Erasmus University Rotterdam

Signalling and the Hold-up Problem in Takeover Auctions

On value signalling, due diligence and renegotiating

Erasmus School of Economics
Economics Department
MSc Economics of Markets, Organisations & Policy

July 2010
Rotterdam, the Netherlands

Name	Frederik R. de Pont
Student Number	279189
Email	279189fp@eur.nl
Supervisor	Dr. V. Karamychev *Economics Department*
Second Reader	Prof. Dr. R. Dur *Economics Department*

Abstract

This study sets out with the intention to demonstrate the importance of post-bid due diligence and renegotiation in the light of resolving a potential hold-up problem in takeover auctions. We develop and analyze a formal model in which we demonstrate that a hold-up problem would appear if a takeover auction ended after final bids were submitted. This hold-up problem appears because the bidders are not willing to analyze and interpret the information given to them by the seller ex-ante, worried that the seller overstates this information. This results in a lower outcome ex-post. We argue that the extension of a takeover auction with a post-bid due diligence and renegotiation stage reduces, but not completely resolves, this hold-up problem as it effectively reduces the incentive of the seller to overstate information[1].

[1] I thank Vladimir Karamychev for his valuable support and advice during the concept and writing stages of my thesis. I also thank Robert Dur for his efforts as second reader.

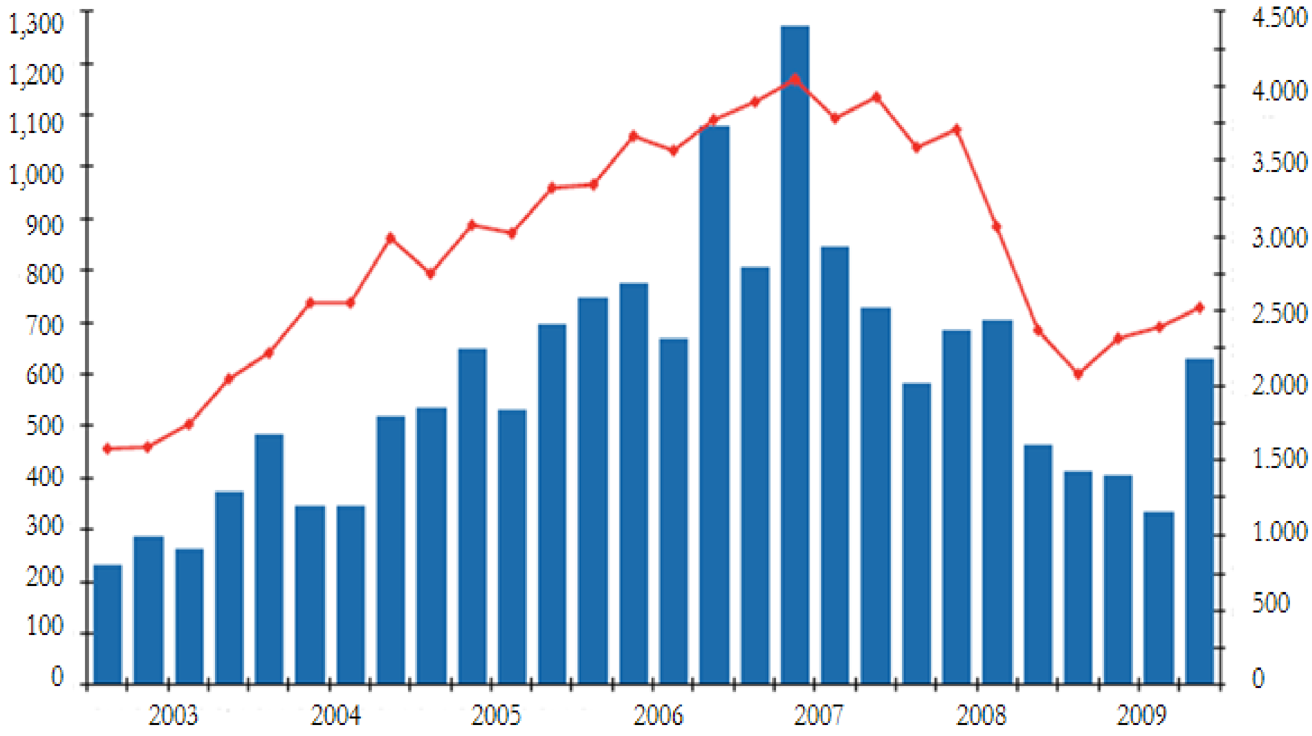
Table of Content

'The art of due diligence is being lost. Buyers aren't analyzing the operations and books of prospective acquisitions with nearly enough vigor'. (Fortune Magazine, 3 September 2001)

1 Introduction

Corporate takeovers have occupied the attention of scholars for over several decades. Ever since Manne (1965) introduced the 'market for corporate control', a growing body of literature was dedicated to topics within this field such as merger waves, gains from takeovers, sales mechanisms and antitrust policies (Grossman and Hart, 1981; Jensen and Ruback, 1983; Betton and Eckbo, 2008). This substantial amount of attention can be explained by two factors. First, strong historic and current growth rates[2] of both value and volume in the global mergers and acquisitions, hereinafter called M&A, market (see table 1) provide a strong need to understand the dynamics and behaviour in this field. Second, the decision to acquire another firm probably belongs to one of the largest and most complex investment decisions that firms can possibly engage in, with many important management actions to be taken and therefore provides a rich and interesting fundament for research.

Illustration 1 - Global M&A Activity



Source: mergermarket press release

[2] Except for 2008 and 2009. Reason for this dip is the recent credit crisis, which completely locked the market for corporate loans, and thereby locked the M&A market which is highly dependent on these loans.

In this paper, we focus on the process of takeover auctions, examine information issues present in such auctions and suggest the existence of a hold-up problem. Despite the significant number of fields in which the body of M&A literature has developed, hold-up problems in this context have not extensively been discussed, leaving an area open to explore. To that end, this paper relates to the literature on the use of auctions and the existence of a hold-up problem in an M&A setting.

A takeover auction is, next to a negotiation format, a dominant sales mechanism to accomplish a takeover transaction. Both provide an efficient price formation process (McAfee & McMillan, 1987), the auction through competition and the negotiation based on bargaining. We have chosen an auction process as instrumental framework for this paper because its competitive structure to allocate an object to competing bidders provides excellent features for game-theoretical analysis and the highly transparent and objective process of an auction, with a relatively standardized structure, enhances the applicability and transferability of its results to similar situations in a different context. Negotiations, on the other hand, are characterized by a loose structure and high degree of subjectivity which yields results that are more bound to a specific situation and thus less transferable to other situations.

Comparing the result of auctions and negotiations, some scholars (Bulow and Klemperer, 1996) claim that the competition element of an auction is more valuable than bargaining skills in a negotiation setting[3]. However, most authors (French and McCormick, 1984; Cramton et al., 1991; Boone and Mulherin, 2007) agree that the prosperity of using either mechanism depends strongly on contextual aspects, such as the sensitivity of information, the valuation distribution over the bidding group and the preferences of the seller.

The process of a takeover auction, as discussed in section II, is characterized by several dynamics which seem to be somewhat peculiar and lead one to wonder about the reason for their existence. Most importantly, why does the seller limit information provision to the bidders and why is the winning bidder allowed to perform an independent research to verify the value of the firm, hereinafter called post-bid due diligence, and renegotiate the bidding price even after final bids have been submitted?

This paper provides arguments to explain these peculiar dynamics and contributes by giving greater insight in the role of post-bid due diligence and renegotiating in the takeover auction process. We develop a formal game-theoretical model, existing of a basic and extended variant,

[3] The analysis of Bulow and Klemperer (1996) relies, however, heavily on certain assumptions, including the fact that signals of the bidders in an auction have to be independent and bidders have no bargaining power in a negotiation setting, which lack some realism and can be considered highly theoretical.

in which we, using certain assumptions, simulate a takeover auction process. By analyzing this model we first show that in the basic variant of the model a hold-up problem could appear and second, that the post-bid due diligence and renegotiation stage, added in the extended variant of the model, effectively reduces, but cannot completely resolve, this hold-up problem. The intuition behind these results is that bidders lack trust in the information provision of the seller and are not willing to exert any efforts *ex-ante*, which reduces the payoffs of the seller *ex-post* and results in a hold-up problem. Post-bid due diligence and renegotiation allow the winner of the auction to verify the information provided by the seller and renegotiate the final price if new information is detected, which restores trust between seller and bidders. This intuition is illustrated in detail in section III. We also find that the cost of due diligence plays an important role in determining equilibrium situations but unexpectedly, costless due diligence is effective in achieving honest value revelation of the seller but does not have to be used at all times to achieve this.

The remainder of the paper is structured as followed. In section II we focus further attention on the auction as sales mechanism and establish the link between takeover auctions and standard auction theory. In section III we provide arguments for the existence of a hold-up problem in takeover auctions and make predictions about the solution to this hold-up problem. These predictions are theoretically tested in section IV and V in a formal game-theoretical model. Finally, we discuss the results leading from this formal model in section VI and we close with a short conclusion in section VII.

2 Takeover Auctions and Auction Theory

Auction theory describes four standard auctions concepts (Milgrom and Weber, 1982):

I. The 'English' or open ascending price auction in which the price is successfully raised until one bidder remains.
II. The 'Dutch' or open descending price auction which starts off with a high price and descends until a bidder accepts the price or a predetermined reserve price is reached.
III. The first-price sealed-bid auction where all bidders submit their bids, the highest bidder wins the auction and pays the price equal to his bid. This is similar to the English auction but crucial here is that bidders cannot observe each other's bid.
IV. The second-price sealed-bid or 'Vickrey' auction. This auction is similar to the first-price sealed-bid auction, except that the winner pays the price of the second-highest bidder.

These standard auctions are subject to either one of three types of value models (Milgrom and Weber, 1982):

I. The independent private value model in which each bidder knows his valuation of the object and this valuation is private information to the bidder. The bidder will not change his valuation by observing the bids of others and is 'independent' of the other bidders.
II. The common value model in which the actual value of the object is to same to every bidder. The bidders can learn more about the value of the firm through private signals from the seller but also by observing the bids of the other bidders.
III. The interdependent value model, in which each bidder has a private valuation of the object at auction alike the independent private value model but makes a part of his valuation dependent on the value signals of the other bidders alike the common value model.

There are many variations of these standard classes of auctions. The takeover auction is one of these variations and falls in the group of multi-stage auctions[4], with the distinctive feature that multiple rounds of bidding are organized to come to a final bid. Below, we will describe the typical takeover auction process in detail which is meant as framework to develop our intuition in section III and develop our formal model in section IV and V. Important to note is that in this paper, we only consider the auctioning of private firms which has important consequences for the availability of information regarding the value of the firm to the bidders. Where publicly listed firms have a duty to provide investors with the relevant information to value its stocks, privately owned firms have less or even none of such commitments making relevant public information scarcer. This feature will play an important role in our paper.

2.1 Process of takeover auctions

The following description of a typical takeover auction is based on several other papers (Sarkar et al., 2007; Hansen, 2001) and practical sources (Inside media, 2009; KPMG, 2009; Bencis Capital Partners, 2010) and explains how a firm is sold through an auction in practice.

After signing a confidentiality statement, the auctioneer invites a number of interested bidders including competitors, suppliers, customers, strategic buyers and financial buyers to participate in the auction. These bidders receive basic information regarding the status of the firm in the form of an information memorandum. This includes financial, strategic and operational information and contains both historic and forward looking data and includes, amongst other information, market trends, information about production, employment and facilities. Based on this information, bidders must submit a preliminary non-binding indicative bid in which they state a first approximation of their expected bidding price and their rationale for acquiring the business.

[4] See Cassady (1967) and Engelbrecht-Wiggans (1988) for more information about multi-stage auctions.

The seller will then invite only the bidders with the highest bids to proceed to the formal bidding round. The rationale for this is twofold. First, by limiting the number of bidders, the seller sets a reserve price, ensuring that only the bidders with the highest *ex-ante* valuations remain in the auction thereby maximizing the sales price (Hansen, 2001). Second, fewer bidders in an auction decrease the coordination costs which in turn increases the seller's welfare (Levin and Smith, 1994). Coordination costs arise because the seller has to exert efforts to manage the relationship with each single bidder and fewer bidders therefore decrease these coordination costs.

In the formal bidding round, selected bidders are given access to more detailed information, which is gathered in a data room[5], and can conduct management meetings. The information in the data room is more extensive than the information memorandum and involves in-depth information about costs, risks and opportunities of the firm as well as detailed historic and forward looking financial information. During management meetings, the bidders can interview management on its views and expectations concerning the business. Analyzing the information in the formal bidding round is an intense and costly process for bidders as expert advisors have to be hired to flag possible issues arising from the data, which are extremely important for the assumptions made regarding the valuation of the business. Based on these assumptions, the remaining bidders submit a formal bid, which is conditional on post-bid due diligence, and the bidder with the highest bid is chosen as winner of the auction.

After the formal bidding round ended, the winning bidder gets an exclusivity period in which the seller cannot engage in any transactional activities with other potential buyers. In this period the winning bidder has the right to perform due diligence to get a full and independent view of the value of the firm and validate his assumptions made to underline his bid. Based on the outcomes of this due diligence, the winning bidder can renegotiate with the seller about the final price after which the auction ends.

3 Information issues and the hold-up problem

A takeover auction involves assets with extremely high value ranging from several millions to several billions of dollars[6] and so submitting a bid puts the bidder in an exposed position as a wrong valuation of the assets could have disastrous effects might he win the auction. The information received on which his bid is based therefore plays a crucial role. This information comes from the information memorandum, the data room as well as the conducted management meetings during the auction process.

[5] Data-room is a term used for a physical or virtual collection of data concerning the status of the business.

[6] The average transaction value between 2001-2009 was reported to be $188 million (Mergermarket report)

We have observed two remarkable dynamics associated to information in the described takeover auction process in section II. First, there is a large information asymmetry between the seller and bidders. The seller has full access to all relevant information regarding the status of the firm while the bidders are highly dependent on the information provided by the seller as it concerns a private firm. All information provided to the bidders is directed by the selling party who has an assumed incentive to maximize value. Second, to correctly determine the value of the firm, bidders have to exert costly efforts *ex-ante* to submit a bid based on the provided information which is both extensive and highly complex. These efforts are very deal-specific in the sense that they are only useful in evaluating the specific transaction (Hotchkiss et al., 2005).

If the auction process described in section III had ended after the highest bidder was appointed winner of the auction, we suggest that, similar to other models (Klein et al., 1978; Williamson, 1979; and Hotckiss et al., 2005), a hold-up problem would have arisen out of the combined presence of these two dynamics. The seller could have an incentive to behave opportunistic by abusing the large information asymmetry between him and the bidders by means of distorting or withholding valuable information to stimulate higher bids, thereby exploiting the *ex-ante* deal-specific efforts of the bidders. As a result, the bidders might not be willing to exert any deal-specific efforts *ex-ante*, worried that they will not be compensated for the surplus flowing from these efforts. Instead, they under-invest by ignoring the information provided and rely on their own beliefs about the value of the firm and thereby reduce the expected payoffs of the seller *ex-post*.

A supporting argument for the opportunistic behavior of the seller is given by Hansen (2001) who argues that some of the information which is needed by the bidders to form an accurate valuation of the firm is also valuable to parties such as competitors, suppliers or clients of the firm[7] and can therefore be considered highly sensitive. As such parties are usually part of the bidding group; releasing sensitive information could possibly harm the (future) value of the firm which poses a risk on the seller. Hansen quantifies this risk in the term 'competitive information cost', which indicates the negative relationship between the amount of information given out and the value of the firm to any one of the bidders. When competitive information cost rises, the seller finds it optimal to limit the flow of information towards the bidders. Furthermore, the bias of the seller could incline him to highlight positive aspects of the firm and downplay potential risks in formulating growth rates or defining the success rate of business opportunities (Heard and Perry, 2004). Although legally a seller is obliged to provide all relevant information to the

[7] Theoretically, a competitor could just pretend to be a serious bidder and participate in the auction with the sole goal of getting informed about the status of the target firm and receiving inside information about its business.

bidders so they can form a correct valuation, the seller could reduce the provision of sensitive information to a minimum and release full details only to the winning bidder.

To solve the proposed hold-up problem, the seller needs to convince the bidders that the information he signals reflects true value to induce them to exert the necessary deal-specific efforts *ex-ante*. Simply promising the bidders to reveal information honestly would be ineffective as, due to the information asymmetry between the seller and the bidders, any promise would be considered *'cheap talk'* since there is no way the bidders can verify the statement of the seller. Solutions should therefore be sought in more explicit practices.

The literature on contracting poses the design of an *ex-ante* explicit and binding contract as solution for the hold-up problem (Hart and Moore, 1988; Rogerson, 1992). In such a contract all actions of both the seller and bidders must be explicitly specified and be able to be verified by a third party. Although theoretically attractive, in practice the efforts of both the seller and bidders in a takeover auction are so extensive and dependent on specific circumstances that specifying them in advance would be unrealistic. Any attempt to writing such a contract would lead to an implicit and incomplete contract which would still lead to under-investment in *ex-ante* deal-specific efforts by the bidders and, as a result, not offer a solution to the hold-up problem (Hotchkiss et al., 2005).

In this paper, we suggest that the post-bid confirmatory due diligence and renegotiation stage is successful in reducing, but not resolving, the hold-up problem. We show that the winner of the auction will gain trust in the information signaling of the seller when he gets the option to independently validate the status of the firm and is able to detect any new or incongruent information and renegotiate the final bidding price if this new or incongruent information alters his valuation. This also reduces the incentive of the seller to overstate information and leads to a more efficient outcome *ex-post*.

4 The Basic Model

We develop a formal model in which a seller wants to auction a firm to a group of bidders. The model takes the form of a (Bayesian) sequential signalling model comparable to signalling models analyzed by Osborne (1994) and Cobb et al. (2009). Incomplete information and beliefs of the bidders play a key role in this model and the weak perfect Bayesian equilibrium concept, enabling us to find the solutions to the model, will make extensive use of these elements. This equilibrium concept occurs when the action of each player, given his beliefs and the strategies of all players in the future, are optimal in each information set. Furthermore, beliefs in each information set are formed using Bayes' rule where possible (Osborne, 2004).

As this model is a simplification of reality, it involves a number of assumptions including the following:

Assumption 1 *The auction takes the form of a second-price sealed bid auction, or 'Vickrey' auction*[8]*, with a common value model*[9] *and all information signals are public information.*

As a result of this assumption all bidders are symmetrically informed about the value of the firm prior to the auction and any informative signal from the seller will affect the valuation of each bidder equally. A general result from auction theory states that if one bidder's information is available to another bidder, his expected surplus from submitting a bid in equilibrium is zero (Engelbrecht-Wiggans, 1988; Persico, 2000). As all bidders are symmetrically informed, bids are equal in equilibrium and the winner of the auction is chosen randomly out of the group of bidders.

The basic model has two stages and has two groups of players: the seller and several bidders. All players are risk neutral and profits are expected to be maximized. Before the auction begins, nature distributes a value to the firm which is private information to the seller and so unknown to the bidders, but the probabilities regarding this distribution are common information. However, the value of the firm is different to the bidder than to the seller and regarding this we make the following assumption.

Assumption 2 *The seller has a need to sell the firm and therefore has a lower own valuation of the firm compared to actual value of the firm to the bidders. As his need to sell becomes greater, the seller's own valuation of the firm decreases.*

After the seller has become informed about the firm value, stage one of the auction commences. Here we skip a few steps compared to the practical auction process described previously[10] as stage one takes place after the number of bidders is limited through an indicative bidding round. The multi-stage auction as described in section II is thus modeled as an auction with a

[8] Description on page 6
[9] Description on page 7
[10] See page 7 and 8

single bidding round. Reason for this is that solving an auction model with multiple bidding rounds is extremely complex and often does not provide usable results.

In the first stage, the seller sends an information signal, which includes the information gathered in the data room and provided in management meetings, to inform the bidders about the value of the firm. In this information signal, the seller can either correctly describe the value of the firm or overstate[11] firm value to stimulate higher bids. The seller has this choice due to the large information asymmetry between him and the bidders as described in section III.

In the second stage of the auction, the bidders determine their strategy by forming their bid, based on their beliefs about the expected value of the firm. After the bids are submitted, the seller randomly chooses a winner and the auction ends.

4.1 Analysis of the basic model

4.1.1 Players

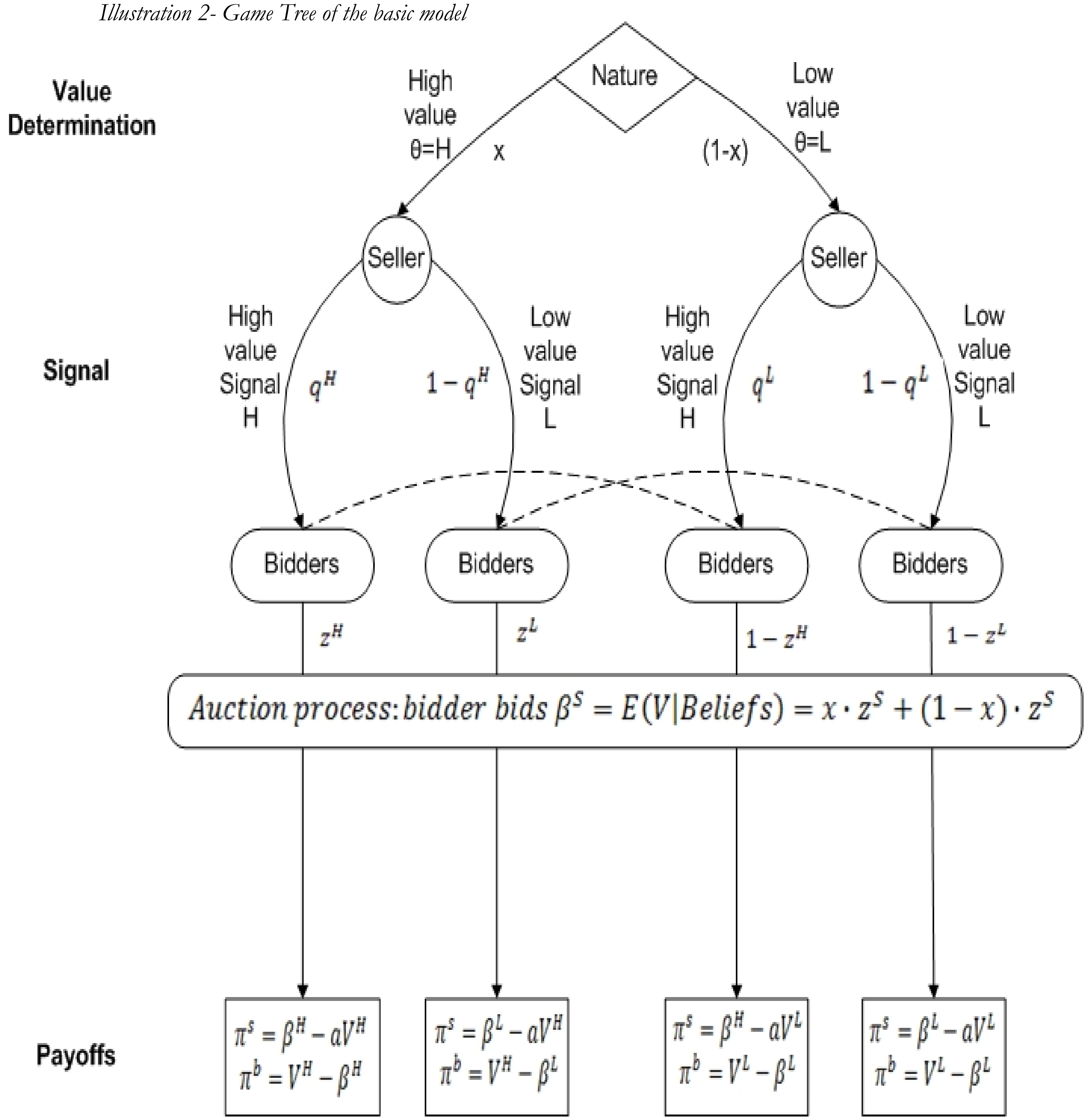
The players consist of a seller (s) and several bidders (b). The value of the firm is determined by nature and is given by $\theta \epsilon [H, L]$ where $H > L$. This value V^{θ} is distributed by probabilities $Pr(V^H) = x$ and $Pr(V^L) = (1 - x)$, where $x \epsilon [0,1]$, which is common knowledge to all players and forms the prior belief of the bidders. The value of the firm to the seller is indicated by $v_0 = \alpha V^{\theta}$, where $0 < \alpha < 1$ and describes the need of the seller to sell the firm. A more urgent need of the seller to sell the firm results in a lower α.

4.1.2 Strategies, beliefs and payoffs

The strategy of the seller consists of the different signals S he can send to the bidders about the value of the firm at auction. The signal can either indicate the firm is of high value or low value, given by $S \epsilon [H, L]$. These strategies are expressed by $q^H = Pr(S = H | \theta = H)$ and $q^L = (S = H | \theta = L)$. The strategy of each of the bidders is his bid, indicated by $\beta(S)$, which is determined using his belief system, based on the signal he receives from the seller. This belief system takes the form of $z^S = Pr(\theta | S)$. The bids will lead to payoff $\pi_s = \beta(S) - aV^{\theta}$ for the seller and $\pi_b = V^{\theta} - \beta(S)$ for the bidder. The model is visualized in a model tree, depicted in illustration 2.

[11] Overstatement can occur by limiting or distortion of information as described on page 9 through which the status of the firm seems more favourable than the actual value.

Illustration 2- Game Tree of the basic model



4.2 Solutions to the basic model

For the basic model, it is useful to determine two[12] equilibrium assessments in the following definition.

Definition 1 *An assessment* $(q^*(\theta), \beta^*(S))$ *is a pooling equilibrium if there is a single signal which is sent by both types of the sender with probability one so the bidders learn nothing from the signal.*
An assessment $(q^*(\theta), \beta^*(S))$ *is a separating equilibrium if both types of the sender send a different signal with probability one so that bidders can infer the private information of the seller completely by its signals (Osborne, 2004).*

The information signal of the seller allows the bidders to update their belief regarding the value of the firm as stated in the following theorem.

Theorem 1 *When having received a signal from the seller, the bidder updates his belief system using Bayes' Rule which can be depicted by*

$$z^S = Pr(\theta|S) = \frac{x \cdot q^S}{x \cdot q^S + (1-x) \cdot (1-q^S)}$$

Assumption 3 *The strategy of the bidder, consisting of the bidding price, can be determined by*

$$\beta(S) = E(\theta|Beliefs) = V^H \cdot z^S + V^L \cdot (1 - z^S)$$

In the following paragraphs we will discuss the two assessments given in definition 1 and pose proposition regarding a stable equilibrium. The proof of these propositions will involve the belief set of the bidder on which his strategy is based, using theorem 1 and assumption 3, and the optimal strategy of the seller, based on his payoffs.

4.2.1 Pooling Equilibrium

We consider the following assessment in which both types of the seller send a high value signal to the bidders:

$$q(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 1 & if\ \theta = L \end{cases}$$

Regarding the existence of a pooling equilibrium, we pose the following proposition:

[12] A third possibility, in the form of a semi-pooling equilibrium in which the seller mixes strategies depending on his type, will be extensively discussed in the main model in section V.

Proposition 1 *The basic model has a pooling weak perfect Bayesian equilibrium*[13]*. In this equilibrium the behavioural strategies* (q^*, β^*) *of the players can be described by*

(A)
$$q^*(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 1 & if\ \theta = L \end{cases}$$

(B)
$$\beta^*(S) = \begin{cases} \beta^H = V^H \cdot x + V^L \cdot (1-x) = E(V) & if\ S = H \\ \beta^L = V^H \cdot z^L + V^L \cdot (1-z^L) & if\ S = L \end{cases}$$

This equilibrium is supported by conditions

(a)
$$z^H = x\ and\ z^L \leq x$$

(b)
$$a < x$$

Payoffs of the seller and bidder in equilibrium are given by

(I) $\theta = H$

$$\pi_s = V^H \cdot x + V^L \cdot (1-x) - aV^H$$
$$\pi_b = V^H - V^H \cdot x + V^L \cdot (1-x)$$

(II) $\theta = L$

$$\pi_s = V^H \cdot x + V^L \cdot (1-x) - aV^L$$
$$\pi_b = V^L - V^H \cdot x + V^L \cdot (1-x)$$

Proof of proposition 1 Given the assessment, the beliefs of the bidder can be described by

$$z^H = \frac{x \cdot 1}{x \cdot 1 + (1-x) \cdot 1} = x$$

and

$$z^L \epsilon [0,1]$$

The bidder uses these beliefs to define his optimal strategy $\beta^*(S)$ given in proposition 1.

The payoffs of the seller, dependent on his strategy, can be described by

When $\theta = H$

$$\pi_s(S = H | \theta = H) = \beta^H - aV^H = V^H \cdot x + V^L \cdot (1-x) - aV^H$$
$$\pi_s(S = L | \theta = H) = \beta^L - aV^H = V^H \cdot z^L + V^L \cdot (1-z^L) - aV^H$$

When $\theta = L$

$$\pi_s(S = H | \theta = L) = \beta^H - aV^L = V^H \cdot x + V^L \cdot (1-x) - aV^L$$

---

[13] This equilibrium has a symmetric mirroring equilibrium in which the seller always sends a low value signal to the bidders. This case is exactly opposite from the current equilibrium and gives that the assessment $(1-q^H) = (1-q^L) = 1$ is a pooling weak perfect Bayesian equilibrium if and only if $z^L = x$ and $z^H \leq x$.

$$\pi_s(S = L|\theta = L) = \beta^L - aV^L = V^H \cdot z^L + V^L \cdot (1 - z^L) - aV^L$$

For both types of the seller, we need condition $z^L \leq x$ to conclude that sending signal H is the profitable strategy. Additionally, when $\theta = H$, sending signal H is only his profitable strategy when condition $a < x$ holds. ■

4.2.2 Separating equilibrium

We consider the following assessment of a separating equilibrium in which the seller reveals value honestly and so the high type of the seller sends a high value signal and the low type sends a low signal, which leads to

$$q(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 0 & if\ \theta = L \end{cases}$$

Regarding the existence of a separating equilibrium, we pose the following proposition:

Proposition 2 *The basic model has no separating weak perfect Bayesian equilibrium*[14].

Proof of proposition 2 Given assessment, the bidder's belief system can be defined by

$$z^H = \frac{x \cdot 1}{x \cdot 1 + (1 - x) \cdot 0} = 1$$

and

$$z^L = \frac{x \cdot 0}{x \cdot 0 + (1 - x) \cdot 1} = 0.$$

The optimal strategy of the bidder, given his beliefs, can therefore be determine by

$$\beta^*(S) = \begin{cases} \beta^H = V^H \cdot 1 + V^L \cdot 0 = V^H & if\ S = H \\ \beta^L = V^H \cdot 0 + V^L \cdot 1 = V^L & if\ S = L \end{cases}$$

The payoffs of the seller are described by

When $\theta = H$

$$\pi_s(S = H|\theta = H) = \beta^H - aV^H = V^H \cdot 1 + V^L \cdot 0 - aV^H = V^H - aV^H$$

$$\pi_s(S = L|\theta = H) = \beta^L - aV^H = V^H \cdot 0 + V^L \cdot 1 - aV^H = V^L - aV^H$$

When $\theta = L$

$$\pi_s(S = H|\theta = L) = \beta^H - aV^L = V^H \cdot 1 + V^L \cdot 0 - aV^L = V^H - aV^L$$

$$\pi_s(S = L|\theta = L) = \beta^L - aV^L = V^H \cdot 0 + V^L \cdot 1 - aV^L = V^L - aV^L$$

[14] Similarly to the pooling equilibrium, the separating equilibrium has a symmetric mirroring equilibrium in which the seller always gives a value signal opposite to its type. This assessment also does not lead us to a weak perfect Bayesian equilibrium.

As $V^H > V^L$ we can conclude that the optimal strategy for the seller is

$$q^*(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 1 & if\ \theta = L \end{cases}$$

This shows he deviates from the proposed assessment. ■

4.3 Equilibrium of the basic model

The basic model has a pooling weak perfect Bayesian equilibrium in which both types of the seller send the same signal. In the first version of the equilibrium, the seller always sends a high value signal to the bidders and in the mirroring pooling equilibrium, the seller always sends a low value signal. Although the mirroring pooling equilibrium is theoretically existent, is does not seem likely in practice as a seller probably rather overstates than understates value. The basic model does not have a separating equilibrium in which honest information revelation occurs.

Interpreting the outcomes, we observe clear evidence of a hold-up problem. In the only stable solution to the model, the pooling equilibrium, the bidders are not willing to exert *ex-ante* deal-specific efforts necessary to bid according to the information sent by the seller and instead revert back to their prior belief x concerning the actual value of the firm. Due to the *ex-ante* under-investment of the bidders in the pooling equilibrium, we observe an inefficient outcome *ex-post*. In the assessment of a separating equilibrium, in which the bidders trust the seller in revealing value honestly and are willing to exert efforts, the seller misuses this trust and overstates value.

In the next section we will analyze a model in a post-bid due diligence and renegotiation stage is added to the auction and analyze its impact on the auction process.

5 The main model

The first part of the main model replicates the process of the basic model in which a bidder submits a bid after having received a signal from the seller of the firm. We extend the basic model with a third stage in which the winner of the auction is given the opportunity to perform due diligence at a certain cost. Regarding this due diligence, we make the following assumption:

Assumption 4A *The due diligence result comes in the form of a perfect signal concerning the true value of the firm.*

The renegotiation occurs in the form of a 'take-it-or-leave-it' offer in which the winning bidder states a new price that the seller can either accept or reject. Regarding the renegotiation process, we assume the following:

Assumption 4B *If the signal from due diligence provides sufficient evidence that value was overstated in the information signal sent by the seller, the winning bidder can renegotiate the bidding price down to the lowest acceptable price for the seller, which is equal to his own valuation of the firm. The seller will incur a certain amount of reputational damage when rejecting this new price. If no sufficient evidence is provided, the seller can obtain a fair price by holding a new auction and will reject any renegotiated price.*

This assumption implies that a winner of an auction will not renegotiate the price when he has no sufficient evidence, as he prefers to obtain the firm and will not risk losing it by bluffing in the renegotiation stage to get a lower price

Reputational damage originates if the seller is deemed untrustworthy by the bidders and as a result, the firm is considered 'damaged goods'. The impact of this reputational damage is assessed after the deal failed. Once a possible renegotiation is performed and the deal is completed, the auction ends.

5.1 Analysis of the main model

5.1.1 Players

Compared to the basic model, the players in the game remain the same except for the fact that one of the bidders will be assigned the winner (w) of the auction.

5.1.2 Strategies, beliefs and payoffs

In the main game, the strategies available to both the seller and bidder remain the same as the basic model. The strategies of the winner of the auction consist of performing due diligence DD or refraining from it $No\ DD$. These strategies are expressed by $d = Pr(DD|S)$. Performing due diligence results in receiving a perfect signal $\hat{S} = \theta$ which costs the winner amount $-K$. Not performing due diligence $No\ DD$ results in no additional costs. The signal from due diligence can either match or conflict with the signal the seller sent earlier in the game. If the signal from due diligence conflicted with the signal from the seller, the winner can, only by providing evidence, renegotiate the bidding price. We make the following assumption about a possible renegotiation.

Assumption 4C *If the due diligence performed by the winning bidder results in conflicting information regarding the value of the firm so that* $S = H$ and $\hat{S} = L$ *the winning bidder has the right to renegotiate the price down to* $\hat{\beta} = v_0(V^L) = \alpha V^L$. *A seller refusing this price in the renegotiation will incur reputational damage equal to* σ, *where* $\sigma > a$, *after the auction finished so that his payoff in any new transaction would be* $\pi_s = \beta^L - \sigma - aV^L$ *which gives* $\pi_s < 0$.

This latter part of assumption 4C is in line with Hotchkiss et al. (2005) who state that positive termination costs avoid opportunistic behaviour[15] of the players in an auction. After the choice of due diligence is made by the winner and possible renegotiation occurred, the game ends and leads to the payoffs in table 1. The full game is depicted in illustration 3.

[15] Hotckiss argues that a termination fee for either party must be set to avoid opportunistic behaviour. This fee includes tactics such as lock-up agreements and toehold acquisitions. For more information, see Hotchkiss et al. (2005)

Illustration 3- Game Tree of the main model

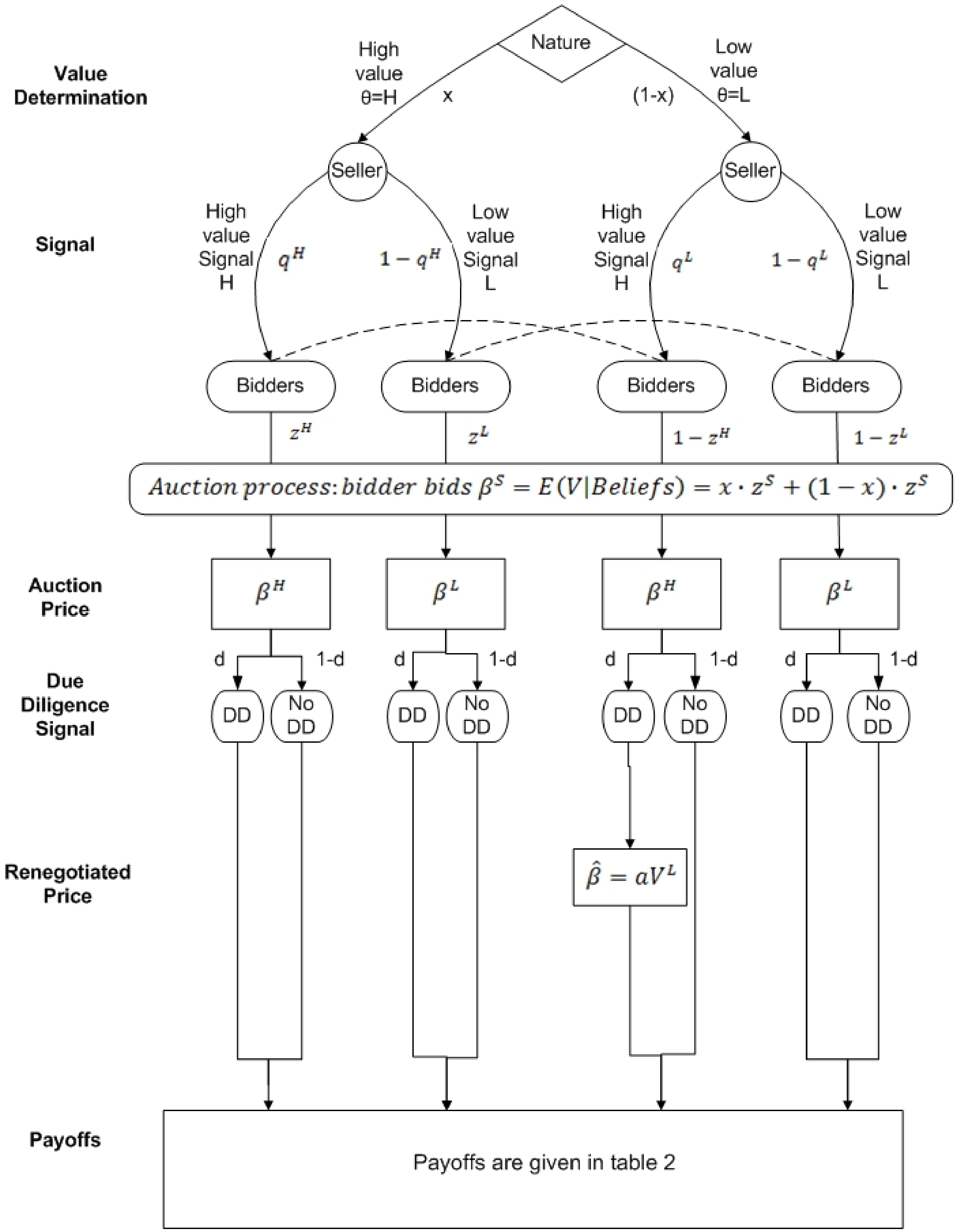


Table 1- Payoffs of the main game

	Seller type $\theta = H$ with probability x		Seller type $\theta = L$ with probability (1-x)	
Winner	**High signal**	**Low signal**	**High signal**	**Low signal**
Due Diligence	$\pi_w = V^H - \beta^H - K$ $\pi_s = \beta^H - aV^H$	$\pi_w = V^H - \beta^L - K$ $\pi_s = \beta^L - aV^H$	$\pi_w = V^L - \hat{\beta} - K$ $\pi_s = \hat{\beta} - aV^L$	$\pi_w = V^L - \beta^L - K$ $\pi_s = \beta^L - aV^L$
No Due Diligence	$\pi_w = V^H - \beta^H$ $\pi_s = \beta^H - aV^H$	$\pi_w = V^H - \beta^L$ $\pi_s = \beta^L - aV^H$	$\pi_w = V^L - \beta^H$ $\pi_s = \beta^H - aV^L$	$\pi_w = V^L - \beta^L$ $\pi_s = \beta^L - aV^L$

5.2 Solutions to the main model

Similarly to the basic model, we will evaluate the assessments given by definition 1. Additionally, it is useful to determine another assessment for the main model.

Definition 2 *An assessment* $(q^*(\theta), \beta^*(S), d^*(S, K))$ *is a semi-pooling equilibrium if one type of the sender always sends a single signal with probability one, while the other type randomizes over several signals so that it is partially revealing but the bidders will not be able to draw conclusions with certainty from the received signal (Osborne,2004).*

The proofs for the propositions posed regarding a solution to the main game will again make use of theorem 1 and assumption 3 by which the beliefs and optimal strategy of the bidder are defined after which the optimal strategies of both the winning bidder and seller will be formulated. For the sake of the fluency of the paper, longer proofs will be given in the appendix.

5.2.1 Pooling equilibrium

We consider an assessment in which both types of the seller send a high value signal to the bidders, so

$$q(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 1 & if\ \theta = L \end{cases}$$

We make the following proposition regarding the existence of a pooling equilibrium:

Proposition 3 *The main game has a pooling weak perfect Bayesian equilibrium*[16]. *In this equilibrium the behavioural strategies* (q^*, β^*, d^*) *can be described by*

(A)
$$q^*(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 1 & if\ \theta = L \end{cases}$$

(B)
$$\beta^*(S) = \begin{cases} \beta^H = V^H \cdot x + V^L \cdot (1-x) = E(V) & if\ S = H \\ \beta^L = V^H \cdot z^L + V^L \cdot (1 - z^L) & if\ S = L \end{cases}$$

(C)
$$d^* = 0$$

This equilibrium is supported by conditions

(a)
$$z^H = x \text{ and } z^L \leq x$$

(b)
$$a < x$$

(c)
$$K > (1-x)(E(V) - aV^L) \qquad (K^P)$$

Payoffs of the seller and bidder in equilibrium are given by

(I) $\theta = H$

$$\pi_s = V^H \cdot x + V^L \cdot (1-x) - aV^H$$
$$\pi_b = V^H - V^H \cdot x + V^L \cdot (1-x)$$

(II) $\theta = L$

$$\pi_s = V^H \cdot x + V^L \cdot (1-x) - aV^L$$
$$\pi_b = V^L - V^H \cdot x + V^L \cdot (1-x)$$

Proof of proposition 3 *See appendix.*

5.2.2 Separating equilibrium

We consider an assessment in which the seller is honest and the high type of the seller sends a high value signal to the bidders and the low type sends a low signal, which leads to

$$q(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = 0 & if\ \theta = L \end{cases}$$

Regarding a possible equilibrium in the main model, we pose the following proposition:

Proposition 4 *The main game has no separating weak perfect Bayesian equilibrium*[17].

---

[16] This equilibrium has a symmetric mirroring equilibrium in which the seller always sends a low value signal to the bidders. This case is exactly opposite from the current equilibrium and gives that the assessment $(1-q^H) = (1-q^L) = 1$ is a pooling weak perfect Bayesian equilibrium if and only if costs are greater than equation (K^P) and $z^L = x$ and $z^H \leq x$.

Proof proposition 4 The belief system of the bidder can be defined by

$$z^H = \frac{x \cdot 1}{x \cdot 1 + (1-x) \cdot 0} = 1$$

and

$$z^L = \frac{x \cdot 0}{x \cdot 0 + (1-x) \cdot 1} = 0$$

this leads to his optimal strategy

$$\beta^*(S) = \begin{cases} \beta^H = V^H \cdot 1 + V^L \cdot 0 = V^H & if\ S = H \\ \beta^L = V^H \cdot 0 + V^L \cdot 1 = V^L & if\ S = L \end{cases}$$

We observe that the winner beliefs in honest value signaling of the seller and will therefore not perform due diligence. Leading from his strategy, we can immediately refer back to the assessment of a separating equilibrium in the basic model on page 16 in which the seller misuses the trust of the winner and overstates value. ■

5.2.3 Semi-pooling equilibrium

We consider an assessment in which the seller always sends a high signal when $\theta = H$ occurs and mixes signals when $\theta = L$, expressed as

$$q(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ 0 < q^L < 1 & if\ \theta = L \end{cases}$$

Given the assessment, we pose the following proposition:

Proposition 5 *The main game has a semi-pooling weak perfect Bayesian equilibrium. In this equilibrium the behavioural strategies* (q^*, β^*, d^*) *can be described by*

(A) $$q^*(\theta) = \begin{cases} q^H = 1 & if\ \theta = H \\ q^L = \dfrac{2xK}{(1-x)\left((V^H - aV^L - 2K) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}\right)} & if\ \theta = L \end{cases}$$

(B) $$\beta^*(S) = \begin{cases} \beta^H(DD) = \dfrac{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}}{2} & if\ S = H \\ \beta^L = V^L & if\ S = L \end{cases} \quad if\ K \leq K^n$$

(C) $$\beta^*(S) = \begin{cases} \beta^H(No\ DD) = V^H \cdot x + V^L \cdot (1-x) = E(V) & if\ S = H \\ \beta^L = V^L & if\ S = L \end{cases} \quad if\ K > K^n$$

---

[17] Similarly to the pooling equilibrium, the separating equilibrium has a symmetric mirroring equilibrium in which the seller always gives a value signal opposite to its type. This assessment also does not lead us to a Weak Perfect Bayesian Equilibrium.

(D) $$d^* = 1 - \frac{V^L(2-a)}{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)} - 2aV^L} \quad if\ K \leq K^n$$

This equilibrium is supported by conditions

(a) $$z^H = \frac{\beta^H - aV^L - K}{\beta^H - aV^L}$$

(b) $$z^L = 0$$

(c) $$K^n = \begin{cases} if\ (2-a)V^L \leq V^H & K^1 = \frac{1}{4} \cdot \frac{(V^H - aV^L)^2}{(V^H - V^L)} \\ if\ (2-a)V^L > V^H & K^2 = (1-a)V^L \end{cases}$$

Payoffs of the seller and bidder in equilibrium are given by

(I) $\theta = H$

$$\pi_s = \frac{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}}{2} - aV^H$$

$$\pi_b = V^H - \frac{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}}{2}$$

(II) $\theta = L$

$$\pi_s = V^L - aV^L$$

$$\pi_b = V^L - V^L$$

Proof of proposition 5 *See appendix.*

5.3 Equilibria of the main model

We conclude that the main model embodies two equilibria of which the first one is a pooling equilibrium where the seller always sends a high value signal regardless of his type and the winner never performs due diligence[18]. The second equilibrium is a semi-pooling equilibrium in which seller always sends signal H when $\theta = H$ and randomizes between signal L and H when $\theta = L$. In this equilibrium, the winner performs due diligence parts of the time. Similar to the basic model, no separating equilibrium could be constructed in the main model. We conclude that the semi-pooling equilibrium comes closest to resolving the hold-up problem demonstrated in the basic game. However, in this equilibrium concept, value will be overstated with a positive probability so the hold-up problem is not completely resolved but rather reduced.

[18] This pooling equilibrium exists again out of a normal form and mirroring variant alike the basic model.

We have observed that cost of due diligence plays a crucial role in supporting the two equilibria in the main game. The cost condition supporting the pooling equilibrium is $K > K^P$ and the cost conditions supporting the semi-pooling equilibrium are

$$K = \begin{cases} K \leq K^1 & if\ (2-a)V^L \leq V^H \\ K \leq K^2 & if\ (2-a)V^L > V^H \end{cases}$$

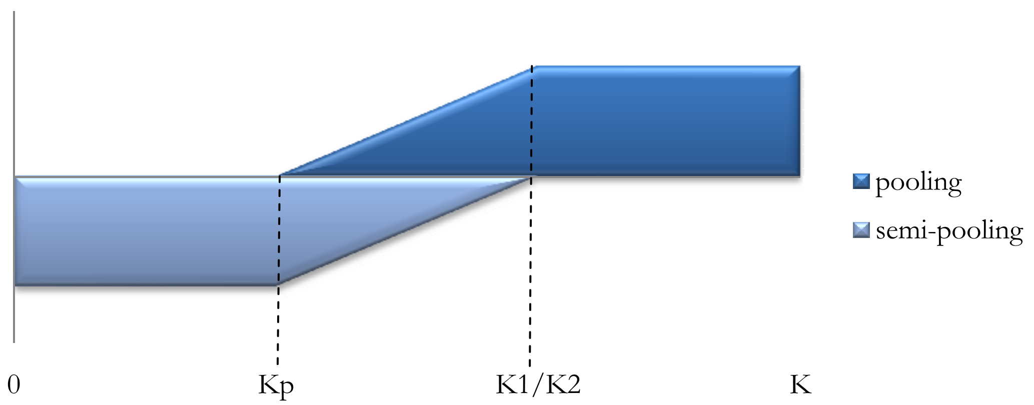
We need to determine how the cost level of the pooling equilibrium relates to the cost levels of the semi-pooling equilibrium to sketch the spectrum of equilibria in the main game. Regarding this relation we pose the following proposition:

Proposition 6 *Both* K^1 and K^2 *are greater than* K^P

Proof of proposition 6 *See appendix.*

Following proposition 6, we observe a game spectrum in which costs smaller than K^P yield a situation with only a semi-pooling equilibrium, costs between K^P and either K^1 or K^2 give grounds for both equilibria to co-exist and costs above K^1 or K^2 will result in a situation with only a pooling equilibrium. This spectrum is displayed in illustration 4.

Illustration 4 – Equilibria of the main game



Important to repeat is the crucial impact of assumption 5 in section V to support our general equilibria. Renegotiation of the bidding price after delivering evidence from due diligence is only effective if the price in a new auction would lead to an even lower payoff for the seller. Reputational damage effectively fills this role and makes renegotiation work.

5.4 Costless due diligence

A question which arises from the cost conditions imposed on the different equilibria is what would happen if the cost of due diligence K is moving down to zero so that due diligence becomes costless? Following intuition, we would suggest that the winner would always employ this strategy and so always verifies the information signaled by the seller. Consequently, the seller would never have the incentive to overstate value, knowing that this will always be detected and price renegotiations will follow. We can test this intuition using the strategies from the semi-pooling equilibrium.

The overstatement strategy of the seller gives

$$q^{L^*} = \frac{2xK}{(1-x)\left((V^H - aV^L - 2K) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}\right)}$$

when plugging in $K = 0$ we observe indeed that

$$q^L = 0$$

However, when using the due diligence strategy of the winner

$$d^* = 1 - \frac{V^L(2-a)}{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)} - 2aV^L}$$

we observe that when $K = 0$ the level of due diligence becomes

$$d = \frac{V^H - V^L}{V^H - aV^L}$$

Unexpectedly, we observe that the winner will not always perform due diligence when it is costless to him and instead, he chooses a level based on the value level of the firm. Reason for this is that this level of due diligence is already effective in inducing the seller to reveal value honestly. Leading from this outcome, we argue that costless due diligence, and consequently renegotiation, works as a threat to the seller and is effective in altering his behaviour.

6 Discussion

This study sets out with the intention to demonstrate the importance of post-bid due diligence and renegotiation in the light of resolving a potential hold-up problem in takeover auctions. The results of this paper show that, due to the large information asymmetry between the seller and the bidders and the dependency of the bidders on the information provision of the seller, a hold-up problem comes to exist if the auction process would have ended after final bids were submitted. The post-bid confirmatory due diligence and renegotiation stage is shown to be effective in reducing, but not completely resolving, this hold-up problem. In the equilibrium that comes closest to resolving the hold-up problem, the seller will still overstate value with a small but positive probability while the winner of the auction performs due diligence some of the times.

The cost of due diligence proves to play a crucial role in the determination of equilibria in our game-theoretical model. We have indicated several cost conditions, which should hold to support the existence of the equilibria in the model. An unanticipated finding was that in case due diligence would be costless to the winner; he would still not always employ this strategy. However, when the seller is aware of the costless option of due diligence to the winner, this affects his strategy to such a degree that he will never overstate value. Using this result, we argue that the mechanism of due diligence and renegotiation works as a threat to the seller, which strongly reduces his incentive to exploit the *ex-ante* deal-specific efforts of the bidders and makes him inclined to reveal value honestly.

Few studies have discussed the hold-up problem in an M&A setting and most papers considering this topic in a general setting are from the strand of contracting literature (Myerson, 1983; Hart and Moore, 1988; Maskin and Tirole, 1992; Hotckiss et al., 2005). Although our research takes a different perspective, our results collaborate with the results from this strand in resolving the hold-up problem. The construction of an explicit mechanism, either an *ex-ante* contract or allowing the winner to perform post-bid due diligence and to renegotiate, reduces opportunistic behaviour of the principal and induces the agent to exert relationship-specific efforts *ex-ante,* resulting in an efficient outcome *ex-post.*

Furthermore, our finding that *ex-post* information acquisition stimulates higher bids supports similar findings from the strand of information acquisition in auctions (Lee, 1984; Riley, 1988).

Because our findings result from a theoretical formal model, we should consider them in a real-life perspective. We observe that cost conditions of due diligence play an important role in our paper but have to note that they are not a significant barrier in real-life takeover auctions (KPMG, 2009; Bencis Capital Partners, 2010). A winner will normally always perform due diligence and costs are of such a low percentage of total value that the occurrence of a pooling equilibrium, as given in our game spectrum, is very unlikely. However, it is often the quality of due diligence, rather than the costs, restraining the winner from detecting new information (Herd and Perry, 2004). Considering this, our results would not change much because we can easily replace cost levels with the quality levels of due diligence and argue that a semi-pooling equilibrium could occur if the seller anticipates on low quality of due diligence performed and a semi-pooling equilibrium occurs if high quality due diligence is expected from the bidders.

There are several important management implications flowing from our results. First, we accentuate the crucial importance of careful due diligence and information investigation by bidders during and after the bidding process. A major difficulty in performing effective due diligence is the increasingly complex and globalising business environment, which makes it harder to correctly identify key risks that affect the business (Angwin, 2001; Herd and Perry, 2004). A striking example of this is the recent credit crisis, which struck the global business world. Considering a firm, which would be for sale in an auctioning process right before the start of this crisis, with the process enduring well into the midst of the crisis, the information provided by the seller could greatly overstate the actual business status as growth projections of most firms were dramatically corrected downwards. Another (more dated) example of a period in which overstatement was common over a longer period is the 'IT-bubble' in the late 1990s. During this hype, small IT firms were sold with extreme premiums, well above their actual value, based on tremendous growth projections shaped by the selling party and supported by the common market belief. Once the IT-bubble burst, it was hard to belief that these premiums were commonly accepted and bidders adopted growth assumptions of seller with such ease. Therefore, a belief for more thorough due diligence of businesses data was widely accepted. An M&A practitioner commented: *'Bidders should, next to the traditional financial analysis, perform qualitative risk assessments and employ industry expert to assess the business independently and challenge traditional assumptions about risk and value'* (Herd and Perry, 2004).

Second, we show that increased trust of the bidders in the actions of the seller enhances the result of the auction for the seller. Although we argued that soft practices are not effective in developing trust, the seller could comfort the bidder by providing information from sources that are more objective of nature. A practice closely aligned with this thought and which rapidly gains popularity in M&A auctions is the provision of a 'vendor due diligence' report by the selling party (KPMG, 2009; Bencis Capital Partners, 2010). This report is created by an expert third party, which values the business independently, and is provided to the seller as a means to increase bidders' trust in the information provision. Even though this improves the objectivity of information presented, there will always be some suspicion regarding the independence of the report as the expert party has a client relationship with the seller.

As mentioned in the introduction, the highly structured and transparent process of a takeover auction enhances the transferability of results to a different context. Both procurement as real estate auctions show great similarities in structure to a takeover auction and are reported to have similar issues regarding exploitation of information asymmetry by the principal (Waehrer, 1994;

Wang, 2000; Bajari and Tadelis, 2001). The results presented in our paper could therefore be interesting to apply in such a context. However, care should be taken in interpreting and generalizing the finding of this study as it is subject to certain limitation due to the number of (strong) assumptions we made to analyze the hold-up problem in our formal model.

First, the auction process is modelled as a common value auction in which all bidders are symmetrically informed. This poses a highly unrealistic situation, as there are always information differences between bidders in reality. For example, a direct competitor of a firm would have much deeper market knowledge than a pure financial bidder. Reason for the adoption of this assumption is that a private or interdependent value model[19] would increase the complexity of the model and focus most of the attention on the bidding process while this is only instrumental in our paper. The use of these models would result in the best-informed bidder winning the auction instead of a randomly chosen winner and the information signals having different value to each of the bidders.

Second, the choice for a binary value determination system, instead of a continuous value distribution, results in rather static outcomes. Instead of simply overstating value or honestly revealing it, the seller could have a choice in the degree of overstatement, enhancing the realism of the model. Again, this choice would dramatically increase the complexity of the model and although our model depicts a more simple variation, we can put forward the main conclusion regarding the hold-up problem with confidence, albeit with less detail than a more sophisticated model would offer. The same criticism applies to the assumption regarding the level of due diligence performed by the winner. We assume that the signal coming from due diligence is perfect while a signal with different levels of noise added would put forward more sophisticated results.

The last important limitation is caused by the assumption that a winner can only renegotiate the submitted bidding price by providing sufficient evidence after which the seller will accept this renegotiated price. In reality, there will be occasions where the winner of an auction will sabotage the process by renegotiating the price without any real evidence. This is very much dependent on the bargaining power of the bidder vis-à-vis the seller. For example, if the seller has a strong need to sell, he could feel forced to accept a renegotiated price in order to establish a sale and avoid any reputational damage. This is common tactic amongst experienced bidders, who have excellent judgement over the bargaining power of the seller in an auction. The assumptions made in our model was chosen for simplicity purposes to focus attention to the hold-up problem rather than spending much attention to the renegotiation process.

[19] See page 7 for a description. For papers on auctions with private or interdependent value models, see Milgrom and Weber (1982) and McAfee and McMillan (1987).

These limitations provide interesting topics for further research. Most prominently, a more sophisticated model with a continuous value distribution and a continuous due diligence distribution could improve the accurateness of the model and give more detailed and sophisticated predictions about the behaviour of both seller and the winner in a takeover auction. Another interesting topic is the area of reputational damage. In our model, reputational damage was a key assumption but not very much elaborated upon as it only played a supporting role in our research. How reputational damage comes to exist, influences new transactions and the amount of reputational damage needed to influence the behaviour of both bidder and seller in takeover auction process would be extremely interesting to identify. Empirical evidence on the dynamics of due diligence and renegotiation in its function to resolve the hold-up problem in takeover auctions would be interesting, although obtaining information regarding private transaction is difficult due to its strictly confidential nature.

7 Conclusion

Takeover auctions are a frequently used sales mechanism to establish a change in control of corporate ownership and papers related to these auctions are therefore an important part of M&A literature. This paper studies information issues in takeover auctions of private firms and argues the presence of a hold-up problem, a topic which has not been thoroughly discussed in a M&A context.

We design and analyze a formal model in which we demonstrate that a hold-up problem would emerge if a takeover auction had ended after formal bids were submitted. This hold-up problem appears because of the considerable information asymmetry between seller and bidders and the dependency of the bidders on the seller as sole source of information. Bidders are not willing to exert efforts *ex-ante*, in the form of analyzing information signalled by the seller, worried that the seller will exploit these efforts by overstating information in his signals. This reduces the efficiency of the auction results *ex-post*.

Extending this model, we show that a post-bid due diligence and renegotiation stage is effective in reducing, but not completely resolving, this hold-up problem. The cost level of due diligence proves to be important and can impede the winner of the auction from performing due diligence. Unexpectedly, we find that if due diligence is costless for the winner he will not employ this strategy with absolute certainty. However, when the seller is aware of this costless strategy, he alters his strategy to such a degree that he always reveals value honestly. We therefore argue that due diligence works as a strong threat to the seller and is effective in reducing his incentive to overstate value. To that end, this paper provides evidence for the importance of careful due diligence to the bidders in a takeover auction and supports the initial quote in Fortune Magazine that bidders should put strong efforts in information investigation.

8 Appendix

Proof of proposition 3 Given assessment, the beliefs of the bidder can be described by

$$z^H = \frac{x \cdot 1}{x \cdot 1 + (1-x) \cdot 1} = x$$

and

$$z^L \epsilon [0,1]$$

To determine the best strategy for the winner, we need to determine the maximum cost level which forms the tradeoff between performing and refraining from due diligence. When the bidder receives signal H, the winner will perform due diligence if his profits from doing so are greater than refraining from due diligence, $\pi_w(DD, H) \geq \pi_w(No\ DD, H)$, so

$$x(V^H - \beta^H - K) + (1-x)(V^L - aV^L - K) \geq x(V^H - \beta^H) + (1-x)(V^L - \beta^H)$$

And gives

$$K \leq (1-x)(\beta^H - aV^L)$$

The optimal bid price $\beta^H(DD)$ in equilibrium needed for this equation is the price which leads to zero economic profits in equilibrium and can be determined by

$$\pi_w(DD, H) = x(V^H - \beta^H - K) + (1-x)(V^L - aV^L - K) = 0$$

This leads to

$$\beta^H(DD) = \frac{E(V) - (1-x) \cdot aV^L - K}{x}$$

Plugging this price into equation (1) and solving for K gives

$$K \leq (1-x)(E(V) - aV^L) \qquad (K^P)$$

If costs are equal or lower than equation (K^P), the winner will perform due diligence and if the level of K would be greater than (K^P), he would find it more profitable to refrain from performing due diligence. In the latter case, he sets a new price $\beta^H(No\ DD)$ in which the profits of refraining from due diligence are set to zero economic profits in equilibrium.

$$\pi_w(No\ DD, H) = x(V^H - \beta^H) + (1-x)(V^L - \beta^H) = 0$$

This gives

$$\beta^H(No\ DD) = x \cdot V^H + (1-x) \cdot V^L = E(V)$$

When receiving signal L, performing due diligence is the profitable strategy for the winner when $\pi_w(DD, L) \geq \pi_w(No\ DD, L)$, so

$$z^L(V^H - \beta^L - K) + (1-z^L)(V^L - \beta^L - K) \geq z^L(V^H - \beta^L) + (1-z^L)(V^L - \beta^L)$$

This gives

$$K \leq 0$$

We can see that performing due diligence is never a profitable strategy for the winner as K can never be smaller than zero. At a level equal to zero, the winner is indifferent between performing due diligence and refraining from it. The price that will be submitted after receiving signal L is determined by the point at which economic profits from refraining from due diligence are set to zero, so

$$\pi_w(No\ DD, L) = z^L(V^H - \beta^L) + (1 - z^L)(V^L - \beta^L) = 0$$

This leads to

$$\beta^L(No\ DD) = z^L \cdot V^H + (1 - z^L) \cdot V^L$$

When determining the optimal strategy for the seller, we know from the outcome of the basic model that if the bidders do not have a chance to verify the information signaled by the seller, the seller will overstate information which occurs when costs are greater than (K^P). In this situation we can refer back to proposition 2 on page 15. Therefore, we will now only need to review the situation in which costs are lower than equation (K^P). In this case, the payoffs of the seller can be described by:

When $\theta = H$

$$\pi_s(S = H, \theta = H) = \beta^H - aV^H = \frac{E(V) - (1 - x)aV^L - K}{x} - aV^H = \frac{(1 - a)E(V) - K}{x}$$

$$\pi_s(S = L, \theta = H) = \beta^L - aV^H = V^H \cdot z^L + V^L \cdot (1 - z^L) - aV^H$$

Reviewing these payoffs we can conclude that in case $\theta = H$, the strategy of sending signal H is profitable when

$$z^L < \frac{x(E(V) - V^L) - K}{x(V^H - V^L)}$$

When $\theta = L$ we need to carefully note that if the winner performs due diligence this will lead to conflicting information when the seller sends signal H and will give the winner sufficient evidence to renegotiate the price down to the lowest acceptable level for the seller $\hat{\beta} = v_0(V^L) = \alpha V^L$

$$\pi_s(S = H, \theta = L) = \hat{\beta}^L - aV^L = aV^L - aV^L = 0$$

$$\pi_s(S = L, \theta = L) = \beta^L - aV^L = z^L \cdot V^H + (1 - z^L)V^L - aV^L$$

Reviewing these payoffs we can conclude that in case $\theta = L$, sending signal H is a profitable strategy if $z^L < 0$. This cannot exist and so the seller deviates from the proposed assessment of a pooling equilibrium and rather sends signal L. ■

Proof of proposition 5

Whereas in other assessment both players exercise pure strategies, the seller uses a mixed strategy when $\theta = L$ in this assessment. Therefore we need to find the thresholds in which both players are indifferent between their available strategies. The belief system of the bidder can be defined as followed

$$z^H = \frac{x \cdot 1}{x \cdot 1 + (1 - x) \cdot q^L}$$

and

$$z^L = \frac{x \cdot 0}{x \cdot 0 + (1 - x) \cdot (1 - q^L)} = 0$$

The mixing strategy of the low value type of the seller gives the winner the incentive to mix his strategy as well. Consider a situation in which $d = 1$ and so the winner will always perform due diligence after observing signal H. This would give the seller the incentive to always send signal L when $\theta = L$ and set $q^L = 0$, which contradicts with $0 < q^L < 1$ given in the assessment. An opposite situation would occur when $d = 0$ which would also contradict with the assessment. Therefore, it logically flows from this argument that $0 < d < 1$ and to find the exact level of d in equilibrium we need to find the threshold in which the winner is indifferent between performing due diligence and refraining from it.

When the bidder receives signal H

$\pi_b(DD, H) = \pi_b(No\ DD, H)$, which gives

$$z^H \cdot (V^H - \beta^H - K) + (1 - z^H) \cdot (V^L - aV^L - K)$$
$$= z^H \cdot (V^H - \beta^H) + (1 - z^H) \cdot (V^L - \beta^H)$$

Solving the equation for z^H gives

$$z^H = \frac{\beta^H - aV^L - K}{\beta^H - aV^L}$$

which gives that q^L should have a value equal to

$$q^L = \frac{xK}{(1 - x)(\beta^H - aV^L - K)} \tag{6}$$

To complete equation (6), we need to determine the appropriate bidding price β^H. We can do this by setting the economic profits of both performing and refraining from due diligence to zero.

$$\pi_b(DD, H) = \pi_b(NDD, H) = \frac{\beta^{H^2} - \beta^H(V^H + aV^L) + aV^L V^H + V^H K - V^L K}{\beta^H - aV^L} = 0$$

this leads to a bidding price of [20]

$$\beta^H(DD) = \frac{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}}{2} \tag{7}$$

From this equation we can derive that the maximum cost levels which allows the winner to perform due diligence is

$$K \leq \frac{1}{4} \cdot \frac{(V^H - aV^L)^2}{(V^H - V^L)} \tag{K^1}$$

Mathematically, if K would be greater than equation K^1, the square root in equation (7) would be negative which is not allowed. Interpreting equation K^1 economically, a K greater than equation K^1 would mitigate all potential profits from due diligence and induce the winner to refrain from performing due diligence which would take us back to a pooling equilibrium situation at page 15 in which $\beta^H = E(V)$.

Inserting the bidding price of equation (7) into equation (6) gives

$$q^L = \frac{2xK}{(1-x)\left((V^H - aV^L - 2K) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}\right)}$$

When the winner receives signal L

$\pi_w(DD, L) \geq \pi_w(NDD, L)$, so

$$z^L(V^H - \beta^L - K) + (1 - z^L)(V^L - \beta^L - K) \geq z^L(V^H - \beta^L) + (1 - z^L)(V^L - \beta^L)$$

This leads that

$$K \leq 0$$

The winner will never perform due diligence after observing signal L. To determine the appropriate bidding price for this situation, we set the strategy of refraining of due diligence to result in zero economic profits

$$(1 - z^L) \cdot (V^L - \beta^L) = 0$$

This gives that

$$\beta^L = V^L \tag{10}$$

We conclude that the winner will refrain from due diligence when he receives signal L but will perform due diligence after observing signal H, however, only when q^L is equal to equation (6) and K is smaller or equal to equation K^1.

[20] We used the mathematical rules determined by the ABC-formula to construct this equation. One rule concerns the choice between a + or – sign before the square root. In our case, we choose to use the + sign as the bid price β^H should be decreasing in K which will only happen if there is a + sign before the square root.

When $\theta = H$, the seller faces the following profit functions

$\pi_s(\theta = H, S = H) = \beta^H - aV^H = (d^H \cdot \beta^H + (1 - d^H) \cdot \beta^H) - aV^H = \beta^H(DD) - aV^H$

$\pi_s(\theta = H, S = L) = \beta^L - aV^H$

He will send signal H when $\beta^H \geq \beta^L$. We Use equation (7) and (10) to fill this condition in

$$\frac{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)}}{2} \geq V^L$$

Leading from this equation we can conclude that if $(2 - a)V^L \leq V^H$[21] there are no restrictions to the value of K so $K\epsilon[0, \infty]$. However, if $(2 - a)V^L > V^H$ the following restriction must hold to let the strategy of sending signal H be the profitable strategy

$$K \leq (1 - a)V^L \qquad (K^2)$$

When $\theta = L$, the seller can chose to either send a high or a low signal. As $0 < q^L < 1$, we will search the threshold point in which the seller is indifferent between sending signal H and signal L which occurs when $\pi_s(V^L, H) = \pi_s(V^L, L)$

$\pi_s(\theta = L, S = H) = \left(d \cdot \hat{\beta} + (1 - d) \cdot \beta^H\right) - aV^L = (d \cdot aV^L + (1 - d) \cdot \beta^H) - aV^L = (1 - d)(\beta^H - aV^L)$

$\pi_s(\theta = L, S = L) = \beta^L - aV^L = V^L - aV^L$

Therefore, it must hold that $(1 - d)(\beta^H - aV^L) = V^L - aV^L$ to make the seller indifferent which gives us the following level of due diligence at which the seller is indifferent between sending H and L

$$d = 1 - \frac{V^L \cdot (1 - a)}{\beta^H - aV^L}$$

Plugging the appropriate β^H from equation (7) into this equation leads us to

$$d = 1 - \frac{V^L(2 - a)}{(V^H + aV^L) + \sqrt{(V^H - aV^L)^2 - 4K(V^H - V^L)} - 2aV^L} \qquad (11)$$

■

Proof of proposition 6

If $(2 - a)V^L > V^H$ we know that cost level K^2 is restrictive. We can conclude that K^2 is greater than K^P because

---

21 $\frac{(V^H + aV^L)}{2} \geq V^L$ leads to $(2 - a)V^L \leq V^H$

$$K^2 = (1-a)V^L$$
$$K^P = (1-x)(xV^H + (1-x)V^L - aV^L)$$
$$K^2 - K^P = [(1-a)V^L] - [(1-x)(xV^H + (1-x)V^L - aV^L)]$$
$$= x((1-a)V^L - (1-x)(V^H - V^L)) = x((2-a)V^L - V^H + x(V^H - V^L)$$

and

$$x((2-a)V^L - V^H + x(V^H - V^L) > 0$$

If $(2-a)V^L \leq V^H$ we know that cost level K^1 holds. We can conclude that K^1 is greater than K^P because

$$K^1 = \frac{1}{4} \cdot \frac{(V^H - aV^L)^2}{(V^H - V^L)}$$
$$K^P = (1-x)(xV^H + (1-x)V^L - aV^L)$$
$$K^1 - K^P = \left[\frac{1}{4} \cdot \frac{(V^H - aV^L)^2}{(V^H - V^L)}\right] - [(1-x)(xV^H + (1-x)V^L - aV^L)]$$
$$= \frac{4((V^H - V^L)^2 x^2 - 4(V^H - V^L)(V^H - (2-a)V^L)x + (V^H - (2-a)V^L)^2}{4(V^H - V^L)}$$
$$= \frac{(2(V^H - V^L)x - (V^H - (2-a)V^L))^2}{4(V^H - V^L)}$$

and

$$\frac{(2(V^H - V^L)x - (V^H - (2-a)V^L))^2}{4(V^H - V^L)} \geq 0$$

■

9 References

Angwin, D. (2001). Mergers and Acquisitions across European Borders: National Perspectives on pre-acquisition Due Diligence and the Use of Professional Advisers. *Journal of World Business*, *Vol.36*, *No. 1*, pp.32-57.

Bajari, P., Tadelis, S. (2001). Incentives versus Transaction Costs: A Theory of Procurement Contracts. *The RAND Journal of Economics*, *Vol. 32, No. 3*, pp. 387-407.

Bencis Capital Partners. Several persons. (Personal communication, January 2010)

Betton, S., Eckbo, B.E., Torburn, K.S. (2006). Corporate Takeovers, *Handbook of Corporate Finance: Empirical Corporate Finance,* chapter 15 (Elsevier/North-Holland, Handbooks in Finance Series).

Boone, A., Mulherin,H. (2007). How firms are sold? *Journal of Finance, Vol. 62, No. 2*, 847-875.

Bulow, J., Klemperer, P. (1996). Auctions versus Negotiations. *The American Economic Review, Vol. 86, No.1,* pp.180-194.

Cassady, R., R., Jr. (1967). Auctions and auctioneering. *University of California Press*, Berkeley, CA.

Cobb, B.R., Choudhary, A.B. (2009). A Decision Analysis Approach to Solving the Signaling Game. Working Paper, *Lexington, Virginia Military Institute.*

Cramton, P., Schwartz, A. (1991). Using Auction Theory to Inform Takeover Regulation. *Journal of Law Economics and Organization, Vol.7, No.1*, pp. 27-53.

Engelbrecht-Wiggans, R. (1988). Revenue Equivalence in Multi-object Auctions. *Economic Letters*, *Vol. 26*, pp.15-19.

French, K.R., McCormick, R.E.(1984). Sealed Bids, Sunk Costs, and the Process of Competition. *Journal of Business, Vol. 57, No. 4*, pp. 417-41.

Gibbons, R. (1992). Game theory for applied economists. Princeton, NJ: *Princeton University Press.*

Grossman, S. J., Hart, O.D.,(1983). Implicit Contracts Under Asymmetric Information. *The Quarterly Journal of Economics*, *Vol. 98*, pp. 123-156.

Hansen, R.G. (2001). Auctions of Companies. *Economic Inquiry, Vol.39, No. 1,* pp.30-43.

Hart,O., Moore J. (1988). Incomplete Contracts and Renegotiation. *Econometrica*, *Vol. 56, No. 4*, pp. 755-785.

Herd, T.J., Perry, J.S. (2004). Mergers and Acquisitions: Reducing M&A risk through improved due diligence. *Strategy* & *Leadership, Vol. 32, No.2*, pp.12-19.

Hotchkiss, E., Qian, J., Song, W. (2005). Holdups, Renegotiation, and deal protection in mergers.

SSRN Discussion Paper

Insider Media, URL: http://www.insidermedia.com/productsandservices/archive/nwbi/2006-03/deals/index.html

Jensen, M., Roeback, R. (1983). The market for corporate control: Empirical evidence. *Journal of Financial Economics, Vol. 11*, pp. 5-50.

Klein, B., Crawfurd, R.G., Alchain, A.A. (1978). Vertical Integration, Appropriable Rents, and the Competitive Contracting Process. *The Journal of Law and Economics*, vol. 21

KPMG. Several persons. (Personal communication, May 2009)

Lee, T. K.(1984). Incomplete Information, High-Low Bidding and Public Information in First Price Auctions. *Management Science*, *Vol. 30, No. 12*, pp. 1490-1496

Levin, D., Smith, J.L. (1994). Equilibrium in Auctions with Entry. *The American Economic Review*, *Vol. 84, No. 3*, pp. 585-599.

Manne, H. G. (1965). Mergers and the Market for Corporate Control. *Journal of Political Economy*, *73*, pp. 110–120.

Maskin, E.,Tirole, J. (1992). The Principal-Agent Relationship with an Informed Principal, II: Common Values. *Econometrica*, *Vol. 60, No. 1*, pp. 1-42.

McAfee, R.P., McMillan, J. (1987). Auctions and bidding. *Journal of Economic Literature, Vol. XXV,* pp.699-738.

Mergermarket (2009). *Mergermarket Global M&A Round-up for Year End 2009*

Milgrom, P.R., Weber, R.J. (1982). A Theory of auctions and competitive bidding. *Econometrica, Vol 50, No.5,* pp.1089-1122.

Myerson, R. (1981). Optimal auction design. *Mathematics of Operations Research, Vol. 6*, pp. 58-73.

Osborne, M.J., (2004). An introduction to Game Theory. *Oxford University Press.*

Persico, N.(2000). Information Acquisition in Auctions. *Econometrica. Vol. 68, No. 1*, pp. 135-48.

Riley, J. G., Samuelson, W. (1981). Optimal auctions. *American Economic Review, Vol. 71*, pp. 381-392.

Riley, J.G., (1988). Ex Post Information in Auctions. *The Review of Economic Studies*, *Vol. 55, No. 3*, pp. 409-429.

Rogerson, W.P. (1992). Contractual Solutions to the Hold-Up Problem. *The Review of Economic Studies*, *Vol. 59, No. 4*, pp. 777-793.

Sarkar, T., Zimmerman, P., Pettit, J., Marais, F., Stoldt, D. M. and Smith, S. D. (2007). Auctions in the M&A Process: A Financier Worldwide Roundtable. *Financier Worldwide*.

Waehrer, K. (1991). A Model of Auction Contracts with Liquidated Damages. *Journal of Economic Theory, Vol. 67*, pp. 531-555.

Wang, R. (2000). Bidding and Renegotiating in Procurement Auctions. *European Economic Review Volume 44, Issue 8*, pp. 1577-1597.

Williamson, O.E. (1979). Transaction-cost economics: the governance of contractual relations. *Journal of Law and Economics*, *Vol. 22*, pp. 233-61.