Essays on Using Options to Elicit Market Beliefs about Mergers

by

Paul Borochin

Department of Business Administration
Duke University

Date: ____________________

Approved:

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David Robinson, Supervisor

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Alon Brav

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Ron Gallant

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Paige Ouimet

Dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Business Administration
in the Graduate School of Duke University
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Abstract

The first essay of my dissertation introduces a new method for eliciting market beliefs about the expected outcomes of a merger negotiation after announcement. During a merger negotiation, the market prices of the firms involved reflect beliefs about their values both in the merged and standalone states, as well as the likelihood of either outcome. These beliefs determine stock price reactions to news of a possible merger, but those prices alone do not contain sufficient information to identify the latent beliefs that they reflect. I develop a new method which, by using additional data in the form of option prices, is able to identify these beliefs. This method allows for a clear decomposition of a negotiating firm's expected value change into two parts: the value of the transaction to the firm, and new information about its standalone value. Previous research into estimating merger synergies has struggled to obtain an appropriate alternative against which to measure the realized outcome. The market's beliefs about state-contingent firm values give an estimate of both. Through a direct comparison of the estimates of a firm's value in both the merged and standalone states, I obtain a strong, practical measure of the expected value-creating potential of a merger before its consummation.

The second essay applies the state-contingent payoff estimation method developed previously to addressing questions about the size effect in mergers. A growing body of evidence indicates that large acquisitions destroy value. However, we do not yet know why. Several theories have been advanced, but their effects are difficult to observe in isolation. It has thus been impossible to tell whether negative post-announcement acquirer returns are caused by market expectations of value-destroying acquisitions or revealed bad news about standalone value. This paper resolves this issue by decomposing expectations about merger outcomes into expected value change from completing the acquisition and revision of beliefs about standalone firm value. The data show that deal size is correlated with value destruction, while acquirer size is correlated with release of unfavorable information. Deal size correlates with value destruction, acquirer size with bad news about the firm. Furthermore, the results suggest that overpayment is a prerequisite for large acquisitions. These findings reduce the set of possible theoretical explanations for the size effect.

To my parents.

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1 Introduction

This thesis, as a collection of two essays, presents contributions toward the empirical analysis of mergers. In the first essay I develop a new method which, by using additional data in the form of option prices, is able to identify latent market beliefs about firm values in both possible merger outcomes: the merged and standalone states. By comparing these state-contingent expectations I am able to provide the first strong test of merger value creation, something that previous research has struggled with. Observable stock prices are determined by a combination of expectations about firm value in both of these states. However, the single observed price is insufficient to disentangle the two expectations that inform it. I am able to solve this problem by developing a method that makes use of additional informative data in the form of option prices. These additional data allow a simultaneous identification of both state-contingent expected values of target and acquirer firms in merger negotiations. The identification is possible under cash, mixed, and stock offer terms.

This identification strategy exploits nonlinearities in changes in daily firm equity option prices with respect to the value of the underlying. The intuition behind this is straightforward. Options with either different strike prices or different times to maturity will have different sensitivities to changes in the value of the firm. Therefore, each option's value will change with respect to the value of the equity, providing unique information. This is best illustrated by considering the case in which, after a merger announcement, one of the two possible state-contingent payoffs falls between two options' strike prices. This means one option is now in the money in that state, and one is not. Having different strike prices means these two options are non-redundant, and the shifts in both their values help identify the level of that state-contingent payoff. A large enough set of daily option prices can identify all the parameters of interest on a given day, including the probability and both state-contingent payoffs.

I follow Subramanian (2004) and Bester Martinez and Rosu by expressing theoretical option values as functions of latent variables representing merged- and standalone-state payoffs to the underlying equity. I estimate daily values of these latent variables by minimizing the square difference

$$\sum_{i=1}^{N}(P_{i,\,theoretical} - P_{i,\,observed})^2$$

where $P_{i,\,theoretical}$ and $P_{i,\,observed}$ are option prices predicted by the model and observed in the market respectively. I achieve identification by using a suitably large number of option contracts N because the theoretical value of each option responds to changes in latent parameters uniquely, excepting options made redundant by put-call parity. Subramanian (2004) uses a similar approach to identify each day's expected probability of acquisition, as well as state-contingent firm volatilities, in a set of 26 transactions using a maximum of 18 near the money, short maturity, single stock options.

The intuition for this approach is verified by examining changes in Black-Scholes option value with respect to the spot price, or in this case the latent variables representing expectations about it. The value of a call, as a function of the spot price variable, is

$$C(S) = SN(d_1) - Ke^{-r(T-t)}N(d_2)$$

$$d_1 = \frac{\ln(S/K) + (r + \sigma^2/2)(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

The first and second derivative of the theoretical value of the call with respect to the latent variable S, $\frac{\partial C(S)}{\partial S}$ and $\frac{\partial^2 C(S)}{\partial S^2}$, depend on $N(d_1)$ and therefore both the strike price K and time to maturity $(T-t)$. $\frac{\partial^2 C(S)}{\partial S^2}$, the gamma of an option, is identical only for put-call parity equivalent securities. All other options are therefore not redundant: the theoretical prices in the square difference objective above will respond differently from each other to variations in the latent variable S, and therefore each will provide additional restrictions on it.

In the second essay I apply this identification method to determining the mechanism that drives the transaction size effect on acquirer returns during mergers. Using the method from the first essay, I am able to distinguish between the four proposed explanations of the empirical size effect. Two of them focus on explanations of downward revision of standalone value in response to new information, and two are hypothesized to affect value destruction in cases where takeovers are consummated. The same estimation can be applied to answering other questions about causes of value creation and destruction in mergers, and to other areas of empirical corporate finance.

This method can also be directly applied to several other key finance decisions with binary outcomes such as distressed firms considering bankruptcy. More indirectly, the theory of corporate finance provides a wealth of other cases where other nonlinear identification strategies can lead to insight about previously unobservable, but economically essential, variables.

2

When Does a Merger Create Value? Using Option Prices to Elicit Market Beliefs

2.1 Introduction

This paper introduces a method to estimate the market's expectations about a firm's values in the two possible outcomes for an ongoing merger negotiation: as a merged and as a standalone entity. In doing so, it provides an answer to the most fundamental question for the shareholders of a firm involved in such a negotiation: would they be better off if the merger did or did not occur? Answering this question requires knowledge of both possible outcomes. Since the market observes only one and not the other, even after the negotiation is finished a shareholder cannot directly make this measurement. Due to this, a strong test of value created in a merger has thus far been elusive. However, by identifying the market's latent beliefs about a firm's value in both the merged and standalone states, I provide just such a test through the comparison of those values. Furthermore, since these are expectations about the future this test is available ex ante, when it is most valuable. The identification of state-contingent beliefs also enables a disentanglement of the effects of perceived synergies from newly revealed information about the individual firms.

In responding to a newly announced merger, the market forms beliefs about the economic parameters of interest in the proposed transaction. It estimates the probability of a successful takeover and simultaneously updates its beliefs about the stand-alone values of the bidder and target companies. It also forms beliefs about the value of the combined firm that would be created if the merger proposal succeeds. These beliefs determine stock price reactions to a merger announcement, but the stock prices alone do not contain sufficient information to separately identify the beliefs that they reflect. Thus, observed price reactions to merger announcements can be indicative of a wide variety of possible expectations. Attempting to pin down the true set of the market's expectations is therefore analogous to an attempt at solving an underidentified system. There are only two ways forward: to either reduce the number of parameters estimated or to add more restrictions through additional data points.

Previous research has for the most part advanced through the former approach of parameter reduction. Brown and Raymond (1986), Barone-Adesi, Brown and Harlow (1994), Hietala, Kaplan and Robinson (2003), Subramanian (2004), Bhagat, Dong, Hirshleifer and Noah (2005), and Bester, Martinez and Rosu (2009) developed methods to identify some subsets of the full set of beliefs about mergers. These earlier efforts have worked primarily toward identifying situations in which it is possible to reduce the number of parameters that require estimation. Their results describe some situations in which it is possible to gain insight into some of parameters describing the market's beliefs about a proposed merger, falling short, however, of a generally applicable method to identify the entire set.

This paper takes the latter approach of adding additional data, and allows for the first time the separate identification of the full set of beliefs arising after merger announcements, regardless of offer terms. It accomplishes this by adding acquirer and target option price data which are determined by the same set of beliefs as the stock prices. The inclusion of options prices adds sufficient data to pin down the market's entire set of beliefs describing the possible outcomes of the merger announcement. Since contemporary options markets for large firms are reasonably liquid, they contain sufficient information to analyze all types of merger announcements regardless of offer terms or number of participants.

I apply the method to analyze Microsoft's failed attempt to acquire Yahoo in the spring of 2008. The ultimately unsuccessful bid by Microsoft presents an interesting case study since the outcome was sufficiently uncertain for the entirety of the talks. Although the board of Yahoo rejected the half-equity half-cash offer of approximately $31 per share shortly after its unsolicited proposal on February 1, 2008, Microsoft pressed its case for two subsequent months, threatening the target with a replacement of its board of directors, the imposition of a deadline at which time it would proceed with a hostile offer directly to shareholders, and a cessation of all talks. Yahoo meanwhile attempted to find strategic alliances with Time Warner, Google and News Corp. The result was a tumultuous negotiation occurring in a tumultuous time as the subprime crisis was making itself truly felt in the markets. Eventually even the Microsoft board became uncertain about which course of action to take. The proposed takeover failed just as it looked like it might succeed, and talks were terminated after a weekend negotiation on May 4, 2008. That weekend Microsoft finally raised its previously steady offer, but not sufficiently to sway Yahoo's board.

The February-May negotiation provides an interesting series of events that continually update the market's beliefs about the takeover attempt's possible outcomes and it showcases the ability of this new method to track the evolution of beliefs through time. I also repeat the estimation with a reduced number of parameters obtained through identifying assumptions about firm standalone values and the probability of success, similar to methods used in earlier research. I show that the results obtained are highly sensitive to assumptions that have been previously used to reduce the set of estimated parameters, such as pre-visible firm fallback values.

To push my model beyond its direct application, I test it with a counterfactual merger: the acquisition of Yahoo by Goldman Sachs. By substituting Goldman Sachs data in place of Microsoft's in the same time window, I am able to test the method's ability to differentiate between real and fictional scenarios. If the model is sensible, it should estimate a low probability of success and tie market prices to fundamental, standalone firm values. The model does this.

Finally, I test the method's ability to identify rapid belief shifts around the announcement of the merger. I do this by comparing the change in model parameters estimated immediately before and after the announcement, a change that should be material only for the real participants in the negotiation.

Prior research has made efforts to mine the informational content of prices around takeover negotiations, extracting beliefs about some of the parameters of interest in some takeover scenarios, and I include a brief summary of related papers in what follows. Brown and Raymond (1986) propose a no-arbitrage argument for inferring the probability of merger success for cash offers. Their method relies on the assumption that the target's stand-alone value would revert to its pre-merger state, and since the cash offer made the target's merged value predetermined, they were able to solve for the probability of merger success as a function of the current price. They show this measure has statistical power in predicting successful takeovers. Barone-Adesi, Brown and Harlow (1994) build on this foundation by using implied volatility from option contracts combined with the Brown and Raymond (1986) probability of success estimate. They predict the time until resolution of merger uncertainty, though still relying on the same identifying assumption.

Hietala, Kaplan and Robinson (2003) describe the full set of information implicit in equity value change around takeovers. Their approach decomposes the observed total value change into firm-specific synergy and information effects, and provides a set of cases where the system of equity price expectations can be solved. This solution concept relies on an identifying assumption that ex-ante expectations about stand-alone values were equivalent to their ex-post values when they were observed. This leaves a restricted set of treatable cases comprised of failed single-bidder and successful dual-bidder negotiations. Subramanian (2004) makes use of merger-relevant information content of option prices and develops a framework of option pricing with a jump process for the underlying stock representing a return to a fundamental standalone value in case of a breakdown in negotiations. He shows that the risk-neutral probability of a jump due to negotiation breakdown is indicative of the ultimate outcome of a merger, even early on in the negotiation process. Bhagat, Dong, Hirshleifer and Noah (2005) propose an alternative method of calculating the expected synergy of a tender offer using in-sample logit estimations of the probability of success and a strong formulation of the hubris hypothesis. Furthermore, in the context of competing tender offers, by assuming that the competing offer does not reveal new information about synergies or the fundamental value of the original bidder, they use the original bidder's price reaction to the new offer as another measure of expected synergy and average overpayment. Bester, Martinez and Rosu (2009) return to options as a source of additional identification for the Hietala, Kaplan and Robinson (2003) framework applied to cash mergers and estimate the target's stand-alone value and risk-neutral merger probability jointly. However, restricting identification to the target alone prevents them from being able to make statements about the expected accrual of value to participants in a proposed cash merger. The probability of this jump is empirically shown to have predictive power for negotiation outcomes.

The remainder of the paper is organized as follows: In section 2 I identify the set of parameters that fully describe the market's expectations about merger outcomes and derive an identification strategy from the implications of the parameters for market prices. Next I describe the estimation procedure that implements this strategy. Section 3 presents applications of the method to real and counterfactual merger data and the results they generate. The paper concludes with a summary of the findings and a consideration of further applications of the method to information-based theories of mergers.

2.2 What The Market is Thinking

Consider two firms, A and B, that are initially priced at \$15 and \$10 respectively in a stock market. After A submits an offer to buy B for \$7 and $\frac{1}{3}$ A shares each, the two firms are observed to trade at \$14 and \$12 each. These new prices are consistent with a wide range of market beliefs about possible merger outcomes.

The economic quantities of interest necessary to fully describe the market's updated beliefs which drive the observed price changes are as follows: A set of beliefs $S_{i,t} = \{q_i, P_t(A|M), P_t(A|N), P_t(B|N)\}$ contains q, the probability of successful takeover, $P_t(A|M)$ the time t expected value of A conditional on the merger occurring and $P_t(A|N)$ and $P_t(B|N)$, analogous expectations conditional on it not occurring. $P_t(B|M)$ is identified from the value of $P_t(A|M)$ and the offer terms: \$7 and a third of the value of the acquirer's share conditional on a successful takeover, so $P_t(B|M) = \$7 + \frac{1}{3}P_t(A|M)$. Two examples of such belief sets, both of which are consistent with observed stock prices, are:

$$S_1 = \{.6,\ 14\tfrac{1}{3},\ 13\tfrac{1}{2},\ 12\tfrac{1}{3}\}$$
$$S_2 = \{.2,\ 10,\ 15,\ 12.42\}$$

These two sets of beliefs reflect two very different outcomes for firms A and B, as shown in Table 2.1.

Under S_1 the total new value the market expects to be created from the transaction, expressed as the difference between the values of the two firms conditional on takeover success and their pre-announcement prices $(P_t(A|M)-A_0)+(O(P_t(A|M))-B_0)$, is positive at \$1.11. Firm A is expected to underpay for B as it is worth more conditional on merging, the difference between its value as an acquirer and a standalone firm, $P_t(A|M)-P_t(A|N)$, is positive. Firm B is expected to accept a slightly undervalued bid, as the difference between the offer amount and its standalone value $O(P_t(A|M))-P_t(B|N)$ is negative. Even if the deal fails, new information released causes A to be revalued lower and B higher. However under S_2 the total value expected to be created is substantially negative with A overpaying for B, and B accepting a very undervalued bid. In this scenario information about a standalone A is not updated, and B is again increased.

Both can be verified to be consistent with observed prices in a risk-neutral expectation setting as both satisfy

$$\begin{aligned} 14 &= q * P_t(A|M) + (1-q) * P_t(A|N) \\ 12 &= q * (7 + \tfrac{P_t(A|M)}{3}) + (1-q) * P_t(A|N) \end{aligned}$$

Appearing indistinguishable from prima facie evidence (market prices of A and B), the two scenarios represent drastically different outcomes. In fact, since the prices of A and B present only two restrictions on the set S_i describing possible outcomes, there is an infinite number of such scenarios. This presents a challenge to any study that intends to measure the impact of a merger from related stock prices.

The problem of identifying the one S_i^* that matches the future outcome out of all those S_i consistent with the prices of A and B is thus one of solving an under-identified system. This can be handled through reducing the cardinality of S_i via identifying assumptions until there are enough restrictions to identify it, or by producing additional restrictions. However, the former approach of assuming the value of any of the elements of S_i propagates these assumptions throughout the rest of the parameters due to the structure of the pricing relationships above. Jointly solving for all of the parameters is the only way to obtain an unbiased answer.

To get at these beliefs, this approach employs a solution concept that relies on market expectations about state-contingent payoffs to assets whose value is tied to the outcome of the negotiation. At the announcement of a merger all assets that derive value from that of the firms involved become contingent claims on two mutually exclusive states of the world: one where the firms combine and one where they remain independent. Only one of these is ever realized; the other is forever unobservable. However, by representing both in a state-contingent payoff framework the unobservable outcome can be inferred. Hietala, Kaplan and Robinson (2003) present an application of state-contingent valuations to stocks undergoing merger negotiations. Subramanian (2004) creates a similar framework for options prices using continuous-time stock processes.

This must hold true for all security classes: equity, where the relationship is linear and direct, as well as options, where payoffs are nonlinear functions of the equity. I treat the expected equity values that determine payoffs as latent variables to be estimated. Since each day's prices contain useful information about that day's expectations about future payoffs, the method makes separate estimates of the variables of interest representing these expectations for each day. This allows us to track the evolution of beliefs about the merger outcomes through time.

Although the expected payoffs from the possible outcomes of a merger are not directly observable, they may be inferred through the implications these beliefs have on prevailing prices. A risk-neutral probability measure allows the analysis to approach these beliefs about payoffs directly without worrying about risk adjustments. A risk-neutral measure $\mathbb{Q}$, under which any price process P_t becomes a martingale, exists in the absence of arbitrage as shown in Harrison and Pliska (1981) and Dalang, Morton, and Willinger (1990). This is to say that under the $\mathbb{Q}$ measure, the price observed on today's date t is just the discounted expected future payoff at the terminal date T:

$$P_t = E_{\mathbb{Q}}(P_T)$$

The $\mathbb{Q}$ measure was defined over a finite set of states in Harrison and Pliska (1981) and shown to exist in an extension with infinite states by Dalang, Morton and Willinger (1990). In the context of a merger negotiation two states are enough to cover possible outcomes: the case where the merger takes place, and its complement where it does not. Thus, the risk-neutral expected payoff $E_t^{\mathbb{Q}}(P_T)$ for a company undergoing acquisition negotiations that resolve at date T can be expressed in terms of its state-contingent values in the merged and unmerged states and a risk-neutral probability as

$$P_t = [q_t * E_t(P_{merged,T}) + (1 - q_t) * E_t(P_{unmerged,T})]$$

assuming that the state-contingent payoffs $P_{merged,T}$, $P_{unmerged,T}$ are known. A time subscript t indexes each of these quantities to denote the fact that the market's beliefs are being revised over time as new information becomes available. Since these payoffs are in reality uncertain, only beliefs about them are known and it is these beliefs that are the quantities of interest.

For a simple merger with a single potential acquirer firm A and target firm B, the arbitrage pricing theorem states that observed prices $A_t,\ B_t$ must be equal to discounted risk-neutral expectations of future payoffs $E_{\mathbb{Q}}(A_T),\ E_{\mathbb{Q}}(B_T)$ and thus

$$\begin{aligned} A_t = E_{\mathbb{Q}}(A_T) = [q_t * P_t(A|M)_t + (1 - q_t) * P_t(A|N)_t] \\ B_t = E_{\mathbb{Q}}(B_T) = [q_t * O(P_t(A|M)_t) + (1 - q_t) * P_t(B|N)_t] \end{aligned} \tag{2.1}$$

where for notational simplification, let A_t and B_t represent the prices of A and B at time t, $P_t(A|M)_t$ represent the market's current belief about the terminal value of A if its bid is successful, and $P_t(A|N)_t$ otherwise. Likewise, $P_t(B|N)_t$ is B's current expected stand-alone value at T, and let the value of the offer $O(P_t(A|M)_t)$, whose terms may be dependent on $P_t(A|M)_t$, be the value of the target firm if it is acquired ($P_t(B|M) = O(P_t(A|M)_t)$). I assume that the terms, and therefore the functional form, of the offer $O(P_t(A|M)_t)$ are known as they are announced at the start of negotiations. Let A_0 and B_0 denote the known pre-announcement values of the two firms. Thus, the total currently observed value change is a probability-weighted sum of value changes relative to pre-announcement prices in either outcome:

$$\begin{aligned}[A_t - A_0] + [B_t - B_0] &= \\ q_t\,[P_t(A|M)_t) - A_0 + O(P_t(A|M)_t) - B_0] \\ -(1-q_t)\,[P_t(A|N)_t - A_0 + P_t(B|N)_t - B_0]\end{aligned}$$

The synergy captured by shareholders if the merger occurs is the difference between the (known) pre-announcement and (expected) post-consummation values $[P_t(A|M)_t - A_0 + O(P_t(A|M)_t) - B_0]$. This, as in HKR (2003) is then decomposed by firm into

$$\begin{aligned}[P_t(A|M)_t - A_0 + O(P_t(A|M)_t) - B_0] &= \\ [P_t(A|M)_t - P_t(A|N)_t] + [O(P_t(A|M)_t) - P_t(B|N)_t] &+ \\ [P_t(A|N)_t - A_0] + [P_t(B|N)_t - B_0]\end{aligned} \tag{2.2}$$

where the components are

$$\begin{aligned}Total\ Synergy\ Captured\ by\ Shareholders &: [P_t(A|M)_t - A_0 + O(P_t(A|M)_t) - B_0] \\ Acquirer\ Gain &: [P_t(A|M)_t - P_t(A|N)_t] \\ Target\ Gain &: [O(P_t(A|M)_t) - P_t(B|N)_t] \\ Revealed\ Information\ About\ Acquirer &: [P_t(A|N)_t - A_0] \\ Revealed\ Information\ About\ Target &: [P_t(B|N)_t - B_0]\end{aligned}$$

where the perceptions about value are time-varying as the market assimilates new information. Thus, to characterize the sources of value creation and destruction in a merger negotiation, $P_t(A|M)_t$, $P_t(A|N)_t$, $P_t(B|N)_t$ must be identified. It is necessary, and may also be interesting, to know the risk-neutral probability of the merger taking place, q_t, but with the caveat that it is a constructed probability that includes expectations about risk and may be different from the physical $\mathbb{P}$ probability measure. Together, they form the set S of cardinality 4 that fully characterizes the expected outcome of a merger.

The relationships presented in (1) form a system of two equations with four unknowns. The unknown quantities of interest are: (i) the risk-neutral probability of deal success (q_t); (ii) the expected value of the acquirer if the deal goes through ($P_t(A|M)_t$); (iii) the expected value of the acquirer if the deal fails ($P_t(A|N)_t$), and (iv) the expected value of the target if the deal fails ($P_t(B|N)_t$). This by itself is an underidentified system that cannot be solved with a generally applicable method without resorting to identifying assumptions about the values of the two free parameters.

2.2.1 How Options Can Help

Solving the system in (1) requires a strategy for identifying at least four unknown variables in a system incorporating the above two equations. Namely, we can use the prices of well-traded options to identify the system of equations. Market efficiency implies that derivative prices, assuming liquid markets, have as much information about the underlying's future value as does its own price.

Therefore, while stock prices alone do not provide sufficient data points to identify all of the elements of S_i, additional restrictions necessary to pin them down are available through pricing relationships for option derivatives tied to, but linearly independent from, the stocks of A and B. This necessitates expanding S_i to include state-contingent volatilities of $(A|M)$, $(A|N)$, and $(B|N)$ for the purpose of pricing the options, but since the cardinality of the set of liquid, near-term options on a large contemporary firm is greater than 3, the tradeoff is well worth it.

The determination of the price of an option during an open merger offer proceeds analogously to the price of one of the participating firms' stocks. For example, in the case of several calls on both A and B for any given day t the following relationship must hold:

$$\begin{aligned} A_t &= (q_t * P_t(A|M)_t + (1-q_t)P_t(A|N)_t) \\ B_t &= q_t * P_t(B|M)_t + (1-q_t)P_t(B|N)_t \\ C_{1t}(B,K_1) &= q_t * C_{1t}(P_t(B|M)_t,K_1) + (1-q_t) * C_{1t}(P_t(B|N)_t,K_1) \qquad (2.3) \\ &\ldots \\ C_{nt}(A,K_n) &= q_t * C_{nt}(P_t(A|M)_t,K_n) + (1-q_t) * C_{nt}(P_t(A|N)_t,K_n) \end{aligned}$$

in which the call option price $C_{it}(P_t(B|N)_t, K_i)$ is expressed as a function of $P_t(B|N)_t$ and K_i using the Black-Scholes formula which holds for close-to-the-money options. Analogous value functions can be assigned to $C_{it}(P_t(B|M)_t, K_i)$, $P_{it}(P_t(B|N)_t, K_i)$, $P_{it}(P_t(B|M)_t, K_i)$ and the acquirer options $C_{it}(P_t(A|M)_t, K_i)$, $C_{it}(P_t(A|N)_t, K_i)$, $P_{it}(P_t(A|M)_t, K_i)$ and $P_{it}(P_t(A|N)_t, K_i)$. Thus, the price of an option on a state-contingent payoff can itself be represented in a state-contingent framework as a risk-neutral expectation of the possible payoffs. While the spot price and volatility parameters are state-contingent, the rest of the option parameters can reasonably be expected to be state-invariant in the short-term horizon of a merger negotiation.

In order to correctly compute the value of the options with Black-Scholes, not only must the expectation about security price be state-dependent, but so must the volatility. As shown in Barone-Adesi et al (1994) the implied volatilities of an underlying security during its merger negotiation period are expectations over the two possible terminal volatility states corresponding to the two possible outcomes. The two states for the acquirer represent its independent volatilities as a stand-alone or merged firm respectively, $\sigma_{P_t(A|N),t}$ and $\sigma_{P_t(A|M),t}$. In the case of the target, its terminal volatility in the acquired state either collapses to zero in the case of a deterministic offer or becomes proportional to $\sigma_{P_t(A|M),t}$ in the case of a stock exchange. In the standalone state, the target's volatility is an independent $\sigma_{P_t(B|N),t}$. These three auxiliary variables for state-contingent firm volatilities must also be identified by the system of equations, increasing the number of model variables by three. To make the expectation about terminal volatility time-consistent, I restrict the options data used to options maturing after Microsoft terminated the merger negotiation.

Generally, in cases where extracting market beliefs about ongoing mergers would be concerned, simply taking maximally well-traded options with sufficiently long maturity to plausibly outlast merger negotiations should be sufficient for eliciting consistent beliefs. By way of guidance, summary statistics of the universe of SDC database merger negotiations with deal size over $20m, comprising 21,967 transactions, show a mean negotiation duration of 107 days and a median of 75, a little over three months. This means that ex ante market beliefs will treat the values of options with more than three months' maturity remaining as likely to be dependent on the outcomes of the negotiation.

Thus it is possible to solve for the entire set of $P_t(A|M)_t$, $P_t(A|N)_t$, $P_t(B|N)_t$ and q_t and auxiliary variables $\sigma_{P_t(A|M),t}$, $\sigma_{P_t(A|N),t}$ and $\sigma_{P_t(B|N),t}$ given a sufficient number of options on the participants without resorting to assumptions about any of these unknowns as in previous solution strategies. Leaving all unknowns as free parameters allows for potential analysis of any number of potential acquirers and outcomes, and avoids restrictive assumptions about price processes.

The inclusion of five options on A and B stocks, coupled with the stocks themselves, would be sufficient to form an exactly identified system of seven unknowns in seven equations. The option contracts used vary with each day, and are selected based on a volume criterion to maximize information content through frequency of trades. With additional option data available, I can overidentify the system.

This proves prudent in light of put-call parity. Since the relationship between the acquirer's stock and call is given by $S - K * e^{rt} = C - P$, for a pair of equations analogous to

$$A_t = q_t * P_t(A|M)_t + (1 - q_t) * P_t(A|N)_t$$
$$C_{1t}(A_t, K_1) = q_t * C_{1t}(P_t(A|M)_t, K_1) + (1 - q_t) * C_{1t}(P_t(A|N)_t, K_1)$$

we can subtract $K*e^{rt}$ from top and $q_t*P_{1t}(P_t(A|M)_t, K_1)+(1-q_t)*P_{1t}(P_t(A|N)_t, K_1)$ from the bottom and end up with two equations that are identical. Thus, solving for $P_t(A|M)_t$, $P_t(A|N)_t$, $P_t(B|N)_t$ and q in a seemingly exactly identified system runs the risk of underidentification and therefore a lack of a unique solution. Any system that simultaneously considers the acquirer's stock A_t and options $C_{it}(A_t, K_i)$, $P_{it}(A_t, K_i)$ derived from it is at risk for underidentification if put-call parity holds. The same logic can be applied to target B_t's securities in the case of a cash merger, though not in that of a mixed or stock-only offer. For this reason, in a departure from previous approaches, I over-identify the system by including four options each on A and B for a total of ten restrictions on seven parameters. Thus, enough linearly independent equations remain to maintain identification in any case.

Additionally, if parity is violated it will introduce additional regression error into the estimation as the stock prices may deviate from option prices. Kalay and Pant (2008) suggest voting rights as one possible channel for parity violation, as stocks would get a premium for the votes they possess that options do not. This type of violation would cause the stock prices to include a premium not captured in Equation (2.3) and introduce additional noise into the estimation, making significant results harder to obtain. In applying the method this does not prove to be an issue.

2.2.2 Solution Concept

Using options data it is possible to present the problem of finding the vector θ, the set of variables $\{q, P_t(A|M)_t, P_t(A|N)_t, P_t(B|N)_t, \sigma_{P_t(A|M)_t}, \sigma_{P_t(A|N)_t}, \sigma_{P_t(B|N)_t}\}$ that solves Equation (2.3) as a nonlinear least squares problem tractable by the Gallant and Tauchen (1996) EMM implementation of MCMC objective function maximization to get at the optimal values of the unknown variables $P_t(A|M)_t$, $P_t(A|N)_t$, $P_t(B|N)_t$ and q_t, as well as the auxiliaries. I use the array of price relationships in the overidentified system presented in equation (2.3) to form the objective vector to be minimized. It represents the squared distance (error) between a given day's observed prices which are fed in as the data, and the prices implied by rational expectations which are a function of the seven model variables

$$\mathbf{v} = \begin{bmatrix} A_t & - & (q_t * P_t(A|M) + (1-q_t) * P_t(A|N)) \\ B_t & - & (q_t * O(P_t(A|M)) + (1-q_t) * P_t(B|N)) \\ P_t(A,K_1) & - & (q_t * BS(P_t(A|M),K_1) + (1-q_t) * BS(P_t(A|N),K_1)) \\ C_t(A,K_2) & - & (q_t * BS(P_t(A|M),K_2) + (1-q_t) * BS(P_t(A|N),K_2)) \\ \ldots & & \\ P_t(B,K_7) & - & (q_t * BS(O(P_t(A|M)),K_7) + (1-q_t) * BS(P_t(B|N),K_7)) \\ C_t(B,K_8) & - & (q_t * BS(O(P_t(A|M)),K_8) + (1-q_t) * BS(P_t(B|N),K_8)) \end{bmatrix} \tag{2.4}$$

Here $P_t(B|M)_t$ can be replaced with the publicly known offer terms, a function of the acquirer's value contingent on merger consummation: $O(P_t(A|M)_t)$. The squared error vector of differences between observed and implied prices $[p_t - \hat{p}(\theta)]$ can be used to form a standard least squares objective of the form

$$s_n(\theta) = [p_t - \hat{p}(\theta)]' \, (\tilde{W}) \, [p_t - \hat{p}(\theta)] \tag{2.5}$$

However, there are insufficient restrictions to characterize the form Ω of the covariance matrix needed to compute the GLS weighting matrix $\tilde{W} = \sigma^2(X'X)^{-1}(X'\Omega X)(X'X)^{-1}$, so instead I must use a two-step procedure to obtain the standard errors. First, I use a weighting matrix of $\tilde{W} = I$ to obtain the unbiased, but inefficient ordinary least squares estimates of θ_t for each day. Then I calculate the standard errors from this time series of estimates:

$$SE(\theta_i) = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(\hat{\theta}_{i,t} - \overline{\theta}_{i,t})^2}$$

The objective function is therefore the squared norm of the vector $\mathbf{v} = [p_t - \hat{p}(\theta)]$ representing the difference between today's observed price of the securities and the price implied by the risk-neutral expectation.

$$obj_t = \min_{q_t, P_t(A|M)_t, P_t(A|N)_t, P_t(B|N)_t} \mathbf{v}_t' \mathbf{I} \mathbf{v}_t \tag{2.6}$$

where $\mathbf{I}$ is an 10x10 identity matrix.

I use the Metropolis-Hastings algorithm to minimize the objective function numerically. The MCMC sampler draws candidate realizations of θ and generates the theoretically implied prices of securities as functions of these. It then computes the $\mathbf{v}$ vector as the difference between the observed price data and theoretically implied prices as functions of the proposed draws of the variables as in equation (2.3). The Metropolis-Hastings algorithm builds a posterior distribution for the variables by retaining proposed values in proportion to the relative amount by which they minimize the objective.

I specify an uninformative prior on all estimated variables θ. I then set the support range from which the estimation will draw proposals for the variables using historical minima and maxima observed in the past six months.

Finally, I set the starting values for the above variables based on observed levels at each iteration. I initialize the state-contingent payoffs to $P_t(A|M)_0 = P_t(A|N)_0 = A_t$ and $P_t(B|N)_0 = B_t$, the observed prices of the securities. Analogously, I initialize the state-contingent volatility variables as averages of observed implied volatilities of the option contracts used in the current iteration, $\sigma_{P_t(A|M)_t,0} = \sigma_{P_t(A|N)_t,0} =$

$\frac{iv_{A1}+iv_{A2}+iv_{A3}+iv_{A4}}{4}$ and $\sigma_{P_t(B|N)_t,0} = \frac{iv_{B1}+iv_{B2}+iv_{B3}+iv_{B4}}{4}$ where iv_{Ai} is the current day's implied volatility for the i^{th} option contract on A. I initialize the probability variable to the ratio of current target price to current offer value, using the logic of Brown & Raymond (1986).

For $obj_t = \mathbf{v}_t'\mathbf{I}\mathbf{v}_t$, the likelihood function is $\mathcal{L}(\theta) = e^{-\mathbf{v}_t'\mathbf{I}\mathbf{v}_t}$ and since the proposal density is a random walk, the drawn parameter vector θ is accepted with probability α where

$$\alpha = min\left[1, \frac{\pi(\theta_{prop}, \psi)\mathcal{L}(\theta_{prop})}{\pi(\theta_{old}, \psi)\mathcal{L}(\theta_{old})}\right] \tag{2.7}$$

since the proposal density adjustments are symmetric and correspondingly cancel out. The EMM code places possible proposal draws on a discretized grid of adjustable granularity, and draws candidate θ_{prop} from a random walk on this grid. If the Metropolis-Hastings criterion shown above does not accept the new proposal, the simulation retains the old values of θ_{old} for that iteration.

The Metropolis-Hastings algorithm produces a chain of length N $\{\theta_i\}_{i=1}^N$ of draws of the parameters describing the market's beliefs that day. Since the optimal values of θ have the highest likelihood of being accepted by Metropolis-Hastings, it is the modes of the chain that are of interest.

Repeating this procedure for all days in the period between merger start and end gives a time series of expectations about the probability of the merger as well as the expected values for both A and B in the merged and unmerged states, as well as the probability of takeover and the state-contingent volatilities. These estimates allow identification of the sources of value creation and destruction.

2.3 Applications

I apply the method developed above to two real sets of data. The first, a test of the method's ability to calculate useful information in the context of an ongoing merger negotiation, is the analysis of the market's beliefs about possible outcomes of takeover talks between Microsoft (MS) and Yahoo (YH) started on February 2008. The time series of daily estimates of the market's expectations about state-contingent values of Microsoft in the merged ($P_t(MS|M)$) and unmerged ($P_t(MS|N)$) states, as well as an analogous expectation for Yahoo ($P_t(YH|N)$) shows the evolution of beliefs through time. One expects the model to precisely estimate both state-contingent payoffs for the real acquirer and to respond to important junctures in the negotiation process in a sensible way. The second application is a test of the method's ability to ignore false information through an analysis of an implausible merger with Goldman Sachs data instead of Microsoft's. The state-contingent payoff framework is general enough to handle being fit to a non-existent merger, with a proper output placing no statistical significance on the payoffs conditioned on the merger occurring, and with a correspondingly low q_t. Finally, with both estimation results side by side, one can examine their sensitivity to important events in the negotiation. A broad negative shock to the market should affect both the real and counterfactual estimations but only the estimation with the real acquirer should show belief revision in response to a negative shock to the factual negotiation.

2.3.1 Microsoft-Yahoo, The Real Case

Using the terms of the offer as expressed by Microsoft in their February 1, 2008 letter to the Yahoo board, we can set up the system of equations developed in section 2 as follows. We can value the stock component of the offer, 1/2 the total outstanding shares of YH to be bought for .9509 $P_t(MS|M)$ shares each, at the currently expected price of MS should it win, $P_t(MS|M) = E_t(P_T(MS|M))$. The mixed offer's cash component is a fixed \$31 for the remaining half. Assuming the market takes upcoming dilutions into account in formulating the acquirer's final price, $P_t(YH|M)$ can be substituted for using the terms of one-half cash and one-half stock offer giving:

$$\begin{aligned} MS_t &= q_t P_t(MS|M) + (1-q_t)P_t(MS|N) \\ YH_t &= q_t \left[\frac{\$31}{2} + \frac{0.9509}{2} P_t(MS|M) \right] + (1-q_t)P_t(YH|N) \end{aligned}$$

The latent variables of interest, $S = \{q,\, P_t(MS|M),\, P_t(MS|N),\, P_t(YH|N)\}$, are today's expectations about the risk-neutral probability of merger and conditional valuations in the merged and unmerged states that minimize the **v** vector of differences between today's observed and expected prices. In order to be able to make use of option prices, the set of estimated parameters must be expanded with auxiliary parameters representing state-contingent volatilities for Microsoft in the merged and unmerged state, and for Yahoo in the unmerged:

$\theta_t = \{q,\, P_t(MS|M),\, P_t(MS|N),\, P_t(YH|N),\, \sigma_{(MS|M),t},\, \sigma_{(MS|N),t},\, \sigma_{(YH|N),t}\}$

I form the vector **v** from the deviations from equality in equation (2.3):

$$\mathbf{v} = \begin{bmatrix} YH_t - (q_t * O(P_t(MS|M)) + (1-q_t) * P_t(YH|N)_t) \\ MS_t - (q_t * P_t(MS|M)_t + (1-q_t) * P_t(MS|N)_t) \\ C_{1,YH_t} - q_t * E_t(C_{YH}(O(P_t(MS|M), K_1)) - (1-q_t) * E_t(C_{YH}(P_t(YH|N), K_1) \\ \cdots \\ P_{8,MS_t} - q_t * E_t(P_{MS}(P_t(MS|M), K_8) - (1-q_t) * E_t(P_{MS}(P_t(MS|N), K_8) \end{bmatrix}$$

The two stock prices and eight option prices provide sufficient restrictions to identify the seven primary and auxiliary parameters.

I obtain the price data from CRSP and OptionMetrics at daily frequency for stocks and options respectively, along with strike prices, implied volatilities, and the continuously compounded risk-free rate.

As in the general case, I take a flat prior with regard to the probability of acquisition, the state-contingent payoffs of MS and YH, and the state-contingent firm volatilities. I initialize the state-contingent payoffs to be the prices observed at market closing

$$\begin{aligned} P_t(MS|M)_{t,0} &= P_t(MS) \\ P_t(MS|N)_{t,0} &= P_t(MS) \\ P_t(YH|N)_{t,0} &= P_t(YH) \end{aligned}$$

I obtain support ranges for terminal state-contingent firm volatilities from historical volatility data, and starting values as averages of implied volatilities of option contracts in each day's dataset, $\sigma_{(MS|M)_{t,0}} = \sigma_{(MS|N)_{t,0}} = \frac{iv_{MS1}+iv_{MS2}+iv_{MS3}+iv_{MS4}}{4}$ and $\sigma_{(YH|N)_{t,0}} = \frac{iv_{YH1}+iv_{YH2}+iv_{YH3}+iv_{YH4}}{4}$ where iv_{YHi} is the current day's implied volatility for the i^{th} option contract on YH.

During the period of open negotiations, I use a simplified version of the Brown & Raymond (1986) result as the initial value for the variable representing the probability of success.

$$q_{t,0} = \frac{P_t(YH) - 22.0}{31.0 - 22.0}$$

Draws of θ are retained with a probability given by the Metropolis-Hastings rule.

I run the simulation each day for ten million iterations with each hundredth acceptance retained to minimize autocorrelation, for a chain of 100,000 draws for each day. For the purposes of comparison with an out-of-negotiation sample the data sample comprises 104 days from 01/02/2008 to 05/30/2008, with the merger negotiation period lasting 64 of those days from 2/1/2008 to 5/3/2008.

2.3.2 Discussion

The values of $\hat{\theta}_t$ along with σ_i standard errors calculated from the time series of $\hat{\theta}_t$ for the 103 days of the sample allow for a graphical examination of the evolving likelihood of value creation in the Microsoft-Yahoo merger negotiation in the Spring of 2008.

Table 2.2 presents the summary statistics of the time series of the actual Microsoft-Yahoo negotiation broken up by period. The first interval is the pre-announcement month of January. The February 1^{st} - May 2^{nd} period is the duration of the merger negotiation. Finally, the remainder of May is the post-negotiation period.

The model estimates the set of parameters with little noise, especially given the conservative nature of the Fama-McBeth-type standard errors used. Since these standard errors assume time-invariant parameter values, they cannot differentiate between belief revisions and estimation noise, and compound both into the standard error.

Period I of Table 2.2 presents a noisy estimation as the model being fit incorporates offer terms that have not yet been announced, and therefore assumes an expected payoff structure that likely not yet in place. The probability of the acquisition being completed is less than two standard deviations away from zero, and the state-contingent payoff for Microsoft in the merged state is quite noisy. The average standalone-state payoffs for both Microsoft and Yahoo correspond closely to the actual observed price averages at the time.

The Period II estimation shows an abrupt reversal from the status quo: the value of Microsoft acquiring Yahoo ($P_{(II)}(MS|M) = 33.067$) closely matches its average pre-announcement price ($P_{(I)}(MS) = 33.253$), however the standalone value of Microsoft in the same period is discounted sharply to $P_{(II)}(MS|N) = 25.572$. With the risk-neutral probability very significantly different from zero and averaging around 41%, this implies that the merger announcement revealed a fundamental overvaluation of Microsoft stock. The revision of beliefs from Period I to II comes as a jump on announcement day as shown in Figures 1-3(a). This is further supported by a substantially higher merged-state value for Microsoft, suggesting that the market believed that it could preserve most of its overstated value by using it to acquire Yahoo. This behind-the-scenes discounting of standalone value (as Microsoft's average price during the negotiation was $P_{(II)}(MS) = 28.635$) is consistent with the overvaluation explanation of mergers as in Jensen (2005) and Dong, Hirshleifer, Richardson, and Teoh (2006).

Simultaneously, the market also revised upward its estimate of the standalone value of Yahoo from the pre-announcement average of \$21.924 to $P_{(II)}(YH|N) = 26.082$. This upward revision of standalone value that accompanies the (still higher) revised merged-state value is consistent with the Song and Walkling (2000) acquisition probability hypothesis which states that firms experience abnormal returns during acquisition attempts on rivals, regardless of outcome. This is due to the signal of misvaluation implicit in the premium of the existing offer, which motivates a reassessment of the value of similar firms. Given the substantial premium at which Microsoft had offered to acquire Yahoo, the upward revision in standalone value is consistent with an expectation of similar offers in the future.

The Period III estimation shows that the market beliefs were still adjusting during the post-announcement month, as the probability of merger, though dropping slightly to 39% was significantly different from zero. This explains why the expected standalone values in Period II do not match the realized values in Period III, though historically both firms drop to, and then fall below, their expected standalone values of $P_{(II)}(MS|N) = 25.572$ and $P_{(II)}(YH|N) = 26.082$. Yahoo drops to the expected Period II value in June, and Microsoft in July. As the market's expectations of a deal persisted beyond the official end of negotiations, the standalone expected values I estimate in Period II are substantially forward-looking.

Using the period averages in Table 2.2, we are now able to address the fundamental issue of separating expected synergies from revealed information. These average estimates of the state-contingent payoffs to both firms allow the decomposition of the expected merger payoff into transaction gains to both parties and standalone value information revealed through the negotiation as in Equation (2.2), presenting a full picture of beliefs about the outcome of the merger. This decomposition represents the market's beliefs about how the total surplus generated by the transaction will be divided between Microsoft and Yahoo in Panel A of Table 2.3. Thus, the model estimates the difference between merged-state and baseline values of the two firms to be $9.11. Standard errors of differences between random variables representing the state-contingent payoffs are determined from the Fama-McBeth standard errors of the individual estimates according to $\sigma_{A-B} = \sqrt{\sigma_A^2 + \sigma_B^2 + 2 * \sigma_{A,B}^2}$ and are between $1 and $2. Statistical significance is assumed for estimates that are more than two standard deviations away from zero. Thus the per-share value expected to be created in the merger is significantly different from zero. The acquirer-specific effects are diametrically opposed, with the difference between beliefs about Microsoft in the merged and unmerged states indicating that Microsoft stands to gain $7.50 in value from the transaction, with a high degree of statistical significance. The information revealed about Microsoft's standalone value is significantly negative however, with a difference of -$7.68 between its pre-announcement baseline and expected standalone values. This suggests that the market believed Microsoft stock to be significantly overvalued on its own, but priced in the possibility of using this overvaluation to subsidize the acquisition of Yahoo. The effects for the target are both estimated to be positive, with Yahoo expected to gain $5.14 in the transaction with significance. The information the negotiation revealed about the value of Yahoo is also significantly positive, with a $4.16 upward revision of beliefs about its standalone value.

Overall, the decomposition presented in Panel A indicates that the market had a strong view on the creation and allocation of merger value, with a significant gain by Yahoo as most of the value created comes from the difference between the offer value of around $31 and Yahoo's pre-announcement value of $21.92. Though Microsoft was not expected to gain additional value beyond its pre-announcement baseline of \$33.25, the value of the transaction given by the difference between Microsoft's merged and standalone values is substantial. This value comes from the evident belief that Microsoft needed to acquire Yahoo to maintain its value. The transaction value for Yahoo is also substantially positive due to the premium offered.

The amount of information about both firms revealed in the negotiation is substantial and highly significant, with a strong downward revision of belief about the value of Microsoft and an upward one for Yahoo. This is consistent with the signals sent about the value of the two firms by the pursuit of the acquisition by the Microsoft board, and the substantial premium that Microsoft placed on Yahoo shares.

It is also interesting to compare the product of the full estimation of the variable set θ with results that would have been generated through adapting my method to the earlier approach that sought to reduce the number of parameters estimated through identifying assumptions. Panels B-C of Table 2.3 and A-C of Table 2.4 present a simplified estimation that holds constant some of the parameters using identifying assumptions similar to those of Brown and Raymond (1986), Barone-Adesi, Brown and Harlow (1994) and Hietala, Kaplan and Robinson (2003). I create the reduced-size estimation by making use of some common assumptions about the values of one or more of the elements of θ to hold it constant. By repeating the original estimation of all the parameters but the one fixed by an assumption, I demonstrate the biases that would arise if identifying the full set of θ were impossible.

As with many of the methodologies that sought to analyze the information content of stock prices alone, Panels B-C of Table 2.3 and A of Table 2.4 present a reduced-size estimation through a "fallback" assumption of a previsible value of the firm in the standalone case. As is commonly done in these cases, I take the assumed value to be a baseline pre-announcement value on the assumption that should the merger be called off, the firm in question will revert to its baseline (pre-announcement) value. For the purposes of these estimations, the baseline values are taken as the average pre-announcement month values. There are many respects with regard to which this assumption is correct, as in the case of a breakdown in negotiations no physical changes will have occurred for the firms involved. However, it does not account for the revelation of new information during the talks and this biases the results significantly.

The results presented in Table 2.3 Panel B are derived under the assumption that no new information was revealed about Microsoft, and that it will revert to its pre-announcement value if the merger falls through. Since this overstates Microsoft's standalone value significantly, the beliefs this estimation presents are significantly more pessimistic about the merged state. The merger is expected to on average destroy value, with Microsoft losing a statistically significant \$7.07 on the acquisition. Yahoo's gain is slightly, but insignificantly, negative and the updating of beliefs about its standalone value is larger than the full-estimation case, though substantially noisier.

Table 2.3 Panel C presents the opposite case of an assumption about the previsibility of Yahoo's standalone value. Since Yahoo's stock price increased significantly from the pre-announcement to the post-announcement month, by almost \$5 as seen in Table 2.2, this assumption significantly understates Yahoo's standalone value and thus is much more optimistic about the merged state. This perspective on the merger expects it to result in \$7.15 of new value, with magnified gains from merger and standalone value discount for Microsoft, and large and significant \$8.69 of gain to Yahoo that conflates gains from transaction and information revelation.

Table 2.4 Panel A employs both identifying assumptions simultaneously, as one would have to to identify the state-contingent payoffs and probability, four parameters, with only the two restrictions available through stock prices. This approach shuts down the information revelation entirely and thus misses the discounting of Microsoft's standalone value and the appreciation of Yahoo's. Thus the estimation shows a \$4.90 loss for Microsoft as it is unable to differentiate between fundamental value and the overvalued component of the firm's price. For the target, the \$7.09 merged value gain is slightly smaller than the sum of transaction gain and information revelation from Panel A. The alternative estimations in Tables 2.3-2.4 illustrate the peril of relying on historical firm data to create plausible alternatives against which to measure merger outcomes. The estimation of a subset of market beliefs appears to be highly sensitive to assumptions about the subset's complement, with a biasing effect on the entire estimation.

Table 2.4 Panel B illustrates the effect of an assumption about the probability of acquisition. For this, I use the Bhagat, Dong, Hirshleifer and Noah (2005) estimation of the unconditional success rate of tender offers in a sample of 1018 attempted acquisitions in 1962-2001. Of the 1018 offers, the target accepted 690 giving an unconditional probability of $q = 0.678$. While this is an estimation for the probability of success of a tender offer, a step which Microsoft threatened but never actually undertook in the negotiation, it gives an example of the effect that a static assumption about q would have. The average results are similar to the full estimation but are much less precise, producing standard errors that are around 25% higher.

Table 2.4 Panel C uses annualized three-month historical volatility measured in the three pre-announcement months to fix the variables representing standalone-state volatilities for both firms. This results in estimations similar to those in Panel A, with slightly lower standard errors since the volatility variables are the ones most noisily estimated.

The market's opinion of the proposed merger terms in the full estimation from Panel A shows a large \$7.50 underpayment due to Microsoft's overvalued equity coupled, perhaps unexpectedly, with a \$5.14 gain for Yahoo in a successful merger. The negotiation revealed substantial amounts of information about both participants, favorably for Yahoo and unfavorably for Microsoft. Since the market expected Microsoft to be able to preserve its value of $33.07 should its bid for Yahoo succeed, this would allow Yahoo to capture most of the substantial premium offered in the mixed cash and stock offer.

While Yahoo's CEO Jerry Yang rejected the terms as substantially undervaluing his company at $33, by November 2008 Yahoo shares had fallen below $10 and Yang had announced his impending departure. Since then its price has increased to levels only a couple of dollars below that of its pre-announcement price of $19, but it has never topped that previous level. The historical record shows that Yang could indeed have extracted more surplus from Microsoft given that the transaction was believed to be worth $7.50 per share to the firm. However, had the deal gone through as offered it would have still created substantial value for both sides, and the Yahoo CEO was criticized for turning it down.

2.3.3 Goldman Sachs-Yahoo, The Counterfactual Comparison

I now consider a fictitious merger with a counterfactual acquirer as a robustness check for the method proposed. To implement this, I repeat the same estimation presented in Panel A of Table 2.2 replacing Microsoft data with contemporaneous data for Goldman Sachs. Using hypothetical offer terms analogous in value to the real Microsoft offer, I set the stock component of the counterfactual offer to 0.155 $P_t(GS|M)$ shares each. This produces an expected payoff structure to the equity of the firms involved similar to earlier cases:

$$\begin{aligned} GS_t &= q_t P_t(GS|M) + (1-q_t)P_t(GS|N) \\ YH_t &= q_t \left[\frac{\$31}{2} + \frac{0.155}{2}P_t(GS|M)\right] + (1-q_t)P_t(YH|N) \end{aligned}$$

Adding similarly structured options payoffs produces a set of restrictions analogous to the Microsoft-Yahoo estimation:

$$\begin{bmatrix} YH_t - (q_t * O(P_t(GS|M)) + (1-q_t) * P_t(YH|N)_t) \\ GS_t - (q_t * P_t(GS|M)_t + (1-q_t) * P_t(GS|N)_t) \\ P_{1,YH_t} - q_t * E_t(C_{YH}(O(P_t(GS|M), K_1)) - (1-q_t) * E_t(C_{YH}(P_t(YH|N), K_1) \\ \dots \\ C_{8,GS_t} - q_t * E_t(P_{GS}(P_t(GS|M), K_8) - (1-q_t) * E_t(P_{GS}(P_t(GS|N), K_8) \end{bmatrix}$$

This identifies an analogous set of primary and auxiliary parameters,

$\theta = \{q,\ P_t(GS|M),\ P_t(GS|N),\ P_t(YH|N),\ \sigma_{(GS|M),t},\ \sigma_{(GS|N),t},\ \sigma_{(YH|N),t}\}$

Priors and starting points are determined analogously to the real estimation. I again run the simulation each day for one million iterations with each fourth acceptance retained to minimize autocorrelation, for a chain of 250,000 draws for each day. For the purposes of comparison with an out-of-negotiation sample, the data sample comprises 104 days from 01/02/2008 to 05/30/2008, with the merger negotiation period lasting 64 of those days from 2/1/2008 to 5/3/2008.

The counterfactual merger estimation in Table 2.5 with Goldman Sachs as potential acquirer shows the robustness of the solution method, with average probability not significantly different from zero in Periods II and III as the relatively high coefficients of 34% and 20% respectively are accompanied by standard errors of 21%. The model estimates the state-contingent values of Goldman Sachs with a high level of noise with standard errors approximately 30% of the mean. It identifies similar magnitudes for the standalone value of Yahoo to the real estimation, but with a higher standard error than the real case. The high variability of estimates is consistent with the model being misspecified, since Goldman Sachs data should have no information about the payoffs in the Microsoft-Yahoo transaction and not contribute to any meaningful identification of parameters. This shows that the solution concept is sound, and that the underlying principles of rational expectation enable differentiation between a true alternative and a counterfactual one through the comparison of the quality of estimation.

Additionally, a closer examination of a transaction-specific shock of offer terms announcement on February 1^{st} illustrates the model's ability to distinguish between real and counterfactual scenarios. Table 2.6 presents the change in the estimated parameters in reaction to both of these shocks. One should expect the negotiation-specific shock of February 1^{st} to influence only the belief revisions about the true acquirer.

The model picks up a significant revision in beliefs around Microsoft's announcement date when applied to data of the two firms involved, as presented in the first part of Table 2.6. Most directly, the estimated probability of acquisition jumps from 6.6% to 38.7%. The downward revision of Microsoft's price by 6.6% happens simultaneously with a 18% discounting of the firm's standalone value. The 48% increase in Yahoo's price is only partially matched by a 38% upward revision in standalone value, with the rest coming from the expected offer premium.

This event does not strongly affect the fictitious scenario of Goldman's acquisition of Yahoo in the second part of Table 2.6. In this scenario virtually all of the effect is captured by the standalone values. The probability of takeover rises from 7.4 to 10.5%, and while the merged value of Goldman rises, the magnitude of its 25% rise from \$92.78 to \$116.16 coupled with the \$53.65 standard error of the estimates from 2/01/2008 - 5/5/2008 shows that this is not a reliable belief. The standalone value of Goldman moves in concert with its observed stock price, dropping 5.01% and 4.12% respectively. The Yahoo standalone increase of 53.23% slightly overstates the stock price rise of 47.97%, but this is due to a discrepancy in levels with the standalone parameter rising from \$18.91 to \$28.97, and the stock rising from \$19.18 to \$28.38. Thus, an examination of the reactions of the two scenarios to the negotiation-specific shock shows a ready difference in the model's response. The real scenario shows a sensible reaction in both the merged and standalone state parameters, while the counterfactual scenario captures the majority of the effect in the standalone parameters only.

Tables 2.2-2.6 present the summary of the estimations, but it is also useful to be able to consider the evolution of market beliefs through time. Since I run the model with new closing prices each day, the time series formed by these daily estimations tracks changes in the market's expectations about the negotiation. The market seems to adjust its beliefs frequently, and significant events during the negotiation process show up as marked changes in the levels of the parameters.

The time series of estimates over the 104-day period considered are plotted with confidence intervals equal to $CI_{\theta_i} = \theta_i \pm 2\sigma_i$. Large jumps in merger success probability in Figure 2.1 are 02/1/08 and 03/17/08, the dates of important events in the negotiation process described in Table 2.7. While the risk-neutral probability of success is not the foremost variable of importance in the analysis of value creation, it does convey the market's confidence in the negotiation's progress and can be mapped to real events. The probability of success maintains a high level throughout, commensurate with analysts' pessimistic sentiments about Yahoo's future as a stand-alone company. However, it falters significantly in response to the market's general tumble over Monday's news of Bear Stearns' demise over the weekend of 03/16/08 and the seriousness of the looming subprime crisis, showing that outside events have a significant bearing on market beliefs captured by my model. The probability drops precipitously again after the ignored expiration of Microsoft's deadline for a decision by Yahoo on 4/25/08. Meanwhile, the counterfactual probability of acquisition by Goldman Sachs in Figure 2.2 remains too highly variable to be meaningful. The estimate of the value of a merged Microsoft is much more precise than the widely oscillating estimate of the value of a merged Goldman, reflecting the implausibility of the latter in Figures 2.3-2.4. Similarly, the time series of estimates of standalone value of Microsoft as the acquirer is much more precisely defined than that of Goldman Sachs in Figures 2.5-2.6. The standalone value of Yahoo shown in Figures 2.7-2.8 is similar across the real and counterfactual estimations, though more noisy in the scenario with Goldman Sachs as acquirer. This decrease in the precision of the estimates produced with Goldman Sachs data is due to model misspecification in the fictitious case.

2.4 Conclusion

I have matched the flexible solution concept of an MCMC nonlinear least squares solver to the theory of state-contingent option pricing that for the first time allows the full identification of the market's beliefs about the outcomes of a proposed takeover regardless of offer terms. By identifying the state-contingent payoffs consistent with observed prices, I am able to calculate the market's expectations about the values of a negotiation's participants in the two possible outcomes. This enables a direct comparison of the expected value of a firm in the state where the merger occurred to its value in the state where it did not, providing the strongest possible ex ante test of the value-creating potential of a merger proposal. Furthermore, since these variables are estimated based on observable closing prices on each day of a negotiation, the result is a record of the evolution of these beliefs through time.

The announcement of a merger presents a compelling opportunity to examine the information contained in market prices and to obtain valuable insight into expected sources of value creation and destruction. These sources are unobservable, and while substantial effort has been already directed at eliciting expectations about them, their identification has proven elusive. Previous research has been able to uncover some of these expectations, but it has been limited by the insufficiency of stock price data alone in identifying the market's underlying beliefs. To solve this problem, it is necessary to either reduce the set of parameters estimated, or obtain additional data points. Previous research has advanced along the former path. The method presented in this paper enables advancement along the latter.

I apply this method to the unsuccessful acquisition of Yahoo by Microsoft through a mixed cash and stock bid to demonstrate its ability to identify the market's beliefs about the proposed acquisition's outcome ex ante. The estimation identifies a substantial underpayment by Microsoft due to an overvalued share price, and a substantial value gain for Yahoo in the case of an acquisition due to the premium offered. The estimation also shows sizeable and significant belief revisions about the standalone values of the two firms.

The model discards as implausible a counterfactual acquisition of Yahoo by an unrelated firm, Goldman Sachs, showing that the method is not picking up false positives. Furthermore, I repeat the estimations with identifying assumptions about standalone values and probability of success similar to those in earlier research, demonstrating the sensitivity of results to these assumptions and therefore illustrating the value of a full estimation.

Aside from obtaining a strong view on the possibilities of value creation in a proposed merger, this method is readily applicable to other areas with binary outcomes for equity prices such as bankruptcy decisions, managerial buyouts, dilutive issuances, and corporate lawsuits. Furthermore, with modification it can be applied to situations with multiple discrete outcomes such as multi-acquirer takeover contests or corporate fire sales such as occurred later in 2008. This method of eliciting the latent beliefs that inform observable prices allows useful insight into previously hidden, but economically significant, variables.

Table 2.1: Two Possible Scenarios for a Takeover

An example of substantively different expected outcomes for a proposed merger, both of which are consistent with observed post-announcement stock prices. The sets $S_i = \{q_i, P_t(A|M), P_t(A|N), P_t(B|N)\}$ contain q, the risk-neutral probability of successful takeover, $P_t(A|M)$ the time t expected value of A conditional on the merger occurring and $P_t(A|N)$ and $P_t(B|N)$, the expectations about A and B conditional on the merger not occurring. The payoff to B in the merged state is dictated by the functional terms of the merger offer, $P_t(B|M) = O(P_t(A|M)$. Many such sets satisfy the risk-neutral pricing expectations:

$$14 = q_i * P_t(A|M) + (1-q) * P_t(A|N)$$
$$12 = q * (7 + \frac{P_t(A|M)}{3}) + (1-q) * P_t(A|N)$$

The two example belief sets we consider are:

$$S_1 = \{.6, 14\tfrac{1}{3}, 13\tfrac{1}{2}, 12\tfrac{1}{3}\}$$
$$S_2 = \{.2, 10, 15, 12.42\}$$

These two sets of beliefs reflect two very different outcomes for firms A and B, as shown below.
The two scenarios differ both in the total amount of value creation expected, and the allocation of it to the two parties. The beliefs in S_1 describe a value-creating merger with an underpayment by the acquirer. S_2 describes a value-destroying merger with a substantial overpayment. This inability to distinguish which one of these vastly different sets of beliefs is actually true shows that stock prices alone are insufficient to describe the expected effect of a merger.

Quantity of interest	S_1	S_2	Notational expression
Total value created	1.11	-4.67	$(P_t(A|M) - A_0) + (O(P_t(A|M)) - B_0)$
Acquirer gain/loss	0.83	-5.0	$P_t(A|M) - P_t(A|N)$
New acquirer info	-1.50	0.00	$P_t(A|N) - A^0$
Target gain/loss	-0.56	-2.09	$O(P_t(A|M)) - P_t(B|N)$
New target info	2.33	2.42	$P_t(B|N) - B^0$

Table 2.2: Microsoft-Yahoo: Average Estimates of Parameters by Subperiod

Summaries of the time series of estimates of the primary parameters describing the market's beliefs about merger outcomes during the 2008 negotiation. The primary parameters are q the risk-neutral probability of successful acquisition, $P_t(X|M)$ the expected payoff to firm X in the merged state, and $P_t(X|N)$ the same for the unmerged state. Parameters are estimated at the close of each trading day. Historical firm prices are also summarized as $MSFT$ and $YHOO$.
Period (I) is the pre-announcement month 01/02/2008-01/31/2008. Period (II) is the negotiation, 02/01/2008-05/02/2008. Period (III) is the post-negotiation month, 05/05/2008-05/30/2008. The total number of days is 104, and I estimate the parameters as the mode of 100,000 draws from the nonlinear least squares Metropolis-Hastings sampler for each day. The reported values are the time series averages of the daily parameter estimates by subperiod. Fama-McBeth standard errors are in parentheses.

		(I)		(II)		(III)	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
MS-YH	q_t	0.114	(0.0565)	0.415	(0.113)	0.390	(0.120)
	$P_t(MS\|M)$	25.490	(5.340)	33.067	(1.097)	32.867	(1.149)
	$P_t(MS\|N)$	34.210	(1.175)	25.572	(1.323)	26.518	(1.474)
	$P_t(YH\|N)$	21.153	(1.552)	26.082	(1.734)	23.926	(1.165)
	$MSFT$	33.253	(1.012)	28.635	(0.896)	29.114	(0.729)
	$YHOO$	21.924	(1.579)	28.262	(0.825)	26.73	(0.993)
N (days)		21		64		19	

Table 2.3: The Market's View on the Allocation of Merger Surplus in Microsoft-Yahoo Deal

Time series averages of the decomposition of value creation estimates in the negotiation between Microsoft and Yahoo, 02/01/2008-05/02/2008. I use the average firm prices for the pre-announcement month to set the baselines MS_0 and YH_0. By separately identifying the expected state-contingent values of both firms, I am able to separate Microsoft and Yahoo's respective expected gains from the merger ($[P_t(MS|M)_t - P_t(MS|N)_t]$ and $[O(P_t(MS|M)_t) - P_t(YH|N)_t]$ from expected standalone value revisions ($[P_t(MS|N)_t - MS_0]$ and $[P_t(YH|N)_t - YH_0]$). I present these quantities, as well as the total expected value of the merger ($[P_t(MS|M) - MS_0 + O(P_t(MS|M)) - YH_0]$ in Panel A.
It is also useful to compare the result of the full estimation of all seven parameters with results that would have been generated through adapting my method to the earlier approaches that sought to reduce the number of parameters estimated through identifying assumptions. Panels B-C present a simpler estimation that holds constant some of the parameters using identifying assumptions. I create the reduced-size estimation by making use of some common assumptions about the values of one or more of the elements of θ to hold it constant. By repeating the original estimation of all the parameters but the ones fixed by an assumption, I demonstrate the biases that these assumptions introduce. Here, the fallback assumption about a reversion of the value of the post-negotiation standalone state to the baseline pre-announcement value is employed for the acquirer (B) and target (C).
The total number of days in the negotiation subsample is 64, and I estimate the parameters as the mode of 100,000 draws from the nonlinear least squares Metropolis-Hastings sampler for each day. The reported values are the time series averages of the daily parameter estimates during the negotiation window. Standard errors are given in parentheses. Standard errors of differences between random variables are determined from the Fama-McBeth standard errors of the individual random variables according to $\sigma_{A-B} = \sqrt{\sigma_A^2 + \sigma_B^2 + 2 * \sigma_{A,B}^2}$.

Panel A
(Full Estimation)

	Coef.	S.E.	
Total value created	9.112	(1.619)	$(P_t(MS|M) - MS_0) + (O(P_t(MS|M)) - YH_0)$
Acquirer gain/loss	7.495	(2.032)	$P_t(MS|M) - P_t(MS|N)$
New acquirer info	-7.681	(1.323)	$P_t(MS|N) - MS_0$
Target gain/loss	5.140	(2.054)	$O(P_t(MS|M)) - P_t(YH|N)$
New target info	4.158	(1.734)	$P_t(YH|N) - YH_0$
N (days)	64		

Panel B
$P_t(MS|N) = MS_0 = 33.253$

	Coef.	S.E.	
Total value created	-1.038	(2.273)	$(P_t(MS|M) - MS_0) + (O(P_t(MS|M)) - YH_0)$
Acquirer gain/loss	-7.074	(1.541)	$P_t(MS|M) - P_t(MS|N)$
New acquirer info	0.000	(N/A)	$P_t(MS|N) - MS_0$
Target gain/loss	-1.491	(2.551)	$O(P_t(MS|M)) - P_t(YH|N)$
New target info	7.527	(2.928)	$P_t(YH|N) - YH_0$
N (days)	64		

Panel C
$P_t(YH|N) = YH_0 = 21.924$

	Coef.	S.E.	
Total value created	7.153	(1.526)	$(P_t(MS|M) - MS_0) + (O(P_t(MS|M)) - YH_0)$
Acquirer gain/loss	9.888	(2.710)	$P_t(MS|M) - P_t(MS|N)$
New acquirer info	-11.413	(2.129)	$P_t(MS|N) - MS_0$
Target gain/loss	8.689	(0.492)	$O(P_t(MS|M)) - P_t(YH|N)$
New target info	0.000	(N/A)	$P_t(YH|N) - YH_0$
N (days)	64		

Table continues on next page

Table 2.4: Effect of Other Common Identifying Assumptions on the Allocation of Merger Surplus in Microsoft-Yahoo Deal

Panels A-C present additional simplified estimations that hold constant some of the parameters using identifying assumptions. I create the reduced-size estimation by making use of some common assumptions about the values of one or more of the elements of θ to hold it constant. By repeating the original estimation of all the parameters but the ones fixed by an assumption, I demonstrate the biases that these assumptions introduce. Here, the fallback assumption about a reversion of the value of the post-negotiation standalone state to the baseline pre-announcement value is employed for both the acquirer and target (A). The full-sample unconditional mean success rate of tender offers from Bhagat, Dong, Hirshleifer and Noah (2005) is used as the fixed value for the probability of success (B). I also use the three-month annnualized historical volatility measured over the three months previous to announcement to fix the values of standalone firm volatility variables (C).
The total number of days in the negotiation subsample is 64, and I estimate the parameters as the mode of 100,000 draws from the nonlinear least squares Metropolis-Hastings sampler for each day. The reported values are the time series averages of the daily parameter estimates during the negotiation window. Standard errors are given in parentheses. Standard errors of differences between random variables are determined from the Fama-McBeth standard errors of the individual random variables according to $\sigma_{A-B} = \sqrt{\sigma_A^2 + \sigma_B^2 + 2 * \sigma_{A,B}^2}$.

Panel A

$P_t(MS|N) = MS_0 = 33.253,\ P_t(YH|N) = YH_0 = 21.924$

	Coef.	S.E.	
Total value created	2.186	(1.311)	$(P_t(MS|M) - MS_0) + (O(P_t(MS|M)) - YH_0)$
Acquirer gain/loss	-4.901	(0.889)	$P_t(MS|M) - P_t(MS|N)$
New acquirer info	0.000	(N/A)	$P_t(MS|N) - MS_0$
Target gain/loss	7.087	(0.423)	$O(P_t(MS|M)) - P_t(YH|N)$
New target info	0.000	(N/A)	$P_t(YH|N) - YH_0$
N (days)	64		

Panel B

$q_t = \bar{q} = 0.677$

	Coef.	S.E.	
Total value created	5.473	(1.904)	$(P_t(MS|M) - MS_0) + (O(P_t(MS|M)) - YH_0)$
Acquirer gain/loss	5.939	(2.383)	$P_t(MS|M) - P_t(MS|N)$
New acquirer info	-8.592	(2.721)	$P_t(MS|N) - MS_0$
Target gain/loss	4.998	(2.583)	$O(P_t(MS|M)) - P_t(YH|N)$
New target info	3.127	(2.827)	$P_t(YH|N) - YH_0$
N (days)	64		

Panel C

$\sigma_{(MS|N),t} = \bar{\sigma}_{MS} = 0.252,\ \sigma_{(YH|N),t} = \bar{\sigma}_{YH} = 0.503$

	Coef.	S.E.	
Total value created	8.460	(0.921)	$(P_t(MS|M) - MS_0) + (O(P_t(MS|M)) - YH_0)$
Acquirer gain/loss	7.544	(1.720)	$P_t(MS|M) - P_t(MS|N)$
New acquirer info	-8.172	(1.425)	$P_t(MS|N) - MS_0$
Target gain/loss	5.207	(1.533)	$O(P_t(MS|M)) - P_t(YH|N)$
New target info	3.881	(1.502)	$P_t(YH|N) - YH_0$
N (days)	64		

Table 2.5: Goldman Sachs-Yahoo: Average Estimates of Parameters by Subperiod

Summaries of time series estimation of the primary parameters describing the market's beliefs about merger outcomes for the counterfactual control estimation for the period of Microsoft's offer negotiation. The control is contemporaneous data for Goldman Sachs. The primary parameters are q the risk-neutral probability of successful acquisition, $P_t(X|M)$ the expected state-contingent payoff to firm X in the merged state, and $P_t(X|N)$ the same for the unmerged state. Historical stock prices are also summarized as GS and $YHOO$.
Period (I) is the pre-announcement month 01/02/2008-01/31/2008. Period (II) is the negotiation, 02/01/2008-05/02/2008. Period (III) is the post-negotiation month, 05/05/2008-05/30/2008. The total number of days is 104, and the parameters are estimated as the mode of 100,000 draws from the nonlinear least squares solution using each day's closing price data. The coefficients are the time series averages of the daily parameter estimates by subperiod. The standard errors are given in parentheses.

		(I)		(II)		(III)	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
GS-YH	q	0.139	(0.065)	0.341	(0.218)	0.204	(0.206)
	$P_t(GS\|M)$	122.037	(28.346)	147.154	(53.655)	127.656	(38.883)
	$P_t(GS\|N)$	206.743	(6.035)	168.460	(24.019)	185.955	(20.432)
	$P_t(YH\|N)$	21.365	(1.504)	27.164	(2.170)	25.952	(2.292)
	GS	196.461	(5.140)	176.328	(11.640)	184.937	(7.793)
	$YHOO$	21.924	(1.579)	28.262	(0.825)	26.73	(0.993)
N (days)		21		64		19	

Table 2.6: Real and Counterfactual Estimation Responses to Microsoft Offer Announcement

The transaction-specific shock on February 1st illustrates the model's ability to distinguish between real and counterfactual scenarios. The shock is the announcement of the unsolicited offer by Microsoft to the Yahoo board.
For both the real and counterfactual scenario, with Microsoft and Goldman Sachs data respectively as the acquirer for Yahoo, I present the pre-announcement day estimates of the main parameters, the announcement-day estimates, and the percentage change between the two. This change captures the market's initial revision of beliefs upon incorporating the announcement news. I obtain both sets of estimates through MCMC nonlinear least squares using closing price data.
Examining the parameter changes from their previous-day values shows the method's ability to differentiate between real and fictional mergers by incorporating new information appropriately. The counterfactual estimation has standalone value revisions that simply track the price changes of the day during the transaction-specific announcement event. The change in the probability parameter is an order of magnitude higher in the real estimation, corresponding to the substantially increased likelihood of acquisition estimated in the case when real signal is conveyed through prices.

		Parameter					
Scenario		$\hat{q}_t$	$\hat{P}_t(A\|M)$	$\hat{P}_t(A\|N)$	$\hat{P}_t(YH\|N)$	$P_t(A)$	$P_t(YH)$
True (A=MS)	1/31/2008	0.066	20.719	33.219	18.719	32.60	19.18
	2/01/2008	0.387	35.156	27.094	25.844	30.45	28.38
	% Change	482.36%	69.68%	-18.44%	38.06%	-6.60%	47.97%
False (A=GS)	1/31/2008	0.074	92.781	208.16	18.906	199.55	19.18
	2/01/2008	0.105	116.16	218.59	28.969	207.78	28.38
	% Change	42.11%	25.20%	5.01%	53.23%	4.12%	47.97%

Table 2.7: Notable Events

Relevant events during the merger negotiation between Microsoft and Yahoo during 02/01/08–05/04/08 obtained from a survey of the ABI-INFORM database of financial news articles from the time period.

Date	Event
02/01/08	Merger terms are announced to Yahoo board.
02/11/08	Yahoo board of directors rejects terms of offer.
02/28/08	Microsoft is fined an additional 899m euros for violating anti-competitiveness laws.
03/06/08	Yahoo announces indefinite delay of board nominations to avoid decision on merger.
03/11/08	News Corp announces intent to not compete with Microsoft in acquisition contest.
03/14/08	Microsoft and Yahoo executives meet for the first time to discuss bid, no banking advisors present.
03/17/08	JP Morgan buys Bear Stearns for $2 per share, stock markets fall in the face of subprime crisis.
03/19/08	Yahoo issues optimistic forecast suggesting Microsoft offer is undervalued.
04/04/08	Another executive meeting occurs, with no resolution.
04/07/08	Microsoft sets a self-imposed deadline of April 26^{th} for resolution of friendly negotiations, threatens hostile takeover otherwise.
04/11/08	Yahoo considers alliance with Time Warner, a deal with News Corp, or a combined Microsoft-News Corp acquisition.
04/15/08	Google-Yahoo strategic alliance is seen as unlikely to be permitted by regulators.
04/23/08	Yahoo reports positive profits in excess of expectations as Microsoft deadline closes. Microsoft refuses to raise offer.
04/26/08	Microsoft deadline for commencing hostile takeover, but no decision is made by either side. Microsoft threatens both hostile bid and termination of negotiations.
04/28/08	19 Wall Street brokerages are convinced Microsoft will pursue hostile bid, 3 believe it will raise offer, 3 more believe it will terminate negotiations.
04/29/08	Microsoft considers naming alternate board for Yahoo and initiating a proxy fight. No negotiations occur.
05/01/08	Microsoft board of directors can't reach a consensus about raising offer to $33, starting a proxy fight, or ending negotiations.
05/02/08	Microsoft is rumored to consider a hostile bid of $33.
05/03/08	Microsoft negotiates with Yahoo about a friendly bid increase to $33.
05/04/08	The increase is not fruitful, and Microsoft abandons negotiations.

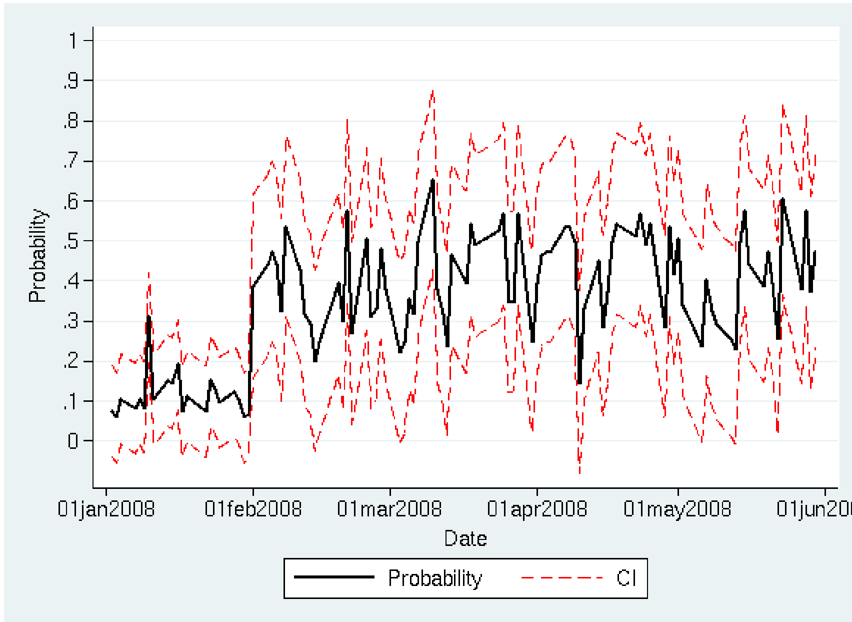

Figure 2.1: Time series of estimates of the market's beliefs about $\mathbb{Q}$-probability of success: MS-YH

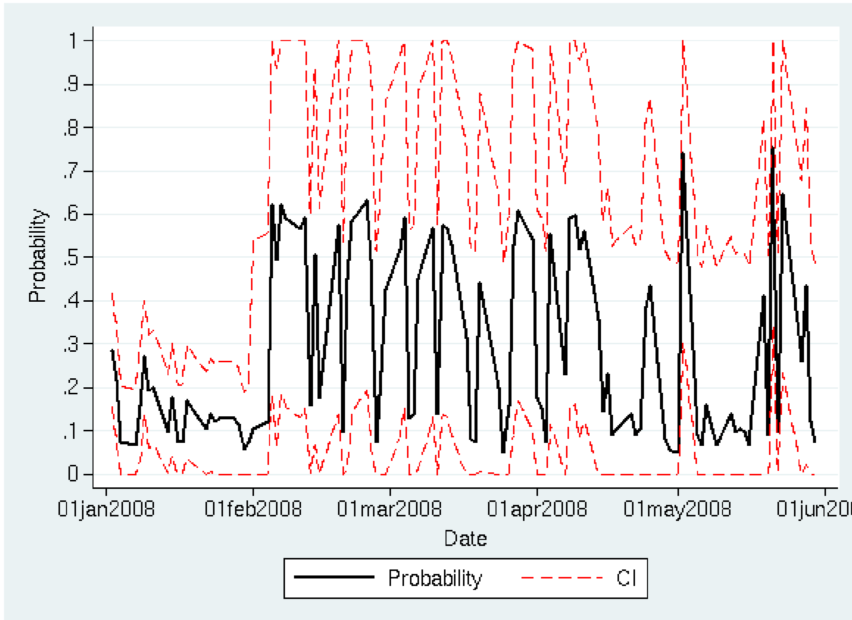

FIGURE 2.2: Time series of estimates of the market's beliefs about $\mathbb{Q}$-probability of success: GS-YH

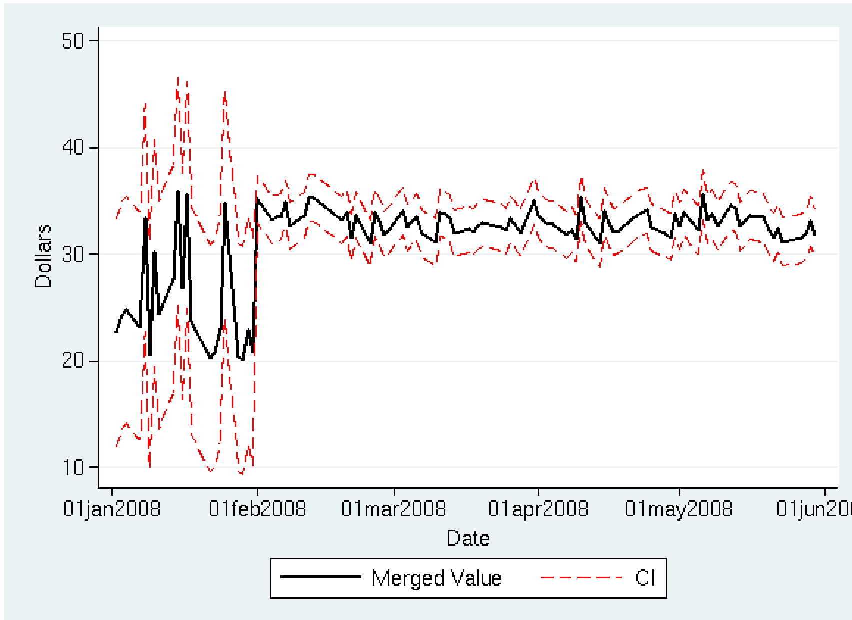

FIGURE 2.3: Time series of estimates of the market's beliefs about the value of the combined firm, $P_t(A|M)$: MS-YH

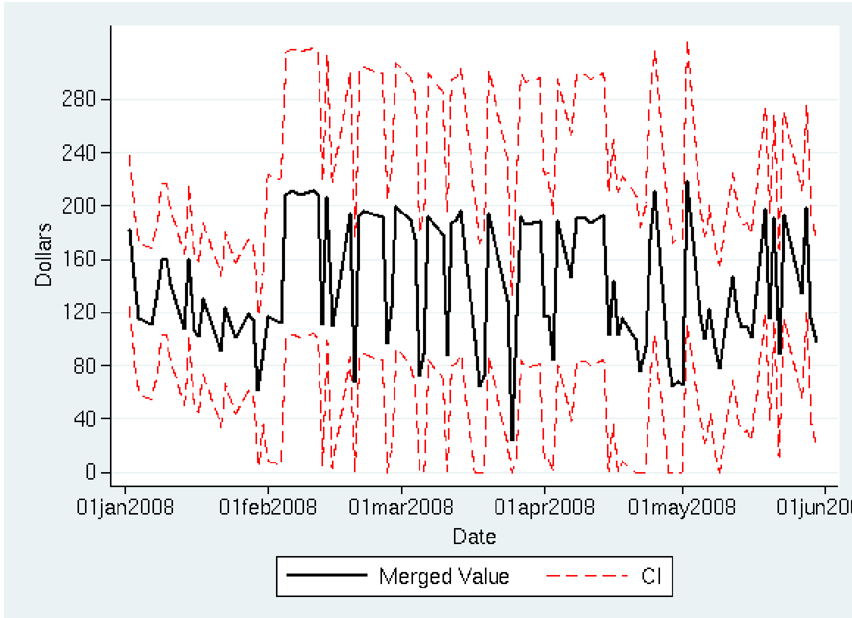

Figure 2.4: Time series of estimates of the market's beliefs about the value of the combined firm, $P_t(A|M)$: GS-YH

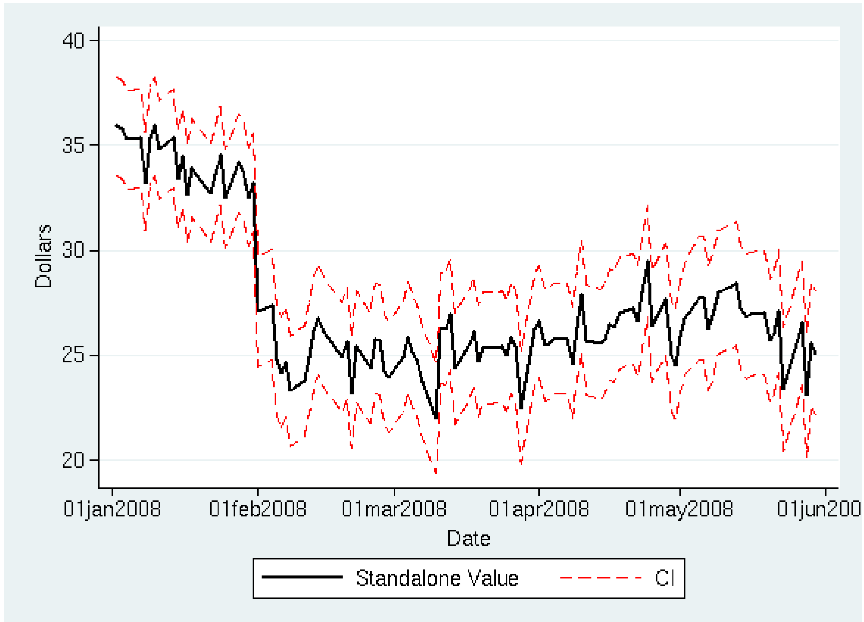

FIGURE 2.5: Time series of estimates of the market's beliefs about the standalone value of the acquirer, $P_t(A|N)$: MS-YH

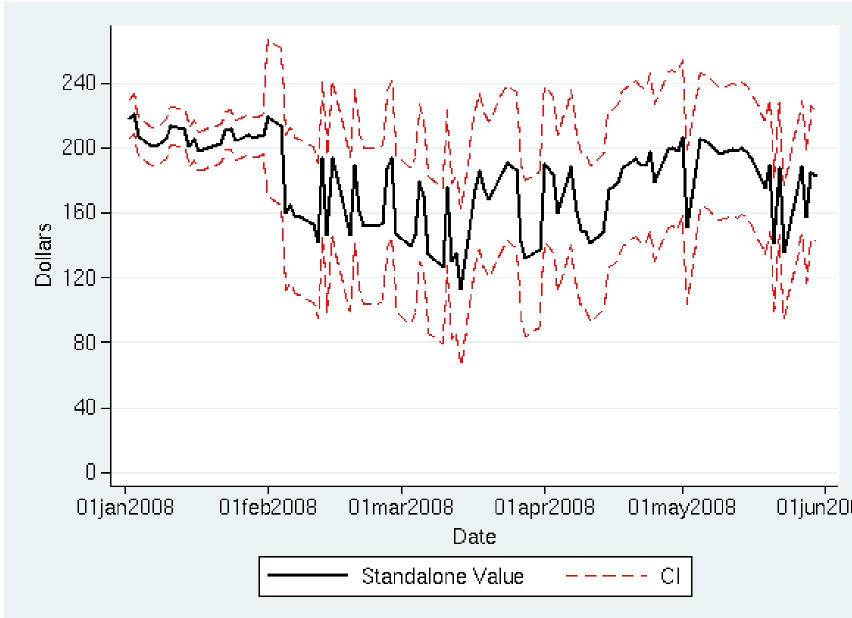

FIGURE 2.6: Time series of estimates of the market's beliefs about the standalone value of the acquirer, $P_t(A|N)$: GS-YH

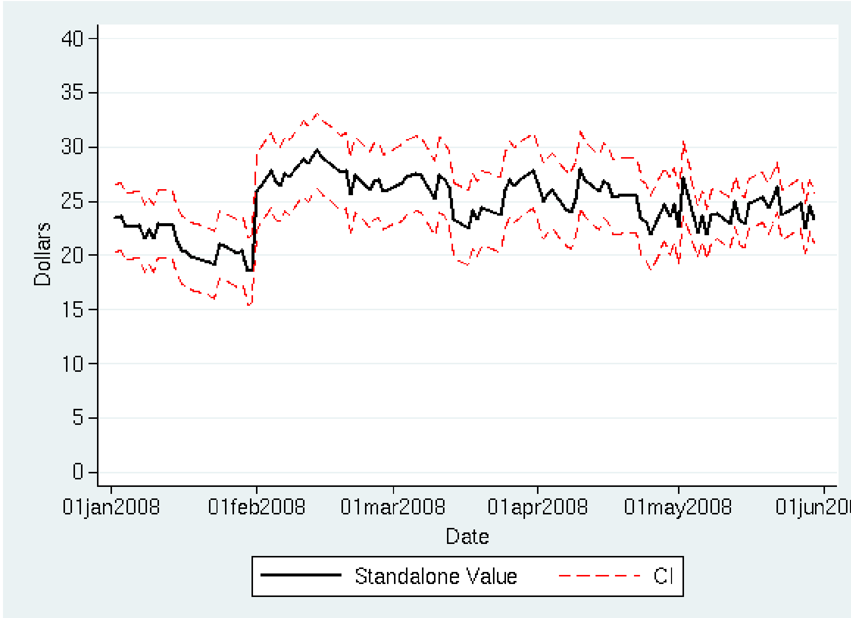

FIGURE 2.7: Time series of estimates of the market's beliefs about the standalone value of the target, $P_t(B|N)$: MS-YH

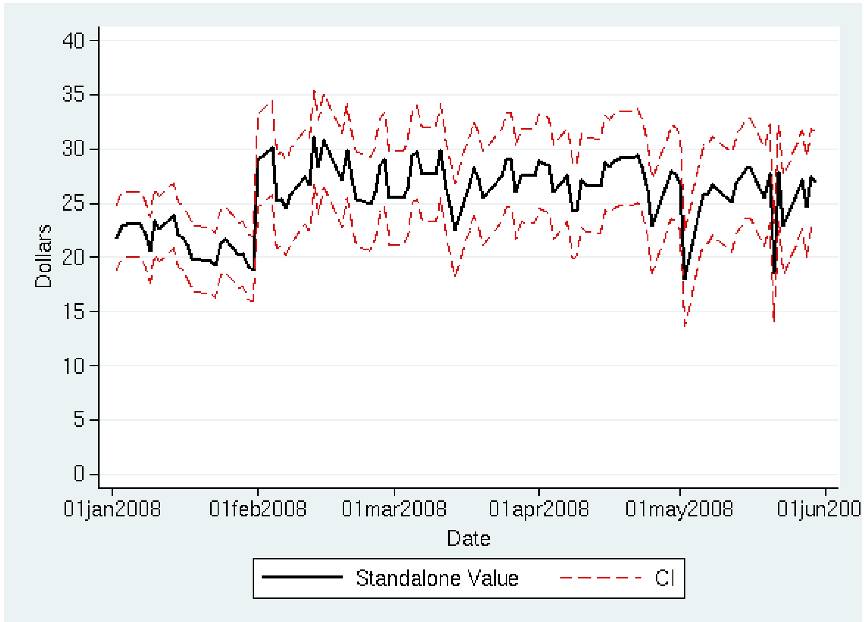

Figure 2.8: Time series of estimates of the market's beliefs about the standalone value of the target, $P_t(B|N)$: GS-YH

3

When and Why Does Size Destroy Value in Mergers?

3.1 Introduction

Four competing theories have been advanced to explain the growing body of evidence that large acquisitions destroy value. These are acquirer overvaluation, lack of internal projects, managerial hubris, and managerial agency issues. Fundamentally, these four effects are divisible into two broad categories: revision of beliefs about the acquirer as a standalone entity, and expectations about the value of the combined firm. The above leading theoretical explanations for price changes around mergers fall into one or the other. Observable prices conflate standalone value revisions and merged value expectations, making measurement difficult. The contribution of this paper lies in disentangling the two, thereby providing new data on when and why value is destroyed during mergers. I examine the effect of acquirer and transaction size on the market's expectations about the acquirer's merged and standalone state. The results demonstrate that transaction size is correlated with value destroying mergers, whereas acquirer size is correlated with standalone value revisions. I am further able to discriminate between the value destroying effects of hubris and agency by considering the context for overpayments.

Stock overvaluation and a lack of internal investment opportunities are effects specific to the acquirer as a standalone entity. Both have been theorized to cause negative abnormal acquirer returns. Stock overvaluation gives managers incentive to cash out through acquisition (Shleifer and Vishny, 2003; Jensen, 2005). The announcement of such an acquisition may lead to revaluation and a collapse in the standalone firm's value. Similarly, a lack of quality internal projects (McCardle and Viswanathan, 1994; Jovanovic and Braguinsky, 2002) revealed during a takeover bid causes a revision of beliefs about the value of the firm attempting the acquisition.

Theories that explain value destruction in the merged firm deal with managerial behavior. The first of these is the hubris hypothesis advanced by Roll (1986), under which managers who overvalue potential targets are the ones most likely to overpay. The second concerns managerial agency issues raised by Jensen (1986) and Shleifer and Vishny (1989). Suboptimal acquisitions result when managers engage in empire-building rather than returning free cash flows to shareholders for personal benefits or when they seek job security through entrenchment in an increasingly complex firm. Determining which of these theories correlate with the stylized facts about size and merger value change is a useful contribution to the literature of corporate governance. This decomposition of value change is nontrivial since observed prices include expectations about both standalone and merged firm value.

When a merger is announced, the market forms beliefs about the possible outcomes and adjusts prices. It estimates the probability of a successful takeover. Simultaneously, it updates its beliefs about the standalone values of the bidder and target companies should they remain independent, as well as the value of the combined firm should the merger succeed. These beliefs determine stock price reactions to a merger announcement, but these stock prices do not contain sufficient information to separately identify the underlying beliefs that they reflect. Of the four theories explaining post-announcement acquirer losses, the former two affect the estimate of the firm's standalone value and the latter two the value of the combined firm. Only one of these two values is directly measurable even after takeover negotiations are resolved, making it difficult to find support for any of the four proposed explanations. This precludes clear recommendations for corporate governance.

I am able to address this difficulty using the merger value change decomposition method from Borochin (2011). By augmenting stock data on public targets and acquirers with option prices, I am able to infer the possible outcomes of the merger announcement ex ante. Options markets contain sufficient information in the form of unique contracts to place sufficient identifying restrictions on the market beliefs above. Moreover, this approach is generalizable to all types of merger announcements regardless of offer terms. I am therefore able to simultaneously identify the market's expectations about the value of a firm in both the merged and standalone states, as well as the probability of either. Comparing its expected standalone value to a pre-announcement baseline gives an estimate of the news revealed about a firm during the negotiation. Similarly, comparing the expected standalone and merged values of a firm gives an estimate of the value created or destroyed in the transaction.

Both equity overvaluation and lack of investable internal projects should manifest themselves as bad news about the acquirer, affecting its standalone value. Managerial hubris and agency problems should instead show up as merged value destruction, since their effects on firm value require the takeover to occur. I am able to see whether standalone value revision or expected merged-state value destruction is correlated with large acquisitions. Separately considering these channels of firm value change helps to identify the mechanism by which large mergers have been observed to go badly.

A size effect in mergers has been documented and studied in both acquiring firm and deal sizes. Moeller, Schlingemann and Stulz (2004) report a robust negative bidder size effect in cumulative abnormal returns controlling for deal and firm characteristics in both private and public firms. The robustness of the effect leads the authors to suggest managerial hubris is the cause. In a later paper, Moeller, Schlingemann and Stulz (2005) also report that a small subset of large-loss and large-size deals during the 1998-2001 boom period was responsible for the average value loss from mergers during that interval. These large loss deals were often preceded by successful deals, but seldom followed by them. Due to the previous acquisition successes the authors rule out the lack of internal projects as the sole explanation, and due to the magnitude of losses for both acquirers and targets in the 2005 data they rule out the value transfer implied by the hubris hypothesis. The authors instead suggest that the acquirers' losses are due to revisions of standalone value from the negative signal the large loss acquisition sends about the firms' future expansion prospects. In a recent working paper, Bayazitova, Kahl and Valkanov also show that in 1980-2007 deals a specific population of large-size large-loss deals exists. In addition to CAR analysis, they use analyst forecasts and the intervention method from Bhagat, Dong, Hirshleifer & Noah (2005) to estimate the expected value improvement from the first bidder's price fluctuation in the case of a contested deal. Their analysis also shows value destruction taking place. Since firms that engage in these deals have weaker corporate governance, they hypothesize that the cause is managerial malfeasance.

One cannot easily find direct support for any of the four size effect explanations through observation of firm price movements because it is not clear whether the market is revising standalone or merged firm value, or both. This makes the decomposition of the overall size effect into standalone value and deal value effects useful. This utility relies on the assumption that the lack of internal projects and equity overvaluation theories affect standalone value revision, while managerial hubris and agency problems affect expected merged value. I am able to show that transaction size is correlated with value destruction in the merged state. Conversely, acquirer size is correlated with downward value revision in the standalone state. Since I demonstrate that the transaction size effect manifests in the merged state value only, it is likely caused by managerial hubris or malfeasance - the two explanations of value destruction through mergers. It is unlikely to be caused by equity overvaluation or lack of investable projects, because those two explanations are expected to affect standalone state since they signal new information about the standalone value of the acquiring firm. Following similar logic, since acquirer size affects downward revision of standalone state acquirer value, the acquirer size effect is likely to be driven by the revelation of bad news about firm value inherent in those two theories rather than by value destruction through bad acquisitions.

I next explain the decomposition of observed price reactions into merged-state and standalone-state effects, and the method of eliciting market beliefs about their respective quantities. Then I apply this decomposition to generate a time series of estimated market beliefs for 30 of the largest proposed deals in 2002-2009. I then use regression analysis to show whether the negative deal size effect is correlated with expectations of downward revision of standalone value or destruction of value in the merged firm. This enables me to differentiate between the four possible explanations of negative acquirer returns since two of them are hypothesized to affect expectations about standalone value change and the other two are hypothesized to affect expected merged value. I conclude with discussion and future extensions.

3.2 Methodology

The analysis starts with a dataset of observable firm prices. I need both stock and option prices to achieve identification of market beliefs about merger outcomes, requiring acquirers and targets that both have frequently traded options. This means focusing on large acquisitions in recent times. I therefore sort the SDC dataset of domestic mergers from 2002-2009 by announcement-day transaction value. Transaction value is defined as the total value of consideration paid plus liabilities assumed and excluding fees. When common stock is part of the deal, it is valued based on its closing price on the last trading day before announcement. This definition allows a transaction value to be assigned at announcement regardless of the later outcome of the negotiation. I take 30 deals with liquid options from this ranked list, requiring four traded contracts each day for both participant firms. For the actual price data, I turn to CRSP and OptionMetrics for stock and option prices respectively. When choosing between option contracts, I sort them by daily volume since the most frequently traded contracts should have the most informative prices. Since negotiation durations vary from two months to more than a year, I limit the time series of prices to the post-announcement month for the sake of consistency between deals.

I apply a two-step procedure to these data to measure the impact of deal size on both standalone and merged-state values of the acquirer and target firms. First, I use daily security prices for each firm to identify its expected values in both potential outcomes for each firm during a merger negotiation, whether the acquisition is accomplished or whether it remains independent. I estimate these expectations daily for the first post-announcement month, forming a time series for each of the deals considered. Second, I combine the time series produced for each deal in the first step, and run regressions controlling for deal and firm characteristics, the market, and uncertainty in the estimation from the earlier step. This regression allows me to measure the effect of deal size and acquirer size on expected state-contingent firm values and separate the effects relevant to revisions in standalone value (the lack of growth options and overvaluation) from the ones relevant to merged firm value (managerial hubris and agency issues).

The use of multiple security prices as restrictions on latent parameters describing market beliefs follows Borochin (2011). The set of parameters S_t necessary to fully describe the time t market beliefs about possible outcomes of a negotiation between acquirer A and target B is parsimonious. As new information is potentially revealed every day, the set's components are time-varying: $S_t = \{q_t,\ P_t(A|M),\ P_t(A|N),\ P_t(B|N)\}$ whose elements are q_t, the probability of successful takeover, $P_t(A|M)$ the expected value of A conditional on the merger occurring and $P_t(A|N)$ and $P_t(B|N)$, analogous expectations of firm value conditional on it not occurring. $P_t(B|M)$ is determined by the offer terms, and will often depend on the value of $P_t(A|M)$ as many large offers combine cash and equity. I estimate the daily values of these parameters for the first post-announcement month of each transaction.

These latent parameters representing market beliefs are sufficient to express the quantities of economic interest at the heart of merger analysis. Following the work of Hietala, Kaplan and Robinson (2003), I construct the market's expectations about synergy, transaction gains, and standalone value revisions as functions of the parameters in the set of beliefs S_t:

$$\begin{aligned}
Total\ Synergy\ Captured\ by\ Shareholders &: [P_t(A|M)_t - A_0 + O(P_t(A|M)_t) - B_0] \\
Acquirer\ Gain\ From\ Merger &: [P_t(A|M)_t - P_t(A|N)_t] \\
Target\ Gain\ From\ Merger &: [O(P_t(A|M)_t) - P_t(B|N)_t] \\
Updated\ Acquirer\ Standalone\ Value &: [P_t(A|N)_t - A_0] \\
Updated\ Target\ Standalone\ Value &: [P_t(B|N)_t - B_0]
\end{aligned}$$

This analysis requires an estimate of the pre-announcement values of the acquirer and target A_0 and B_0 respectively, which I separately measure as the average of the [-20,-1] pre-announcement trading day interval.

Since the acquirer and target's daily stock prices are generally insufficient to identify the values of the four belief parameters in S_t, following Borochin (2011) I obtain additional data points using daily option prices. The prices of the options in the merged and standalone states can be expressed as functions of the beliefs about payoffs to equity described in S_t above and the Black-Scholes pricing formula to represent dispersion about those levels. This also requires the parametrization of beliefs about state-contingent volatilities for the two firms, which are treated as nuisance parameters.

The first step proceeds one transaction, one day at a time. It uses an MCMC solver to identify each day's values of the latent belief parameters in S_t, using observable prices as restrictions. Thus, its inputs are the daily stock prices of the target and acquirer, the daily option prices for four of the most liquid contracts for both firms as measured by trading volume, and the riskfree rate. These are collected every day during the post-announcement month. During 2002-2009, the 30 largest transactions in the SDC database with liquid options such that there is a nontrivial number of days where eight contracts have a trading volume above zero range from the ATT-Bellsouth merger valued at \$70bn to Thermoelectric-Fisher valued at \$10bn. Table 1 shows the effect of size on firm returns in my sample. The table shows the effect of acquirer size and deal size on changes in price from pre-announcement baseline values for the 30 sample transactions. *transval* is the final value of the deal and A_0 is the pre-announcement value of the acquirer, both in units of \$10bn. I control for negotiation, offer, and acquisition types by adding dummy variables $friendly$ for friendly negotiations, *cashonly* and *stockonly* for offers including only one or the other, and *sameind* for acquisitions between firms in the same industry. For both firms, the announcement-day return $R(X_{ann})$ is the change in value on announcement day normalized by baseline value, and the final return $R(X_T)$ is the holding period return for the entire negotiation window. Superficially, the size of the transaction does not seem to matter, while acquirer size does significantly affect the firm's own returns for the holding period. For each \$10 billion of acquirer value, the net return to the acquiring firm decreases by 1.4%. This suggests that even in the category of large deals, variation in firm size may affect outcomes. However, stock price data alone is insufficient to determine what the causes of this value change are.

Table 2 presents a summary of the transactions in the data sample for the first step of the analysis, the estimation of market beliefs. The table shows the descriptive statistics of of the dataset of the largest 30 merger deals with liquid options from the SDC database in 2002-2009. Control dummy variables represent successfully concluded deals ($outcome = 1$), friendly negotiations ($friendly = 1$), stock-only and cash-only offers ($stockonly = 1$; $cashonly = 1$), and same-industry acquisitions ($sameind = 1$). The *duration* of the negotiation is measured in months. The pre-announcement values of the target B_0 and acquirer A_0 firms, as well as the final deal size $transval$ are in units of nominal \$10bn. I compute announcement day returns as the normalized change from pre-announcement day prices for both target $R(B_{ann})$ and acquirer $R(A_{ann})$. The top 30 deals reflect previously documented details of large mergers: over 80% of them are friendly, over 90% of them ultimately succeed, the acquirer is larger than the target, and the acquirer's return is negative whereas the target's is positive, albeit with high dispersion. I apply the MCMC belief estimation method for each day in each transaction in this sample. Not all deals have sufficiently liquid options markets to obtain the eight liquid option contracts necessary for overidentification on each day, so some time series are shorter than the full post-announcement month.

The need for informative option prices requires the use of near-term options because they are the most frequently traded. I therefore restrict the minimum maturity to be greater than one month, and then select the most liquid contracts each day. Because of this, the maturities of the contracts used are generally within the range of two to three months. This is a departure from Borochin (2011) which specified options with maturities greater than the expected unconditional duration of merger negotiations. As a robustness check, I repeat both steps of the analysis with contract maturities exceeding six months. The results from both steps are similar to those produced with near-term options, but much noisier.

A summary of the time series of evolving market beliefs produced by the first step is presented in Table 3. The table shows the average values of the modes and standard errors of estimated belief parameters and their economically significant functions for the 30 transactions during the first month of negotiations. The expectations elicited are q, the risk-neutral probability of the deal succeeding, $R(A^m)$,the return to the equity of the acquirer in the merged state, $R(A^u)$, the return to the equity in the standalone state, $R(B^m)$, the return to the equity of the target in the merged state, $R(B^u)$, the return to the equity of the standalone state, $R(synergy)$, the combined merged-state return to both firms in excess of their pre-announcement values, $R(A^m - A^u)$, the merged-state return to the acquirer in excess of its standalone value, $R(A^u - A_0)$, the standalone-state return to the acquirer in excess of the pre-announcement price, $R(B^m - B^u)$, the merged-state return to the target in excess of its standalone value, and $R(B^u - B_0)$, the standalone-state return to the target in excess of the pre-announcement price. I calculate the standard errors ($SE(.)$) of A^m, A^u, B^m, B^u from the daily MCMC chains, and estimate the standard errors of the merged-state differences ($SE(A^m - A^u)$, $SE(B^m - B^u)$) assuming independence between the variables.

The average probability of success is statistically different from zero, but substantially less than the 93% ex-post probability observed from deal outcomes. The acquirer is expected to have negative returns (relative to pre-announcement value) in both merged and standalone states, though the averages are not statistically significant. The target can expect statistically significant positive returns in the merged state, and insignificantly positive returns in the standalone. The return expected to accrue to the combined firms should (synergy) is not significantly different from zero. The average difference between returns in merged and standalone states, indicative of expected gains from the transaction, is negative for the acquirer and positive for the target, albeit with high dispersion. The return expected in the standalone state in excess of the baseline prices, indicative of information revelation about the standalone value of the firms, is slightly negative for acquirers and positive for targets, also without statistical significance. The data must be analyzed further.

The second step follows standard econometric procedures for analyzing pooled data from several groups. I estimate heteroskedasticity-robust standard errors, and cluster observations at the deal level. I control for market movements during the time of the transactions by adding S&P 500 data, as well as parameter uncertainty by including the standard errors from the first step. The results of the second step, comprising the main points of the paper, are presented below.

3.3 How Size Affects Merger Value

The two-step approach this analysis takes allows a separate, simultaneous examination of the effect of acquirer and deal size on expected value creation from acquisition and revised beliefs about firm standalone values. Of the four main hypothesized channels of value change during merger negotiations, the theories of equity overvaluation and lack of investment options manifest themselves through revised standalone values as the proposed new information is absorbed by the market. Analogously, hubris and managerial malfeasance manifest themselves through the destruction of acquirer value through deal consummation as the proposed behaviors result in suboptimal acquisitions. I summarize these results in Table 4.

The table shows the effect of deal characteristics and size on expected synergies and individual firm gains expected from the merger transaction itself and revisions about standalone value in units of \$10bn. Dummy variables control for friendly negotiations ($friendly = 1$), stock-only and cash-only offers ($stockonly = 1$; $cashonly = 1$), and same-industry acquisitions ($sameind = 1$). The level of the S&P500 index in thousands, $SP500_t$, controls for the state of the market's influence on expected payoffs. Firm and deal size has a significant effect on value creation in merger deals. Acquirer size causes a loss in expected synergies of 9.2% of their own size. Large acquirers also experience substantial negative information revelation upon announcement, around 14% of their total pre-announcement value. Acquirers making large deals are expected to lose \$0.34 of every \$1 of deal size, destroying value. Interestingly, deal size positively affects expectations about acquirer value in cases of merger failure, by 18% of deal size. The targets of large deals experience substantial positive information revelation upon announcement of a takeover, around 16% of the deal's value. The size of the acquiring firm has a negative impact on its standalone value, consistent with bad news about the acquirer. The size of the deal has a negative impact on the takeover gains for the acquirer, consistent with value destruction, and a positive impact on the standalone value of the target, consistent with good news about the target. Size effects have a strong negative effect on acquiring firms, and this effect has distinct mechanics for acquirer and deal sizes.

The above results allow a finer separation of effects than has been previously possible. Transaction size affects expectations of value destruction if the merger occurs. At the same time, there is no evidence that transaction size negatively affects expected standalone acquirer value. The evidence thus links the documented negative transaction size effect to the value destruction theories of hubris and agency, finding no support for equity overvaluation and lack of internal projects as explanations. Similarly, acquirer size negatively affects standalone acquirer value revision. This finding suggests that negative post-announcement returns that accrue to large acquirers do so because of informational effects, while finding no support for managerial hubris and malfeasance. Thus, both deal and acquirer size have negative effects on acquirer prices around merger announcements, but the mechanical explanations for these effects are likely to be distinct.

3.3.1 Why Deal Size Destroys Value

The above result suggests that acquirers overpay in large deals, destroying value and narrowing the explanations of the deal size effect to hubris and malfeasance. A closer examination of the context in which overpayment occurs can help differentiate between the two. There are two reasons for acquirers to offer large premia above target pre-announcement value: generous offers might be put together either because of a misvaluation of the target by the acquirer, or as an incentive to bring an initially-reluctant target to an eventual agreement. The former type of offer would be consistent with the Roll (1986) hubris hypothesis, where the bidding firms are the ones with the most optimistic estimate of target value in a context of incomplete information. In the latter case, the overpayment is necessary to accomplish the transaction rather than the result of a valuation error. Rational overpayment is consistent with agency issues raised by Jensen (1986), a case of managerial malfeasance rather than hubris. To differentiate between the two explanations of large premia, I examine the role of size in determining the likelihood of takeover. The MCMC belief estimation step, in addition to delivering the state-contingent payoffs to the equity of the two involved firms, also estimates the expected probability of deal consummation. Table 5 presents the results of regressing the estimated likelihood of takeover on deal characteristics, net premium, and size.

The table shows the effect of deal characteristics and jointly estimated beliefs on the risk-neutral probability of deal completion q, as described by modes of the daily EMM estimation. Dummy variables control for friendly negotiations ($friendly = 1$), stock-only and cash-only offers ($stockonly = 1$; $cashonly = 1$), and same-industry acquisitions ($sameind = 1$). To account for market effects, I include the S&P500 holding period return from announcement, $R(SP500_{t-0})$. As an additional measure of overpayment, $premium$ is the net ratio of deal size to pre-announcement target value. Uniformly, larger deals are expected to be less likely to go through by 4.5% for every $10 billion in deal size. Deals with values substantially higher than pre-announcement target value do not have an additional effect. Causality is not determinable from this regression: either big deals are less likely to go through due to shareholder and board resistance, or large deals are put forward in low-likelihood cases.

Among the largest recent deals, big deal sizes occur in merger negotiations with low expectations of success. This is in line with the latter hypothesis that observed premia above pre-announcement value are a tool to get the target to go along with the proposal, rather than the product of a misvaluation. A competing explanation can be advanced, that overpayment through misvaluation results in longer running negotiations because of resistance to the overly generous terms from the acquirer's board or shareholders. By examining the determinants of the duration of successful negotiations, I can distinguish between the two alternatives.

I measure duration in months for each successful negotiation in my sample. All but two of the thirty deals were ultimately successful, producing a very slightly reduced set of data. If overpayment faces opposition from the acquiring firm's shareholders, the acquirer's gains from the transaction should be a determinant of length of negotiations. This would support the competing explanation of corporate governance working against value-destroying deals. If, on the other hand, only target gains are a determinant then the observed value destruction through overpayments is a necessary part of securing the large deals. Table 6 shows that target gains are a significant determinant of negotiation duration.

The table shows the effect of deal characteristics and estimated market beliefs on the realized duration (in months) of successfully completed negotiations using a Poisson model of count data. Dummy variables control for friendly negotiations, offer terms, and same-industry acquisitions. To account for market effects, I include the S&P500 holding period return from announcement, $R(SP500_{t-0})$. In the full model (2), large deals take longer to conclude at 0.07 months per $10bn of deal value. Friendly and same-industry negotiations conclude sooner, all else equal. More importantly, expected outcomes for the firms involved play a significant role. Return from synergies shortens duration by 0.74 months per 1% of excess return. Decomposing excess returns from synergy in (2) into target and acquirer state-contingent payoffs shows that firm welfare affects time until acquisition. Target gains lower time to acquisition by 0.56 months per $10bn, and good news about acquirer standalone value lowers it by 1.35 months. Furthermore, the target firm welfare effect is inversely linked to the deal size effect, as models (3)-(4) show. Big deals and target gains are two sides of the same coin: deal size is a payment to induce targets to accept.

Synergy shortens the duration of negotiations, but its decomposition into firm state-contingent returns shows that this is driven largely by the target's gains from merger, as well as by good news about the acquirer. Expected acquirer losses have no effect on duration, finding no evidence of expectations of intervention by shareholders. The evidence that target welfare hastens an acquisition supports the original hypothesis that large transaction values occur because of long-shot deals, and not the other way around. The observed connection between low expected merger likelihood and deal size is thus correlational, not causational. Target gain decreases the time to acquisition, whereas acquirer loss does not detectably increase it. Therefore large transaction size is not likely to cause lower likelihood of takeover, even though it occurs in the presence of lower likelihood. Since target welfare is a determinant of length of negotiations, the evidence suggests that overpayment occurs when chances of success are low. This does not support hubris as an explanation of value destruction in large deals, as under that hypothesis overpayment is a symptom of incomplete information, rather than a deliberate choice. The findings are instead in favor of managerial agency issues, at least in the case of the very largest of recent mergers.

3.4 Conclusion

Using data from the 30 largest takeover attempts of the last several years, I show that acquirer size is correlated with the release of bad news about the acquiring firm. Deal size, however, is correlated with active destruction of value in the acquiring firm through overpayment. I further show that this overpayment is employed in cases where likelihood of success is low, and bargaining power lies with targets. This suggests that the higher premia offered are a necessary cost of the acquisition, rather than the product of misvaluation as in Roll (1986). The observed negative deal size effect for acquiring firms is therefore most likely driven by the agency issues of Jensen (1986).

The existing body of theory has identified four main channels of value destruction in mergers. Two of these are informational effects that cause downward revisions of the acquiring firm's standalone value, and two are transactional effects that lead to value-destroying acquisitions. Using price data from both stock and options for the participants in the 30 largest recent merger proposals, I am able to separately estimate the two types of effect. The former two informational effects are the lack of good internal projects and the overvaluation of acquirer equity which become conflated in revisions of belief about standalone acquirer value. The latter two transactional effects are the hubris hypothesis and managerial agency issues which may both contribute to expectations about the outcome of a successful deal. These beliefs about standalone and merged value are themselves conflated in observed prices, obscuring a clear view of the mechanisms by which prices and state-contingent firm values change.

By the disentangling of transactional and informational value changes in firms during merger negotiations this paper presents a clearer examination of situations in which value is actively destroyed in mergers. It separates the standalone firm value effects from the transactional ones. The ability to infer market beliefs about the possible outcomes of merger transactions gives insight into the mechanical causes of that value destruction. This enables advancement of the understanding of corporate governance by paring down the set of theoretical explanations for value destruction observed in large mergers.

Table 3.1: Firm Size and Observed Merger Reactions

The table shows the effect of acquirer size and deal size on changes in price from pre-announcement baseline values for the 30 sample transactions. *transval* is the final value of the deal and A_0 is the pre-announcement value of the acquirer, both in units of $10bn. I control for negotiation, offer, and acquisition types by adding dummy variables *friendly* for friendly negotiations, *cashonly* and *stockonly* for offers including only one or the other, and *sameind* for acquisitions between firms in the same industry. For both firms, the announcement-day return $R(X_{ann})$ is the change in value on announcement day normalized by baseline value, and the final return $R(X_T)$ is the holding period return for the entire negotiation window. Superficially, the size of the transaction does not seem to matter, while acquirer size does significantly affect the firm's own returns for the holding period. For each $10 billion of acquirer value, the net return to the acquiring firm decreases by 1.4%. This suggests that even in the category of large deals, variation in firm size may affect outcomes. However, stock price data alone is insufficient to determine what the causes of this value change are.

	(1) acq_ann_ret	(2) tgt_ann_ret	(3) acq_fin_ret	(4) tgt_fin_ret
friendly	-0.15	-0.12	-0.20	-0.19
	(-1.43)	(-0.82)	(-1.48)	(-1.34)
cashonly	-0.095	0.18	-0.44	0.30*
	(-1.85)	(1.22)	(-1.89)	(2.66)
stockonly	-0.060	-0.16*	-0.18*	-0.24*
	(-1.47)	(-2.21)	(-2.43)	(-2.33)
sameind	0.072	-0.10	0.12	0.079
	(0.67)	(-0.83)	(0.57)	(0.34)
transval	0.00061	0.019	0.020	0.051
	(0.05)	(0.96)	(0.83)	(1.64)
A_0	-0.0054	-0.0073	-0.014*	-0.0099
	(-1.65)	(-1.14)	(-2.40)	(-1.07)
Constant	0.11	0.37*	0.25	0.31
	(1.06)	(2.47)	(1.14)	(1.15)
Observations	30	30	30	30
Adjusted R^2	0.205	0.224	0.249	0.255

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.2: Deal Summary

The table shows the descriptive statistics of of the dataset of the largest 30 merger deals with liquid options from the SDC database in 2002-2009. Control dummy variables represent successfully concluded deals ($outcome = 1$), friendly negotiations ($friendly = 1$), stock-only and cash-only offers ($stockonly = 1$; $cashonly = 1$), and same-industry acquisitions ($sameind = 1$). The *duration* of the negotiation is measured in months. The pre-announcement values of the target B_0 and acquirer A_0 firms, as well as the final deal size *transval* are in units of nominal $10bn. I compute announcement day returns as the normalized change from pre-announcement day prices for both target $R(B_{ann})$ and acquirer $R(A_{ann})$. The top 30 deals reflect previously documented details of large mergers: over 80% of them are friendly, over 90% of them ultimately succeed, the acquirer is larger than the target, and the acquirer's return is negative whereas the target's is positive, albeit with high dispersion.

	mean	sd
outcome	.933	.254
friendly	.833	.379
stockonly	.433	.504
cashonly	.100	.305
sameind	.900	.305
duration	6.567	3.607
A_0	7.967	7.117
B_0	2.429	1.562
transval	3.141	1.997
$R(A_{ann})$	-.0288	.114
$R(B_{ann})$	.128	.207
Observations	30	

Table 3.3: Summary Statistics

The table shows the average values of the modes and standard errors of estimated belief parameters and their economically significant functions for the 30 transactions during the first month of negotiations. The expectations elicited are q, the risk-neutral probability of the deal succeeding, $R(A^m)$,the return to the equity of the acquirer in the merged state, $R(A^u)$, the return to the equity in the standalone state, $R(B^m)$, the return to the equity of the target in the merged state, $R(B^u)$, the return to the equity of the standalone state, $R(synergy)$, the combined merged-state return to both firms in excess of their pre-announcement values, $R(A^m - A^u)$, the merged-state return to the acquirer in excess of its standalone value, $R(A^u - A_0)$, the standalone-state return to the acquirer in excess of the pre-announcement price, $R(B^m - B^u)$, the merged-state return to the target in excess of its standalone value, and $R(B^u - B_0)$, the standalone-state return to the target in excess of the pre-announcement price. I calculate the standard errors ($SE(.)$) of A^m, A^u, B^m, B^u from the daily MCMC chains, and estimate the standard errors of the merged-state differences ($SE(A^m - A^u)$, $SE(B^m - B^u)$) assuming independence between the variables.

The average probability of success is statistically different from zero, but substantially less than the 93% ex-post probability observed from deal outcomes. The acquirer is expected to have negative returns (relative to pre-announcement value) in both merged and standalone states, though the averages are not statistically significant. The target can expect statistically significant positive returns in the merged state, and insignificantly positive returns in the standalone. The return expected to accrue to the combined firms should (synergy) is not significantly different from zero. The average difference between returns in merged and standalone states, indicative of expected gains from the transaction, is negative for the acquirer and positive for the target, albeit with high dispersion. The return expected in the standalone state in excess of the baseline prices, indicative of information revelation about the standalone value of the firms, is slightly negative for acquirers and positive for targets, also without statistical significance.

	mean
q	.401
$SE(q)$	.246
$R(A^m)$	-.0722
$\frac{SE(A^m)}{A\_0}$	.105
$R(A^u)$	-.0274
$\frac{SE(A^u)}{A\_0}$	.125
$R(B^m)$	.132
$\frac{SE(B^m)}{B\_0}$	.0685
$R(B^u)$	.103
$\frac{SE(B^u)}{B\_0}$	.147
$R(synergy)$	-.0114
$SE(synergy)$	.0681
$R(A^m - A^u)$	-.0450
$SE(A^m - A^u)$	.150
$R(A^u - A\_0)$	-.0242
$SE(A^u - A\_0)$	.117
$R(B^m - B^u)$	.0296
$SE(B^m - B^u)$	.159
$R(B^u - B\_0)$	.103
$SE(B^u - B\_0)$	.134
N	20.356
Observations	587

Table 3.4: Determinants of Value Creation in Mergers

The table shows the effect of deal characteristics and size on expected synergies and individual firm gains expected from the merger transaction itself and revisions about standalone value in units of $10bn. Dummy variables control for friendly negotiations ($friendly = 1$), stock-only and cash-only offers ($stockonly = 1$; $cashonly = 1$), and same-industry acquisitions ($sameind = 1$). The level of the S&P500 index in thousands, $SP500_t$, controls for the state of the market's influence on expected payoffs. Firm and deal size has a significant effect on value creation in merger deals. Acquirer size causes a loss in expected synergies of 9.2% of their own size. Large acquirers also experience substantial negative information revelation upon announcement, around 14% of their total pre-announcement value. Acquirers making large deals are expected to lose $0.34 of every $1 of deal size, destroying value. Interestingly, deal size positively affects expectations about acquirer value in cases of merger failure, by 18% of deal size. The targets of large deals experience substantial positive information revelation upon announcement of a takeover, around 16% of the deal's value. The size of the acquiring firm has a negative impact on its standalone value, consistent with bad news about the acquirer. The size of the deal has a negative impact on the takeover gains for the acquirer, consistent with value destruction, and a positive impact on the standalone value of the target, consistent with good news about the target. Size effects have a strong negative effect on acquiring firms, and this effect has distinct mechanics for acquirer and deal sizes. I report t-statistics in parentheses formed from robust standard errors clustered by deal.

	(1) Synergy	(2) Acq_gain	(3) Acq_info	(4) Tgt_gain	(5) Tgt_info
$friendly$	-0.53	-0.54	0.16	0.18	-0.31*
	(-1.94)	(-1.78)	(0.49)	(1.19)	(-2.47)
$stockonly$	-0.050	0.34	-0.019	-0.0094	-0.37
	(-0.11)	(1.02)	(-0.06)	(-0.06)	(-1.82)
$cashonly$	0.21	-0.20	0.26	-0.0024	0.14
	(0.61)	(-0.93)	(0.72)	(-0.02)	(0.80)
$sameind$	-0.25	-1.32	0.95	0.28	-0.16
	(-0.35)	(-1.78)	(1.48)	(0.78)	(-0.54)
A_0	-0.092*	0.043	-0.14***	0.021	-0.014
	(-2.68)	(1.11)	(-5.14)	(1.24)	(-0.85)
$transval$	-0.058	-0.34***	0.18*	-0.051	0.16**
	(-0.47)	(-4.49)	(2.37)	(-1.60)	(3.08)
$SP500_t$	4.05*	2.96**	0.63	0.54	0.018
	(2.24)	(3.41)	(0.65)	(1.27)	(0.04)
Constant	-3.70	-1.41	-1.76	-0.97	0.33
	(-1.41)	(-1.09)	(-1.26)	(-1.34)	(0.43)
Observations	587	587	587	587	587
Adjusted R^2	0.230	0.147	0.401	0.053	0.262

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.5: Determinants of the Expected Likelihood of Acquisition

The table shows the effect of deal characteristics and jointly estimated beliefs on the risk-neutral probability of deal completion q, as described by modes of the daily EMM estimation. Dummy variables control for friendly negotiations ($friendly = 1$), stock-only and cash-only offers ($stockonly = 1$; $cashonly = 1$), and same-industry acquisitions ($sameind = 1$). To account for market effects, I include the S&P500 holding period return from announcement, $R(SP500_{t-0})$. As an additional measure of overpayment, *premium* is the net ratio of deal size to pre-announcement target value. Uniformly, larger deals are expected to be less likely to go through by 4.5% for every $10 billion in deal size. Deals with values substantially higher than pre-announcement target value do not have an additional effect. Causality is not determinable from this regression: either big deals are less likely to go through due to shareholder and board resistance, or large deals are put forward in low-likelihood cases. I report t-statistics in parentheses formed from robust standard errors clustered by deal.

	(1) q	(2) q
friendly	0.059	0.071
	(0.70)	(0.78)
stockonly	0.025	0.033
	(0.42)	(0.62)
cashonly	-0.058	-0.081
	(-0.32)	(-0.50)
sameind	0.0052	0.0046
	(0.07)	(0.07)
transval	-0.044**	-0.046**
	(-2.81)	(-3.31)
premium	-0.068	
	(-0.48)	
A_0	0.0028	0.0032
	(0.93)	(1.05)
$R(SP500_{t-0})$	0.40	0.36
	(1.68)	(1.70)
Constant	0.49***	0.46***
	(6.12)	(5.76)
Observations	587	587
Adjusted R^2	0.087	0.086

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.6: Determinants of Negotiation Duration

The table shows the effect of deal characteristics and estimated market beliefs on the realized duration (in months) of successfully completed negotiations using a Poisson model of count data. Dummy variables control for friendly negotiations, offer terms, and same-industry acquisitions. To account for market effects, I include the S&P500 holding period return from announcement, $R(SP500_{t-0})$. In the full model (2), large deals take longer to conclude at 0.07 months per \$10bn of deal value. Friendly and same-industry negotiations conclude sooner, all else equal. More importantly, expected outcomes for the firms involved play a significant role. Return from synergies shortens duration by 0.74 months per 1% of excess return. Decomposing excess returns from synergy in (2) into target and acquirer state-contingent payoffs shows that firm welfare affects time until acquisition. Target gains lower time to acquisition by 0.56 months per \$10bn, and good news about acquirer standalone value lowers it by 1.35 months. Furthermore, the target firm welfare effect is inversely linked to the deal size effect, as models (3)-(4) show. Big deals and target gains are two sides of the same coin: deal size is a payment to induce targets to accept. I report t-statistics in parentheses formed from robust standard errors clustered by deal.

	(1) Duration	(2) Duration	(3) Duration	(4) Duration
q	-0.32	-0.21	-0.44*	-0.54*
	(-1.83)	(-1.31)	(-2.41)	(-2.52)
$friendly$	-0.58***	-0.70***	-0.62***	-0.41
	(-3.74)	(-5.21)	(-3.74)	(-1.80)
$stockonly$	-0.065	-0.15	-0.11	-0.022
	(-0.60)	(-1.26)	(-0.87)	(-0.19)
$cashonly$	0.18	0.0066	0.13	0.30
	(0.57)	(0.02)	(0.47)	(0.87)
$sameind$	-0.33**	-0.34***	-0.37**	-0.25*
	(-3.11)	(-3.35)	(-3.18)	(-2.34)
$transval$	0.045	0.072*		0.030
	(1.30)	(2.36)		(0.74)
$premium$	0.32	0.59		0.17
	(1.15)	(1.91)		(0.55)
A_0	-0.0046	-0.012	0.0011	0.0065
	(-0.35)	(-0.86)	(0.08)	(0.44)
$R(SP500_{t-0})$	2.17**	2.51***	2.35***	2.26**
	(3.22)	(4.10)	(3.55)	(2.90)
$R(synergy)$	-0.74**			
	(-2.77)			
$Rg(A^m)$		-0.19	-0.30	
		(-1.03)	(-1.52)	
$Rg(A^u)$		-1.35***	-0.95**	
		(-4.78)	(-2.85)	
$Rg(B^m)$		-0.56**	-0.24	
		(-2.59)	(-0.90)	
$Rg(B^u)$		0.42	0.48	
		(1.51)	(1.38)	
Constant	2.65***	4.32***	3.97***	2.51***
	(8.10)	(6.80)	(6.07)	(7.30)
Observations	547	547	547	547

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Biography

Paul Alexander Borochin was born on April 3, 1983, in St. Petersburg, Russia. He received his BS from the University of Pennsylvania in 2005. He will start as an Assistant Professor at the University of Connecticut School of Business in the Fall.