to bid. For example, if a bidder's valuation is only slightly above the opponent's bid, potential gains from submitting a higher bid may be below the bidding costs. Alternatively, the winning bid is not necessarily an upper bound on losing bidders' valuations if the winner has made a strategic preemptive bid. To see whether our results are robust to these concerns, we relax Assumption 2: instead of assuming that a bidder does not allow an opponent to win at a price she is willing to bid, we assume that a bidder

[34] Both sample and simulated takeover premiums have high standard deviations, so the fact that the observed average of the takeover premium is slightly above the upper boundary implied by the model is not surprising.

does not allow an opponent to win if her valuation exceeds the opponent's bid by more than 5 percentage points of the target's value under the current management. This increases the upper bound on the valuation of a losing bidder from $b_{i,1}$ to $b_{i,1} + 0.05$. Table VIII, Model IV presents estimates of the modified model and shows that the results of Section IV are robust to this modification.

Second, we alter Assumption 3. If there is a chance that the target's shareholders agree to sell the company at a price below the value under the current management, then bidding behavior may violate Assumption 3. For example, this can happen in the presence of pressure from a large shareholder of the target. In addition, our measure of the target's value under the current management may be imprecise. To see whether our estimation results are robust to these concerns, we relax Assumption 3: instead of assuming that a bidder does not make an informal bid if her valuation is below the target's value under the current management, we assume that a bidder does not make an informal bid if her valuation is below 90 percent of the target's value under the current management. This lowers the lower bound on the valuation of a losing bidder who submitted an informal bid from 1 to 0.9. Table VIII, Model V presents the modified estimates which indicate that our prior results are also robust to this modification.

Finally, we alter the assumption that private components of valuations, $\epsilon_{i,j}$, are distributed normally. This assumption is a natural starting point of the analysis but can be criticized if one believes that distribution of potential synergies exhibits fat tails. To check for robustness of our results to presence of fat tails, we replace the assumption of Normal distribution of $\epsilon_{i,j}$ with that of t-distribution with known degrees of freedom ν. We assume $\nu_s = \nu_f = 5$.[35] The estimates, presented in Table VIII, Model VI, suggest that most results of the baseline model are robust to the distributional assumption.

[35] For examples of use of t-distribution in various econometric models to achieve robustness see, e.g., Lange, Little, and Taylor (1989), Albert and Chib (1993), and Liu (2006). Liu (2006) shows that maximum likelihood estimators of so-called "robit" models, to which ours is similar, are robust if the number of degrees of freedom in t-distribution is known, and suggests the use of 5–7 degrees of freedom. We have also estimated models with other degrees of freedom and found similar results.

VI.C Further Discussion of Approach Validity

We complete this section with a discussion of other less explicit identification assumptions and sample selection, and argue that our results are unlikely to be overturned with alternative assumptions in place.

Sample selection. One issue that may create a problem in interpretation of the results is the sample selection bias. Specifically, our sample consists of: *(i)* takeovers where the winning bid was made in cash; and *(ii)* takeovers that were completed. Because bids in stock are almost exclusively submitted by strategic bidders rather than by financial bidders, considering only takeover auctions in which the winning bid was made in cash creates a bias that increases (decreases) estimates of valuations for financial (strategic) bidders. However, because we find that valuations of strategic bidders are on average higher than valuations of financial bidders in our sample of takeover auctions, elimination of this bias will act in the way of increasing the difference between strategic and financial valuations even further. As for particular coefficients in the sample that contains auctions won in both cash and stock, the size coefficient will likely become smaller in absolute value and insignificant for strategic bidders, because ability to bid in stock relaxes their financial constraints and allows them to compete for larger targets. Second, because the ability to bid in stock is likely to be independent from debt market conditions, in the full sample of completed takeovers financial bidders will lose an even larger proportion of deals when the credit spread is high, so the coefficient on credit spread for their valuation will likely decrease. There is no clear intuition however why in the full sample of completed takeovers any of our main results will be overturned.

Because our sample consists of takeovers that were completed, the estimates of valuations are likely to be biased upwards compared to the ex-ante valuations of targets that are unconditional on the sale having been completed. Intuitively, takeover auctions, in which bidders' valuations are lower, are less likely to result in a sufficiently high premium for the target and, as a result, are often not observed by the researcher. Because of this sample selection issue, our valuations must be interpreted as valuations conditional on the sale of the target rather than unconditional valuations. However, it is unclear why this bias can have systematically different effects on strategic and financial bidders that can lead to the significant differences between them other than those we estimate.

Common values. Another potential issue is the assumption that the unobserved components of valuations are independent across potential bidders in the auction for the same target. Clearly, in reality valuations of different bidders can have a common component that is not reflected in the observable characteristics of the target. In other words, while we attribute $\varepsilon_{i,j}$ to the private component of the bidder's valuation, in reality part of it can be attributed to the common component. To address this concern, we distinguish between two different cases: when the common component is observable to the bidders (but not to the researcher) during due diligence and when the common component is only partially observable to the bidders during due diligence and thus is revealed in the course of the auction.

If the common component is observable to the bidders prior to submitting bids, then the problem of common values is equivalent to that of unobserved heterogeneity. It may affect the interpretation of the difference between σ_s and σ_f as the difference in the levels of heterogeneity of strategic and financial bidders. However, note that the estimated difference between σ_s and σ_f is extremely high: we estimate σ_s to be almost twice larger than σ_f. To have such a large difference between σ_s and σ_f and the same level of heterogeneity of strategic and financial bidders at the same time, it must be the case that a very large part of the unobserved component is attributed to the common component for strategic bidders and a very small part of the unobserved component is attributed to the common component for financial bidders. This is unlikely to be the case in the takeover market. In fact, it is often commonly asserted that unobserved common component of valuations is more important for financial bidders than for strategic bidders. For example, Bulow, Huang, and Klemperer (1999) model takeover battles between financial bidders as "common value" auctions and contrast them to takeover battles between strategic bidders that are "private value" auctions.

If the common component is only partially observable to each bidder prior to submitting bids through an imperfect signal, then bidders will rationally shave their bids by inferring signals of other bidders from the bidding process. As a result, valuations estimated from data on bids are likely to be lower and less dispersed than valuations of bidders after due diligence but before the auction starts. The difference increases with the amount by which bidders shave their bids, which, in turn, increases with the amount of information revealed in the bidding process. Because a greater part of the common component is usually revealed during the due diligence process rather than during the bidding process (e.g., Hansen (2001)), this difference is unlikely to be high. In addition, a target and, in turn, a researcher are likely to be more interested in post-bidding heterogeneity than pre-bidding heterogeneity. From the point of view of the target firm, post-bidding heterogeneity is the only important one because it is the one that affects the target's expected surplus from the auction.

Model of synergies. Another important identification assumption is the functional form of the bidders' valuations. Specifically, (1) assumes that the maximum premium that the bidder is willing to pay for the target is proportional to the market value of the target's equity under the current management. While proportionality to some benchmark value is an intuitive assumption, given that the set of characteristics includes the size of the target and its q-ratio, the choice of the benchmark could be different. Another reasonable assumption is that the maximum premium that the bidder is willing to pay is proportional to the book enterprise value of the target rather than the value of equity. While this approach is plausible from the theoretical perspective, it is problematic to apply empirically because the dynamics of the target's enterprise value is not perfectly observed. More precisely, while the market value of equity is observed on the daily basis from the data on stock prices, the enterprise value of the target is observed only quarterly when the data on cash balances and debt is published. Likely because of this problem, the imperfect measure of the enterprise value, which is constructed as the current market value of equity less cash balances plus the book value of debt, where the latter two components are taken from the latest financial statements data, as well as the imperfect measure of bids for the enterprise, are negative or very close to zero for approximately 6% of the targets in the sample. Because of these data imperfections, our estimation approach is based on the assumption that the valuations are proportional to the market value of the target's equity. Nevertheless, as a robustness check, we also used data on targets, whose ratio of the winning bid to the enterprise value is truncated by 1 from below and 4 from above (in the same way as truncation of the data for the original model was made in Section III), to estimate a model based on enterprise values and found very similar results.

Measurement of the value under the current management. In the estimation of the baseline model, we measure the value of the target under its current management as its market value 4 weeks before the takeover announcement, if there was no public announcement of the auction before that, and 1 day before the announcement of the auction, otherwise. For robustness check, we also re-estimated the model using a different measure of the value of the target under its current management: market value 3 months before the takeover announcement, if there was no public announcement of the auction, and 1 day before the announcement of the auction, otherwise. The results of the estimation are similar to the results reported in Table V.

VII Concluding Remarks

As recognized in business literature, potential acquirers are usually classified into two broad groups, strategic bidders and financial bidders. This paper studies how the two groups of bidders differ with respect to valuations of potential takeover targets. We use hand-collected data from SEC filings on formal and informal bids as well as types of potential bidders to separate the impact of observable target characteristics and the unobservable component on bidders' valuations of the target. We find that valuations of strategic and financial bidders differ along multiple dimensions. First, strategic bidders appear to value targets with different observable characteristics than financial bidders. Second, valuations of financial bidders are significantly affected by aggregate economic conditions: financial bidders value targets more following a period of low market returns and when debt markets conditions are favorable. At the same time, we find no evidence that aggregate economic conditions are important for valuations of participating strategic bidders. Third, valuations of strategic bidders are substantially less tied to observable target characteristics than valuations of financial bidders. This result suggests that from the target's point of view, all financial bidders look alike, while strategic bidders are more unique. Finally, consistent with the common belief, valuations of strategic bidders are typically higher than valuations of financial bidders. At the same time, there exists a subsample of targets that are valued more by financial bidders: these are large mature targets that underperform.

Several potential avenues for future research may be interesting. First, one may look at further link between the bidders' valuations and the takeover premiums paid by strategic and financial bidders. It is well known that strategic acquirers pay more for targets they acquire than financial acquirers. In this paper, we show that this observation is consistent with two of our results. First, this is consistent with higher valuations of strategic bidders; second, with higher heterogeneity of strategic bidders: because valuations of strategic bidders within the auction are more different from each other, the acquirer's valuation exceeds valuation of the average strategic bidder by a larger amount, resulting in a higher takeover premium. An interesting question for future research is to evaluate the importance of each of these effects in explaining the observed difference in takeover premiums paid by strategic and financial bidders. Second, as we show in the paper, there exists a considerable heterogeneity in the number of bidders in each auction. A potential avenue for future research is to look at the sources of this heterogeneity, and at the differences in participation decisions between strategic and financial bidders. Ultimately, the aim is to understand the complex interrelation between participation decisions, valuations, and the resulting takeover premiums. Finally, it can be interesting to study what selling mechanisms are optimal in the presence of two distinct categories of bidders. It is well known that symmetric auction formats are typically sub-optimal in the presence of bidder asymmetries. However, it is not obvious how the optimal selling mechanism should look like in the complex takeover market. Povel and Singh (2006) make contribution in this direction, showing that when two bidders are asymmetrically informed about the target, a sequential procedure in which the target first offers an exclusive deal to a better-informed bidder is optimal. It is an open question whether similar mechanisms can substantially improve revenues for at least some companies subject to a potential takeover.

Appendix A Example of a Takeover Auction

This appendix provides extracts from the background of the sale process of Manor Care. The text is taken from the SEC filings.

At a meeting of the board held on April 10, 2007, our board of directors considered a review of our strategic plan and potential alternatives to maximize shareholder value. ... After further discussions between members of the board and our management, the board determined at the meeting that it was advisable and in the best interests of Manor Care and our stockholders to further explore strategic alternatives to enhance shareholder value, including through a potential sale of Manor Care. We retained JPMorgan as financial advisor, and Cravath, Swaine & Moore LLP ("Cravath") as legal counsel, to Manor Care and the board. We announced our board's determination to explore strategic alternatives to enhance shareholder value in an April 11, 2007 press release.

JPMorgan also began to contact potential strategic and financial acquirors to gauge their interest in acquiring Manor Care. Over the course of the following weeks, JPMorgan contacted 48 potential acquirors, including 10 potential strategic acquirors, to assess their interest in acquiring Manor Care. ... We subsequently executed confidentiality agreements with 21 potential financial acquirors and two potential strategic acquirors. At the regular meeting of our board of directors on May 8, 2007, ... representatives of JPMorgan also updated the board on the progress of the potential sale of the company process, noting that, of the 23 parties that had entered into confidentiality agreements, eight potential financial acquirors and two potential strategic acquirors had provided preliminary indications of interest to JPMorgan. ... During the course of their due diligence process and prior to the submission of final acquisition proposals, all but two of the potential buyers dropped out of the process. On June 8, 2007, JPMorgan distributed a bid procedures letter and a draft merger agreement to the seven potential financial acquirors and one potential strategic acquiror that were still actively engaged in the process.

By June 25, 2007, Carlyle and one continuing strategic acquiror submitted proposals for the acquisition of Manor Care, together with debt financing commitments and comments on the draft merger agreement and, in the case of Carlyle, an equity financing commitment and sponsor guarantee. Carlyle offered merger consideration of $67.00 per share in cash, while the potential strategic acquiror offered merger consideration of $65.00 per share divided equally between cash and the acquiror's common stock. ... With respect to the potential sale of the company process, representatives of

JPMorgan and Cravath discussed with the board, in light of the proposals made by each of the potential acquirors, the process to solicit improved terms from the potential acquirors. ... The board also directed JPMorgan and Cravath to seek improved terms from each of the potential acquirors. ... Prior to the meeting of the board on the morning of June 28, 2007 described below, Carlyle orally informed JPMorgan that it was increasing its proposal to a best and final offer of $67.50 per share ... . The potential strategic acquiror informed Manor Care in writing that it was not willing to increase its offer price any further.

Management and JPMorgan informed the board that, in responding to questions raised by Carlyle in the course of the due diligence process, management and JPMorgan had determined that a sale of Manor Care would give rise to additional costs in connection with the termination of certain options purchased and warrants issued by Manor Care with respect to its common stock in connection with Manor Care's 2.125% convertible senior notes due 2035. ... In order to offset the option value cost in the context of a sale of Manor Care (which cost Manor Care and its hedge counterparty had agreed to fix at $47 million), Carlyle submitted a revised offer to purchase Manor Care for $67.00 per share.

On the evening of July 1, 2007, our board met to review Manor Care's strategic alternatives and the revised financial and legal terms that had been proposed by Carlyle. ... Following additional discussion and deliberation, our board of directors determined that, based on all information available to the board, a sale of Manor Care to Carlyle at $67.00 per share would provide our stockholders with greater value than any of Manor Care's other strategic alternatives, and the board unanimously ... approved the merger agreement with an entity sponsored by Carlyle, the merger and the other transactions contemplated by the merger agreement, authorized Manor Care to enter into the merger agreement and resolved to recommend that our stockholders vote to adopt the merger agreement. The merger agreement was executed by Manor Care, Inc. and MCHCR-CP Merger Sub Inc. as of July 2, 2007. On July 2, 2007, before the opening of trading on the NYSE, Manor Care and Carlyle issued a joint press release announcing the merger.

Appendix B Estimation Methodology

II.A Estimation of Fully Observable Bidder Types

Consider auction i. First, suppose that all N_i potential bidders' types are observed by the researcher (the number of bidders with unobservable type is $N_{u,i} = 0$)[36], and there are $N_{s,i}$ strategic bidders and $N_{f,i}$ financial bidders, such that $N_{s,i} + N_{f,i} = N_i$. Suppose that bidders within each auction are sorted in the descending order by the maximum bid, as described in Section II.C. Let $b_{i,j}$ and $t_{i,j}$ denote denote their maximum bids and types correspondingly.

The likelihoods of events from Section II for each auction i are then:

1. Bidder 1 *submits formal bid* $b_{i,1}$ and *wins* an auction. By Assumption 1, the likelihood of this event is

$$\begin{aligned} l_{i,1}(v_{i,1}|X_i, b_{i,1}, t_{i,1}; \theta) &= \mathbb{P}\{b_{i,1} \leq v_{i,1}|X_i, t_{i,1}; \theta\} = \mathbb{P}\left\{\frac{\log\frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,1}}}{\sigma_{t_{i,1}}} \leq \epsilon_{i,1}\right\} \\ &= 1 - \Phi\left(\frac{\log\frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,1}}}{\sigma_{t_{i,1}}}\right). \end{aligned} \tag{B1}$$

2. Bidder $j > 1$ *submits formal bid* $b_{i,j}$ and *loses* to bidder 1. By Assumptions 1 and 2,

$$\begin{aligned} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta) &= \mathbb{P}\{b_{i,j} \leq v_{i,j} \leq b_{i,1}|X_i, t_{i,j}; \theta\} = \mathbb{P}\left\{\frac{\log\frac{b_{i,j}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}} \leq \epsilon_{i,j} \leq \frac{\log\frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right\} \\ &= \Phi\left(\frac{\log\frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right) - \Phi\left(\frac{\log\frac{b_{i,j}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right). \end{aligned} \tag{B2}$$

3. Bidder $j > 1$ *submits informal bid* of any size and *loses* to bidder 1. By Assumptions 1 - 3,

$$\begin{aligned} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta) &= \mathbb{P}\{M_i \leq v_{i,j} \leq b_{i,1}|X_i, t_{i,j}; \theta\} = \mathbb{P}\left\{\frac{-X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}} \leq \epsilon_{i,j} \leq \frac{\log\frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right\} \\ &= \Phi\left(\frac{\log\frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right) - \Phi\left(\frac{-X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right). \end{aligned} \tag{B3}$$

4. Bidder $j > 1$ *does not submit any bid.* If the bidder *does not inform the target* about this

[36] By assuming complete type observability, this section lays down basic building blocks of our identification strategy. Appendix B, Section II.B deals with a more complicated case when types of some losing bidders are not observable.

decision, then by Assumptions 1 and 2,

$$\begin{aligned} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta) &= \mathbb{P}\{0 \le v_{i,j} \le b_{i,1}|X_i, t_{i,j}; \theta\} = \mathbb{P}\left\{-\infty \le \epsilon_{i,j} \le \frac{\log \frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right\} \\ &= \Phi\left(\frac{\log \frac{b_{i,1}}{M_i} - X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right). \end{aligned} \tag{B4}$$

If the bidder *informs the target* that her valuation is below the market value of the company under its current management m_i, then by Assumption 1,

$$\begin{aligned} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta) &= \mathbb{P}\{0 \le v_{i,j} \le M_i|X_i, t_{i,j}; \theta\} = \mathbb{P}\left\{-\infty \le \epsilon_{i,j} \le \frac{-X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right\} \\ &= \Phi\left(\frac{-X_i\beta_{t_{i,j}}}{\sigma_{t_{i,j}}}\right). \end{aligned} \tag{B5}$$

The likelihood function for auction i with observable bidder types can be written as

$$L_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta) = \prod_{j=1}^{N_i} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta), \tag{B6}$$

so that the complete log-likelihood function of the model with fully observable data is given by

$$\begin{aligned} \mathfrak{L}(v|N_s, N_f, N_u, X, b, t; \theta) &= \frac{1}{\sum_{i=1}^{I} N_i} \sum_{i=1}^{I} \mathfrak{L}_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta) \\ &= \frac{1}{\sum_{i=1}^{I} N_i} \sum_{i=1}^{I} \sum_{j=1}^{N_i} \log l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta). \end{aligned} \tag{B7}$$

Denote $N = \sum_{i=1}^{I} N_i$. From the theory of maximum likelihood estimators, slightly abusing notation $(\mathfrak{L}_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta) \equiv \mathfrak{L}_i(\theta))$,

$$\sqrt{N}(\hat{\theta} - \theta) \xrightarrow{d} \mathcal{N}(0, I^{-1}(\theta)) \tag{B8}$$

$$I(\theta) = -p \lim_{N\to\infty} \sum_{i=1}^{N} \frac{d^2\mathfrak{L}_i(\theta)}{d\theta d\theta'} = p \lim_{N\to\infty} \sum_{i=1}^{N} \frac{d\mathfrak{L}_i(\theta)}{d\theta} \frac{d\mathfrak{L}_i(\theta)}{d\theta'}. \tag{B9}$$

The asymptotic confidence interval for parameter $\theta_k \in \theta$ is given by

$$\left[\hat{\theta} + q_{\alpha/2}^{\mathcal{N}(0,1)}\sqrt{\frac{1}{N}I^{-1}(\hat{\theta})}; \hat{\theta} + q_{1-\alpha/2}^{\mathcal{N}(0,1)}\sqrt{\frac{1}{N}I^{-1}(\hat{\theta})}\right]. \tag{B10}$$

II.B Estimation with Partially Unobservable Bidder Types

Consider the estimation framework of Section II.C, but now suppose that some of potential bidders' types are unobservable. Let $N_{s,i}$ and $N_{f,i}$ be the observable number of strategic and financial bidders in auction i, and $N_{u,i} = N_i - N_{s,i} - N_{f,i} \geq 0$ be the number of bidders with unobservable type. Also, denote by U_i and O_i the set of unobservable and observable bidders in auction i. Clearly, in the model with fully observable data $U_i = \{\emptyset\}$ and $O_i = \{1, 2, ..., N_i\}$ for all i. With partially unobservable data, O_i contains at least bidder 1 – the identity and the type of the winner is always known. The rest of the framework follows that of Section II.C.

The straightforward way to deal with unobserved data is to maximize the likelihood function (B7), treating all possible unobservable types $t_{i,j}$ as additional parameters of estimation that can take values $\{s, f\}$, and find the set of types that provides the highest function value. This approach is computationally unfeasible in all but most simple setups. As an alternative, we propose a method similar to the expectation maximization (EM) algorithm, which dates back to Dempster, Laird, and Rubin (1977) and was extended in many ways to deal with the unobserved latent data in recent years[37]. The method allows us to iteratively solve the following two-step problem. On the first step, the probability $\mathbb{P}\{t_{i,j}|Z_i;\gamma\}$ that a bidder of type $t_{i,j} \in \{s, f\}$ enters an auction is calculated from the observable data. The vector of target characteristics Z_i that affects this probability includes X_i. It also contains the information about auction outcomes available to the researcher (e.g., winning bid, winning bidder's type, total number of bidders). On the second step, the *expected* likelihood function is maximized with respect to structural parameters. In this function, the likelihood of each missing observation is substituted with the expected likelihood $\mathbb{E}\left[l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j};\theta)|t_{i,j}\right]$, which is the weighted sum of the likelihoods conditional on the type $t_{i,j}$ being observable with probability weights of each $t_{i,j}$ given by the first step estimate.

The two-step EM algorithm for a model with partially unobservable data proceeds as follows:

[37] See Mclachlan and Krishnan (2008) for comprehensive overview of state-of-the-art expectation maximization methods.

1. Calculate fitted values $\hat{\mathbb{P}}_s(Z_i'\hat{\gamma}) = \mathbb{P}\left(t_{i,j} = s|Z_i, \hat{\gamma}\right) \in [0,1]$ of the flexible parametric regression for probability of strategic bidder's entrance

$$\mathbb{P}_{s,i,j} = \Gamma(Z_i'\gamma, \nu_{i,j}),\ j > 1, \tag{B11}$$

where $\mathbb{P}_{s,i,j}$ is equal to one if the observed type of bidder j in auction i is strategic, and is equal to zero if its type is financial. Also, compute $\hat{\mathbb{P}}_f(Z_i'\hat{\gamma}) = 1 - \hat{\mathbb{P}}_s(Z_i'\hat{\gamma})$. For our purposes, Γ can be any function that limits its values to [0,1], e.g., logistic or Probit-like function. We give more detail on the likelihood function that is estimated on the first step and discuss why we can use the information about losing bidders from auctions with both perfectly and imperfectly known types in Appendix B, Section II.C. In total, each auction contributes $N_{s,i}+N_{f,i}-1$ observations to the estimation. Note that we exclude the winner of auction i from the estimation;

2. (a) Compose the expected log-likelihood function for auction i as

$$\mathfrak{L}_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta) = \log \mathbb{E}[L_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta)|t_i], \tag{B12}$$

where, because types are independent across all the bidders in the economy,

$$\mathbb{E}[L_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta)|t_i] = \prod_{j=1}^{N_i} \mathbb{E}[l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta)|t_{i,j}] \tag{B13}$$
$$= \prod_{j \in O_i} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta) \prod_{j \in U_i} \sum_{t_{i,j} \in \{s,f\}} l_{i,j}(v_{i,j}|X_i, b_{i,j}, t_{i,j}; \theta) \mathbb{P}_{t_{i,j}}(Z_i'\hat{\gamma}).$$

That is, the likelihood function of auction i is the product of likelihoods of bidders with observable and unobservable types, such that the likelihood of unobservable type is the weighted sum of likelihoods conditional on the type $t_{i,j}$ being observable with probability weights obtained on the first step.

(b) Maximize

$$\mathfrak{L}(v|N_s, N_f, N_u, X, b, t; \theta) = \frac{1}{\sum_{i=1}^{I} N_i} \sum_{i=1}^{I} \mathfrak{L}_i(v_i|N_{s,i}, N_{f,i}, N_{u,i}, X_i, b_i, t_i; \theta) \tag{B14}$$

with respect to θ.

The winning bidder is excluded from calculations of $\hat{\mathbb{P}}_s(Z_i'\hat{\gamma})$ and $\hat{\mathbb{P}}_f(Z_i'\hat{\gamma})$ because of the potentially large bias which perfect knowledge of the winner in each auction introduces to the estimation. Consider a simple example. For every i, suppose that $X_i'\beta_s \gg X_i'\beta_f$, $\sigma_s = \sigma_f$, and $O_i = \{1\}$, that is, only the winning bidder's type is observed. Also, suppose that the true probability of strategic bidder's entry is $\mathbb{P}_s = \Gamma((1\ Z_i)' \cdot (\gamma_1\ 0 \ldots 0))$ – a constant. As Z varies, similar fractions of strategic and financial bidders will enter the auction, but the estimation of the probability of strategic bidder's entry will always give $\hat{\mathbb{P}}_s(Z_i'\hat{\gamma}) \simeq 1$ and $\hat{\mathbb{P}}_f(Z_i'\hat{\gamma}) \simeq 0$. This happens because valuations of strategic bidders significantly first order stochastically dominate those of financial buyers. As a result, the first step estimation will predict unobserved bidding types with bias: when only the winning bidder's type is observed, none of the potentially numerous financial bidders has any chance of actually winning the auction, have its type revealed and contribute to the first step estimation.

Of course, the above example is an extreme case of the problem – in reality bias will likely be less pronounced because for the bidder of any type, the probability of entry and that of winning are generally positively correlated, and extreme overvaluation of the company by one type of bidder relative to the other type is not observed. To remove the bias, we must estimate the probability of entry *conditional* on ex-post event of the bidder with the *known type not winning* the auction. As $N \to \infty$, this probability will coincide with the probability of entry conditional on ex-post event of the bidder of the *unknown type not winning* the auction.

The asymptotic properties of the estimator with unobserved data are the same as those described in Appendix B, Section II.A.

II.C Recovering Types of Bidders with Missing Information

Suppose that in auction i, a losing bidder is strategic with probability $\mathbb{P}_s = \Gamma(Z_i'\gamma)$. The number of losing strategic bidders in an auction with the total of N_i bidders, $N_{u,i}$ of which have unobserved type, is distributed as *Bernoulli* $((N_i - N_{u,i})\Gamma(Z_i'\gamma), (N_i - N_{u,i})\Gamma(Z_i', \gamma)\,(1 - \Gamma(Z_i', \gamma)))$. The probability that $N_{s,i}$ losing bidders are strategic in such auction is then

$$\mathbb{P}\{N_{s,i}|N_i, N_{u,i}, Z_i; \gamma\} = C_{N_i}^{N_{s,i}} \Gamma(Z_i'\gamma)^{N_{s,i}} \left(1 - \Gamma(Z_i'\gamma)\right)^{N_i - N_{u,i} - N_{s,i}} \tag{B15}$$

Define $N_s = (N_{s,1}, N_{s,2}, ..., N_{s,I})'$, $N = (N_1, N_2, ..., N_I)'$, and $N_u = (N_{u,1}, N_{u,2}, ..., N_{u,I})'$. The complete likelihood function of the model that recovers types of losing bidders with missing information is

$$L(N_s|N,N_u,Z;\gamma)=\prod_{i=1}^{I}C_{N_i}^{N_{s,i}}\Gamma(Z_i'\gamma)^{N_{s,i}}\left(1-\Gamma(Z_i'\gamma)\right)^{N_i-N_{u,i}-N_{s,i}}. \tag{B16}$$

Taking logarithm,

$$\begin{aligned}
\mathfrak{L}(N_s|N,N_u,Z;\gamma) &= \sum_{i=1}^{I}C_{N_i}^{N_{s,i}}\Gamma(Z_i'\gamma)^{N_{s,i}}\left(1-\Gamma(Z_i'\gamma)\right)^{N_i-N_{u,i}-N_{s,i}}\\
&= const+\sum_{i=1}^{I}N_{s,i}\log\Gamma(Z_i'\gamma)+\sum_{i=1}^{I}(N-N_{u,i}-N_{s,i})\log(1-\Gamma(Z_i'\gamma))\\
&= const+\sum_{i=1}^{I}\sum_{j=1}^{N_{s,i}}\log\Gamma(Z_i'\gamma)+\sum_{i=1}^{I}\sum_{j=1}^{N_{f,i}}N_{f,i}\log(1-\Gamma(Z_i'\gamma)),
\end{aligned} \tag{B17}$$

because $N_{s,i}+N_{f,i}+N_{u,i}=N_i$ for every i. Maximizing (B17) with respect to γ, we obtain the ML estimate $\hat{\gamma}$ and the projected probabilities of a losing bidder to be strategic $\hat{\mathbb{P}}_s(Z_i'\hat{\gamma})$. It is also immediately clear that, because the presence of bidders with unobservable type in an auction does not create complications in the likelihood for observed bidder types, using information from auctions with both fully and partially observed data is optimal.

II.D Details of Numerical Procedures

Because of the unobservability of types, complete likelihood the model of valuations is non-convex and as such has multiple local maxima[38]. To deal with this problem, we propose the following two-step numerical procedure to find the global maximum:

1. The original starting point $\theta^{(0)}$ is obtained from economic considerations. The likelihood is first optimized using the simulated annealing method, which allows us to safely escape local maxima that are substantially far away from the global maximum. This step simulates the set of parameters $\theta^{(k)}, k=1,...,30,000$ using the modified Accept-Reject method and finds the intermediary optimum θ^{*}[39].

2. θ^* serve as the starting point for the simplex method optimization (see, e.g., Nelder and Mead (1967)). This method can also escape local maxima and is in general efficient in finding the

[38]This problem is known in applied econometrics as the "mixture of types" problem.

[39]More detail on the parametrization of the simulated annealing procedure is available from the authors upon request.

global maximum if the starting point is sufficiently close to it, which is ensured by the first numerical step. The optimization continues until a new intermediary optimum is found, and then is repeatedly restarted using the newly obtained optimum as the starting point until the sequential optima coincide. The final iteration of the simplex method gives $\hat{\theta}$.

The combination of methods performs consistently well in the simulated data, for which true valuation parameters are known, even for original starting points substantially far away from the true maximum.

Appendix C Simulations

III.A Discussion

In this section, we examine performance of the estimator obtained using our incomplete model of English auctions with three assumptions on bidding behavior. We simulate artificial data with bidding patterns which are poorly approximated by any particular structure and which to some extent resemble bidding patterns in takeover auctions. For simplicity, we continue to use terms "strategic" and "financial" to differentiate between the two types of bidders. In the course of each simulated auction, we allow strategic and financial bidders to arrive with new offers in random sequence and submit bids (both informal and formal) with discrete increment of random size. To focus on the performance of the valuation model only, we keep types of all bidders known in the resulting data set.[40] We consider three different parameterizations of the simulation procedure that differ in the distribution of observable target characteristics across auctions and the number of auction participants. Appendix C, Section III.B describes the simulation procedure in detail. We also compare performance of our estimator to the estimator obtained from the linear OLS model in which bidder valuations are simply assumed to be equal to their final bids (underspecified model), and the estimator obtained under the commonly employed assumption that in all auctions, bidders can increase their bid continuously (overspecified "button" model of auctions)[41].

[40] The results are similar if we implement partially unobservable types, i.e., randomly "forget" the true type for a subset of losing bidders in the simulated data, consistent with our assumption about the actual data.

[41] Table IX presents the "button" model estimated using only winning bids, due to the inability of the traditional "button" framework to incorporate the informational content of informal bids. We also estimated the modified "button" model, which takes into account informal bids, with similar results.

The estimation results of the simulated data using the incomplete model of English auctions for three different parameterizations of the simulation procedure are presented in Table IX, Panels A–C. Also, Table IX shows estimates obtained under the assumption that the bidder always bids its true valuation (the linear OLS model), and under the assumption that the auction is "button" with continuous bid increment. The results produced by the incomplete model of English auctions are very close, both economically and statistically, to true valuation parameters. On the other hand, the results of the linear model and the structural "button" model are widely inconsistent.

First, consider a linear model. Because takeover premiums are complex functions of all bidders' valuations, this takeover premium regression lacks identification to reliably distinguish among different factors that separately shape strategic and financial valuations. Takeover premiums tend to be above average bidder valuations, more so when the number of potential bidder in an auction is higher. This is evidenced by overestimated mean of valuations, $\beta_{s,1}$ and $\beta_{f,1}$, for every parametrization of the simulated data, and by overall higher coefficients for the parametrization presented in Panel A as compared to Panel B where the average number of participants across auctions is smaller. Moreover, a simple change in the properties of exogenous data can substantially affect all coefficients: an increase in the variance of X_2 in the parametrization presented in Panel C, as compared to Panel A, increases (decreases) both the average and the variance of takeover premiums paid by financial (strategic) bidders[42], which under the linear model results in inverse relationship between estimated magnitudes of private valuations, σ_s and σ_f, for the two types of bidders. Finally, takeover premiums paid by strategic and financial bidders tend to differ by approximately the same amount across auctions, as reflected in a reduced and almost insignificant difference between $\beta_{s,2}$ and $\beta_{f,2}$, compared to true values, for two parametrizations. Second, to a smaller extent, the same problems plague estimation results of the "button" model in which for all bidders with formal offers except the winner, valuations are still assumed to be equal to their bids.

The conclusion is that when too little or too much structure is imposed, the inference and predictions of the misspecified empirical model can contain substantial bias. In real data sets, due to complex correlations between the components of bidders' valuations X, the biases from misspecification become even more pronounced, as evidenced by results at the end of Section IV.B. On the other hand, the method that we offer is designed to be robust to a large variety of bidding

[42] Financial bidders start to win more often and on average more easily against strategic bidders due to high sensitivity of their valuations to X_2.

patterns observed in takeover auctions.

III.B Simulation Example: OLS versus "Button" versus Incomplete Models of Takeovers

We simulate three data sets, each containing $I = 200$ auctions, and each corresponding to the following three parameterizations:

1. All auctions have from $\underline{N}_i = 2$ to $\overline{N}_i = 8$ bidders with equal probability; two valuation shifters (observable target characteristics) $X_i = (X_{i,1}, X_{i,2})'$ are: $X_{i,1} = 1$ (fixed component of valuation) and $X_{i,2} \sim \mathcal{N}(\mu_X, \sigma_X^2)$, where $(\mu_X, \sigma_X) = (0, 0.4)$;
2. $(\mu_X, \sigma_X) = (0, 1.2)$, with the rest of parametrization the same as in 1.;
3. $\overline{N}_i = 4$, with the rest of parametrization the same as in 1.

The probability of each bidder to be strategic is $\mathbb{P}_s = 0.3$. The market value of the target is simulated as $M_i = \exp(\mathcal{N}(\mu_M, \sigma_M^2))$, where $(\mu_M, \sigma_M) = (4, 0.5)$. The true parameter set is: $\beta_s = (\beta_{s,1}, \beta_{s,2})' = (0.1, 0.1)'$, $\beta_f = (\beta_{f,1}, \beta_{f,2})' = (0.1, 0.5)'$; $\sigma_s = 0.25$, $\sigma_f = 0.15$.

Bidders start to make offers knowing that M_i is the lowest bid that will be accepted, and are chosen to come up with new offers at random. To capture discreteness of bid increments, we set the minimum bid increment equal to $M_i/100$. Bidders choose the size of the increment at random, uniformly from a discrete set of values $\{M_i/100, 2M_i/100, ..., 10M_i/100\}$. If bidder j's valuation is such that $v_{i,j} < b_{i,\max} + kM_i/100$ where $k \leq 10, k \in \mathbb{N}$ and $b_{i,\max}$ is the current highest bid, they will rationally choose from a subset $\{M_i/100, 2M_i/100, ..., (k-1)M_i/100\}$. If $k < 1$, the bidder will drop out of the auction. The choice of this somewhat simplistic bidding procedure is for expositional purpose and without loss of generality, as the incomplete empirical framework can also deal with strategic jump bids, strategic exits and re-entries, etc. In fact, even with such simple structure of bidding patterns, which represents the minimal deviation from the continuous-increment bidding, we are able to achieve our aim: We show that estimation of realistic bidding patterns via a misspecified model can be inconsistent and will likely lead to wrong conclusions.

The simulated data is estimated using three empirical methods: incomplete structural model of English auctions, linear OLS model of takeover premiums, and "button" model which assumes that bidders can can continuously increase their offers. The results are presented in Table IX, and discussed in Appendix C, Section III.A.

Appendix D The Challenges of Modeling Takeovers Completed in Securities

Here we present the problems which a researcher has to overcome in order to study valuations in takeovers completed in securities:

1. *The cash value of a stock bid to the bidder is unknown to the researcher; only the value of such bid to the market is known.*

   When a bidder's value of a bid is unknown, the consequence is a potentially large bias in recovering boundaries of valuations for all bidders, especially if such bidder wins. If the bidder makes a bid of $X in cash, it is unambiguous that her valuation of the target must be above $X. However, if the bidder makes a bid of $X (market value) in the bidder's stock, then it is unclear whether her actual valuation of the target is bounded from below by $X or not. For example, if the bidder believes that her stock is overpriced or contains the probability of future acquisition (for repeat acquirers), then her actual valuation of the bid is likely to be below the market value of $X.[43]

   Suppose first a stock bidder wins an auction. Then, a bias in the lower boundary of the winner's valuation is introduced. Critically, this bias immediately affects the upper boundaries of all the losing bidders who should have had their valuations bounded from above by the actual value of the winning bid to the winner. As a result, intervals of valuations of all auction participants are likely to be biased. For losing stock bidders in such an auction, Problem 2. can further magnify the bias.

   Next, suppose a cash bidder wins an auction. Then, there is no bias in the lower boundary on the winner's valuation and, as a result, in the upper boundaries of valuations of other auction participants. While losing stock bidders are still likely to have bias in the lower boundaries of their valuations, it is empirically negligible, because the number of losing stock bids in such

[43] In fact, bids in stock are likely more common when the bidder believes that her stock is overpriced.

auctions is small. For these bidders, we employ a conservative estimate for their valuations: we assume that their valuations are above the target's current value. However, we find that our results are robust to changes in this assumption.

2. *The cash value of a stock bid to the target is unknown to the researcher (and can be different from the value both to the market and to the bidder).*

   This problem is related to the first one but conceptually is even more challenging: it makes the ordering of stock bids ambiguous. For example, if bidder A offers a bid of $X (market value) in bidder A's equity, and bidder B offers a bid of $Y>$X (market value) in bidder B's equity, it can be the case that the target accepts a bid of bidder A because of her private belief that stock of bidder A is valued more.

   As a result, the implication that the winning bidder has the highest valuation is reasonable for auctions completed in cash (and supported by Revlon Duty in practice) but may not hold for auctions completed in stock. Approximately 10-15% of targets in takeover auctions completed in stock agree to a bid with lower market value than a competing stock bid. Using our three robust assumptions and without imposing extra controversial ones, it is impossible to reliably recover valuations in this subsample of auctions.

Though beyond the scope of this paper, modeling and estimation of auctions with non-cash bids using available data is an interesting and challenging direction of future research.

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Table I. Descriptive statistics of bidder participation in all auctions, auctions won by strategic and auctions won by financial bidders, and across industries

The table shows descriptive statistics (mean, standard deviation, and median) of bidder participation for auctions won by different types of bidders and across 11 industries, as classified by Fama and French (1997). *Number* is the number of auctions; *Potential* bidders are those who signed confidentiality agreements; *Unknown* bidders are those for whom the information about their type is not provided in deal backgrounds. The winning bid is in units of target's value under the current management.

	Stat.	Number	Potential	Strategic	Financial	Unknown	Winning Bid
All Auctions	mean	349	12.507	2.269	3.453	6.785	1.425
	s.d.		(15.493)	(2.910)	(8.236)	(12.574)	(0.323)
	med.		6.000	1.000	1.000	1.000	1.339
Won by S	mean	211	9.886	2.706	1.370	5.810	1.464
	s.d.		(12.637)	(2.486)	(4.154)	(11.251)	(0.324)
	med.		5.000	2.000	0.000	1.000	1.380
Won by F	mean	138	16.514	1.601	6.638	8.275	1.365
	s.d.		(18.390)	(3.360)	(11.356)	(14.279)	(0.315)
	med.		9.000	1.000	2.000	1.000	1.306
Consumer Nondurables	mean	13	17.154	1.000	9.308	6.846	1.492
	s.d.		(17.573)	(0.707)	(17.895)	(6.926)	(0.593)
Consumer Durables	mean	4	18.250	4.000	7.000	7.250	1.415
	s.d.		(16.520)	(1.633)	(9.695)	(13.200)	(0.650)
Manufacturing	mean	25	29.360	3.480	7.120	18.760	1.308
	s.d.		(26.372)	(5.636)	(15.584)	(21.495)	(0.251)
Oil, Gas, and Coal	mean	7	16.286	0.714	0.857	14.714	1.398
	s.d.		(13.376)	(0.756)	(0.900)	(12.932)	(0.296)
Chemicals etc.	mean	9	11.111	3.778	4.778	2.556	1.361
	s.d.		(23.235)	(5.848)	(11.777)	(5.897)	(0.198)
Business Equipment	mean	138	9.616	2.297	1.891	5.428	1.434
	s.d.		(11.708)	(2.297)	(4.131)	(10.614)	(0.320)
Telephone & Television	mean	10	10.400	2.000	0.500	7.900	1.348
	s.d.		(8.897)	(1.826)	(0.972)	(9.386)	(0.154)
Utilities	mean	2	21.000	8.500	12.500	0.000	1.122
	s.d.		(24.042)	(7.778)	(16.263)	(0.000)	(0.146)
Wholesale, Retail	mean	47	17.574	1.213	6.468	9.894	1.400
	s.d.		(18.838)	(2.021)	(9.915)	(17.328)	(0.297)
Healthcare, Medical etc.	mean	48	6.479	2.646	1.396	2.438	1.418
	s.d.		(6.823)	(2.771)	(3.780)	(4.617)	(0.270)
Other	mean	46	11.109	2.152	3.630	5.326	1.524
	s.d.		(11.861)	(2.521)	(7.628)	(10.009)	(0.354)

Table II. Descriptive statistics of target characteristics in all auctions, auctions won by strategic and auctions won by financial bidders, and across industries

The table shows descriptive statistics (mean, standard deviation, and median) of target characteristics for auctions won by different types of bidders and across 11 industries, as classified by Fama and French (1997). *Size* is equal to book value (in $ millions); *Leverage* is the ratio of book value of debt to the sum of market value of equity and book value of debt; *q-ratio* is the ratio of the sum of market value of equity and book value of debt to book value of the target; *Cash Flow* is the sum of last 4 quarterly cash flows; *Cash* is the sum of cash, short-term investments and marketable securities. *Cash Flow, Cash, R&D, and Intangibles* are normalized by target size.

	Stat.	Size	Leverage	q-ratio	Cash Flow	Cash	R&D	Intangibles
All Auctions	mean	654.3	0.148	1.498	0.008	0.260	0.017	0.149
	s.d.	(2327.4)	(0.211)	(1.139)	(0.270)	(0.242)	(0.031)	(0.189)
	med.	164.4	0.040	1.233	0.070	0.194	0.000	0.059
Won by S	mean	318.4	0.101	1.703	-0.029	0.324	0.025	0.146
	s.d.	(786.7)	(0.177)	(1.295)	(0.329)	(0.243)	(0.037)	(0.178)
	med.	128.6	0.010	1.356	0.058	0.305	0.015	0.073
Won by F	mean	1167.8	0.220	1.184	0.064	0.161	0.005	0.154
	s.d.	(3517.3)	(0.238)	(0.749)	(0.119)	(0.203)	(0.012)	(0.206)
	med.	258.9	0.129	1.000	0.082	0.078	0.000	0.047
Consumer Nondurables	mean	476.1	0.219	1.161	0.067	0.114	0.000	0.155
	s.d.	(821.7)	(0.259)	(0.579)	(0.051)	(0.087)	(0.000)	(0.207)
Consumer Durables	mean	289.7	0.283	1.253	0.089	0.118	0.009	0.060
	s.d.	(238.4)	(0.318)	(0.476)	(0.125)	(0.208)	(0.017)	(0.070)
Manufacturing	mean	362.5	0.190	1.219	0.105	0.085	0.004	0.105
	s.d.	(577.5)	(0.187)	(0.408)	(0.075)	(0.091)	(0.008)	(0.156)
Oil, Gas, and Coal	mean	211.1	0.268	1.431	0.143	0.030	0.001	0.039
	s.d.	(189.5)	(0.261)	(0.639)	(0.103)	(0.027)	(0.001)	(0.103)
Chemicals etc.	mean	1390.8	0.183	1.410	0.072	0.149	0.005	0.118
	s.d.	(3421.1)	(0.230)	(0.521)	(0.097)	(0.208)	(0.005)	(0.128)
Business Equipment	mean	516.9	0.058	1.519	-0.050	0.399	0.032	0.183
	s.d.	(2812.2)	(0.114)	(1.005)	(0.356)	(0.228)	(0.039)	(0.193)
Telephone & Television	mean	2021.9	0.207	1.338	0.109	0.234	0.004	0.248
	s.d.	(5476.8)	(0.229)	(0.543)	(0.071)	(0.187)	(0.007)	(0.248)
Utilities	mean	2971.5	0.162	0.748	0.062	0.028	0.000	0.017
	s.d.	(2556.0)	(0.229)	(0.035)	(0.040)	(0.015)	(0.000)	(0.024)
Wholesale, Retail	mean	771.8	0.222	1.082	0.068	0.080	0.000	0.084
	s.d.	(1501.1)	(0.261)	(0.613)	(0.105)	(0.077)	(0.000)	(0.130)
Healthcare, Medical etc.	mean	417.1	0.137	2.530	-0.028	0.312	0.026	0.173
	s.d.	(500.6)	(0.216)	(1.965)	(0.235)	(0.260)	(0.034)	(0.218)
Other	mean	959.7	0.260	1.143	0.025	0.190	0.002	0.126
	s.d.	(2359.3)	(0.252)	(0.795)	(0.267)	(0.229)	(0.007)	(0.198)

Table III. Descriptive statistics of formal and informal bids by strategic, financial and unknown types of bidders (per auction)

The table shows descriptive statistics (mean and standard deviation) of formal and informal bids by strategic, financial and unknown types of bidders per auction. The size of formal bid is in units of target's value under the current management.

	Total Number	Per Auction	Informal Bids	Formal Bids	Size of Formal Bid
Strategic	792	2.269	1.330	0.736	1.456
		(2.910)	(1.261)	(0.643)	(0.332)
Financial	1205	3.453	1.295	0.533	1.344
		(8.236)	(2.020)	(0.701)	(0.319)
Unknown	2368	6.785	1.370	0.095	1.461
		(12.574)	(2.839)	(0.401)	(0.294)
Total	4365	12.507	3.994	1.364	1.413
		(15.493)	(3.255)	(0.688)	(0.328)

Table IV. Determinants of the identities of unobserved bidder types.

The table shows the estimation results of the Logit model $\mathbb{P}(t = s|Z)$, used to recover the probabilities of losing bidders with unobservable type to be strategic. The model is outlined in detail in Section II.C, and the results are discussed in Section IV.A. In the first specification, Z contains observable target characteristics, characteristics of the economy, and auction outcomes. In the second specification, Z is updated with industry fixed effects following the five-industry classification by Fama and French (1997). The sample size (the total number of losing bidders with observable types) is 1648. Bold font denotes 5% significance.

	Baseline model	With industry f.e.
Const	**3.932**	–
	(0.751)	–
log(Size)	-0.075	-0.052
	(0.047)	(0.049)
q-ratio	0.139	0.100
	(0.095)	(0.104)
Leverage	**-1.393**	**-1.337**
	(0.375)	(0.395)
Cash flow	**-1.953**	**-2.351**
	(0.596)	(0.666)
Cash	0.197	0.134
	(0.416)	(0.511)
Intangibles	**-7.451**	**-10.231**
	(2.124)	(2.313)
R&D	**-0.680**	**-1.065**
	(0.310)	(0.387)
Market Return	**-2.502**	**-2.024**
	(0.830)	(0.889)
Credit Spread	-29.041	-31.949
	(16.112)	(17.262)
log(# bidders)	**-0.650**	**-0.674**
	(0.067)	(0.075)
Won by F dummy	**-1.082**	**-0.918**
	(0.131)	(0.137)
Winning bid	-0.385	0.073
	(0.227)	(0.251)

Table V: Results of estimation of the valuations model, Models I–III, and OLS on takeover premiums.

The table shows the estimation results for the determinants of valuations of strategic and financial bidders. Model I is the basic comparison of means and standard deviations of valuations. Model II (the baseline model) studies valuation determinants in detail using the incomplete model of English auctions. Model III expands the baseline model to include industry factors (industry dummies following five-industry classification by Fama and French (1997) and industry concentration). Model II is compared to a simple linear OLS regression of scaled winning bids on characteristics of the target and the economy (which, under the assumption that bidders bid their true valuations, can also be interpreted as the regression that studies average valuations). Bold font denotes 5% significance.

	Model I			Model II			Model III			OLS on winning bids		
	Strategic	Financial	Diff.	Strategic	Financial	Diff.	Strategic	Financial	Diff.	Strategic	Financial	Diff.
St. Dev. of PV	**0.275**	**0.166**	**0.109**	**0.258**	**0.153**	**0.105**	**0.238**	**0.152**	**0.086**	0.295	0.279	0.016
	(0.009)	(0.002)	(0.009)	(0.009)	(0.003)	(0.010)	(0.008)	(0.002)	(0.009)	–	–	–
Const	**0.113**	**0.043**	**0.070**	0.106	**0.142**	-0.036	–	–	–	**0.879**	**0.772**	0.107
	(0.014)	(0.007)	(0.016)	(0.072)	(0.023)	(0.077)	–	–	–	(0.155)	(0.208)	(0.259)
log(Size)	–	–	–	**-0.028**	0.000	**-0.028**	**-0.033**	-0.006	**-0.027**	**-0.055**	**-0.034**	-0.021
	–	–	–	(0.007)	(0.003)	(0.008)	(0.007)	(0.003)	(0.008)	(0.019)	(0.017)	(0.026)
Leverage	–	–	–	**0.483**	**0.195**	0.288	**0.354**	**0.189**	0.165	0.280	-0.119	0.399
	–	–	–	(0.161)	(0.063)	(0.177)	(0.155)	(0.066)	(0.173)	(0.378)	(0.314)	(0.493)
Leverage^2	–	–	–	**-0.584**	**-0.212**	-0.372	**-0.439**	**-0.248**	-0.191	-0.568	0.672	-1.240
	–	–	–	(0.221)	(0.077)	(0.238)	(0.219)	(0.081)	(0.239)	(0.550)	(0.399)	(0.680)
q-ratio	–	–	–	0.001	0.003	-0.002	-0.006	-0.004	-0.002	**-0.058**	-0.018	-0.040
	–	–	–	(0.010)	(0.008)	(0.013)	(0.009)	(0.008)	(0.013)	(0.017)	(0.038)	(0.042)
Cash Flow	–	–	–	**-0.063**	**-0.380**	**0.317**	-0.037	**-0.340**	**0.304**	-0.018	-0.374	0.356
	–	–	–	(0.028)	(0.052)	(0.060)	(0.027)	(0.054)	(0.061)	(0.072)	(0.254)	(0.264)
Cash	–	–	–	**0.154**	0.058	0.096	0.072	-0.022	0.093	0.028	-0.155	0.184
	–	–	–	(0.054)	(0.035)	(0.067)	(0.057)	(0.038)	(0.070)	(0.112)	(0.154)	(0.191)
R&D	–	–	–	**1.593**	-0.037	**1.630**	**1.562**	-0.072	**1.634**	-0.016	-0.157	0.141
	–	–	–	(0.332)	(0.481)	(0.601)	(0.318)	(0.498)	(0.607)	(0.128)	(0.128)	(0.181)
Intangibles	–	–	–	0.028	**-0.093**	**0.121**	-0.039	**-0.155**	0.116	0.771	-0.812	1.583
	–	–	–	(0.054)	(0.025)	(0.061)	(0.055)	(0.029)	(0.064)	(0.640)	(2.390)	(2.475)
Market Return	–	–	–	-0.010	**-0.250**	0.241	-0.014	**-0.168**	0.153	**-0.622**	**-0.662**	0.041
	–	–	–	(0.115)	(0.045)	(0.126)	(0.107)	(0.047)	(0.120)	(0.223)	(0.283)	(0.361)
Credit Spread	–	–	–	2.308	**-2.446**	**4.754**	3.144	**-3.348**	**6.492**	-1.891	-5.182	3.291
	–	–	–	(2.102)	(0.744)	(2.275)	(1.962)	(0.930)	(2.217)	(4.250)	(6.272)	(7.576)

Table VI. Average valuations of strategic and financial bidders when target characteristics change

The table shows average valuations of strategic and financial bidders (restored according to Model II) when target characteristics change (calculated for 10% and 90% sample quantiles of each target characteristic, keeping the rest of characteristics fixed at their average values). The corresponding average valuations in an auction for the average target are 1.191 and 1.118.

	Strategic, 10%	Strategic, 90%	Financial, 10%	Financial, 90%
log(Size)	1.253	1.129	1.118	1.119
Leverage	1.123	1.239	1.092	1.142
q-ratio	1.190	1.193	1.115	1.122
Cash Flow	1.207	1.180	1.213	1.057
Cash	1.147	1.261	1.102	1.143
R&D	1.160	1.254	1.119	1.117
Intangibles	1.186	1.201	1.134	1.089
Market Return	1.194	1.190	1.178	1.078
Credit Spread	1.175	1.219	1.135	1.091

Table VII. Simulated economy, 100x original sample, at estimated valuation parameters

The table shows the descriptive statistics (mean, standard deviation, and median) of composition of competition, as well as bounds on the outcome of takeover auctions in a simulated economy, in which bidders value targets according to Model II, Table V. Each target in the sample is replicated 100 times; for each replication, a different set of bidder valuations is simulated.

	Stat.	Number	Potential bidders	Strategic	Financial	Winning LB	Winning UB
All Auctions	mean	34900	12.507	4.619	7.888	1.302	1.524
	s.d.		(15.471)	(4.524)	(12.978)	(0.235)	(0.316)
	med.		6.000	3.000	3.000	1.283	1.477
Won by S	mean	24987	11.724	5.391	6.333	1.329	1.591
	s.d.		(15.204)	(4.655)	(12.028)	(0.250)	(0.330)
	med.		5.000	4.000	1.000	1.313	1.551
Won by F	mean	9913	14.481	2.675	11.806	1.235	1.355
	s.d.		(15.956)	(3.486)	(14.385)	(0.176)	(0.192)
	med.		8.000	1.000	5.000	1.226	1.342

Table VIII: Results of estimation of the valuations model, Models IV–VI (robustness checks)

The table provides robustness checks of estimation results for the baseline model (Model II). Model IV relaxes Assumption 2, so that the upper bound on valuations from losing formal bids is equal to 105% of target's value under the current management. Model V relaxes Assumption 3, so that the lower bound on valuations from informal bids is equal to 90% of target's value under the current management. Model VI checks robustness of model predictions to potential presence of fat tails in the distribution of unobservable private valuations (by assuming that they come from t-distribution with 5 degrees of freedom). Bold font denotes 5% significance.

	Model IV			Model V			Model VI		
	Strategic	Financial	Diff.	Strategic	Financial	Diff.	Strategic	Financial	Diff.
St. Dev. of PV	**0.252**	**0.159**	**0.093**	**0.272**	**0.167**	**0.105**	**0.245**	**0.112**	**0.133**
	(0.009)	(0.004)	(0.011)	(0.010)	(0.004)	(0.011)	(0.009)	(0.004)	(0.010)
Const	0.128	**0.169**	-0.041	0.073	**0.117**	-0.044	0.073	**0.097**	-0.023
	(0.075)	(0.034)	(0.084)	(0.078)	(0.043)	(0.091)	(0.064)	(0.037)	(0.077)
log(BV)	**-0.027**	0.000	**-0.027**	**-0.028**	0.001	**-0.029**	**-0.018**	0.001	**-0.019**
	(0.007)	(0.004)	(0.009)	(0.008)	(0.004)	(0.009)	(0.007)	(0.003)	(0.008)
Leverage	**0.470**	**0.204**	0.265	**0.490**	**0.197**	0.292	**0.333**	**0.429**	-0.097
	(0.165)	(0.072)	(0.183)	(0.172)	(0.070)	(0.190)	(0.151)	(0.056)	(0.166)
Leverage^2	**-0.563**	**-0.221**	-0.343	**-0.572**	**-0.213**	-0.359	**-0.345**	**-0.670**	0.325
	(0.229)	(0.088)	(0.248)	(0.239)	(0.085)	(0.257)	(0.211)	(0.075)	(0.230)
q-ratio	-0.001	0.003	-0.005	0.002	0.004	-0.002	0.004	0.002	0.002
	(0.010)	(0.009)	(0.014)	(0.010)	(0.009)	(0.014)	(0.008)	(0.007)	(0.011)
Cash Flow	**-0.070**	**-0.394**	**0.325**	**-0.068**	**-0.397**	**0.329**	**-0.081**	**-0.362**	**0.281**
	(0.028)	(0.060)	(0.067)	(0.030)	(0.059)	(0.067)	(0.029)	(0.044)	(0.053)
Cash	**0.146**	0.059	0.087	**0.157**	0.061	0.095	**0.112**	**0.082**	0.030
	(0.055)	(0.040)	(0.071)	(0.057)	(0.040)	(0.072)	(0.049)	(0.031)	(0.061)
R&D	**1.621**	-0.033	**1.654**	**1.673**	-0.084	**1.757**	**1.489**	0.114	**1.375**
	(0.339)	(0.559)	(0.670)	(0.350)	(0.543)	(0.662)	(0.287)	(0.429)	(0.531)
Intangibles	0.027	**-0.105**	**0.133**	0.034	**-0.102**	**0.136**	0.007	**-0.092**	0.099
	(0.055)	(0.029)	(0.064)	(0.058)	(0.029)	(0.066)	(0.049)	(0.023)	(0.057)
Market Return	-0.028	**-0.276**	0.248	-0.011	**-0.269**	0.258	0.028	-0.079	0.107
	(0.117)	(0.055)	(0.132)	(0.122)	(0.059)	(0.138)	(0.105)	(0.046)	(0.119)
Credit Spread	2.192	**-3.327**	**5.519**	2.533	**-2.944**	**5.477**	2.213	-1.274	3.487
	(2.142)	(0.736)	(2.288)	(2.231)	(1.147)	(2.570)	(1.885)	(1.073)	(2.268)

Table IX. Results of estimation of the simulated model with stochastic jump bids, incomplete model of English auctions vs. linear OLS model vs. "button" model

S and F columns correspond to true and estimated parameters (with standard errors) of strategic and financial bidders. σ_t is the variance of private components; $\beta_{t,1}$ and $\beta_{t,2}$ are sensitivities of type $t \in \{s, f\}$ to the two observable target characteristics. Bold font denotes estimates for which the true parameter lies within 95% confidence bounds.

Panel A: $N \in [2, 8]$, $X_2 \sim N(0, 0.4^2)$.

	True		Incomplete model		"Button" model		Linear model	
t	S	F	S	F	S	F	S	F
σ_t	0.25	0.15	**0.308**	**0.164**	0.181	**0.141**	0.106	0.103
			(0.031)	(0.008)	(0.023)	(0.010)	(0.012)	(0.006)
$\beta_{t,1}$	0.1	0.1	**0.077**	**0.112**	0.157	0.141	0.229	0.199
			(0.022)	(0.008)	(0.020)	(0.009)	(0.013)	(0.012)
$\beta_{t,2}$	0.1	0.5	**0.094**	**0.546**	**0.152**	0.436	0.272	0.386
			(0.061)	(0.026)	(0.050)	(0.023)	(0.041)	(0.031)

Panel B: $N \in [2, 4]$, $X_2 \sim N(0, 0.4^2)$.

	True		Incomplete model		"Button" model		Linear model	
t	S	F	S	F	S	F	S	F
σ_t	0.25	0.15	**0.244**	**0.167**	0.144	0.123	0.087	0.100
			(0.029)	(0.011)	(0.020)	(0.009)	(0.010)	(0.008)
$\beta_{t,1}$	0.1	0.1	**0.129**	0.121	0.168	0.162	0.195	0.140
			(0.023)	(0.010)	(0.017)	(0.008)	(0.013)	(0.011)
$\beta_{t,2}$	0.1	0.5	**0.033**	**0.452**	**0.036**	0.353	0.201	0.303
			(0.056)	(0.032)	(0.053)	(0.021)	(0.031)	(0.028)

Panel C: $N \in [2, 8]$, $X_2 \sim N(0, 1.2^2)$.

	True		Incomplete model		"Button" model		Linear model	
t	S	F	S	F	S	F	S	F
σ_t	0.25	0.15	**0.318**	**0.139**	0.138	0.183	0.087	**0.150**
			(0.035)	(0.006)	(0.017)	(0.013)	(0.011)	(0.008)
$\beta_{t,1}$	0.1	0.1	**0.127**	0.124	0.177	0.151	0.221	0.188
			(0.023)	(0.009)	(0.014)	(0.017)	(0.014)	(0.028)
$\beta_{t,2}$	0.1	0.5	**0.111**	0.528	0.064	0.471	**0.106**	**0.465**
			(0.022)	(0.010)	(0.017)	(0.014)	(0.013)	(0.024)