A Theory of Merger-Driven IPOs

Evgeny Lyandres[a] Alexei Zhdanov[b,c,d] Jim Hsieh[d]

[a]*Jones Graduate School of Management, Rice University, Houston TX, USA*
email: lyandres@rice.edu
[b]*University of Lausanne, Lausanne, 1007 Switzerland, email: azhdanov@unil.ch*
[c]*Swiss Finance Institute*
[d]*George Mason University, Fairfax, VA, USA, email: jhsieh@gmu.edu*

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Abstract

We propose a model that links a firm's decision to go public with its subsequent takeover strategy. A private bidder does not know its true market valuation, which affects its gain from a potential takeover. Consequently, a private bidder pursues a suboptimal restructuring policy. An alternative route is to complete an initial public offering first. An IPO eliminates valuation uncertainty, leading to an efficient acquisition strategy, therefore enhancing firm value. We calibrate the model using data on IPOs and M&As. The resulting comparative statics generate several novel qualitative and quantitative predictions, which distinguish our model from alternative theories and provide an avenue for empirical research. In addition, our illustrative empirical analysis shows that, consistent with the model, periods of abnormally high merger activity are preceded by periods of high IPO activity.

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1 Introduction

Initial Public Offerings (IPOs) and Mergers and Acquisitions (M&As) tend to occur in waves. For example, Ibbotson and Jaffe (1975), Ibbotson, Sindelar and Ritter (1988), Lowry and Schwert (2002), Lowry (2003), and Helwege and Liang (2004) find a substantial variation in IPO volume over time, with numerous peaks of abnormally high IPO activity, usually referred to as "hot IPO markets". Mitchell and Mulherin (1996), Andrade and Stafford (2004), and Harford (2005), among others, demonstrate that mergers also cluster in time.

Given that both IPOs and mergers come in waves, a natural question is whether these waves are independent or related. Recent empirical literature suggests that there might be a link between the timing of IPOs and mergers. According to a survey of 336 CFOs by Brau and Fawcett (2006), facilitating potential takeover transactions is one of the most important motivations for going public. Consistent with this survey evidence, Rau and Stouraitis (2006) document that IPO and merger waves tend to overlap in time, with IPO waves typically starting first and merger waves continuing after the end of IPO waves. Schultz and Zaman (2001) find evidence that many internet firms that went public in the late nineties pursued aggressive post-IPO acquisition strategies.

This paper proposes an explanation for the relation between IPOs and mergers by providing a real-options-based theory that links the decisions to go public and subsequently engage in M&As. This link is quite intuitive. Absent market valuation, there is uncertainty surrounding the value of a private firm's capital, which affects the gain from a potential takeover if the firm chooses to merge with another firm in the future. A private firm, not knowing the precise value of its capital, is unable to make optimal restructuring decisions. Thus, valuation uncertainty leads to a suboptimal M&A policy and reduces firm value. An IPO removes valuation uncertainty and allows the firm to pursue an efficient acquisition strategy, or, in other words, to exercise its restructuring option optimally.

In addition to reducing (or eliminating) uncertainty about firm value, performing an IPO allows a potential bidder to credibly communicate its valuation to a potential target. Importantly, while we focus our discussion and the model on the benefit of an IPO to potential bidders, firms that consider themselves potential acquisition targets have a similar motivation to go public. Our theory can be applied to the case of potential target firms.

The basic assumption behind our analysis, that firms learn about their valuation from the capital market, appears reasonable. The effect of an IPO on the reduction in firm's valuation uncertainty has been highlighted in several models. For example, Benveniste and Spindt (1989) model the process through which investors reveal their information about an IPO firm to its underwriter. In Dow and Gorton (1997), stock market traders have information about firms' investment opportunities that managers do not have. Alti (2005) shows that IPOs facilitate a release of investors' private information and cause information spillovers to other firms considering going public, which, in turn, facilitate their

IPOs. Similarly, Benveniste, Busaba, and Wilhelm (2002) suggest that IPO firms generate information externalities for other firms in their industry. In Chemmanur and Fulghieri's (1999) model, a firm trades off the information production costs in the IPO market versus the risk premium required by private financiers.

Empirical evidence also suggests that firms' managers adjust the valuations of their firms following updates in market valuations. For example, Brau and Fawcett (2006) document that 51% of surveyed CFOs regard the impact of post-IPO stock price on their assessment of the company's value as important. Luo (2005) finds that the market reaction to an M&A announcement predicts the likelihood of the consummation of the proposed deal, suggesting that "insiders learn from outsiders". Subrahmanyam and Titman (2001) argue that one of the reasons for the importance of market valuation is that it impacts firms' cash flows through its effect on the actions of firms' non-financial stakeholders.

The logic of our model is not inconsistent with the fact that private firms that require access to public equity markets can choose between an IPO and an acquisition of a public firm or by a private firm (e.g., Brau, Francis and Kohers, 2003). In our model, some private firms go public through a traditional IPO, while others become public by merging directly with seasoned public firms. The sequential link between IPOs and M&As that we propose suggests that the merger/IPO decisions are not mutually exclusive but can, instead, be complementary.

Our paper contributes to the IPO literature by suggesting a new motivation for going public. Existing theories are based on product market competition (e.g., Maksimovic and Pichler, 2001; and Stoughton, Wong and Zechner, 2001), market timing (e.g., Alti, 2005), liquidity (e.g., Amihud and Mendelson, 1988), dispersed ownership (e.g., Zingales, 1995; and Mello and Parsons, 1998), executive remuneration contracts (e.g., Holmström and Tirole, 1993), and diversification (e.g., Benninga, Helmantel and Sarig, 2005). In Pastor and Veronesi's (2005) model, optimal IPO timing depends on expected market return, expected aggregate profitability, and uncertainty regarding IPO firms' prospects. We argue that an additional important reason for a firm to go public is the resulting ability to optimally exercise its restructuring option, which increases its value.

Our analysis is also related to several articles that examine M&A deals in a dynamic framework. This path has been pioneered by Lambrecht (2004) and Morellec and Zhdanov (2005), who analyze the dynamics of takeovers motivated by operational synergies. Lambrecht and Myers (2007) show that takeovers may serve as a mechanism to force disinvestment in declining industries. Margsiri, Mello and Ruckes (2005) analyze the impact of internal growth on takeover transactions. Morellec and Zhdanov's (2005) model focuses on abnormal returns around merger announcements and incorporates imperfect information and competition among bidding firms. Leland (2007) examines the role of purely financial synergies in motivating mergers. Hackbarth and Morellec (2007) study the dynamics of firm betas around takeover announcements. Morellec and Zhdanov (2007) examine the effect of capital structure on optimal takeover strategies. Bernile, Lyandres, and Zhdanov (2007) examine the dynamics of mergers motivated by market power and a threat of potential entry, while Hackbarth and Miao (2007) study the effect of industry concentration on firms' incentives to merge in oligopolistic industries. We introduce a new theme into this literature by linking IPO and M&A markets. Private firms seeking takeover opportunities exercise their options to merge with other firms either through one-step (without an IPO) or two-step (with an IPO) acquisitions.

In addition to providing a novel link between IPOs and mergers, our model generates a number of unique empirical predictions that relate the likelihood and timing of IPOs and M&As to various firm and industry characteristics, such as the degree of valuation uncertainty surrounding a firm, the cost of going public, and the expected gains from potential acquisitions. We calibrate the model using M&A and IPO data from the Securities Data Company and analyze the quantitative (economic) effects of various parameters of the model on the likelihood of mergers following IPOs. We find that many of the parameters, especially the degree of valuation uncertainty and the valuation errors revealed during IPOs have economically large effects on the likelihood and timing of acquisitions by newly public firms.

Finally, our theory offers a new explanation for the existence of hot IPO markets. In the model, an IPO helps reduce valuation uncertainty and increases the value of subsequent takeover opportunity. IPO timing is, then, linked to optimal merger timing. Therefore, our theory links hot IPO markets to factors responsible for spikes in M&A activity (merger waves). Consistent with this logic, we provide an illustrative empirical evidence suggesting that abnormally high IPO activity is related to abnormally high merger intensity in following years.

Our theory is not the only one that suggests a link between IPOs and mergers. Two alternative theories lead to a similar result. First, a private bidder contemplating a stock merger could decide to go public to alleviate the asymmetric information problem (e.g., Hansen, 1987; Fishman, 1989; and Eckbo, Giammarino and Heinkel, 1990). Second, an IPO could be a means to obtain cash to be used in future acquisitions.

However, the predictions of our model differ from those of alternative theories in a number of important dimensions. First, we assume rational investors and efficient markets in which securities are fairly priced. Thus, our theory should hold for all acquisitions, regardless of the method of payment, in contrast to the asymmetric information theory (disproportionately many stock mergers following IPOs) and the deep pockets story (disproportionately many cash acquisitions). Second, the timing dimension is crucially important in our model. The optimal exercise of the option to go public and the option to merge leads to unique predictions about the time between an IPO and a subsequent merger and about the probability of observing an acquisition by a newly public firm in the years following its IPO. The illustrative empirical evidence we provide shows similarities between the merger probabilities produced by the model and their empirical counterparts. On the contrary, the timing dimension is missing in alternative theories, whose literal interpretation leads to a merger immediately following an IPO. Third, if IPOs are simply a way to raise cash to finance future takeovers, then a similar link should exist between Seasoned Equity Offerings (SEOs) and M&A transactions, while our theory holds for IPOs only. We discuss further these differences between our model's predictions and the predictions following from alternative theories in subsection 3.4.

The remainder of the paper is organized as follows. The next section presents the model linking the IPO and restructuring decisions. In Section 3 we calibrate the model using real-world data on mergers and IPOs and perform a comparative statics analysis of the likelihood of M&As following IPOs, which generates numerous qualitative and quantitative empirical predictions. Section 4 presents an illustrative empirical analysis that demonstrates that spikes in M&A activity seem to follow periods of unusually high IPO activity, consistent with the evidence in Rau and Stouraitis (2006). (This analysis should not be viewed as a full-fledged empirical study of the link between IPOs and M&As or as an attempt to distinguish among the various explanations of this link. Rather, it provides an illustration of the empirical regularity that motivates our study.) We summarize our findings and conclude in Section 5. Proofs are provided in the Appendices 1-3. Appendix 4 contains an extension of the model in which we allow firms to undo mergers that turned out to be unsuccessful.

2 The Model

In this section we present a model that demonstrates the potential benefit of going public before engaging in M&As. The benefit of doing IPO is that a publicly traded firm is able to estimate the value of the takeover gain resulting from a potential acquisition more precisely than a similar private firm. The ability to reduce the uncertainty regarding future takeover surplus allows a public firm to exercise its option to merge optimally, whereas a private firm has to base the restructuring (merging) decision on an incomplete information about the potential takeover gain. The trade-off between the benefit of going public and the direct cost of doing so provides interesting predictions regarding the driving forces behind the IPO decision, its optimal timing, and the timing of subsequent acquisitions.

In the model we focus on the case in which a private bidder contemplates a merger with a potential public target and may decide to go public in order to be able to exercise its restructuring option optimally. Note, however, that our model is fully adaptable to the opposite case, in which a privately held target goes through an IPO to increase the value of its option to be acquired, and almost identical results obtain. The model can also be extended to the case of a private bidder considering an acquisition of a private target.[1]

The dynamic nature of our real options model is essential for our analysis. The values of the option to go public and the option to engage in a merger depend on when these options are exercised. The optimal timing of their exercise is endogenously determined in our model. Therefore, it generates

[1] While the logic and the intuition of the model would remain intact, assuming that a potential target is not publicly traded complicates the algebra and the interpretation of the results.

predictions regarding the expected time between IPOs and subsequent takeover transactions. Such predictions could not be obtained in a static model. Furthermore, our model produces quantitative predictions regarding the distribution of merger times for post-IPO firms and the likelihood of a merger within a given time period and allows us to examine quantitative effects of changes in the model parameters on takeover probabilities.[2]

2.1 Assumptions and discussion

Assumption 1: The bidder's and target's capital stocks and valuation

We follow Shleifer and Vishny (2003), Morellec and Zhdanov (2005) and Hackbarth and Morellec (2007) and assume that there exist two firms – a potential bidder and a potential target with the per-unit-of-capital valuations of their core businesses denoted by X and Y respectively. The bidder's and target's capital stocks are denoted by K_B and K_T respectively.

Initially, the potential acquirer is a privately held company. Absent a value attributed by market investors, the bidder only has a noisy signal about its true value. Therefore, X is the private bidder's management's subjective estimate of its value. The true per-unit value of the bidder's capital is $X_{true} = X(1+\varepsilon)$. The valuation parameter, ε, is not observed by the management. Thus, the management's valuation is almost always either strictly below ($\varepsilon > 0$) or strictly above ($\varepsilon < 0$) the true value. We further assume that the management's valuation is unbiased: $\mathbb{E}(\varepsilon) = 0$ ($X = \mathbb{E}(X_{true})$), and that ε is drawn from a uniform distribution with support $[-\lambda, \lambda]$, where $\lambda \in \mathbb{R}_+$.[3] The distribution of the valuation error is assumed to be known to the management. Since the target is public, its true per-unit-of-capital stock market valuation, Y_{true}, is known. As mentioned above, the model can be adjusted to the case of a private target whose subjective valuation, Y, is unbiased: $Y = \mathbb{E}(Y_{true})$. In what follows, we slightly abuse the notation and write Y instead of Y_{true}.

Note that our assumptions do not imply that there is mis-valuation or that financial markets are inefficient. As long as the bidder is private, its market valuation is not observable. This precludes the bidder's management from knowing the precise value of the firm. We also assume that the target's management has the same beliefs about the value of the bidder as the bidder's management, so there is no information asymmetry between the bidder and the target, but the valuation of the bidder's capital

[2] In addition, the real options in our model (as in most real options models) are optimally exercised when they are strictly in the money. This differentiates our model from a static set-up, in which the decisions to merge and to go public would have to be based on the simple NPV rule. This difference is essential. For example, as we discuss in Appendix 4, allowing for reversibility of a merger bid in cases when the revealed takeover gain is negative, produces an immaterial effect on our results. This happens because the option to go public is only exercised when the (expected) value of the restructuring option is strictly positive. On the contrary, introducing merger bid reversibility in a static model would make the option to do an IPO worthless.

[3] We further assume that ε is constant over time, so there is no learning by insiders. Incorporating (partial) learning would significantly complicate the analysis without changing the qualitative results.

is noisy. As will become clear below, imperfect information about the value of the bidder affects the value of its option to merge with the potential target.

The bidder management's subjective valuation and the target's valuation are governed by the following stochastic processes:

$$dA(t) = \mu_A A(t)\, dt + \sigma_A A(t)\, dW_A(t), \qquad A = \{X, Y\}, \tag{1}$$

where $\mu_X < r$, $\mu_Y < r$, $\sigma_X > 0$, and $\sigma_Y > 0$ are constant parameters and W_X and W_Y are standard Brownian motions on $(\Omega, \mathcal{F}, P)$. Equation (1) implies that the growth rate of bidder's and target's valuations are normally distributed with means $\mu_X \Delta t$ and $\mu_Y \Delta t$ and variances $\sigma_X^2 \Delta t$ and $\sigma_Y^2 \Delta t$ over time interval Δt. In addition, we assume that the correlation coefficient between the two sources of uncertainty, W_X and W_Y, is constant and equals ρ.

Assumption 2: IPO and valuation uncertainty

We assume that the (initially privately held) bidder has an option to become public by going through an IPO. If the bidder goes public, the market's (true) per-unit valuation, X_{true}, is revealed to both the bidder and the potential target and is assigned to the bidder's stock of capital. Thus, an IPO eliminates the uncertainty regarding the bidder's value. It is worth noting that, while our assumption that all uncertainty about the bidder's value is eliminated following the IPO may be deemed extreme, it is made for the sake of simplicity. Identical qualitative results obtain under the assumption that the valuation uncertainty is only partially reduced as a result of the IPO.

In our setting, a reduction in bidder's valuation uncertainty potentially increases its value because it allows to choose the timing of its future acquisitions optimally. While it is possible to eliminate valuation uncertainty in ways other than going through an IPO (i.e. by merging "blindly" with a public target and using it as a "shell" (e.g., Brau, Francis and Kohers, 2003), such mechanism of going public would not lead to an optimal acquisition timing. Thus, in our model, which is applicable to private firms seeking to grow via takeovers, an IPO is the only method of reducing valuation uncertainty in a way that can contribute to firm value.

Assumption 3: Takeover gain and cost

At any time $t > 0$, the bidder and target can negotiate a takeover deal. We follow Shleifer and Vishny (2003), Morellec and Zhdanov (2005), and Hackbarth and Morellec (2007) by assuming that the post-takeover value of equity per unit of capital is a linear combination of the pre-takeover values. In addition, we follow Lambrecht (2004) and assume that each party to the takeover incurs a fixed direct cost of going through a merger. This cost is assumed proportional to the value of each firm's capital. In particular, the post-takeover value of the combined firm is given by:

$$V(X_{true}, Y) = K_B X_{true} + K_T Y + \alpha K_T (X_{true} - Y) - c(K_B X_{true} + K_T Y), \tag{2}$$

where α is the "takeover gain factor" and $c > 0$ is the "cost factor". A merger can occur only if the takeover gain exceeds its cost for some levels of X_{true} and Y. We show below that a necessary condition for the possibility of takeover is $\alpha K_T - cK_B > 0$. (This expression is the increase in the net takeover gain caused by a marginal increase in the value of bidder's capital, X_{true}.) Since the target is public and the combined post-merger firm is public regardless of the bidder's pre-merger status (unless it decides to delist its shares), it is natural to assume that the takeover gain is a function of the true value of the bidder (as opposed to bidder management's subjective valuation if it is private).

At the time of the merger, the combined bidder's and target's takeover gain, $G^C(X_{true}, Y)$, equals the combined takeover surplus net of merger costs:

$$G^C(X_{true}, Y) = \alpha K_T(X_{true} - Y) - c(K_B X_{true} + K_T Y). \tag{3}$$

Note that the takeover gain in (3) is the "true" net takeover surplus, which is not equal to the change in the value of the combined firm relative to the sum of pre-takeover target's value and the private bidder management's subjective valuation. The reason is that at the time of the takeover, the private bidder management's valuation error, ε, and the true per-unit of capital bidder's value, X_{true}, are revealed. Thus, a takeover by a private bidder of a public target results in a gain or loss equalling $K_B X \varepsilon$ in addition to the realized takeover surplus. However, this gain/loss is a random variable with zero mean from the private bidder's perspective and, as will be shown below, it does not affect the restructuring decision.

Importantly, the setup of the model limits us to an analysis of a merger between firms with physical capital, in which the synergies follow from the superior ability of a bidder to utilize target's capital. Our model is silent about the motivations for and the outcomes of takeovers by private raiders, LBOs, and MBOs, in which a bidder only provides its management's expertise in managing target's capital, while not contributing any capital of its own.

Equation (3) shows that the takeover surplus can be positive only when the acquiring firm has a higher valuation of its capital than the target ($X_{true} > Y$). If this is the case, restructuring results in a more efficient allocation of resources. This specification is consistent with the Q-theory of mergers (e.g., Jovanovic and Rousseau,2002; and Lambrecht, 2004) that treats takeover targets as bidders' source of capital. According to the Q-theory, mergers are a tool to efficiently allocate capital to its most productive user. Similarly, in Maksimovic and Phillips' (2002) model, less productive firms sell their capacity to more productive ones. Lang, Stulz and Walkling (1989) and Andrade and Stafford (2004) document that bidders' Tobin's q is typically higher than that of targets. Maksimovic and Phillips (2001) provide plant-level empirical evidence consistent with efficient re-allocation of resources in mergers and conclude that "the gain in productivity of assets under new ownership is higher when the selling firm's productivity is low and is higher the more productive the buyer". Stock return evidence in favor of this hypothesis is provided by Hackbarth and Morellec (2007). Thus, it is natural to assume that the takeover gain is larger the larger the contribution of a more efficient bidder to the value of target's capital.[4]

Note that in the case of a private bidder, there is a theoretical possibility that the realization of the takeover gain, $G^C(X_{true}, Y)$, is negative. This can happen for low realizations of ε. Thus, while we assume in the main specification of the model that a merger is irreversible, in Appendix 4 we extend the analysis to the case in which the merged firm can break up right after observing that the post-merger synergies are negative. The option to undo the merger is clearly valuable in the presence of uncertainty about the takeover gain because of the convex relation between the expected merger surplus and uncertainty. The results of the extended model demonstrate, however, that the potential effect of this option is greatly reduced by the fact that it is optimal to exercise the restructuring option when it is already deep in the money (due to the positive value of the option to wait, inherent in our model), making a negative realization of the merger synergy unlikely. It turns out, therefore, that the possibility to undo the merger has almost no effect on the timing of IPOs and the likelihood of acquisitions following IPOs.

Assumption 4: IPO cost

Going public is not free. The underwriting fees make IPO a costly undertaking. We assume that if the potential bidder decides to go public, a cost proportional to the true value of its capital, $\eta K_B X_{true}$, must be incurred, where $\eta \in \mathbb{R}_+$.[5]

Assumption 5: Discounting

All parties are risk-neutral; the risk-free discount rate is r.

2.2 Solution of the model

The timing of the potential takeover depends on the combined net takeover surplus as well as on its allocation between the bidder and target. Also, as discussed below, the restructuring policy depends on whether the bidder's true value, X_{true}, is known, i.e. whether the bidder has become public prior to the takeover bid or has decided to remain private. The difference between the optimal takeover

[4] While it is likely that a typical bidder utilizes its capital more efficiently than a typical target, it is possible to extend the model to the case in which the "know-how" can be transferred not only from the bidder to the target but also in the opposite direction, resulting in the following specification of the takeover gain:

$$G^C(X_{true}, Y) = \max(\alpha K_T[X_{true} - Y], \alpha K_B[Y - X_{true}]) - c[K_B X_{true} + K_T Y].$$

Such specification complicates the solution of the model, however the important qualitative results remain intact.

[5] Empirically, because the majority of IPO underwriters charge a constant gross spread of seven percent of the gross proceeds (see Chen and Ritter (2000)), the variation in η across firms is mainly a function of the IPO size relative to the pre-IPO firm value.

strategies of a private bidder and a public one is the core of our analysis, as it drives the decision to go public and its timing.

We begin the analysis by determining the takeover timing that maximizes the value of the restructuring option. We perform this analysis first for the case of a public bidder and then proceed to the private bidder case. We then consider the optimal IPO timing of a potential bidder that is initially private. The decision to go public involves the trade-off between the benefit of being able to exercise the restructuring option optimally and the direct IPO cost.

Our solution technique relies on finding the fractions of the takeover surplus that accrue to the bidder's and target's shareholders, so that the two firms would have an identical optimal restructuring policies. (The two firms would be willing to exercise the merger option at exactly the same time.) When the bidder's and target's restructuring policies coincide, they correspond to the optimal merging policy resulting from the central-planner formulation. Our model shares this feature with Lambrecht (2004), Morellec and Zhdanov (2005) and Hackbarth and Morellec (2007). Intuitively, the merging firms are interested in maximizing the value of their joint option to merge, and, therefore, divide the takeover surplus in a way that results in the socially optimal restructuring policy.

Suppose that the takeover agreement specifies that a fraction ξ of the combined takeover surplus accrues to bidder's shareholders upon takeover consummation. (ξ is determined endogenously below.) Such an agreement implies that the net gain that the bidding firm's shareholders extract from the merger, $G^B(X_{true}, Y)$ is

$$G^B(X_{true}, Y) = \xi\alpha K_T(X_{true} - Y) - cK_B X_{true}, \tag{4}$$

whereas the surplus accruing to the target's shareholders, $G^T(X_{true}, Y)$, is given by

$$G^T(X_{true}, Y) = (1-\xi)\alpha K_T(X_{true} - Y) - cK_T Y. \tag{5}$$

The first term in (4) is the share of the bidder's shareholders in the combined takeover surplus. The second term is the bidder's cost of merging. A similar interpretation applies to the target's shareholders' net gain in (5).[6]

Importantly, in our model, the method of payment is immaterial. If the takeover currency is bidder's stock, then, if the bidder is public, the target's shareholders would receive a fraction $\frac{K_T Y + (1-\xi)\alpha K_T(X_{true}-Y)}{K_B X_{true} + K_T Y + \alpha K_T(X_{true}-Y)}$ of the merged firm's stock, while if the method of payment is cash, then the target's shareholders would receive $K_T Y + (1-\xi)\alpha K_T(X_{true} - Y)$ in cash for their shares.[7]

[6] In Morellec and Zhdanov (2005) and Hackbarth and Morellec (2007) the takeover agreement specifies the share of the total combined firm accruing to the bidder's shareholders. This specification generates the same qualitative predictions as the one chosen here. Our specification has the advantage of requiring fewer restrictions on parameter values.

[7] Similar expressions, with X_{true} substituted by X, describe the payment to target's shareholders in the case of a private bidder.

Whether the bidder has gone public or remained private, its optimal restructuring policy is determined by maximizing the value of its option to merge. The value of that option and its optimal exercise strategy depend on the bidder's true valuation, X_{true}. While a public bidder, with known X_{true}, can optimize its merger timing depending on its value, a private bidder, which treats X_{true} as a random variable with a known distribution, can only select its restructuring policy by maximizing the expected value of the option to merge (where the expectation is taken over the distribution of the valuation error, ε).

2.2.1 Acquisition by a public bidder

The value of the option to merge depends on the true values of the bidder's and target's capital, X_{true} and Y. Since the values of the total net takeover gain in (3) and the bidder's and target's shares of the surplus net of their cost of merging, in (4) and (5) respectively, are linearly homogenous in X_{true} and Y, the value of the restructuring option depends on the relative values of the bidder's and target's capital stocks. Thus, the optimization program can be reduced to a one-dimensional one, with the state variable given by the ratio of the stochastic valuations of bidder's and target's capital. The value of the total takeover gain in (3) can be re-written as

$$G^C\left(X_{true}, Y\right) = YG^C\left(\frac{X_{true}}{Y}, 1\right) = YG^C\left(\frac{X[1+\varepsilon]}{Y}\right) = YG^C\left(R[1+\varepsilon]\right) =$$
$$= Y\left[\alpha K_T(R\{1+\varepsilon\}-1) - c(K_B R\{1+\varepsilon\} + K_T)\right], \quad (6)$$

where $R = X/Y$.

Given the current values of X and Y (and R) – X_0 and Y_0 (and R_0), the public bidder solves the following optimization program:

$$R^*_{B_{pub}} = \arg\max_{X,Y}(O^B_{pub}(X_0, Y_0, \varepsilon, \xi)) = \arg\max_{R}(Y_0 O^B_{pub}(R_0, \varepsilon, \xi)) =$$
$$\arg\max_{R}\left\{\left(\frac{R_0}{R}\right)^{\beta}\left[\xi\alpha K_T(R\{1+\varepsilon\}-1) - cK_B R(1+\varepsilon)\right]\right\}, \quad (7)$$

where $R^*_{B_{pub}}$ is the bidder's optimal restructuring threshold and $O^B_{pub}(X_0, Y_0, \varepsilon, \xi)$ $(Y_0 O^B_{pub}(R_0, \varepsilon, \xi))$ is the value of its restructuring option and β is the positive root of the following quadratic equation:

$$\frac{1}{2}(\sigma_X^2 - 2\rho\sigma_X\sigma_Y + \sigma_Y^2)\beta(\beta-1) + (\mu_X - \mu_Y)\beta - r + \mu_Y = 0. \quad (8)$$

The value of the merger option is a function of the valuation error, ε, the share of the combined surplus accruing to the bidder's shareholders, ξ, and the current value of R, R_0. We show in Appendix 1 that the optimal restructuring policy of the public bidder, obtained as a solution to (7), is to merge at the first time $R = X/Y$, reaches a threshold $R^*_{B_{pub}}$, given by

$$R^*_{B_{pub}} = \frac{\beta}{\beta-1}\frac{\xi\alpha K_T}{(\xi\alpha K_T - cK_B)(1+\varepsilon)}, \quad (9)$$

from below. Similar to (7), the target maximizes the value of its restructuring option, $O^T_{pub}(X_0, Y_0, \varepsilon, \xi)$:

$$R^*_{T_{pub}} = \arg\max_{X,Y}(O^T_{pub}(X_0, Y_0, \varepsilon, \xi)) = \arg\max_{R}(Y_0 O^T_{pub}(R_0, \varepsilon, \xi)) =$$
$$\arg\max_{R}\left\{\left(\frac{R_0}{R}\right)^{\beta}[(1-\xi)\alpha K_T(R\{1+\varepsilon\}-1) - cK_T]\right\}, \quad (10)$$

where $R^*_{T_{pub}}$ is the optimal restructuring threshold of a target being acquired by a public bidder. The solution of the target's program in (10) results in the target's optimal restructuring strategy. This strategy is to merge the first time the stochastic process $R = X/Y$ reaches $R^*_{T_{pub}}$, given by

$$R^*_{T_{pub}} = \frac{\beta}{\beta-1}\frac{(1-\xi)\alpha + c}{(1-\xi)\alpha(1+\varepsilon)}, \quad (11)$$

from below, where β is given in (8).

Note that the bidder's optimal restructuring threshold, $R^*_{B_{pub}}$, is decreasing in the fraction of the takeover surplus it is entitled to, ξ. When the bidder receives a higher proportion of combined equity, it is willing to speed up the exercise of the restructuring option. Similarly, the target's optimal restructuring threshold is increasing in ξ (decreasing in $[1-\xi]$). Both $R^*_{B_{pub}}$ and $R^*_{T_{pub}}$ are decreasing in the valuation parameter, ε, because the value of the overall takeover gain is increasing in ε.

In the equilibrium that maximizes the combined value of bidder's and target's options to merge, the optimal bidder's and target's restructuring thresholds must coincide (see the discussion above). The equilibrium merger threshold can be found by equating (9) with (11):

$$R^*_{B_{pub}} = R^*_{T_{pub}} (\equiv R^*_{pub}). \quad (12)$$

Solving (12) for ξ yields the equilibrium fraction of the merger surplus accruing to the bidder, ξ^*:

$$\xi^* = \frac{K_B}{K_T + K_B}\frac{\alpha + c}{\alpha}, \quad (13)$$

and the equilibrium merging threshold, R^*_{pub} for the case of a public bidder.

$$R^*_{pub} = \frac{\beta}{\beta-1}\frac{(\alpha + c)K_T}{(\alpha K_T - cK_B)(1+\varepsilon)}. \quad (14)$$

Equation (13) shows that two factors affect the equilibrium allocation of the merger surplus to the bidder's and target's shareholders: the firms' relative capital stocks and the benefit of merger relative to its cost. Equation (14) implies that the optimal restructuring policy depends on the valuation error, ε. The higher the ε, the higher the true per-unit-of-capital value of the bidder's capital stock, $X_{true} = X(1+\varepsilon)$, the larger the restructuring gain (which depends on the difference between X_{true} and Y), and the higher the value of the option to merge. This implies that the higher the ε, the earlier (at a lower level of R^*_{pub}) the merging firms exercise their restructuring option.

Importantly, for any α satisfying $\alpha K_T - cK_B > 0$, there is a threshold, R^*_{pub}, such that when $R = X/Y$ reaches it, a merger occurs. Also, as long as α satisfies the restriction above, the share of the takeover surplus accruing to the bidder's shareholders is bounded between the ratio of bidder's capital to combined bidder's and target's capital, and one: $\frac{K_B}{K_B+K_T} < \xi^* < 1$.

It is also important to note that the solution of the central planner's program:

$$R^*_{CP_{pub}} = \arg\max_R (Y_0 O^{CP}_{pub}(R_0, \varepsilon, \xi)) =$$
$$= \arg\max_R \left\{ \left(\frac{R_0}{R}\right)^\beta [\alpha K_T(R\{1+\varepsilon\} - 1) - c(K_B R\{1+\varepsilon\} + K_T)] \right\}, \quad (15)$$

is identical to R^*_{pub} in (14).

An important quantity in our analysis is the value of the option to merge. As we show below, the difference between the value of this option for a public bidder and that for a private bidder determines the optimal decision of whether (and when) to go public. The value of the option to merge depends on whether the stochastic shock is sufficiently high that the firms should merge immediately, or it is not high enough, in which case it is optimal to wait. We show in Appendix 2 that in the latter case, in which the current state of the stochastic shock, R_0, is below the equilibrium restructuring threshold, R^*_{pub}, the present value of the public bidder's option to merge is given by

$$O^B_{pub}(R_0, \varepsilon) = \frac{1}{\beta - 1} \left[\frac{R_0(1+\varepsilon)(\beta-1)}{\beta} \frac{\alpha K_T - cK_B}{(\alpha+c)K_T} \right]^\beta \frac{(\alpha+c)K_B K_T}{K_B + K_T}, \quad (16)$$

If R_0 exceeds R^*_{pub}, then it is optimal to merge immediately, and the value of the option to merge (which equals the takeover gain) is given by

$$O^B_{pub}(R_0, \varepsilon) = [R_0(1+\varepsilon)(\alpha K_T - cK_B) - (\alpha + c)K_T] \frac{K_B}{K_B + K_T}. \quad (17)$$

As expected, the value of the bidder's option to merge is increasing in the valuation error, ε, and in the synergy parameter, α, and is decreasing in the merger cost parameter, c.

2.2.2 Acquisition by a private bidder

We now turn to the optimal restructuring threshold of a private bidder, which does not know the precise value of X_{true}, but knows that it is a random variable with known distribution. As in the public bidder case, the bidder's objective is to maximize the present value of its option to merge with the target, O^B_{pr}, by choosing the optimal merging threshold, $R^*_{B_{pr}}$:

$$R^*_{B_{pr}} = \arg\max_{X,Y} \mathbb{E}_\varepsilon (O^B_{pr}(X_0, Y_0, \xi)) = \arg\max_R \mathbb{E}_\varepsilon (Y_0 O^B_{pr}(R_0, \xi)) =$$
$$= \arg\max_R \left\{ \left(\frac{R_0}{R}\right)^\beta \mathbb{E}_\varepsilon \left(\xi \alpha K_T[R(1+\varepsilon) - 1] - cK_B R[1+\varepsilon]\right) \right\} =$$
$$= \arg\max_R \left\{ \left(\frac{R_0}{R}\right)^\beta [\xi \alpha K_T(R-1) - cK_B R] \right\}, \quad (18)$$

where $\mathbb{E}_\varepsilon$ denotes expectation over the distribution of ε. Similarly, the target shareholders maximize the value of their share of the takeover surplus by solving the following optimization program

$$R^*_{T_{pr}} = \arg\max_{X,Y} \mathbb{E}_\varepsilon(O^T_{pr}(X_0, Y_0, \xi)) = \arg\max_{R} \mathbb{E}_\varepsilon(Y_0 O^T_{pr}(R_0, \xi)) =$$

$$= \arg\max_R \left\{ \left(\frac{R_0}{R}\right)^\beta \mathbb{E}_\varepsilon\left([1-\xi]\alpha K_T[R(1+\varepsilon)-1] - cK_T\right) \right\} =$$

$$= \arg\max_R \left\{ \left(\frac{R_0}{R}\right)^\beta [(1-\xi)\alpha K_T(R-1) - cK_T] \right\}. \quad (19)$$

The equilibrium is constructed in the same way as in the case of a public bidder, discussed above. The equilibrium merging threshold is now given by

$$R^*_{pr} = \frac{\beta}{\beta-1}\frac{(\alpha+c)K_T}{\alpha K_T - cK_B}, \quad (20)$$

whereas the equilibrium share of the private bidder in the merged entity is same as in the public bidder case and is given by (13).

Similar to the public bidder case, the value of the private bidder's option to merge is given by

$$O^B_{pr}(R_0) = \frac{1}{\beta-1}\left[\frac{R_0(\beta-1)}{\beta}\frac{\alpha K_T - cK_B}{(\alpha+c)K_T}\right]^\beta \frac{(\alpha+c)K_B K_T}{K_B+K_T}, \quad (21)$$

if the current state of the stochastic shock, R_0, is below the equilibrium restructuring threshold R^*_{pr}. If R_0 exceeds R^*_{pr}, then it is optimal to merge immediately, and the value of the option to merge is given by

$$O^B_{pr}(R_0) = [R_0(\alpha K_T - cK_B) - (\alpha+c)K_T]\frac{K_B}{K_B+K_T}. \quad (22)$$

The comparison of the equilibrium restructuring thresholds for the cases of the public and private bidders, in (20) and (14) respectively, demonstrates that the private bidder is at an obvious disadvantage. It does not know its precise valuation, which affects the value of the potential merger gain. The private bidder is, thus, unable to optimally exercise its option to merge. In the presence of imperfect information, a merger involving a private bidder is almost always either too early or too late. In particular, if $\varepsilon > 0$, then the public bidder's optimal restructuring threshold, given in (14) is lower than the one of the private bidder, given in (20). In this case, the private bidder underestimates the value of the potential synergy and exercises its restructuring option inefficiently late. The relation between the two thresholds is reversed for $\varepsilon < 0$.

Because of the inefficient exercise of the option to merge, the private bidder has an incentive to go public and learn its true valuation parameter, X_{true}, and, equally importantly, to make it known to the target. By eliminating the valuation uncertainty, the bidder can increase the value of its restructuring option. The decision of whether (and when) to go public is based on the trade-off between this benefit and the IPO cost. This trade-off is analyzed next.

2.2.3 Optimal IPO timing

A private bidder can follow one of the two alternative strategies. It can either go public at some future date, pay the IPO cost, learn its valuation parameter ε, and then merge optimally with the target, or, alternatively, it can merge blindly as a private firm. If it decides to go public, it maximizes the present value of the restructuring option net of the IPO cost by optimally choosing the timing of the IPO. The present value of its restructuring option net of the IPO cost is given by

$$O^B_{IPO}(R_0) = \sup_{R^{IPO}} \mathbb{E}_\tau \left\{ e^{-r\tau_{R^{IPO}}} \mathbb{E}_\varepsilon \left(O^B_{pub}(R^{IPO}, \varepsilon) - \eta K_B R^{IPO}[1+\varepsilon] \right) \right\} =$$

$$\sup_{R^{IPO}} \mathbb{E}_\tau \left\{ e^{-r\tau_{R^{IPO}}} \left(\mathbb{E}_\varepsilon O^B_{pub}(R^{IPO}, \varepsilon) - \eta K_B R^{IPO} \right) \right\}, \quad (23)$$

where $O^B_{pub}(R^{IPO}, \varepsilon)$ is the value of the option to merge if the bidder goes public at R^{IPO}, given in (16) and (17) for different values of ε.[8] The IPO decision takes the form of an upper threshold, R^{IPO}, such that when $R = X/Y$ first reaches R^{IPO}, the option to go public is exercised by paying the IPO cost. $\tau_{R^{IPO}}$ is a stopping time upon reaching the IPO threshold, R^{IPO}.

If the bidder stays private, the value of its restructuring option, $O^B_{pr}(R_0)$, is given by (21). Therefore, the net gain from going public is given by the difference between $O^B_{IPO}(R_0)$ and $O^B_{pr}(R_0)$:

$$IPO\ gain = O^B_{IPO}(R_0) - O^B_{pr}(R_0). \quad (24)$$

If this gain is positive, the benefit of going public dominates the IPO cost, and performing an IPO before merging is the optimal strategy. Otherwise, the optimal solution is to stay private. In what follows, we derive the value of the restructuring option for a private bidder that decides to go public, $O^B_{IPO}(R_0)$, for all possible values of the IPO threshold. The functional form of the gain from the IPO depends on its timing, determined by the IPO threshold, R^{IPO}. In particular, there are three regions to be analyzed.

Region 1: $R^{IPO} < \frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T - cK_B}\frac{1}{1+\lambda}$

In this region, the option to merge is never exercised immediately after going public. A situation in which a merger announcement immediately follows the IPO is ruled out, since for any possible value of ε, the corresponding equilibrium merging threshold of a public bidder, $R^*_{pub}(\varepsilon) = \frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T - cK_B}\frac{1}{1+\varepsilon}$, is higher than the current state of R, $R^{IPO} < R^*_{pub}(\varepsilon)$. Since immediate merger is never optimal, going public in this region cannot be optimal either. The reason is that the expected present value of the IPO cost is proportional to $R^{1-\beta}_{IPO}$, and is, thus, decreasing in R_{IPO}. Thus, it is always better to wait at least until R reaches the value of $\frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T - cK_B}\frac{1}{1+\lambda}$ before going public.

[8] The realized gain differs from the expected gain due to the valuation error that is revealed at the time of the IPO.

Region 2: $\frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1+\lambda} \leq R^{IPO} < \frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1-\lambda}$

In this region, two scenarios are possible after the potential bidder goes public at R^{IPO} and learns its valuation error, ε. If the state of the stochastic shock at IPO is higher than the merging threshold of a public bidder, $R^{IPO} \geq R^*_{pub} = \frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1+\varepsilon}$, then it is optimal to exercise the restructuring option immediately following the IPO, and the value of the restructuring option is given by (17).

If, on the other hand, $R^{IPO} < R^*_{pub} = \frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1+\varepsilon}$, then it is optimal to merge later, at $R^*_{pub} = \frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1+\varepsilon}$, and the value of the merger option is given by (16). After R passes $\frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1+\lambda}$, by waiting the bidder reduces the set of the values of ε for which the optimal exercise timing of the restructuring option is still in the future.

Integrating the values of the public bidder's option to merge in (16) and (17) over all possible values of ε and subtracting the IPO cost yields the following value of going public:

$$O^B_{IPO}(R_0) = \sup_{R^{IPO}_\tau} \mathbb{E}_\tau\{e^{-r\tau_{R^{IPO}}}\{\int_{\varepsilon=-\lambda}^{\varepsilon^*}\left(\frac{1}{2\lambda}\frac{1}{\beta-1}\left[\frac{R^{IPO}(1+\varepsilon)(\beta-1)}{\beta}\frac{\alpha K_T-cK_B}{(\alpha+c)K_T}\right]^\beta \frac{[\alpha+c]K_BK_T}{K_B+K_T}\right)d\varepsilon +$$
$$+\int_{\varepsilon=\varepsilon^*}^{\lambda}\left(\frac{1}{2\lambda}[R^{IPO}(1+\varepsilon)(\alpha K_T-cK_B)-(\alpha+c)K_T]\frac{K_B}{K_B+K_T}\right)d\varepsilon - \eta K_B R^{IPO}\}. \quad (25)$$

where ε^* is the value of ε leading to the merger threshold, R^*_{pub}, in (14) to be equal to R^{IPO}_τ: $\varepsilon^* = \frac{\beta}{\beta-1}\frac{1}{R^{IPO}}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B} - 1$.

The first term in (25) refers to the case in which it is not optimal to exercise the restructuring option immediately after the IPO, the second term refers to the case of an immediate exercise of the merger option, while the third term is the IPO cost. The result of integrating (25) is presented in Appendix 3.

Region 3: $\frac{\beta}{\beta-1}\frac{[\alpha+c]K_T}{\alpha K_T-cK_B}\frac{1}{1-\lambda} \leq R^{IPO}$

In this region the option to go public is worthless. Regardless of the true value of ε, the optimal restructuring policy is to merge immediately, and the restructuring options of the private and public bidders have identical values. As a consequence, a merger-driven IPO will never be observed in this region.

In the next section we calibrate the model and examine the comparative statics of the IPO and merger thresholds and the likelihood of an acquisition following a merger-driven IPO. This calibration exercise generates numerous empirical predictions regarding the determinants of IPOs and mergers and their timing.

3 Model calibration and empirical predictions

3.1 Calibration

In this section we calibrate the model using data on IPOs and M&As. This calibration exercise will guide us in the comparative statics analysis below, whose goal is to examine the effects of the model's parameters on the timing of IPOs and mergers, the likelihood of acquisitions following IPOs, and the economic significance of these effects.

We obtain data on IPOs and M&As from the Thomson Financial's Securities Data Company (SDC) New Issues and Mergers and Acquisitions databases, respectively. Our dataset contains IPOs and takeover attempts with announcement and resolution dates between 1978 and 2006. The resolution date is the date when a firm becomes public (for IPOs) or when the outcome of the deal is revealed (for takeovers). To be included in our initial sample a merger has to satisfy the following criteria:
1) The deal does not belong to one of the following categories: minority stake purchase, acquisition of remaining interest, acquisition of division, asset swap, divestiture, or spin-off.
2) The deal is not an LBO.

The first restriction ensures that an attempted transaction, if successful, would result in a change of corporate control. The second condition is meant to restrict the sample to mergers between firms with physical capital, which can be utilized more productively as a result of a merger, as opposed to a pure change of control of a single firm with existing physical capital, as in the case of a typical LBO. Our final sample contains 42,925 successful and unsuccessful attempts to acquire public and private targets.[9] (In what follows we refer to both successful and unsuccessful acquisition attempts as mergers.)

To be included in the IPO sample, the company must perform an IPO on one of the three major exchanges, and to have filing or issue date available in the SDC database.[10] After excluding rights issues and unit issues, we are left with 9,964 IPOs between 1978 and 2006. In addition, while calibrating the model, we restrict the IPO sample to IPOs of relatively large firms, defined as firms with market value of equity exceeding $100M (in 2006 dollars) at the end of the IPO year. The reason for this restriction is that small firms are less likely to become bidders in future mergers and, thus, their IPO decision is likely to be dominated by motives other than the facilitation of acquisitions.[11] The model's parameters are calibrated as follows.

Valuation error, ε.

[9] Because many of the model's parameters are going to be calibrated using CRSP and Compustat data, the number of observations used in computing the data moments is much smaller in most cases.

[10] We define an IPO date as the filing date. If the latter is unavailable, we use the issue date as IPO date.

[11] Eliminating this restriction while calibrating the model does not have a material impact on the results.

We use the revision of the IPO offer price relative to the midpoint of the initial filing range as a proxy for valuation error.[12] An offer price revision reflects public information about the value of a potential new issuer that is revealed during the IPO process. This revision is parallel to the difference between the value of a public firm and the subjective valuation of a private firm, ε. The mean value of an offer price revision in our sample is 0.019 (1.9%), the median is 0, while the 5^{th} and the 95^{th} percentiles are -0.286 and 0.323 respectively.

Importantly, we believe that the price-revision-based measure of valuation error is biased towards zero for two reasons. First, the initial filing range already reflects some information about the firm, collected by underwriters during the due diligence process. Second, Hanley (1993), Bradley and Jordan (2002), and Ritter and Welch (2002) report that offer price revisions are positively related to IPO underpricing, leading to the conclusion that the adjustment to public information in the offer price revision is only partial, consistent with Benveniste and Spindt's (1989) information acquisition model. Because of this bias, we are likely to underestimate the economic effects of the model's parameters on the likelihood and timing of post-IPO mergers.

Valuation uncertainty, λ.

In the model, the distribution of the valuation error, ε, is uniform, with bounds $-\lambda$ and λ. Since our proxy for ε, offer price revision, is centered around zero (its median is zero and the mean is insignificantly different from zero), we base our proxy for λ on the distribution of the absolute values of ε, $|\varepsilon|$. Under the uniform distribution assumption, $\mathbb{E}(|\varepsilon|) = \frac{\lambda}{2}$. Thus, our estimate of λ is $2\overline{|\varepsilon|}$, where $\overline{|\varepsilon|}$ is the in-sample mean absolute valuation error, $\frac{\sum_i |\varepsilon_i|}{n}$, n being the number of IPOs in our sample with information on the offer price revision. The estimated value of λ is 0.510.

IPO cost, η.

We estimate the direct cost of going public as the ratio of the gross IPO spread and the "share overhang", defined as the ratio of shares retained by non-selling shareholders to shares sold in an IPO. The reason for normalizing the IPO spread by the share overhang is that the spread is calculated relative to the value of new equity issued, as opposed to overall firm value. The mean gross IPO spread of 6.74% in our sample is similar to that in Chen and Ritter (2000), who report a typical gross spread of 7%. The mean share overhang in our sample is 5.08. It is slightly larger than 3.5, estimated by Loughran and Ritter (2004) and Dolvin and Jordan (2005). This discrepancy is mainly due to our focus on IPOs of either large or moderately-sized firms, which tend to have a larger share overhang than smaller firms. Our resulting estimate of the direct IPO cost, η, is 1.33%.

[12] This definition of offer price revision is also employed by Bradley and Jordan (2002) and Ljungqvist and Wilhelm (2003) among others.

Takeover gain factor, α.
In the model, the gain from a takeover is described by α, the bidder's ability to utilize target's capital more productively. The takeover gain equals the product of α and the difference between the valuations of bidder's and target's capital stocks. We use Tobin's q, proxied by bidder's and target's market-to-book ratios (M/B) at the end of the year preceding the takeover, as a proxy for the valuation of their respective capital stocks. M/B is defined as the sum of market value of equity and book value of debt, Compustat data item 24*item 199+item 9+item 34, divided by book value of assets, item 6. The mean bidder's M/B in our sample is 2.4, while the mean target's M/B is 2.[13] These numbers are close to those in Rhodes-Kropf, Robinson and Viswanathan (2005), who report that the ratio of mean bidder's M/B to target's M/B is 1.22.

We proxy for the takeover gain by the combined bidder's and target's dollar return following an acquisition announcement relative to the pre-merger target's equity market value.[14] The mean takeover gain relative to target's value in our sample is 38%.[15] The estimate of α is the ratio of the mean takeover gain and the relative difference between mean bidder's and target's M/B ratios, $\ln\left(\frac{\overline{M/B_B}}{\overline{M/B_T}}\right)$. Our estimate of α is 2.07.[16]

Merger cost, c.
We follow Saunders and Srinivasan (2001) and estimate the direct cost of a merger as the mean ratio of the sum of bidder's and target's merger advisory fees to combined bidder's and target's pre-merger market value. This ratio averages 0.22% in our sample, which is remarkably close to Saunders and Srinivasan's estimate. They estimate the mean advisory fee of 0.7% of target's value, which corresponds to about 0.2% of combined bidder's and target's value in their sample.

Relative target size, $\frac{K_T}{K_B}$.
We begin by computing the mean ratio of target's and bidder's book assets at the end of the year preceding the acquisition announcement. Relative book values proxy for relative capital levels. The mean ratio of target's to bidder's book assets is 0.49. Next, we notice that in the data, unlike in the

[13] Targets' M/B ratios are available only for public targets. We use all available observations of bidders' and targets' M/B, regardless of whether both are available for a given merger.

[14] Extending the announcement return window to include up to three days before and after announcement days does not alter the estimates of the mean combined return substantially.

[15] Bradley, Desai, and Kim (1983) report a typical combined bidder's and target's announcement return of 7.4%, return to target shareholders of 31.77% and return to bidder shareholders of 0.97%, which translates into the combined announcement return relative to the pre-merger target value of about 35%.

[16] This calculation ignores the costs of takeover. However, these costs are estimated to be relatively small (see below) and their effect on the estimate of α is immaterial.

model, the majority of firms that perform IPOs and engage in M&As after having gone public, acquire more than one target in years following the IPO. In fact, the mean number of acquisitions by newly public firms within five years of their IPO is 1.99. We multiply this number by the average relative target's size to get an estimate of the relative combined value of capital of targets acquired by newly public firms. The resulting estimate of $\frac{K_T}{K_B}$ is 0.97.

Bidder's and target's drift parameters, μ_B and μ_T.
We estimate bidder's and target's drift parameters as the differences between the typical risk-free rate during our sample period and the merging parties' payout yields. We proxy for the mean risk-free rate by the yield on a 3-month T-bill averaged on a monthly basis throughout our sample period. The payout yield is computed as in Boudoukh, Michaely, Richardson and Roberts (2007), as the sum of annual dividends (Compustat item 21), purchases of common and preferred stock (item 115) and reduction in the value of preferred stocks outstanding (item 56), divided by the market value of equity at the beginning of the year. The mean 3-month T-bill yield equals 6.05%. The mean payout yield of bidders (public targets) is 5.23% (5.45%).[17] Our resulting estimates of μ_B and μ_T are 0.82% and 0.6% respectively.

Bidder's and target's volatility and correlation parameters, σ_B, σ_T, and ρ.
In estimating σ_B and σ_T, we follow Strebulaev (2007) and compute the standard deviation of unlevered monthly returns of each bidder and public target in the year preceding the year of the acquisition.[18] Unlevered return is defined as the product of raw return and the ratio of the market value of equity to the sum of market value of equity and book value of debt. Since the autocorrelation of monthly returns is virtually zero in our sample, to annualize our estimates, we multiply each estimated standard deviation by $\sqrt{12}$. We then compute the mean annual standard deviations of unlevered returns using all available observations for bidders and public targets.

The correlation coefficient between bidder's and target's stochastic processes, ρ, is estimated as the mean correlation between bidder's and target's monthly returns in the year preceding the year of the merger, in cases where both series of monthly returns are available. Our resulting estimates of σ_B, σ_T, and ρ are 24.7%, 26%, and 18.4% respectively.[19]

The following table summarizes our calibration exercise and the resulting estimates of the model's parameters. The table specifies the sample(s)/data source(s) used in calibration, the mean values of

[17] These estimates are somewhat higher than the mean payout ratio of 4.29% in Boudoukh, Michaely, Richardson and Roberts (2007).

[18] We only use firm-years with 12 monthly return observations available.

[19] The estimates of the volatility parameters are close to 25.5%, used in Strebulaev (2007).

the inputs used, and the number of available observations for each input.

Insert Table 1 here

3.2 Comparative statics of IPO and merger thresholds

Equipped with the calibrated parameters of the model, we proceed to examine the effects of these parameters on the IPO and restructuring thresholds. As this and the next subsection show, this analysis generates novel empirical predictions regarding the likelihood and timing of IPOs and M&As.

In what follows, we assign the base-case values, found in Table 1, to all the parameters but one and analyze the sensitivity of the IPO and merger thresholds to changes in each parameter separately. We begin by examining the comparative statics of the IPO threshold, R^{IPO}, and the merger threshold of a private bidder, R^*_{pr}, with respect to the degree of valuation uncertainty, λ. Note that R^*_{pr} corresponds to the restructuring threshold of a public bidder whose valuation error, ε, equals zero.

Insert Figure 1 here

The solid line in Figure 1 represents the value-maximizing IPO threshold, if going public is the optimal strategy. The dotted line represents the optimal private firm's merging threshold, R^*_{pr}. Valuation uncertainty is a key determinant of the decision of whether and when to go public. It is worth going through a costly IPO in order to learn the value of the potential merger gain only if there is indeed something to be learnt, i.e. if there is sufficient uncertainty regarding the true value of a potential bidder's capital stock (and the corresponding merger gain should it decide to acquire the target). Consistent with this logic, Figure 1 shows a positive relation between the likelihood of going public and λ.

The critical value of the valuation uncertainty parameter is $\lambda = 0.38$. A lower valuation uncertainty makes the IPO option unattractive because the benefit of learning X_{true} is lower than the IPO cost. When λ is low, there is not much to be learnt by going public, and the firm stays private. On the other hand, for $\lambda > 0.38$, the value of the IPO's potential benefit is sufficiently high, and the firm prefers to go public. In that region the optimal IPO threshold is decreasing in λ. The greater the valuation uncertainty, the greater the value of the option to learn the true value of the bidder, and the sooner this option is going to be exercised. Figure 1 illustrates the following empirical prediction:

Prediction 1

a) The likelihood of an IPO prior to a merger attempt (a "merger-driven IPO") is expected to be increasing in the extent of valuation uncertainty.

b) When a merger follows an IPO, the time between the IPO and merger is expected to be increasing in the degree of valuation uncertainty.

The second part of this prediction follows from the fact that the distance between the IPO threshold and expected public bidder's merger threshold in Figure 1 is increasing in λ.

Another important determinant of the decision to go public is the IPO cost, η, as demonstrated in Figure 2.

Insert Figure 2 here

A regime shift occurs at $\eta = 2.3\%$. While it is optimal for the firm to go public before attempting a merger for values of η below 2.3%, for values of η exceeding 2.3% the IPO cost becomes too high relative to the benefit of learning the valuation error and, consequently, being able to exercise the restructuring option optimally. For high values of η, the potential bidder prefers to merge blindly at the restructuring threshold R^*_{pr} in order to save the cost of going public.

Note that in the "go public then merge" regime, the optimal IPO threshold, R^{IPO}, is increasing in η : the costlier the IPO, the less eager the potential private bidder to go public. As noted in Section 2, the expected present value of the IPO cost is decreasing in R^{IPO}. As η increases, the private bidder chooses to postpone its decision to go public in order to reduce the present value of the IPO cost. However, by postponing the IPO decision further, the bidder also decreases the benefit of going public, as it becomes more likely that the optimal time to merge, corresponding to the bidder's true value, X_{true}, has already passed, and the firm is bound to exercise its restructuring option inefficiently late. The optimal IPO timing is determined by the trade-off between these two effects. This argument translates into the following empirical prediction:

Prediction 2

a) The likelihood of an IPO prior to a takeover is expected to be negatively related to the IPO cost.
b) When an IPO precedes a merger attempt, the time between the IPO and the merger announcement is expected to be decreasing in the IPO cost.

Figure 3 illustrates the relations between the optimal IPO and merger thresholds and the takeover gain parameter, α.

Insert Figure 3 here

The optimal restructuring threshold is decreasing in α. The higher the takeover gain relative to the (fixed) takeover cost, the more eager the firms to merge. Importantly, a greater takeover gain increases the benefit of going public and speeds up the optimal exercise of the IPO option, increasing the distance between the IPO threshold and the restructuring threshold. For sufficiently low values of the takeover gain, learning the precise value of the gain is not valuable enough to offset the IPO cost. An empirical prediction following from Figure 3 is:

Prediction 3

a) The likelihood of an IPO is expected to be increasing in the potential takeover gain that can be

realized by merging with a potential target.
b) The time between an IPO and a subsequent merger is expected to increase in the potential takeover gain.

Figure 4 illustrates the relations between the optimal thresholds and the cost of merger, c.

Insert Figure 4 here

Not surprisingly, the optimal merger and IPO thresholds are increasing in c. The higher the takeover cost, the less attractive the merger and the less willing the bidder is to go through an IPO. For sufficiently high values of the takeover cost, going public in order to learn the value of the takeover gain is not valuable enough to offset the IPO cost. Figure 4 illustrates the following intuitive prediction:

Prediction 4
The likelihood of an IPO is decreasing in the cost of a subsequent takeover.

Figure 5 presents the relation between the IPO and merger thresholds and the size of the target relative to the bidder, K_T/K_B.

Insert Figure 5 here

The optimal takeover threshold is decreasing in the target's size. This reflects the fact that the value of the productivity gain is proportional to the target's size. Therefore, the larger the target the more beneficial the IPO. Figure 5 illustrates the following empirical prediction:

Prediction 5
a) The likelihood of an IPO is expected to be increasing in target's relative size.
b) The time between an IPO and a subsequent merger is expected to be increasing in target's relative size.

Figure 6 displays the relations between the optimal thresholds and the parameters of the valuation processes, X_{true} and Y : μ_X, μ_Y, σ_X, and ρ.[20]

Insert Figure 6 here

Altering the parameters of the processes X_{true} and Y affects both the IPO and the merger thresholds. The economic intuition behind the effects on the optimal restructuring threshold can be explained along the lines of Morellec and Zhdanov (2005). Intuitively, a higher growth rate of bidder's cash flow, μ_X, increases the likelihood of the valuation of bidder's capital relative to target's capital, R, reaching a higher level. This, in turn, increases the value of the option to wait and, therefore, raises the optimal takeover threshold. Similarly, the higher the growth rate of target's cash flow, μ_Y, the

[20] As argued below, the effects of σ_Y on the thresholds are similar to those of σ_X.

more attractive the merger at the current state of R, and the lower the takeover threshold. Similarly, the higher the cash flow volatility of either the bidder or the target, σ_X or σ_Y, and the lower the correlation coefficient between the cash flow processes, ρ, the higher the value of the option to wait and the higher the merger threshold.

Generally, the IPO threshold follows the restructuring threshold because, as shown in the previous subsection, it is not optimal to go public long before the potential merger. The reason is that an early IPO increases the present value of the IPO cost. Importantly, the option to go public is not always valuable. When μ_X is sufficiently high or μ_Y is sufficiently low, the bidder prefers to forego the IPO and to follow the second-best takeover policy in order to save the IPO cost. The intuition is as follows. The value of the private bidder's option to merge in (21) is convex in β. The stronger the convexity, the larger the benefit of the IPO. β can be shown to be decreasing in μ_X and to be increasing in μ_Y. For high enough μ_X and low enough μ_Y, the benefit of going public is dominated by the IPO cost. Similarly, increasing σ_X (or σ_Y) or reducing ρ lowers β, thus reducing the value of going public. The empirical prediction following from Figure 6 can be summarized as follows:

Prediction 6
The likelihood of an IPO is decreasing in the growth rate of bidder's value and in bidder's and target's volatilities, and is increasing in the growth rate of target's value and in the correlation coefficient between bidder's and target's valuation processes.

It is important to note that the model's implication with respect to σ_X and σ_Y should be interpreted with caution. The analysis in Figure 6 assumes that everything else is kept constant while the cash flow volatility changes. However, it is likely that the valuation uncertainty, λ, is positively related to volatility. Thus, the overall effect of an increase in volatility on the incentive to go public could be different from the one in our model, in which λ is fixed.

3.3 Comparative statics of the likelihood of post-IPO merger and its timing

While the comparative statics in the previous subsection generate a plethora of qualitative (directional) predictions regarding the effects of the model's parameters on the decision to go public and to merge, they are silent about the economic magnitudes of the effects of the parameters on the likelihood of observing acquisitions following IPOs and their timing. In what follows, we examine the quantitative aspects of the model.

Specifically, we compute the likelihood of a merger occurring within a certain time period following an IPO (one, two, and three years) for different combinations of parameter values.[21] The likelihoods of acquisitions in the first, second, and third year following IPOs are presented in Table 2. We report

[21] The model provides an analytical expression for the distribution of times between IPOs and subsequent mergers for

the results for the base-case parameter values, while varying each parameter at a time.

Insert Table 2 here

Table 2 shows that changes in many of the model parameters produce economically significant effects on the probabilities of merger (especially, changes in the degree of information uncertainty, λ, merger synergy, α, relative target's size, K_T/K_B, volatility of bidder's (and target's) cash flows, and correlation coefficient, ρ. For example, reducing the variation uncertainty parameter by 0.10 relative to its base-case value of 0.51 results in an increase in the likelihood of a merger within one year of an IPO by more than six percentage points, from 41.5% to 47.9%.

The intuition behind these effects is related to the comparative statics graphs in Figures 1-6. For, example, an increase in λ increases the probability of a high ε (and the probability that the optimal merger threshold is low) and, therefore, increases the cost of waiting, making an earlier IPO more attractive. This, in turn, widens the gap between the optimal IPO and the (average) merger thresholds and reduces the probability of merger within a fixed time period following the IPO. Similar intuition applies to the effects of other parameters.

3.4 Valuation errors and the likelihood of merger

One of the most important determinants of a newly public firm's acquisition strategy is the valuation error that the firm learns at the time of its IPO. A firm whose post-IPO valuation is higher than its pre-IPO subjective valuation (ε is positive) is likely to find it optimal to acquire another firm either immediately after the IPO or soon thereafter. This is because for high levels of ε, the value of the stochastic process R at the time of the IPO, R^{IPO}, is higher than the optimal restructuring threshold, R^*_{pub}. For slightly lower levels of ε, immediate merger is not optimal, but it is likely that R will reach R^*_{pub} soon after the IPO. The lower the ε, the more time it would take for R to reach R^*_{pub}, and the higher the likelihood that the restructuring threshold is not going to be reached within a given time period. In this subsection we examine the relation between the realization of the valuation error and the likelihood of future acquisitions. We provide both calibration-based theoretical predictions and empirical evidence of acquisition patterns of firms with high and low valuation errors.

In Figure 7, left panel, we compute the theoretical probabilities of a merger in the first five years following the IPO for the base set of parameter values. We report the percentage of mergers that occur in years one through five after the IPO for all firms in the top left figure, for firms with $\varepsilon \geq 0$

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any given ε. The probability density function is

$$f(t) = \frac{\left|\ln(R^*_{pub}/R^{IPO})\right|}{\sigma\sqrt{2\pi}t^{3/2}} \left(\frac{R^*_{pub}}{R^{IPO}}\right)^{\frac{\mu-\sigma^2/2}{\sigma^2}} \exp\left(-\frac{\mu-\sigma^2/2}{2} - \frac{\ln^2(R^*_{pub}/R^{IPO})}{2\sigma^2 t}\right),$$

if $R^*_{pub} > R^{IPO}$ and $f(t) = \delta(t)$ if $R^*_{pub} < R^{IPO}$, where $\delta(t)$ is Dirac's delta function.

in the middle left figure, and for all observations with $\varepsilon < 0$ in the bottom left figure. Since only one merger is allowed in the model, for years 2-5 we compute the probabilities of merger conditional on no merger in the previous years.

Insert Figure 7 here

Not surprisingly, many mergers occur in the first post-IPO year, especially within the subset of firms with positive valuation errors. The reason is that in the model it is optimal for a firm with sufficiently high ε to merge right after its IPO. The takeover intensity drops substantially after the first post-IPO year. The takeover intensity for all post-IPO years is higher within the subset of firms with positive ε's than that of firms with negative ε's. Interestingly, for the negative-ε firms, the merger intensity in the first post-IPO year is actually lower than in the second year. The reason is that the valuation errors of many firms in this subset are so negative that the firms find themselves far from the optimal restructuring threshold.

In the right panel of Figure 7 we present an empirical analog of the results in the left panel. Specifically, for each IPO firm in our sample, discussed in the previous section, we track the time (in months) until its first acquisition. We split the sample of all IPO firms to those with non-negative offer price revisions and those with negative revisions and report post-IPO merger intensities using a similar format. The first finding from comparing theoretical and empirical results is that far fewer newly public firms perform acquisitions than the numbers suggested by the model. The reason is simple. While our model highlights one potential reason for going public, there are plenty of other reasons for performing an IPO, mentioned in the introduction. Not all IPOs are motivated by potential takeovers, and therefore the actual takeover activity of post-IPO firms is lower than the one predicted by the model.

A more interesting observation is that firms with non-negative offer price revisions perform many more mergers than firms with negative valuation errors. This finding, while consistent with our model, is also consistent with another theory linking IPOs and M&As, specifically, that high ε increases the amount of acquisition currency a firm possesses. High ε is associated with both deeper pockets in the case of cash acquisitions and higher share price in the case of stock mergers. What the acquisition currency theory does not predict, however, is the evolution of merger intensity after an IPO. The finding of a sharp drop in merger activity after the first post-IPO year for the subsample of IPOs with non-negative offer price revisions and an increase in merger intensity between the first to second post-IPO years for the subsample of IPOs with negative price revisions, is remarkably consistent with our model's predictions.

Overall, the calibration of the model demonstrates that many of the model's parameters, have a pronounced effect on the timing of IPOs and acquisitions and on the likelihood of mergers following IPOs. In addition, the real-life M&A behavior of newly-public firms is similar to that predicted by the model. This evidence is a first step in testing the model and attempting to distinguish it from other models linking IPOs and M&As. In the next section, we present illustrative empirical evidence of the relation between hot IPO markets and merger waves.

4 Implications for the relation between IPO and merger waves

In our model, IPOs happen when the state of the stochastic shock, R, reaches an upper threshold, R^{IPO}. A merger occurs when R reaches another high, R^*_{pr} in the case of a private bidder or R^*_{pub} in the case of a public one. It follows, therefore, that factors that influence the profitability of potential acquisitions also affect the value of the benefit of going public. Thus, an indirect prediction of the model is that periods of high merger intensity (merger waves) are likely to be preceded by periods of high IPO intensity (IPO waves). In this section we test this prediction empirically.

In examining the relation between IPO and merger intensities, we employ the same samples of M&As and IPOs as the ones we use in the calibration of the model in the previous section. We use two measures of annual industry merger intensity to ensure the robustness of our findings:
1) The number of attempted acquisitions in a given industry during a year scaled by the total number of Compustat firms in the same industry in the previous year. The industry grouping is based on Fama and French (1997) classification that assigns firms to 49 industries.[22]
2) The number of completed acquisitions, scaled similarly.

Our measure of IPO intensity is the number of firms belonging to an industry that went public in a given year divided by the total number of Compustat firms in that industry during the previous year. In addition to industry-level IPO and merger intensity measures, we compute market-level measures by aggregating the industry-wide measures across all industries in each year.

To examine whether periods of high IPO intensity precede periods of high merger intensity, we perform the following regression:

$$MA_{i,t} = \alpha + \beta_1 (IPO)_{i,t-3\sim t-1} + \beta' X_{i,t-1}, \tag{26}$$

where $MA_{i,t}$ is one of the two measures of industry i's merger intensity in year t, $(IPO)_{i,t-3\sim t-1}$ is the sum of IPO intensities in years -3 through -1 relative to year t,[23] and $X_{i,t-1}$ is a vector of lagged control variables expected to be related to merger activity.

The choice of control variables is motivated by both behavioral and neoclassical hypotheses of merger waves and generally follows Mitchell and Mulherin (1996), Andrade and Stafford (2004), and Harford (2005). The controls include the industry-level median market-to-book ratio and its standard

[22] In cases in which a bidder and target belong to different Fama and French (1997) industries ("conglomerate mergers"), we assign the merger to the bidder's industry.

[23] Using one-year or five-year lagged IPO intensities produces qualitatively similar results to those reported.

deviation, and four median industry characteristics: cash-to-assets, R&D-to-assets, return on assets, and book leverage. In addition, following Harford (2005), we include two additional control variables. The first one is the spread between the average commercial and industrial loans rate and the Fed rate (C&I rate spread), which proxies for credit availability. The second one is the deregulation shock, proxied by a dummy variable that equals one following a deregulation of an industry.[24,25]

The results of estimating (26) are presented in Table 3. Panels A presents the results obtained using industry-level M&A and IPO intensity measures, respectively. The independent variable, industry-year merger intensity, is based on the full sample of mergers (models 1 and 3) or on the sample of completed deals (models 2 and 4). Models 1 and 2 include utilities and financial industries while models 3 and 4 exclude these industries. To account for the fact that mean merger intensities vary across industries, we estimate (26) using industry fixed effects. To account for cross-sectional correlations and autocorrelations of residuals, we follow Petersen (2007) and compute standard errors clustered by industry and year.

Insert Table 3 here

The main finding in Panel A is that increasing the average annual industry IPO intensity in the past three years by one percentage point increases the merger intensity by 0.16-0.26 percentage points, depending on the sample and regression specification. Consistent with past studies, the coefficient estimates on control variables have the predicted signs, although some of them are insignificant. More importantly, merger intensity is significantly related to IPO intensity in all specifications.

In Panel B, the dependent variable is aggregate (market-wide) merger intensity. The independent variables are economy-wide median characteristics discussed above. Similar to Panel A, past economy-wide IPO intensity is significantly related to the economy-wide M&A intensity. The economic significance is larger for aggregate merger intensity than for industry-wide ones in Panel A: increasing the annual aggregate IPO intensity in the past three years by one percentage point raises the merger intensity by about 1.6 percentage points on average.

We further examine whether past IPO activity is related to industry-wide merger waves. Following Mitchell and Mulherin (1996) and Harford (2005), we estimate merger waves over two-year intervals. Specifically, we first calculate the number of acquisitions in each of the 49 industries in each two-year period. We then compute the total number of mergers in each industry during our 29-year sample period and randomly assign each merger to one of the 29 years. We repeat this procedure 1,000 times and obtain a simulated distribution of the number of mergers during each two-year period under the assumption of no merger waves. Finally, we compare this simulated distribution with the actual

[24] See Harford (2005) for the list of deregulatory events.

[25] Including lagged merger intensities in the set of explanatory variables, in order to make sure the results are not driven by contemporaneous correlations between merger and IPO intensities, coupled with persistence in the merger intensity series, does not affect the results.

number of mergers during each two-year period. If, for each period, the actual number of mergers exceeds the simulated value in more than 950 cases, this period constitutes a merger wave. We perform this exercise for each of the 49 industries and repeat it for the sample of completed acquisitions.

Overall, out of 1,421 industry-years, we have 351 merger-wave-years in the sample of attempted mergers and 361 wave-years in the sample of completed takeovers. The correlation between our two definitions of merger waves is 0.87 and is highly significant. We assign the value of one to wave-years and zero to other years.[26] We use the following logistic regression to examine the relation between IPO waves and merger waves:

$$Wave_{i,t} = \frac{1}{1 + e^{-[\alpha+\beta_1(IPO)_{i,t-3\sim t-1}+\beta' X_{i,t-1}]}}, \tag{27}$$

where $Wave_{i,t}$ is an indicator variable equalling one if industry i is in a merger wave in year t and $X_{i,t-1}$ is the same set of control variables as in (26).

Table 4 presents results from estimating the logistic regressions in (27).

Insert Table 4 here

Consistent with the results in Table 3, logistic regressions also reveal a positive and highly significant relation between the likelihood of merger waves and past IPO activity in all samples. Overall, the results in this section indicate that, consistent with the model, past IPO activity is positively correlated with future merger activity. This result is similar to that in Rau and Stouraitis (2006), who document that IPO and merger waves tend to overlap in time, with IPO waves typically starting first and merger waves continuing after the end of IPO waves.

It is important to note that the results in this section are meant to illustrate the empirical link between IPOs and mergers and are not meant to distinguish the predictions of our model from those following alternative theories connecting IPOs and M&As, such as the asymmetric information theories (e.g., Hansen, 1987; Fishman, 1989; and Eckbo, Giammarino and Heinkel, 1990) or a hypothesis that IPOs are a way to obtain cash to be used in acquisitions.

The difference between the predictions of our model and the predictions of the asymmetric information models is that the latter provide a link between IPOs and stock acquisitions only. Our model, on the contrary, demonstrates the link between IPOs and both cash-based and stock-based M&As.

[26] A complete list of merger waves estimated through this procedure is available upon request. Our procedure is in the spirit of Harford (2005) with several modifications. First, Harford splits his 20-year sample into two 10-year periods and performs a separate analysis within each of the two periods. We characterize merger waves using the whole sample period. Second, Harford allows for one merger wave within each 10-year period, while we do not impose restrictions on the number of merger-wave-years. Third, Harford assigns a value of one to the year starting a wave, while we assign the value of one to each year belonging to a merger wave. To ensure the robustness of our findings, we also employ a procedure that closely follows Harford's methodology. The empirical results are robust to the way merger waves are defined.

Also, unlike the hypothesis that IPOs affect cash merger intensity solely by providing cash for future acquisitions, our model predicts that IPOs would have a larger effect on future takeover activity than Seasoned Equity Offerings (SEOs). This is because an IPO is beneficial due to its ability to reduce valuation uncertainty, while an SEO would imply no such benefit. These differences could serve as a basis for empirical tests trying to distinguish our model from alternative theories linking IPOs and M&As.

5 Conclusions

We present a dynamic model of IPOs motivated by the optimal implementation of subsequent takeover opportunities. A potential bidder may want to go public in order to learn the true value of its capital stock, which affects the future takeover gain it can realize. Equally importantly, an IPO makes the potential bidder's value observable to the potential target. This allows the two firms to exercise their restructuring options optimally. Thus, an IPO eliminates (or reduces) the valuation uncertainty and leads to value-maximizing restructuring policy.

In addition to illustrating a new motivation for going public, the model generates a number of unique empirical predictions that relate the likelihood and timing of IPOs and subsequent mergers to the degree of valuation uncertainty, the IPO cost, the potential merger gain, the merger cost, the size of the firm considering an IPO relative to its potential takeover target, and the parameters of the valuation processes of the bidder and the target. For example, high valuation uncertainty and low IPO cost make an IPO more likely, as does high potential takeover gain. The time between a merger-related IPO and the subsequent merger is expected to be positively related to the degree of valuation uncertainty and to the potential takeover gain, and to be negatively associated with the IPO cost.

We calibrate the model using 29 years of data on IPOs and M&As obtained from the SDC and show that the effects of the model's parameters, especially the extent of valuation uncertainty, the IPO cost, and the potential merger gain, are economically large. In addition, firms that realize positive valuation errors at the time of their IPO pursue a much more aggressive M&A policy in years following the IPO than firms realizing negative valuation errors. We confirm this prediction of the model by examining the post-IPO acquisitions of firms with positive and negative offer price revisions that proxy for valuation errors.

One implication of the model is that periods of high M&A activity are likely to be preceded by periods of hot IPO markets. We present illustrative empirical evidence showing that merger waves are indeed preceded by periods with abnormally high volume of IPOs. This funding suggests that factors affecting merger activity, such as technological, regulatory and demand shocks may also be related to IPO activity.

In sum, we propose a new link between firms' decisions to go public and to engage in M&As. A reduction in valuation uncertainty following an IPO increases the value of a firm's restructuring option, which provides an additional incentive to go public. While our analysis focuses on the decision of a potential bidder to go public, it is fully adaptable to the case of a private firm that considers itself a likely acquisition target. Different from the mis-valuation-based models of mergers, our model relies on rational investors and efficient markets. Although there is uncertainty regarding a private firm's valuation, there is no asymmetry between the bidder's and target's information. Since the motive for going public in our model is to optimize the subsequent acquisition strategy and since we rule out mis-valuation motives for merging and for going public, ours can be considered a "neoclassical" theory of IPOs.

While the calibration of the model and our illustrative empirical evidence suggest that IPO and merger activities seem to be related, testing the predictions of our model and of alternative theories linking IPOs and M&As presents a potentially interesting avenue for future research.

Appendix

A1. Optimal restructuring threshold

In what follows, we outline the solution of the model for the case of a public bidder. The solution for the private bidder case is obtained along the same lines. In the region in which it is not optimal to make a takeover bid immediately, the instantaneous change in the value of public bidder's option to merge, O^B_{pub}, satisfies (by an application of Itô's lemma)

$$dO^B_{pub} = dXO^B_{pub_X} + dYO^B_{pub_Y} + \left[\frac{1}{2}\sigma^2_X X^2 O^B_{pub_{XX}} + \rho\sigma_X\sigma_Y XYO^B_{pub_{XY}} + \frac{1}{2}\sigma^2_Y Y^2 O^B_{pub_{YY}}\right] dt. \quad \text{(A.1)}$$

The equilibrium expected return on the restructuring option is r. Combining this equilibrium condition with (A.1) and taking expectations of both sides, results in the following partial differential equation:

$$rO^B_{pub} = \mu_X XO^B_{pub_X} + \mu_Y YO^B_{pub_Y} + \frac{1}{2}\sigma^2_X X^2 O^B_{pub_{XX}} + \rho\sigma_X\sigma_Y XYO^B_{pub_{XY}} + \frac{1}{2}\sigma^2_Y Y^2 O^B_{pub_{YY}}, \quad \text{(A.2)}$$

Similar to (6), since the value function O^B_{pub} is linearly homogeneous in X and Y, the optimal restructuring policy can be described using the ratio $R = X/Y$, and the value of the restructuring option can be written as

$$O^B_{pub}(X, Y) = YO^B_{pub}(X/Y, 1) = YO^B_{pub}(R). \quad \text{(A.3)}$$

Successive differentiation yields:

$$O^B_{pub_X}(X, Y) = O^B_{pub_R}(R), \quad \text{(A.4)}$$

$$O^B_{pub_Y}(X, Y) = O^B_{pub}(R) - RO^B_{pub_R}(R), \quad \text{(A.5)}$$

$$O^B_{pub_{XX}}(X, Y) = O^B_{pub_R}(R)/Y, \quad \text{(A.6)}$$

$$O^B_{pub_{XY}}(X, Y) = -RO^B_{pub_{RR}}(R)/Y, \quad \text{(A.7)}$$

$$O^B_{pub_{YY}}(X, Y) = R^2 O^B_{pub_{RR}}(R)/Y. \quad \text{(A.8)}$$

Substituting (A.3)-(A.8) in the partial differential equation (A.2) yields the ordinary differential equation

$$\frac{1}{2}[\sigma^2_X - 2\rho\sigma_X\sigma_Y + \sigma^2_Y]R^2 O^B_{pub_{RR}}(R) + [\mu_X - \mu_Y]RO^B_{pub_R}(R) = [r - \mu_Y]O^B_{pub}(R), \quad \text{(A.9)}$$

with the value-matching and smooth-pasting conditions

$$O^B_{pub}\left(R^*_{B_{pub}}\right) = \xi\alpha K_T[R^*_{B_{pub}}(1+\varepsilon) - 1] - cK_B R^*_{B_{pub}}[1+\varepsilon], \quad \text{(A.10)}$$

$$O^B_{pub_R}\left(R^*_{B_{pub}}\right) = \xi\alpha K_T[1+\varepsilon] - cK_B[1+\varepsilon], \quad \text{(A.11)}$$

as well as the no-bubbles condition

$$\lim_{R\to 0} O^B_{pub}(R) = 0. \quad \text{(A.12)}$$

The general solution to (A.9) is given by

$$O^B_{pub}(R) = AR^{\beta_1} + BR^{\beta_2}, \tag{A.13}$$

where A and B are positive constants, and β_1 and β_2 are the positive and negative roots of the quadratic equation

$$\frac{1}{2}[\sigma_X^2 - 2\rho\sigma_X\sigma_Y + \sigma_Y^2]\beta[\beta - 1] + [\mu_X - \mu_Y]\beta - r + \mu_Y = 0. \tag{A.14}$$

Condition (A.12) implies that $B = 0$. Thus, denoting β_1 as β, conditions (A.10) and (A.11) can be re-written as

$$A\left[R^*_{B_{pub}}\right]^\beta = \xi\alpha K_T[R^*_{B_{pub}}(1+\varepsilon) - 1] - cK_B R^*_{B_{pub}}[1+\varepsilon], \tag{A.15}$$

and

$$\beta A\left[R^*_{B_{pub}}\right]^{\beta-1} = \xi\alpha K_T[1+\varepsilon] - cK_B[1+\varepsilon]. \tag{A.16}$$

Solving the system of (A.15) and (A.16) yields

$$A = \left[R^*_{B_{pub}}\right]^{-\beta}\left[\xi\alpha K_T(R^*_{B_{pub}}\{1+\varepsilon\} - 1) - cK_B R^*_{B_{pub}}(1+\varepsilon)\right], \tag{A.17}$$

and

$$R^*_{B_{pub}} = \frac{\beta}{\beta-1}\frac{\xi\alpha K_T}{(\xi\alpha K_T - cK_B)(1+\varepsilon)}. \tag{A.18}$$

The value of the target's restructuring option, $R^*_{T_{pub}}$, is obtained along the same lines.

A2. Equilibrium value of the restructuring option

Again, we describe the solution for the case of a public bidder; the private bidder case is solved analogously. Plugging ξ^* and $R^*_{B_{pub}}$ in (13) and (14) respectively into (A.17) and (A.13) yields the value of the public bidder's restructuring option for the region $R_0 < R^*_{pub}$:

$$O^B_{pub}(R_0,\varepsilon) = \frac{1}{\beta-1}\left[\frac{R_0(1+\varepsilon)(\beta-1)}{\beta}\frac{\alpha K_T - cK_B}{(\alpha+c)K_T}\right]^\beta \frac{[\alpha+c]K_B K_T}{K_B+K_T}. \tag{A.19}$$

If $R_0 \geq R^*_{pub}$, then the bidder launches a takeover bid immediately (at R_0). Plugging ξ^* in (13) into (A.15) yields the value of the takeover gain accruing to the bidder:

$$O^B_{pub}(R_0,\varepsilon) = [R_0(1+\varepsilon)(\alpha K_T - cK_B) - (\alpha+c)K_T]\frac{K_B}{K_B+K_T}. \tag{A.20}$$

A3. IPO and the value of the restructuring option

Integrating the expressions in (25) in region 2 yields the following result:

$$O^B_{IPO}(R_0) = \sup_{R^{IPO}}\left(\frac{R_0}{R^{IPO}}\right)^\beta \{\frac{1}{\beta-1}\left(\frac{R^{IPO}(\beta-1)}{\beta}\frac{\alpha K_T - cK_B}{(\alpha+c)K_T}\right)^\beta \frac{[\alpha+c]K_B K_T}{K_B+K_T}\times$$
$$\left\{\frac{(1+\varepsilon^*)^{\beta+1} - (1-\lambda)^{\beta+1}}{2\lambda(\beta+1)}\right\} + \frac{K_B(\lambda-\varepsilon^*)}{2\lambda(K_B+K_T)}\left\{\frac{1}{2}R^{IPO}(\lambda+\varepsilon^*+2)(\alpha K_T - cK_B) - (\alpha+c)K_T\right\}$$
$$- \eta K_B R^{IPO}\}. \tag{A.21}$$

A4. Reversible merger

In this section we extend the basic model of Section 2 to allow the private bidder and its target to undo the merger in case of low realizations of ε. (This option is worthless for a public bidder, who knows the precise value of ε before the merger and, thus, would not choose to merge when ε is low.) In particular, we assume the following sequence of events in the case of an acquisition by a private bidder. First, once the restructuring threshold is reached, the firms pay their respective merger costs and merge. Second, ε is realized. If ε is so low that $R^*_{pr}(1+\varepsilon) < 1$, the merger is value-reducing and can be undone costlessly. With the cancellation option in place, the private bidder's optimization problem in (18) can be rewritten as

$$\begin{aligned} R^*_{B_{pr}} &= \arg\max_{X,Y} \mathbb{E}_\varepsilon(O^B_{pr}(X_0, Y_0, \xi)) = \arg\max_R \mathbb{E}_\varepsilon(Y_0 O^B_{pr}(R_0, \xi)) = \\ &= \arg\max_R \left(\left[\frac{R_0}{R}\right]^\beta \mathbb{E}_\varepsilon\{\max\left(\xi\alpha K_T[R(1+\varepsilon)-1], 0\right) - cK_B R(1+\varepsilon)\} \right) = \\ &= \arg\max_R \left(\left[\frac{R_0}{R}\right]^\beta \left[\mathbb{E}_\varepsilon\{\max \xi\alpha K_T[R(1+\varepsilon)-1], 0\} - cK_B R\right] \right), \end{aligned} \tag{A.22}$$

where $\mathbb{E}_\varepsilon$ denotes expectation over the distribution of ε. Similarly, the target's shareholders maximize the value of their share of the takeover surplus by solving the following optimization program

$$\begin{aligned} R^*_{T_{pr}} &= \arg\max_{X,Y} \mathbb{E}_\varepsilon(O^T_{pr}(X_0, Y_0, \xi)) = \arg\max_R \mathbb{E}_\varepsilon(Y_0 O^T_{pr}(R_0, \xi)) = \\ &= \arg\max_R \left(\left[\frac{R_0}{R}\right]^\beta \left[\mathbb{E}_\varepsilon\{\max\left([1-\xi]\alpha K_T[R(1+\varepsilon)-1], 0\right)\} - cK_T\right] \right) \end{aligned} \tag{A.23}$$

The optimization problem of the bidder translates into the following form:

$$R^*_{B_{pr}} = \arg\max_R O^B_{pr}(R_0, R, \xi) = \arg\max_R \left(\left[\frac{R_0}{R}\right]^\beta [b(R) - cK_B R] \right), \tag{A.24}$$

where

$$b(R) = \xi\alpha K_T[R-1], \text{ if } R > \frac{1}{1-\lambda}, \tag{A.25}$$

and

$$\begin{aligned} b(R) &= \xi\alpha K_T \frac{1}{2\lambda} \int_{\frac{1}{R}-1}^{\lambda} [R(1+\varepsilon) - 1] d\varepsilon = \\ &= \frac{\xi\alpha K_T}{2\lambda} \left\{ \frac{R(1+\lambda)^2 - (1/R)}{2} - (\lambda + 1 - \frac{1}{R}) \right\}, \text{ if } R < \frac{1}{1-\lambda}. \end{aligned} \tag{A.26}$$

The target's optimization problem is similar

$$R^*_{T_{pr}} = \arg\max_R O^T_{pr}(R_0, R, \xi) = \arg\max_R \left(\left[\frac{R_0}{R}\right]^\beta [t(R) - cK_T] \right), \tag{A.27}$$

where

$$t(R) = [1-\xi]\alpha K_T[R-1], \text{ if } R > \frac{1}{1-\lambda}, \tag{A.28}$$

and

$$t(R) = \xi\alpha K_T \frac{1}{2\lambda}\int_{\frac{1}{R}-1}^{\lambda}[R(1+\varepsilon)-1]d\varepsilon =$$
$$= \frac{[1-\xi]\alpha K_T}{2\lambda}\left\{\frac{R(1+\lambda)^2-(1/R)}{2} - (\lambda+1-\frac{1}{R})\right\}, \text{ if } R < \frac{1}{1-\lambda}. \tag{A.29}$$

The equilibrium restructuring threshold together with the fraction of the surplus accruing to bidder's and target's shareholders now have to be found numerically. The merger threshold is obtained at the intersection of the reaction functions of the bidder and the target:

$$R^*_{B_{pr}}(\xi) = R^*_{T_{pr}}(\xi) \equiv R^*_{pr} \tag{A.30}$$

where $R^*_{B_{pr}}(\xi)$ and $R^*_{T_{pr}}(\xi)$ are given in (A.24) and (A.27) respectively.

When choosing whether or not to go public, a private bidder now compares the value of public bidder's restructuring option net of the IPO cost, $O^B_{IPO}(R_0)$, given in (23), with the value of private bidder's restructuring option. The latter must now be computed numerically and equals $O^B_{pr}(R_0, R^*_{pr}, \xi^*)$, where $O^B_{pr}(R_0, R, \xi)$ is given in (A.24), and R^*_{pr} and ξ^* are the equilibrium restructuring threshold and the equity share of the bidding shareholders, found as the solution to (A.30).

Note that similarly to the majority of real option models, inherent in our model is the option to wait. This option has a positive value and results in restructuring at a threshold corresponding to a strictly positive expected synergy. Therefore, for a private bidder, a merger attempt occurs when X is strictly greater than Y ($R^*_{pr} > 1$). This substantially reduces the likelihood that the actual synergy would turn out negative (which would happen if $R^*_{pr}(1+\varepsilon) < 1$). The likelihood of this event depends on the degree of valuation uncertainty, λ. For the base set of input parameters (see Section 3), the probability of a negative takeover gain is zero, since in equilibrium a merger is always initiated at a threshold such that even in the worst case, $\varepsilon = -\lambda$, $R^*_{pr}(1+\varepsilon) > 1$.

To gauge the effect of the option to withdraw the takeover bid if the actual synergy value is negative, we examine the case of extreme information uncertainty with $\lambda = 0.75$. Even in this case the effect of the takeover bid irreversibility is minimal. In particular, the vector of merger probabilities in the first three post-IPO years changes from (0.331 0.082 0.057) for the case of an irreversible merger attempt to (0.320 0.081 0.056) for the case of a reversible merger attempt. In addition, the comparative statics of the IPO and merger thresholds, as well as those of the merger timing with respect to all of the model's parameters are not affected by the addition of the option to undo the merger.

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Figure 1. Optimal IPO and takeover thresholds and valuation uncertainty
This figure plots the optimal IPO threshold, R^{IPO}, as a function of the degree of valuation uncertainty, λ (the solid line). The dotted line is the optimal merging threshold for the private bidder case, R^{*}_{pr}. Parameter values are set as in the base-case environment (except for λ) $\alpha = 2.07$, $c = 0.00217$, $K_B = 1$, $K_T = 0.973$, $\mu_X = 0.0082$, $\mu_Y = 0.006$, $\sigma_X = 0.247$, $\sigma_Y = 0.26$, $r = 0.0605$, and $\rho = 0.18$.

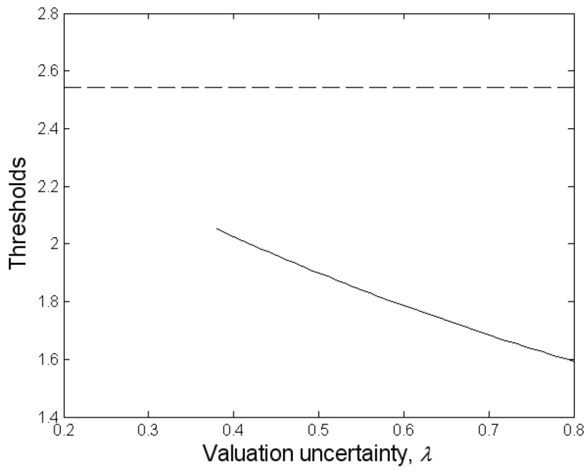

Figure 2. Optimal IPO and takeover thresholds and IPO cost
This figure plots the optimal IPO threshold, R^{IPO}, as a function of the IPO cost η (the solid line). The dotted line is the optimal merging threshold for the private bidder case, R^{*}_{pr}. Parameter values are set as in the base case environment (except for η).

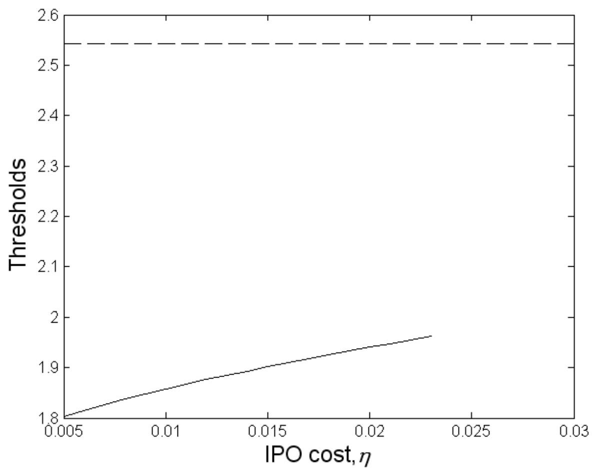

Figure 3. Optimal IPO and takeover thresholds and potential merger gain
This figure plots the optimal IPO threshold, R^{IPO}, as a function of the merger gain parameter, α (the solid line). The dotted line is the optimal merging threshold for the private bidder case, R^*_{pr}. Parameter values are set as in the base case environment (except for α).

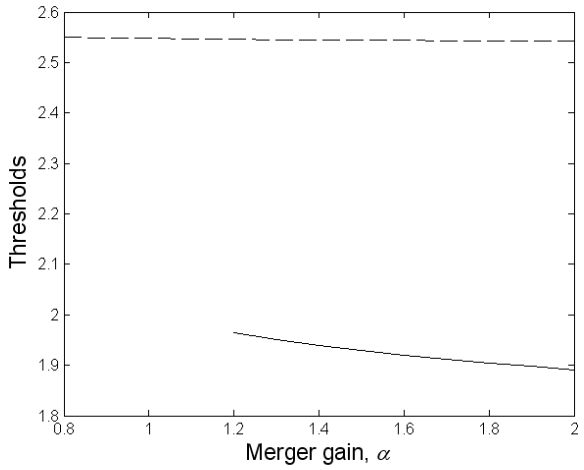

Figure 4. Optimal IPO and takeover thresholds and takeover cost
This figure plots the optimal IPO threshold, R^{IPO}, as a function of the merger cost parameter, c (the solid line). The dotted line is the optimal merging threshold for the private bidder case, R^*_{pr}. Parameter values are set as in the base case environment (except for c).

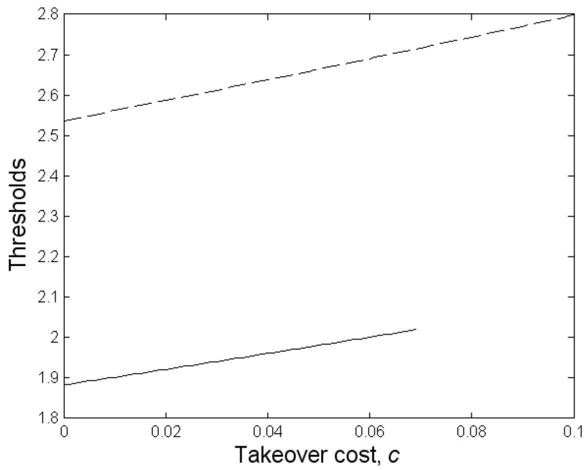

Figure 5. Optimal IPO and takeover thresholds and relative target's size
This figure plots the optimal IPO threshold, R^{IPO}, as a function of the potential bidder's size, K_T (the solid line), while holding K_B equal to 1. The dotted line is the optimal merging threshold for the private bidder case, R^*_{pr}. Parameter values are set as in the base case environment (except for K_T).

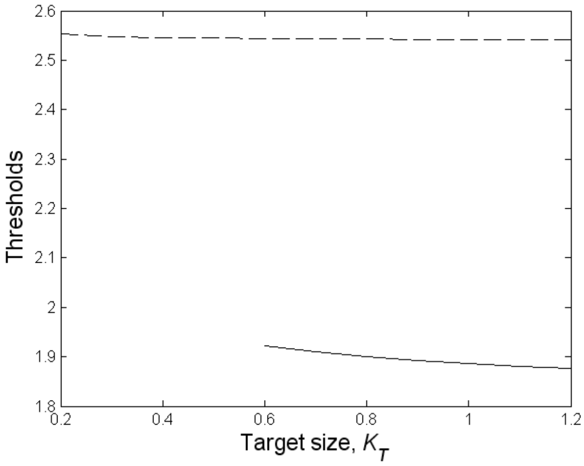

Figure 6. Optimal IPO and takeover thresholds and parameters of the value processes
These figures plot the optimal IPO threshold, R^{IPO}, as a function of the parameters of the bidder's and target's value processes: μ_X, μ_Y, ρ, and σ_X (the solid lines). The dotted lines are the optimal merging threshold for the private bidder case, R^*_{pr}. Parameter values are set as in the base case environment.

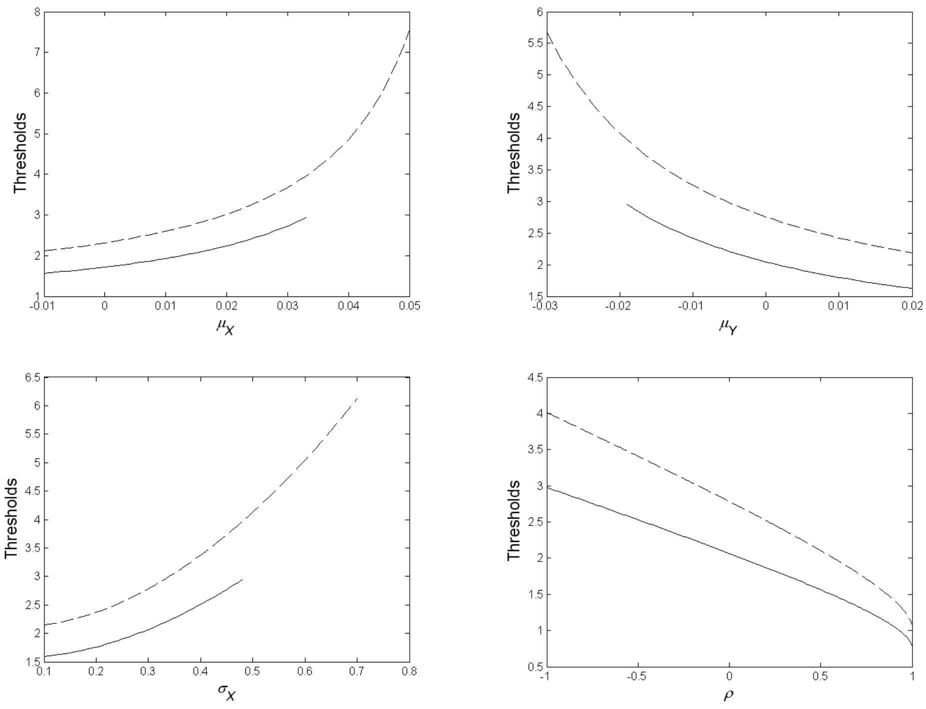

Figure 7. Valuation errors and merger likelihood – predicted and actual

This figure plots the percentage of mergers in years one through five after IPO as a percentage of IPO firms that have not merged until that year. The left panel presents the predictions of the model. The top left figure presents the percentage of post-IPO mergers for all firms, the middle left figure depicts the percentage of mergers for firms with $\varepsilon \geq 0$, and the bottom left figure presents the percentage of mergers for firms with $\varepsilon < 0$. The right panel plots the actual percentage of mergers in years one through five after IPO as a percentage of IPO firms that have not merged until that year. The top right figure presents the percentage of post-IPO mergers for all firms, the middle right figure depicts the percentage of mergers for firms with non-negative offer price revisions and the bottom right figure presents the percentage of mergers for firms with negative offer price revisions. The sample period of IPOs is 1978-2001. The sample period of mergers is 1978-2006.

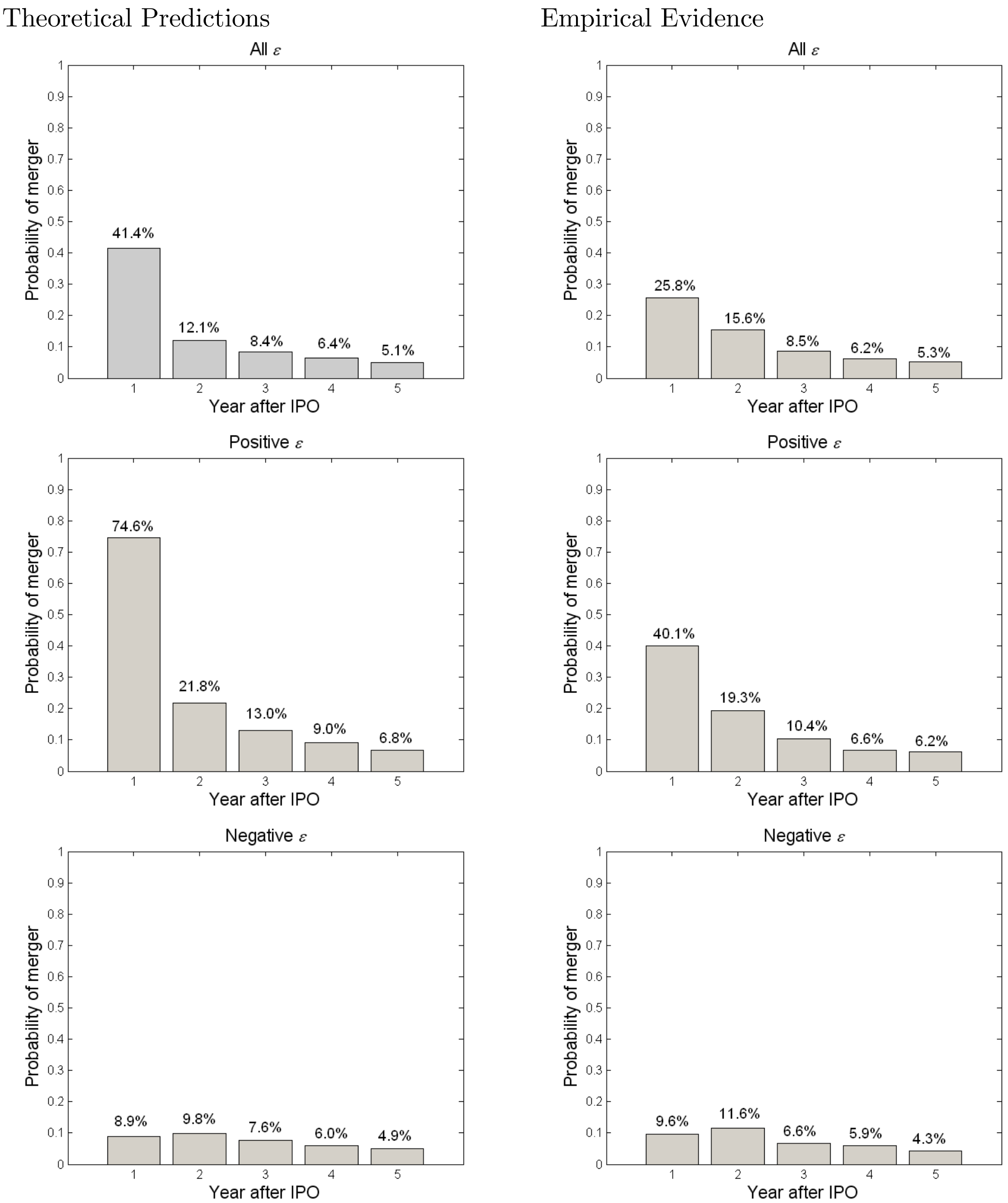

Table 1. Calibration summary

This table presents the summary statistics from the calibration of the model parameters. The data sources are SDC for IPOs and M&As, Compustat for the accounting items, and CRSP for stock returns. The interest rates are from the Federal Reserve. The sample period is 1978-2006. ε is the valuation error. λ is the valuation uncertainty parameter. η is the IPO cost. α is the takeover gain factor. c is the merger cost. $\frac{K_T}{K_B}$ is the target's relative size. μ_B and μ_T are the drift parameters in the bidder's and target's valuation processes, respectively. σ_B and σ_T are the respective volatility parameters, and ρ is the correlation between the two processes. The calibrated value refers to the result of the calibration, which serves as the vector of base-case parameter values. The inputs column presents the variables used in the calibration procedure for each parameter. The mean column reports the average value of each of the included variables. The last column reports the number of observations used to estimate each variable.

Parameter	Calibrated Value	Samples/Databases Used	Inputs	Mean	Number of Obs.
ε			offer price revision	0.019	2,985
λ	0.510	IPOs	$\lvert\varepsilon\rvert$	0.255	2,985
η	1.327%	IPOs	gross spread	6.735%	3,030
			share overhang	5.076	3,005
α	2.070	M&As	$\mathrm{M/B_B}$	2.400	12,934
		Compustat	$\mathrm{M/B_T}$	1.998	6,269
		CRSP	announcement return	37.98%	2,533
c	0.217%	M&As	$\frac{\text{adv. fees}_\mathrm{B}+\text{adv. fees}_\mathrm{T}}{\mathrm{MA_B+MA_T}}$	0.217%	1,668
$\frac{K_T}{K_B}$	0.973	M&As, IPOs	$\mathrm{BA_T/BA_B}$	0.487	2,787
		Compustat	n	1.997	2,313
μ_B	0.818%	M&As	$\mathrm{Y_{Tbill}}$	6.053%	348
μ_T	0.599%	Compustat	$\mathrm{Y_{payout_B}}$	5.235%	5,358
		Fed H15 report	$\mathrm{Y_{payout_T}}$	5.454%	2,219
σ_B	24.71%	M&As	$\mathrm{std(R_B(1\text{-}\frac{ME_B}{MA_B}))}$	7.132%	10,069
σ_T	26.04%	Compustat	$\mathrm{std(R_T(1\text{-}\frac{ME_T}{MA_T}))}$	7.518%	5,796
		CRSP			
ρ	18.38%	M&As CRSP	$\mathrm{corr(R_B(1\text{-}\frac{ME_B}{MA_B}), R_T(1\text{-}\frac{ME_T}{MA_T}))}$	18.38%	2,032

Table 2. Model estimation of probability that a sample firm conducts a merger after going public

This table presents the estimates of the likelihood of a merger occurring within certain time periods following an IPO (first, second, and third years), conditional on no merger happening in previous years. See section 3.3 for detailed descriptions of the estimation procedure. The base case is estimated using the calibrated values in Table 1. The rest of the table reports comparative statics by varying one parameter at a time.

Parameter	Value	Likelihood of Merger in Year 1	Likelihood of Merger in Year 2	Likelihood of Merger in Year 3
Base case		0.4146	0.1215	0.0844
λ	0.310	No IPO	No IPO	No IPO
	0.410	0.4787	0.1498	0.0990
	0.610	0.3798	0.1032	0.0724
	0.710	0.3496	0.0897	0.0625
η	0.008	0.3947	0.1210	0.0844
	0.010	0.4002	0.1207	0.0840
	0.012	0.4177	0.1230	0.0856
	0.015	0.4225	0.1222	0.0848
α	1.5	0.4417	0.1245	0.0864
	2.5	0.4109	0.1222	0.0851
	3.0	0.4021	0.1217	0.0848
	3.5	0.3941	0.1210	0.0844
c	0.001	0.4147	0.1216	0.0844
	0.003	0.4146	0.1215	0.0844
	0.004	0.4145	0.1215	0.0844
	0.005	0.4145	0.1215	0.0844
$\frac{K_T}{K_B}$	0.5	0.4512	0.1259	0.0874
	0.7	0.4351	0.1244	0.0865
	0.9	0.4246	0.1237	0.0861
	1.1	0.4190	0.1230	0.0856
μ_B	-0.02	0.4023	0.1047	0.0689
	-0.01	0.4066	0.1105	0.0741
	0.00	0.4110	0.1165	0.0797
	0.02	0.4199	0.1292	0.0961
μ_T	-0.01	0.4218	0.1319	0.0943
	0.00	0.4173	0.1254	0.0880
	0.02	0.4085	0.1129	0.0764
	0.03	0.4041	0.1071	0.0710
σ_B	0.10	0.3753	0.1054	0.0763
	0.15	0.3847	0.1094	0.0785
	0.20	0.3986	0.1152	0.0815
	0.30	0.4346	0.1287	0.0871
ρ	-0.2	0.4528	0.1343	0.0886
	0.0	0.4344	0.1286	0.0871
	0.4	0.3864	0.1101	0.0789
	0.6	0.3524	0.0951	0.0700

Table 3. IPO intensity and subsequent merger intensity

This table presents results from estimating linear regressions of merger intensity on lagged IPO intensity. The sample period is from 1978 to 2006. Panel A presents results for merger and IPO intensities by industry and by year, while Panel B uses aggregate merger and IPO intensities by year only. In Panel A, industries are classified based on Fama and French (1997). The dependent variable is $NMAS/Nfirms$. $NMAS$ is the number of mergers and acquisitions in an industry within the same year. $Nfirms$ is the number of public firms in the same industry in the previous year. $NIPOS$ is the number of firms going public in each industry during a year. The IPO intensity is calculated from $t = -3$ to -1. Similarly, our control variables are lagged one-year variables. Models 1 and 2 (3 to 6) include (exclude) utility and financial industries. Accounting control variables are excluded when utility and financial industries are included in the sample. Models 1, 3, and 5 use all sample deals while the other models use only completed deals. C&I rate spread is obtained from http://www.federalreserve.gov/releases/e2/e2chart.htm. A deregulatory event (see Harford (2005)) is a dummy variable equal to one in the year following an industry deregulation event. The market-to-book ratio (MV/BV) is the median industry ratio of the sum of the market value of equity and the book value of debt to the book value of assets. σ(MV/BV) is the annual industry-wide standard deviation of the market-to-book ratio. The accounting variables are estimated as industry medians. Cash and R&D are normalized by total assets. Cash includes cash and marketable securities. ROA is the ratio of operating income to total assets. Book leverage is the sum of long-term debt and short-term debt divided by total assets. The regressions are estimated using industry fixed effects. P-values are computed using standard errors clustered by industry and year, and are reported in parentheses.

	Panel A. Aggregate by Year and by Industry				Panel B. Aggregate by Year	
	Sample: All Deals	Sample: Completed Deals	Sample: All Deals	Sample: Completed Deals	Sample: All Deals	Sample: Completed Deals
	[1]	[2]	[3]	[4]	[5]	[6]
Intercept	-0.066	-0.064	-0.116	-0.108	-0.240	-0.203
	(0.000)	(0.000)	(0.000)	(0.000)	(0.428)	(0.484)
$(\frac{NIPOS}{Nfirms})_{t-3\sim t-1}$	0.087	0.074	0.066	0.052	0.574	0.523
	(0.000)	(0.000)	(0.002)	(0.005)	(0.058)	(0.069)
C&I Rate Spread$_{t-1}$	-0.049	-0.046	-0.047	-0.043	-0.017	-0.016
	(0.000)	(0.000)	(0.000)	(0.000)	(0.391)	(0.411)
Deregulatory Event$_{t-1}$	-0.006	-0.009	-0.003	-0.005		
	(0.574)	(0.419)	(0.847)	(0.736)		
MV/BV$_{t-1}$			0.015	0.012	0.025	0.013
			(0.061)	(0.090)	(0.801)	(0.880)
σ(MV/BV)$_{t-1}$			-0.001	0.000	0.019	0.020
			(0.738)	(0.930)	(0.634)	(0.591)
Cash$_{t-1}$			0.248	0.222	-0.105	-0.074
			(0.000)	(0.000)	(0.921)	(0.941)
ROA$_{t-1}$			0.157	0.148	1.790	1.633
			(0.000)	(0.000)	(0.070)	(0.074)
R&D$_{t-1}$			-0.218	-0.143	20.538	19.093
			(0.007)	(0.062)	(0.031)	(0.031)
Leverage$_{t-1}$			0.037	0.030	-0.356	-0.418
			(0.251)	(0.285)	(0.753)	(0.695)
N	1,421	1,275	1,421	1,275	29	29
Adjusted R^2	0.217	0.218	0.246	0.248	0.596	0.599

Table 4. IPO intensity and subsequent merger waves

This table presents results from estimating logistic regressions of industry merger-wave indicator variables on lagged industry IPO intensity. The sample period is from 1978 to 2006. Industries are classified based on Fama and French (1997). See Section 4 for the estimation of the merger wave indicators. The dependent variable is a dummy variable equalling one for each industry-year within a merger wave for all attempted or completed mergers. Models 1 and 2 (3 and 4) include (exclude) utilities and financial industries. Accounting control variables are excluded when utility and financial industries are included in the sample. Models 1 and 3 use all sample deals while the other models use only completed deals. $NIPOS$ is the number of firms going public in each industry during a year. $Nfirms$ is the number of public firms in that industry in the previous year. IPO intensity is calculated from $t = -3$ to -1 relative to the merger wave year. Similarly, the control variables are computed at the end of the previous year. C&I rate spread is obtained from http://www.federalreserve.gov/releases/e2/e2chart.htm. A deregulatory event (see Harford (2005)) is a dummy variable equal to one in the year following an industry deregulation event. The market-to-book ratio (MV/BV) is the median industry ratio of the sum of the market value of equity and the book value of debt to the book value of assets. σ(MV/BV) is the annual industry-wide standard deviation of the market-to-book ratio. The accounting variables are estimated as industry medians. Cash and R&D are normalized by total assets. Cash includes cash and marketable securities. ROA is the ratio of operating income to total assets. Book leverage is the sum of long-term debt and short-term debt divided by total assets. P-values are reported in parentheses.

	Sample: All Deals	Sample: Completed Deals	Sample: All Deals	Sample: Completed Deals
	[1]	[2]	[3]	[4]
Intercept	-5.746	-5.753	-5.414	-5.013
	(0.000)	(0.000)	(0.000)	(0.000)
$(\frac{NIPOS}{Nfirms})_{t-3\sim t-1}$	5.680	6.010	6.116	6.174
	(0.000)	(0.000)	(0.000)	(0.000)
C&I Rate Spread$_{t-1}$	-1.639	-1.544	-1.457	-1.482
	(0.000)	(0.000)	(0.000)	(0.000)
Deregulatory Event$_{t-1}$	1.107	1.070	1.263	1.216
	(0.013)	(0.017)	(0.013)	(0.015)
MV/BV$_{t-1}$			-0.077	0.036
			(0.758)	(0.881)
σ(MV/BV)$_{t-1}$			-0.102	-0.051
			(0.084)	(0.398)
Cash$_{t-1}$			1.268	-1.521
			(0.521)	(0.440)
ROA$_{t-1}$			0.677	-0.938
			(0.713)	(0.606)
R&D$_{t-1}$			6.911	7.281
			(0.031)	(0.020)
Leverage$_{t-1}$			-1.797	-2.963
			(0.119)	(0.007)
N	1,421	1,275	1,421	1,275
Pseudo R^2	0.156	0.162	0.183	0.185