The Design of IPO Lockups

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Abstract

A model explaining the length of IPO lockups is developed and tested. The model demonstrates that, depending upon a firm’s characteristics, the length of the lockup period may be chosen to address either a moral hazard or an asymmetric information problem. The major empirical implication of the model concerns the relation between the optimal lockup length and the underpricing in the IPO. The length of the lockup and the underpricing in the IPO should be positively correlated in the cross section if the lockup solves an asymmetric information problem but should be uncorrelated if it solves a moral hazard problem. Using proxies to identify firms for which the moral hazard problem or the asymmetric information problem is predicted to be the dominant consideration, we present empirical evidence consistent with this prediction.
1 Introduction

Recently, considerable attention has been paid to understanding the lockup provision, which mandates a period of time following an issue for which “firm insiders” commit to abstain from selling secondary shares. The lockup has become a standard part of the contract between an underwriter and a firm engaged in its initial public offering of equity. Much of this literature mentions asymmetric information or moral hazard as potential motivations for the existence of the lockup provision. Brav and Gompers (2003) take a deeper look at this question and are the first to offer an empirical analysis of the possible reasons for the inclusion of the lockup period in the IPO agreement.

We extend the analysis in Brav and Gompers (2003). In a mechanism design framework we develop and test a model that explains the length of IPO lockups. Moral hazard and asymmetric information problems co-exist in all firms in our model. We show that, depending on firm-specific characteristics, the length of the lockup period will be chosen to solve one or the other of these problems. The comparative static properties of the model yield its main testable implication; the length of the lockup period and the underpricing in the IPO will be positively correlated in the cross section of firms for which the lockup period is chosen to address the asymmetric information problem while this correlation will be zero for those firms for which the lockup period is chosen to address a moral hazard problem. The empirical results are consistent with this prediction.

Brav and Gompers (2003) consider three explanations for the cross-sectional differences in the length of lock-ups: (i) lockup length as a signal of firm quality, (ii) lockup length as a commitment device to alleviate moral hazard problems, and (iii)

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lockup length as a means for investment banks to extract added compensation from the
IPO firm. Brav and Gompers interpret their findings as supporting the hypothesis that
lockup lengths are set to alleviate moral hazard problems and as not supporting the
signaling or the rent extraction hypotheses. In their empirical analysis, however, both the
moral hazard and signaling hypotheses rely heavily on arguments based on asymmetric
information making it difficult to distinguish between the two hypotheses.

Brau, Lambson, and McQueen (2005) (BLM) examine this issue further in a
paper that is closely related to Brav and Gompers. BLM argue that the variables used in
the Brav and Gompers (2003) study to indicate the severity of moral hazard problems
may be more naturally interpreted as indicating the severity of an asymmetric information
problem. BLM develop a signaling model of lockup length in which the insiders of good
firms not only retain a greater exposure to the firm’s risk but also willingly commit to
keep that exposure for a longer period than would the insiders of a “bad” firm (i.e. they
consider a separating equilibrium). BLM argue that the empirical findings in Brav and
Gompers (2003) are consistent with their model and also present empirical support for
other predictions of their model (concerning firm transparency or the possible level of
informational asymmetry and the level of firm specific risk). Their analysis, however,
does not examine the moral hazard question.

A common feature of Brav and Gompers (2003) and BLM (2004) is that the
analysis examines the signaling hypothesis and the commitment (or moral hazard)
hypothesis as if they were mutually exclusive. One interpretation is that these papers
seek to determine which of these frictions determines the lockup length for the “average”
firm in the universe of firms that have gone public. The two studies are also similar in
that they use the intuition of a separating signaling equilibrium to generate their empirical predictions. This is somewhat limiting since if the signaling equilibrium is separating, asymmetric information cannot be the explanation for any underpricing at the IPO.

Our analysis differs from the Brav and Gompers (2003) and BLM (2004) studies on both of these dimensions. First, all firms in the model suffer from moral hazard and asymmetric information problems; firms require unobservable managerial effort and managers know their value more precisely than the market. Furthermore, informed investors have more precise information concerning firm value than uninformed investors so that there are two types of asymmetric information in the model. For a given firm, depending on parameter values, either an asymmetric information (between the firm and the market) problem or a moral hazard problem will be the friction that drives the choice of lockup period at the margin. The model provides very different empirical predictions depending upon which problem motivates the choice of lockup period. Secondly, the equilibrium in the asymmetric information problem is semi-separating and the main empirical prediction of the model relates the length of the lockup period to the underpricing at the IPO in an internally consistent model.

In our model, firms require two inputs in order to have positive value, unobservable managerial effort and investment capital. If a firm receives both effort and funding it becomes a “good” (high value) firm, if any firm does not receive one or both of these required inputs it will become a “bad” (low value) firm. Alternatively, a manager can elect not to raise capital, thereby exiting the market.

There are four types of Managers in the model, differentiated by their private cost of effort (low or high) and the value of their external opportunities (low or high). It is
assumed, given the personal cost of effort for the managers, that it is efficient to induce only low cost managers to exert effort. The equilibrium in the model is semi-separating; some bad firms (those whose managers have high-valued outside opportunities) exit the market while some bad firms seek funding. As explained more fully below, ensuring this partial separation is the asymmetric information-based role of lockups. This commitment is beneficial to firms with low cost managers as eliminating a portion of the bad firms seeking funding reduces the underpricing at the IPO.

Initially, the market prices all IPOs equally because funded firms are observationally equivalent based on public information. The secondary market becomes more informative over time, however, and stock prices eventually converge to true value (low or high). An increasingly informative price provides a moral hazard-based motivation for the lockup provision. Were shares sold immediately, they would be sold at a pooled, uninformative price. In that scenario, no managers (even those with low cost of effort) would choose to exert effort since this effort is costly and unobservable. Hence, a commitment not to sell shares until a pre-specified date, by which true value is likely to be revealed, alleviates the moral hazard problem concerning effort provision.

At the optimum of the design problem, the incentive compatibility constraint governing managerial effort may or may not be binding depending on firm characteristics. When it is binding, the length of the lockup is set to solve the moral hazard problem concerning managerial effort. When the constraint is not binding at the optimum, the length of the lockup is set to induce high cost managers with high value outside opportunities to exit the market, reducing the asymmetric information problem. The major empirical prediction of the model is generated by the different comparative
static properties of the model when the incentive compatibility constraint binds versus when it does not. This prediction concerns the relation between the length of the lockup period and the extent of underpricing measured by the difference between the aftermarket price and the offer price. For a set of firms with characteristics such that the asymmetric information problem described above dominates, the length of the lockup and the underpricing in the IPO are positively correlated in the cross-section. When instead the moral hazard problem dominates, there is predicted to be no correlation between the lockup length and underpricing. Intuitively, this difference is derived from the fact that underpricing is driven by information asymmetry rather than by managerial moral hazard.

Our empirical results are consistent with this prediction. Examining the full sample of IPO firms we find that, consistent with Brau, Lambson, and McQueen (2005), for the average firm in the sample asymmetric information appears to be the driving force behind the length of the lockup provision. The sample is then divided into firms for which the length of the lockup is likely to be chosen to solve a moral hazard problem and those for which it is likely to be chosen to solve an asymmetric information problem. We find the predicted relation between lockup length and underpricing in the subsamples.

The paper is organized as follows. Section 2 presents the model and its solution. Section 3 summarizes the main empirical predictions of the model. Section 4 describes the data and section 5 presents our empirical findings. Section 6 concludes.

2 The Model

The model considers an economy in which different types of managers, who run otherwise equivalent firms, compete for capital in the public equity market. Each firm
seeking financing can become a “good” type firm (i.e. high value firm) worth $X$ if it
receives the required outside capital, $I<X$, and unobservable managerial effort
(simultaneous with the financing) as inputs. If any firm receives either no managerial
effort (an unobservable event) or less than the required external capital (an observable
event) it becomes a “bad” firm worth 0. The binary payoffs imply that, without loss of
generality, the securities in this model may be described as equity.

Managers:
Firm managers can supply effort or not. The required effort is personally costly
to the managers and they differ in the level of this unobservable cost. Managers also
differ in the value of their outside options; their alternative wage. Managers have private
knowledge of their own type and this type is unobservable to the market (all other
relevant aspects of the firm are assumed to be observable). We define managerial types
by the levels of effort cost and external value. There are low cost managers who face an
effort cost of $C_L$ and high cost managers who face an effort cost of $C_H$, where $C_L < C_H$.
Within both sets of managers (high or low cost) some have high value ($V$) opportunities
available if they leave the firm and some have low valued (normalized to 0) external
opportunities. There are, therefore, four different managerial types; low cost and high
valued opportunities, low cost and low valued opportunities, etc. The \textit{ex ante} probability
a given manager is a low cost manager is denoted $\theta$ and the \textit{ex ante} probability any
manager has a low valued outside options is $\omega$.

We assume that $C_H$ is such that it is prohibitively costly to induce high cost
managers to exert effort. We also restrict attention to parameter values such that it is
efficient to motivate the low cost managers to exert effort. If this were not the case, all
firms would be bad and the IPO market would have no private information, lockups or
underpricing. Managers are assumed to be risk neutral and face a personal discount factor $\delta^t$ on date $t$ income, where $\delta < 1$. We assume, for simplicity, that there are no alternate sources of capital for the firm.

**The Capital Market:**
The capital market includes two types of investors, informed and uninformed. The informed investors can distinguish between good and bad firms that seek to issue public equity while the uninformed know only the probability that firms are good conditional on the form of the IPO contract. The wealth of the uninformed, expressed as a percentage of the required capital ($I$) is $u \in (0, 1)$. We assume that investment by both the informed and the uninformed is required to carry the issue (this assumption, while shown to be unnecessary in Maksimovic and Pichler (1999), is made for simplicity).

The aftermarket for public equity is assumed to be partially revealing in the sense that after a length of time $T$ following the IPO with probability $Q(T)$ the true value of the firm is publicly revealed, otherwise equity is assumed to trade at its *ex ante* expected value, $EV = \varphi X + (1 – \varphi)0 = \varphi X$, where $\varphi$ is the proportion of good firms seeking funding given the publicly available information.2 We assume that the function $Q(T)$ is such that $Q(0) = 0$, $Q'(T) > 0$, and $Q''(T) \leq 0$. These assumptions on $Q(T)$ are sufficient for our purposes but are made stronger than necessary for simplicity.

**The Initial Public Offering:**
The model allows that the choices in the design of the firm’s initial public offering includes choice over the offer price ($p$), whether to structure the deal to induce managerial effort or not, the fraction of equity to be sold in the IPO ($\alpha$), and the length of

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2 The assumption that the aftermarket price may become perfectly revealing is made for simplicity. All that is required is that with probability $Q(T)$ there will be less adverse selection in the aftermarket than in the IPO market. This can be derived from a model of trade in the aftermarket with liquidity motives for the informed but such a model would be beyond the scope of this paper.
the lockup period \((T)\) on the retained shares. If effort is not induced all firms are bad and none will receive financing. The IPO price is established in equilibrium in the IPO market and is, therefore, not an unconstrained choice. The percent of the equity sold in the IPO is constrained to be (at least) large enough to raise the required capital \(I\). The length of the lockup is chosen in recognition of the partially revealing nature of the aftermarket. The longer the lockup the greater chance the manager sells into an informed aftermarket, however, the discount factor, \(\delta\), implies that it is not optimal for any manager to choose an unlimited lockup. In equilibrium it must be incentive compatible for low cost managers to elect to exert effort and the length of the lockup will influence their incentive to do so. A major theme of the paper is that for different firms the lockup of the retained shares plays different roles and so in the cross section of firms the length of the lockup will be set based on different tradeoffs.

We consider a semi-separating equilibrium in the IPO market. In equilibrium, low cost, low external value managers design their preferred IPO strategy and ultimately bring good firms to the public equity market. Depending on the relative value of running a good firm versus the value of a high outside option the low cost, high external value managers may or may not participate in the IPO market. Their participation or lack thereof only serves to change the proportion of good firms in the market \((\varphi)\) and is otherwise irrelevant for the solution process or the empirical predictions. High cost low external value managers seek funding and so must mimic the observed choices of the low cost managers. They, however, never exert effort and so always run bad firms. We assume the high external value \(V\) is large enough that, in equilibrium, high cost high external value managers pursue their outside options rather than bring bad firms to the market.
The result is an IPO market in which both firms and informed investors have superior information relative to the uninformed investors. It is well known that this type of asymmetric information in the market leads to underpricing relative to the expected value of the population of firms going public.

**Proposition 1:** There exists a unique Bayesian-Nash Equilibrium for the IPO market with the per share price $p \in (0, EV)$ in which the informed investors invest in an issue if and only if it is by a good firm and the uninformed investors always invest. The equilibrium price is

$$p = \frac{\varphi uX}{\varphi u + (1 - \varphi)}.$$

**Proof:** See the appendix.

Defining underpricing as in the empirical IPO literature, $UP = \frac{EV - p}{p}$, the equilibrium underpricing in Proposition 1 is given as

$$UP = \frac{(1 - u)(1 - \varphi)}{u}.$$

**Corollary 1:** The comparative static properties for underpricing in the model are given by

$$\frac{\partial UP}{\partial \varphi} < 0, \frac{\partial UP}{\partial u} < 0,$$

and $\frac{\partial UP}{\partial X} = 0$.

The comparative static properties for underpricing are intuitive. Underpricing is decreasing in $\varphi$. The parameter $\varphi$ is a (inverse) measure of the level of overall risk in the IPO market for the uninformed. As the overall risk is reduced ($\varphi$ is increased) there is less underpricing needed to compensate the uninformed for their informational disadvantage. Underpricing is also decreasing in the relative wealth ($u$) of the uninformed. As relatively less of the good offerings go to the informed, the uninformed face less of a “lemons problem” reducing the need for underpricing. Finally, the equilibrium level of underpricing is independent of $X$ so that the percent underpricing is
independent of the difference in the value of a good versus a bad firm. The structure of
the model implies that both $EV$ and $p$ are proportional to $X$ so $UP$ is independent of $X$.

In designing the IPO the low cost, low external value manager must ensure that at
least $I$ in outside capital will be raised by the firm. This imposes the “capital constraint”
(CC) on the design problem: $\alpha p \geq I$. In order for managerial effort to be exerted it must
be incentive compatible for a low cost manager to do so. For a given lockup length $T$, the
expected value of a low cost manager’s retained shares, given that he exerts effort, is
$(1 - \alpha)[Q(T)X + (1 - Q(T))EV]\delta^T$. Instead of exerting effort, the low cost manager may
shirk, in that case the expected value of his retained shares is $(1 - \alpha)[(1 - Q(T))EV]\delta^T$.
For effort to be optimal it must be that the difference in these values is greater than the
cost of effort $C_L$. The incentive compatibility constraint (IC) on effort can therefore be
written $(1 - \alpha)Q(T)X\delta^T \geq C_L$. Finally, the low cost manager benefits from a reduction
in the equilibrium level of underpricing in the IPO market. Corollary 1 shows that by
reducing the proportion of bad firms seeking funding underpricing will be reduced. The
low cost managers can achieve this outcome by ensuring that the optimal lockup is such
that the high cost managers with high value outside options will choose not to participate
in the market. This non-mimicry constraint is written: $(1 - \alpha)[(1 - Q(T))EV]\delta^T \leq V$.

The problem can be simplified in several ways. Because the IPO price will be set
in equilibrium (as a function of the parameters $\alpha$, $\varphi$, $u$, and $X$; see Proposition 1) the
problem faced by the low cost manager in designing the optimal IPO strategy is to choose
the fraction of shares sold and the length of the lockup provision in order to maximize the
expected value of his shares subject to the capital constraint, the non-mimicry constraint
and the incentive compatibility constraint:
\[ \max_{\alpha, T} \alpha p(u, \varphi, X) - I + (1 - \alpha)[Q(T)X + (1 - Q(T))EV] \delta^T \]
\[ \text{s.t.} \quad (1 - \alpha)Q(T)X \delta^T \geq C L \quad (IC) \]
\[ (1 - \alpha)[(1 - Q(T))EV] \delta^T \leq V \quad (NM) \]
\[ \alpha p(u, \varphi, X) \geq I \quad (CC) \]

Secondly, note that the optimal \( \alpha \) makes the capital constraint hold with equality (define \( \alpha^* \) by \( \alpha^* p = I \)). This is proven formally in the appendix. Intuitively, information arrival over time implies that, quite generally, aftermarket sales suffer a less severe adverse selection problem than do IPO sales. Hence, the low cost manager’s problem becomes:

\[ \max_{T} \alpha^* p(u, \varphi, X) - I + (1 - \alpha^*)[Q(T)X + (1 - Q(T))EV] \delta^T \]
\[ \text{s.t.} \quad (1 - \alpha^*)Q(T)X \delta^T \geq C L \quad (IC) \]
\[ (1 - \alpha^*)[(1 - Q(T))EV] \delta^T \leq V \quad (NM) \]

The design problem is therefore reduced to the choice of the optimal length of lockup period on the manager’s retained shares. The characteristics of the optimal lockup differ depending upon whether the incentive compatibility constraint is binding at the optimum or not. In other words, while each firm suffers from an asymmetric information problem and a moral hazard problem, the choice of lockup period differs depending upon which of these problems the length of the lockup is chosen to solve.

Let \( T_{AI} = \arg \max \{ [Q(T)X + (1 - Q(T))EV] \delta^T \ s.t. \ (1 - Q(T))EV \delta^T \leq V \} \). By definition, \( T_{AI} \) solves the version of problem (2) for which the (IC) constraint does not bind. The incentive compatibility constraint on managerial effort is slack at the optimum so, at the margin, the lockup is chosen to solve the asymmetric information problem. In the appendix it is shown that the mild regularity assumptions for \( Q(\cdot) \) imply that \( T_{AI} \) is uniquely defined.
Now define $T_{MH}$ as the shortest lockup for which the low-cost manager would choose to exert effort. $T_{MH}$ is defined implicitly by $(1 - \alpha)Q(T_{MH})X^{1/T_{MH}} = C_L$. This is the solution to problem (2) when the incentive compatibility constraint is binding at the optimum. For the set of firms for which this is the solution to the IPO design problem the moral hazard problem determines the length of the lockup period.

In general it may be the case that $T_{AI}$ exceeds $T_{MH}$, so the incentive compatibility constraint does not bind and the asymmetric information problem determines the optimal lockup length to be $T_{AI}$. Alternatively, it may be the case that $T_{MH}$ exceeds $T_{AI}$. In that case the optimal lockup length is driven by the moral hazard problem and the optimal lockup length is $T_{MH}$. The following proposition summarizes the two cases.

**Proposition 2:** Using the definitions above,

(a) (Asymmetric Information) If $\frac{C_L}{(1 - \alpha^*)X} \geq Q(T_{AI})^{S_{AI}}$ then the incentive compatibility constraint (IC) does not bind at the optimum and the optimal lockup length is $T_{AI}$.

(b) (Moral Hazard) If $\frac{C_L}{(1 - \alpha^*)X} < Q(T_{AI})^{S_{AI}}$ then the incentive compatibility constraint (IC) binds at the optimum and the optimal lockup length is $T_{MH}$.

**Proof:** See the Appendix.

Note that the incentive compatibility constraint is slack when $C_L$ is low; it is not difficult to motivate effort when it is not costly. In addition, when $I$ is small relative to the other parameters in the model, the amount of equity sold ($\alpha^*$) will be small. Again by inspection of proposition 2 this leads to a slack incentive compatibility constraint; all else equal, a manager holding a large equity stake has a strong incentive to exert effort.
Proposition 2 distinguishes the cases in which lockups are driven by a dominant moral hazard problem from those driven by a dominant asymmetric information problem. We now characterize the comparative static properties of these two cases.

Corollary 2: \( \frac{\partial T_{AI}}{\partial \varphi} < 0 \) and \( \frac{\partial T_{AI}}{\partial X} > 0 \), i.e., \( T_{AI} \) is decreasing in \( \varphi \) and increasing in \( X \).

\[ \frac{\partial T_{MH}}{\partial \varphi} = 0 \] and \( \frac{\partial T_{MH}}{\partial X} < 0 \), i.e., \( T_{MH} \) is independent of \( \varphi \) and decreasing in \( X \).

Proof: See the Appendix.

Thus as the proportion of good firms (\( \varphi \)) in the market rises the length of the lockup will fall if the lockup is chosen to solve the asymmetric information problem. Intuitively, the low cost manager faces the cost of delay when using the lockup period to distinguish the value of his retained shares from the *ex ante* expected value \( EV \). The cost and benefit are of course balanced at the margin. As \( \varphi \) rises, the difference between \( X \) and \( EV \) falls reducing the advantage to delay. To the contrary, the length of a lockup period chosen to solve the asymmetric information problem is independent of the difference in value between a good and bad firm. This occurs because the value to delay is unchanged with changes in \( X \) (\( X = EV = \varphi X \) change proportionally).

The comparative static properties of \( T_{MH} \), the solution to the moral hazard problem, while very different from those of \( T_{AI} \) are also very intuitive. First, when the length of the lockup period is set to solve the moral hazard problem the optimal length is independent of the proportion of good and bad firms in the economy. The incentive to exert effort depends upon the expected value of the low cost manager’s retained shares when he exerts effort as compared to their value when he shirks. Clearly, this is independent of \( \varphi \). Secondly, as the difference in value between good and bad firms, \( X \),
is increased $T_{MH}$ is reduced. The difference in firm value is a primary driver of the incentive for managerial effort. By increasing this difference the incentive for effort is increased and consequently the need for a lengthy lockup period is reduced.

3 Empirical Predictions

The development in section 2 and Propositions 1 and 2 (the comparative static characteristics of the different lockups $T_{MH}$ and $T_{AI}$) provide us with the main empirical implication of the model. To study the cross-section of firms we consider the response to changes in the fundamental parameters that govern the firm characteristics in the model; $X$ and $\phi$. Assuming that in the cross section of firms there is variation in both of these parameters the results reported in Corollaries 1 and 2 provide the following testable hypothesis:

$H1$: In a sample of firms for which the lockup length is driven by asymmetric information the lockup length should positively covary with underpricing. In a sample of firms for which the lockup length is driven by moral hazard, the lockup length should not covary with underpricing.

A decrease in the parameter $\phi$ increases the amount of risk in the capital market. The consequences of this are twofold. First, and most obviously, the uninformed investors will require more of a compensation for participating (this simply restates the result that $UP$ is decreasing in $\phi$). Secondly, $T_{AI}$ is increased while $T_{MH}$ remains constant as $\phi$ decreases. This also implies that for a given firm, a decrease in $\phi$ tends to make it more likely that the asymmetric information problem is the motivating factor in establishing the length of the lockup.

A second empirical implication of the model can be developed by considering variation in the required investment, $I$. Holding the other parameters of the model fixed
this is equivalent to examining variation in the value added of the investment. Recalling that the capital constraint (CC) will always bind we see that the impact of a change in the required investment, $I$, immediately translates to a change in the amount of external equity, $\alpha^*$, that must be sold by the manager. We generate the following hypothesis.

$H2$: In a sample of firms for which the lockup lengths are driven by moral hazard there should be a negative correlation between lockup length and the fraction of the equity retained by the manager. For those firms for which the lockup length is driven by asymmetric information there should be a positive correlation between the length of the lockup and the fraction of the equity retained by the manager.

The intuition is as follows. When retained equity drops, the moral hazard problem increases in severity because the link between managerial wealth and effort is weakened. The lockup must increase to compensate for this change in incentives. By contrast, when retained equity drops, the incentive for bad entrepreneurs to pool is reduced. Hence the minimum lockup required to ensure separation is reduced.

It is important to note that Hypothesis 2 is developed in a model in which the amount invested by each firm is specified exogenously. In a richer model with endogenously determined investment scale, retained equity would be a choice variable and would therefore serve as a signal of firm quality. In general, such a signal could serve either as a complement or a substitute to lockup length.

Testing these two hypotheses requires a means by which we can separate the moral hazard firms (those firms for which the moral hazard problem dominates the asymmetric information problem) and the asymmetric information firms (those firms for which the asymmetric information problem is the dominant friction). We use two characteristics of the IPO firms to separate the moral hazard from the asymmetric
information firms: whether the IPO firm had venture capital financing prior to the IPO, and whether the IPO firm is taken public by a high reputation underwriter.

Beatty and Ritter (1986) and Carter and Manaster (1990) argue that high-quality underwriters serve a certification role, reducing the uncertainty concerning the value of the firm going public. These underwriters have a strong incentive to develop and maintain their reputations and so are said to perform more extensive due diligence and more accurately convey the resulting information relative to low-quality underwriters. Hence, the certification process is argued to reduce the information asymmetry problem. Importantly, while underwriters can convey their own estimates and certification of an IPO’s expected value, they cannot prescribe the manager’s future actions. Certification therefore not predicted to impact on the severity of the moral hazard problem.

Megginson and Weiss (1991) make a similar argument concerning the certification role of venture capitalists (VCs), venture capitalists are repeat players in the IPO market as it represents an important “exit strategy” from their investments. VCs, therefore, also have an interest in maintaining reputations and serving as a screening mechanism for the market. We, therefore, also examine VC-backed IPOs as a subsample of firms that may exhibit reduced information asymmetry.

4 Data

The data for this study was drawn from the Thompson SDC data base and consists of initial public offerings of equity for the period 1988 through 2005. Information was collected for each IPO concerning the proceeds of the offer, the offer price, the market value of the equity after the IPO, the underpricing on the first trading day, the identity of
the lead underwriter(s), the length of the lockup period, insider ownership (in both percentage and in dollar terms), and whether the offering was a unit offering, a carveout, VC backed or from the high-tech industry. Information on underwriter rankings (based on Carter-Manaster (1990)) was gathered from Jay Ritter’s website. Alon Brav and Paul Gompers kindly shared their corrections to the lockup lengths reported on SDC. After substituting these values for the incorrect (or in some cases missing) values in SDC’s database, we have 5153 IPOs with known lockup lengths. For comparability with earlier studies, we further restrict this sample by eliminating several special classes of initial public offerings: ADRs, units, closed-end funds, REITs, limited partnerships, reverse LBOs and equity-carve outs, leaving 3755 observations.

For our main tests, we also require either that underpricing be known (which is the case in 3155 of the 3755 observations), post-IPO insider holdings be known (2908 observations), the market value of post-IPO equity be known (2843 observations), or some combination of these variables all be known. Thus our main tests (Tables 3 and 4) utilize substantially fewer than 3755 observations.3

Table 1 presents the descriptive statistics for our full sample. Note that the size of the offering and the size of the firm (and therefore the dollar value of insiders’ holdings) are highly skewed variables. In all of our tests, we therefore replace these raw figures with logarithmic values.

Although a lockup length has a mode of 180 days, there is also significant clustering on other multiples of 90 and on multiples of 365. The lockup length is also somewhat skewed. Therefore, as a robustness check, we have utilized the log of the

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3 Our main results are qualitatively similar if the aforementioned “special case” IPOs are left in our sample. As mentioned above, the main results require that we observe underpricing, insider holdings and/or market value of equity, and these data are more frequently missing for the special case IPOs.
lockup length in our analysis. This transformation makes no qualitative difference to the main results. Because using log lockup length makes it more difficult to interpret the economic significance of the results that follow, we present only the results employing the raw lockup length.

5 Empirical Tests and Results

Table 2 illustrates the fact the lockup length differs dramatically both over time and across subsample type. IPOs which are underwritten by high-quality investment banks (8 or higher on the Carter-Manaster scale) or which are backed by venture capitalists have much lower average lockup lengths than do IPOs which have neither type of backing. While this lower average is consistent with a reduction in the severity of market imperfections, it does not indicate whether this reflects a reduction in asymmetric information or in moral hazard.

A fact which has significant bearing on our subsequent analysis – and is not identified by the previous literature – is that the presence of either a high-quality bank or a venture capitalist is associated with much lower dispersion in the lockup length. This lower dispersion is especially dramatic for high-quality investment banks, which are associated with very strong clustering on 180 days. In fact, only 13.1% of IPOs underwritten by high-quality banks have a lockup length other than 180 days, and this lack of variation (not surprisingly) hinders our statistical inference in this subset.4 However, VC-backed IPOs as well as IPOs with neither type of backing exhibit sufficient variation in lockup length to allow meaningful statistical analysis.

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4 For this same reason, it is not useful to further distinguish IPOs underwritten by high-quality banks into those which are VC-backed and those which are not. Given the backing of a high-quality underwriter, the lockup length has so little variation it is pointless to consider further subdivisions.
Panel B of Table 2 further shows that the lockup length has shown a striking downward trend over time. This drop was most dramatic at the peak of the IPO boom of the late 1990s, during which the 180 day length became highly standardized.\(^5\) To our knowledge, this trend has not been identified in the literature.

To investigate this puzzling finding, we first consider whether firm characteristics have changed over time in ways that might explain the observed lockup length patterns. A preliminary investigation suggests that this is not the case. As panel B of Table 2 shows, both the percentage of tech IPOs and the percentage of IPOs underwritten by high-quality investment banks increased in the years leading up to the bubble peak in 2000 but decreased thereafter, while the lockup length uniformly decreased throughout the entire sample period. Similarly, the percentage of IPOs with venture capitalist backing fluctuates throughout the sample period, but these fluctuations are unrelated to lockup length trends.

The increased standardization we find has an important parallel in the IPO literature. Chen and Ritter (2000) document a clustering of underwriting fees at exactly 7%, and show that the standardization on this value increased throughout the 1980s and 1990s, particularly for medium sized (proceeds between $20 and $80 Million) offerings. Table 3 establishes that a similar evolution exists in our data. For large sized offerings (more than $80 Million in proceeds) there is a monotonic reduction over time in the percent of offerings using any lockup length other than 180 days (from 26.1% for 1988 – 1993 to 4.5% in 2001 – 2005), representing a six-fold decrease over our sample period.

\(^5\) Initially, we considered using the bubble period itself as another category of IPO to scrutinize. The notion in much of the literature is that this period was characterized by heightened asymmetric information (consistent with the dramatic increase in underpricing). The striking lack of variation in the lockup length during this period, for which we have no explanation, renders statistical analysis impossible.
Medium sized offerings show a similar convergence to the use of 180 days. For small IPOs (less than $20 Million in proceeds) the lockup length has typically been something other than 180 days throughout our sample and there is little apparent trend in its use.

Chen and Ritter (2000) suggest that the standardization of the underwriting fees at 7% may be due to “strategic pricing” in this market; competition based on underwriter quality and analyst coverage rather than fees. Our findings support this conclusion as we document standardization of the IPO contract (involving a feature of the contract of direct concern to firm managers\(^6\) when selecting an underwriter) in the segments of the IPO market dominated by the high quality underwriters (who are most able to compete on quality and analyst reputation) and not in the segment dominated by lower ranked underwriters.\(^7\)

Whatever its cause, this strong intertemporal trend necessitates that we control for the date of the IPO when investigating the determinants of lockup length. As a robustness check, we employ a variety of such measures. Perhaps the simplest approach is to use year dummies, and we do this for the reported results. Alternatively, we have used subdivisions suggested by the data, such 1980s, 1990s pre-bubble, bubble period (1999-2000) and post-bubble. Each of the alternative approaches yields qualitatively similar results and so are not reported.

The empirical predictions generated by the model concern the relation between the length of the lockup period and the IPO underpricing or the amount of equity retained

\(^6\) For example, Chen and Ritter (2000) note on page 1116 that “the objective function of the firm’s managers at the time of the offering includes raising money at the time of the offering, and raising money in future open-market insider sales.”

\(^7\) Chen and Ritter (2000) suggest that economies of scale and the increase in the total fee are responsible for the standardization being more apparent in the medium sized offerings than in the large. This issue doesn’t affect the lockup length which may explain the difference in our findings across the size categories.
by firm insiders after the offering. Specifically, in a subsample of firms for which the lockup length is chosen to solve a moral hazard problem the lockup length should be uncorrelated with the IPO underpricing and negatively correlated with the value of the insider’s equity in the cross section of that subsample. In a subsample of firms for which the lockup length is chosen to solve an asymmetric information problem lockup length should be positively correlated with both underpricing and insider holdings.

Table 4 reports the Pearson correlations between our key variables. Panel A shows strong support for Hypothesis 1; there is a positive correlation between underpricing and lockup length in the asymmetric information subsample and zero correlation in the moral hazard subsamples. Panel B indicates mixed evidence regarding Hypothesis 2. As predicted, VC-backed IPOs show a negative correlation between lockup length and insider holdings. However, this is not the case for IPOs backed by high-quality investment banks. This measure is, however, profoundly affected by the clustering of lockup lengths at 180 days mentioned above. Finally, the correlation for the asymmetric information subsample is of the correct sign but has neither economic nor statistical significance.

We can more completely test hypotheses 1 and 2 using an OLS regression. In a cross sectional regression of lockup length on underpricing, post IPO insider ownership (in either percentage or in the log of dollar value terms), and other control variables we are able to measure the relations of interest. The regression model is specified as:

\[
\text{Lockup Length} = \alpha + \beta_1 \text{underpricing} + \beta_2 \text{inside}
\]
\[
+ \beta_3 \text{Offerprice} + \beta_4 \text{tech} + \beta_5 \ln(\text{proceeds}) + \beta_6 \text{UnderwriterRank} + \beta_7 \text{VC} + \epsilon
\]

The parameters of interest are of course \( \beta_1 \) and \( \beta_2 \) which provide the signs of the relevant correlations considered in the hypotheses. The other variables are included in an attempt
to control for possible spurious correlation between the variables of interest. The model predicts that for the asymmetric information sample, the regression coefficients will satisfy $\beta_1 > 0$ and $\beta_2 > 0$ while for the moral hazard sample $\beta_1 = 0$ and $\beta_2 < 0$.

Table 5 presents the results of this regression of the determinants of lockup length, and confirms (in a multivariate sense) the findings of Table 4. Beginning with models 1 and 2 for the full sample we see that the coefficient on underpricing is positive and highly significant. As this represents an average across all firms, this finding suggests (consistent with Brau, Lambson, and McQueen (2005)) that the average firm in the sample uses the lockup provision to solve an asymmetric information problem.

The same result is generated by the asymmetric information subsample. In models 7 and 8 of Table 5 the coefficient estimate $\beta_1$ is also positive and significant. Thus for a sample of firms that does not benefit from the screening aspect of a high quality investment bank or venture capital financing the correlation between underpricing and the length of the lockup is positive. This finding is consistent with the notion that these firms have a (relatively) heightened problem of asymmetric information which, at the margin, establishes the length of the lockup that is chosen and influences the underpricing at the IPO.

The estimated coefficient on underpricing in the moral hazard samples is near zero as predicted. In the set of firms taken public by high quality underwriters (models 5 and 6) the estimated coefficients are insignificantly different from zero. As these firms benefit from the certification role of the high ranked investment banks that handle their IPOs they are predicted to have much less of an asymmetric information problem, suggesting that on average moral hazard problems should determine the length of the
lockup provisions for these firms. The caveat mentioned above, however, applies. There is a great deal of clustering in this sample at a lockup length of 180 days and so this will bias any estimated coefficient towards zero. In model 6, for example only the constant and the VC dummy are more than marginally significant. In the sample of VC-backed firms the estimated coefficient on the underpricing variable has a positive sign and is marginally statistically significant (10% level). The coefficient’s economic significance is marginal as well. It is an order of magnitude smaller than the equivalent coefficients in models 7 and 8. This result is consistent with the use of venture capital financing also being associated with a drop in the severity of the asymmetric information problem.

The data is therefore broadly consistent with the main hypothesis of the model; that the length of the lockup period in the cross section of firms is chosen to address both moral hazard and asymmetric information problems. As a final robustness test we also estimate the regressions over the period 1988 – 1998, to eliminate the bubble period, the (unreported) results are qualitatively the same.

Hypothesis 2 can also be examined with reference to Table 5. The prediction for this hypothesis is for the estimated coefficient on insider holdings to be negative for samples of firms for the moral hazard firms and positive for the asymmetric information firms. As stated above we use both the fraction of shares held by firm insiders and the (log of) the dollar value of insiders’ shares. The coefficients on the insider holdings variables are negative and significant for VC-backed firms in both specifications, as the model predicts.8 For the high quality underwriter sample, however, we do not find a

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8 Contrary to underpricing result we cannot use the coefficient estimates for the full sample to help identify the nature of the friction for the “average” firm. The predicted reactions have opposite signs across the samples, however the relative magnitude of the effects cannot be determined empirically.
significant coefficient. Recall, however, due to the high degree of standardization of the independent variable such a result is expected for this sample.

Contrary to the results presented in Table 4 the regression results fails to show the predicted positive coefficients on insider ownership in the asymmetric information firms. Models 7 and 8 show a negative and positive (respectively) sign on the insider ownership variable, neither of which is significant. As previously mentioned, this failure may be due to the fact that in a richer model, investment scale would be a choice variable and insider ownership would therefore serve as a signal. In such a scenario insider holdings may either complement or substitute for the lockup length signal making the predicted relation unclear.

6 Conclusions

A basic assumption of the model presented in this paper is that, depending upon firm characteristics, the length of the lockup period in an IPO may be chosen to solve either a moral hazard or an asymmetric information problem. In a mechanism design framework we derive the optimal lockup length, assuming a fixed price offering for a firm’s IPO. In the model the optimal lockup length may indeed be chosen to address either the moral hazard or the asymmetric information problem. The comparative static properties of the model differ depending upon which of these frictions drives the choice of lockup period. The main empirical implication of the model is that there should be a positive correlation between the lockup length and the underpricing in the IPO in the cross section of a sample of firms for which the asymmetric information problem determines the length of the lockup. For a complementary sample of firms for which the
lockup is chosen to address a managerial moral hazard problem there should be no
correlation between the lockup length and the underpricing in the IPO. The intuition for
this prediction can be explained by simply noting that underpricing is driven by
asymmetric information, not by moral hazard. Thus increasing the severity of the
asymmetric information problem should impact both of the variables of interest. The
data supports this prediction.

We also examine the comparative static properties of the model with respect to
the amount of investment and find it predicts a negative correlation between lockup
length and the proportion of equity owned by firm insiders after the IPO for moral hazard
firms and a positive correlation between these variables for asymmetric information
firms. There is mixed support for this hypothesis in the data.

Our empirical analysis identifies two striking facts regarding the degree of
standardization on the 180 day lockup. IPOs underwritten by high-quality underwriters,
and to a lesser degree VC-backed IPOs, are much more likely to use exactly this lockup
period. In addition, the degree of standardization for medium and large sized offers
increased substantially in each of the subsamples throughout our sample period. This
intertemporal trend does not appear to be explained by the changing composition of firms
in our sample, and our theoretical model sheds no light on this matter, and so while this
finding is consistent with the results and conclusions of Chen an Ritter (2000) it
constitutes an unresolved puzzle.
References:


DeMarzo, P. M., and B. Urosevic, 2000, Optimal Trading by a “Large Shareholder”, working paper, Stanford Graduate School of Business.


## Table 1

### Summary statistics, Full Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Median</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proceeds ($ Millions)</td>
<td>28.5</td>
<td>45.67</td>
</tr>
<tr>
<td>Offer Price ($)</td>
<td>11</td>
<td>11.39</td>
</tr>
<tr>
<td>Market Value of Equity ($ Millions)</td>
<td>36.74</td>
<td>93.22</td>
</tr>
<tr>
<td>Underpricing (%)</td>
<td>11.76</td>
<td>21.01</td>
</tr>
<tr>
<td>Days of Lockup</td>
<td>180</td>
<td>224.75</td>
</tr>
<tr>
<td>Underwriter Rank</td>
<td>8.1</td>
<td>6.77</td>
</tr>
<tr>
<td>VC Backed (%)</td>
<td>0</td>
<td>0.43</td>
</tr>
<tr>
<td>High Tech (%)</td>
<td>0</td>
<td>0.49</td>
</tr>
<tr>
<td>Post-IPO insider holding (%)</td>
<td>44.8</td>
<td>43.67</td>
</tr>
</tbody>
</table>
Table 2

Panel A: Distribution of Lockup Length by Subsample

<table>
<thead>
<tr>
<th>Subsample</th>
<th>N</th>
<th>Mean</th>
<th>Min</th>
<th>Median</th>
<th>Max</th>
<th>St. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-Ranked</td>
<td>1871</td>
<td>183</td>
<td>30</td>
<td>180</td>
<td>1095</td>
<td>57.9</td>
</tr>
<tr>
<td>VC-Backed</td>
<td>1618</td>
<td>191.7</td>
<td>30</td>
<td>180</td>
<td>1095</td>
<td>88.9</td>
</tr>
<tr>
<td>Neither</td>
<td>1318</td>
<td>287.3</td>
<td>45</td>
<td>180</td>
<td>1095</td>
<td>192.5</td>
</tr>
</tbody>
</table>

Panel B: Distribution of Lockup Length Across Time

<table>
<thead>
<tr>
<th>Time Period</th>
<th>N</th>
<th>Mean</th>
<th>St. Dev</th>
<th>Insider Holdings</th>
<th>Underpricing</th>
<th>VC-Backed</th>
<th>Tech</th>
<th>Hi-Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988-1989</td>
<td>201</td>
<td>257.4</td>
<td>206.0</td>
<td>46.8%</td>
<td>10.8%</td>
<td>37.8%</td>
<td>36.3%</td>
<td>43.8%</td>
</tr>
<tr>
<td>1990-1991</td>
<td>301</td>
<td>247.8</td>
<td>195.7</td>
<td>35.0%</td>
<td>15.9%</td>
<td>51.8%</td>
<td>49.8%</td>
<td>57.8%</td>
</tr>
<tr>
<td>1992-1993</td>
<td>680</td>
<td>232.9</td>
<td>142.0</td>
<td>42.0%</td>
<td>16.1%</td>
<td>45.6%</td>
<td>39.9%</td>
<td>47.5%</td>
</tr>
<tr>
<td>1994-1995</td>
<td>727</td>
<td>229.5</td>
<td>135.1</td>
<td>44.0%</td>
<td>20.5%</td>
<td>42.4%</td>
<td>48.3%</td>
<td>46.2%</td>
</tr>
<tr>
<td>1996-1997</td>
<td>942</td>
<td>230.1</td>
<td>141.5</td>
<td>45.4%</td>
<td>18.0%</td>
<td>38.6%</td>
<td>49.4%</td>
<td>48.2%</td>
</tr>
<tr>
<td>1998-1999</td>
<td>426</td>
<td>204.8</td>
<td>98.9</td>
<td>46.8%</td>
<td>40.6%</td>
<td>39.8%</td>
<td>58.6%</td>
<td>45.9%</td>
</tr>
<tr>
<td>2000-2001</td>
<td>183</td>
<td>186.1</td>
<td>50.3</td>
<td>43.0%</td>
<td>41.6%</td>
<td>65.6%</td>
<td>79.8%</td>
<td>58.5%</td>
</tr>
<tr>
<td>2002-2003</td>
<td>112</td>
<td>187.5</td>
<td>36.1</td>
<td>39.2%</td>
<td>9.8%</td>
<td>38.4%</td>
<td>47.3%</td>
<td>78.6%</td>
</tr>
<tr>
<td>2004-2005</td>
<td>183</td>
<td>188.9</td>
<td>44.7</td>
<td>37.5%</td>
<td>11.4%</td>
<td>38.8%</td>
<td>38.8%</td>
<td>58.5%</td>
</tr>
</tbody>
</table>
## Table 3
Prevalence of 180 Day Lockup Across Time, By Issue Size

This table shows the proportion of IPOs using lockup lengths other than 180 days. Issue size is converted to Jan 2000 dollars using the US GDP price deflator. Market share of high quality banks is the average of a dummy variable set to one if the Carter-Manaster rank of an investment bank is 8 or higher, and set to zero otherwise.

### Large IPOs (> $80 Million Proceeds)

<table>
<thead>
<tr>
<th>Period</th>
<th>Total Number of IPOs</th>
<th>IPOs Not Using 180 Day Lockups</th>
<th>Proportion of IPOs Not Using 180 Day Lockups</th>
<th>Market Share of High Quality Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>88</td>
<td>23</td>
<td>0.2614</td>
<td>0.9318</td>
</tr>
<tr>
<td>1994-</td>
<td>140</td>
<td>20</td>
<td>0.1429</td>
<td>0.7929</td>
</tr>
<tr>
<td>1997</td>
<td>114</td>
<td>4</td>
<td>0.0351</td>
<td>0.7632</td>
</tr>
<tr>
<td>1998-</td>
<td>155</td>
<td>7</td>
<td>0.0452</td>
<td>0.8571</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Medium IPOs ($20 to $80 Million Proceeds)

<table>
<thead>
<tr>
<th>Period</th>
<th>Total Number of IPOs</th>
<th>IPOs Not Using 180 Day Lockups</th>
<th>Proportion of IPOs Not Using 180 Day Lockups</th>
<th>Market Share of High Quality Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>602</td>
<td>154</td>
<td>0.2558</td>
<td>0.6993</td>
</tr>
<tr>
<td>1994-</td>
<td>980</td>
<td>88</td>
<td>0.0898</td>
<td>0.6306</td>
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<tr>
<td>1997</td>
<td>345</td>
<td>34</td>
<td>0.0986</td>
<td>0.5420</td>
</tr>
<tr>
<td>1998-</td>
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<td>2000</td>
<td>141</td>
<td>6</td>
<td>0.0426</td>
<td>0.5816</td>
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<tr>
<td>2001-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Small IPOs (< $20 Million Proceeds)

<table>
<thead>
<tr>
<th>Period</th>
<th>Total Number of IPOs</th>
<th>IPOs Not Using 180 Day Lockups</th>
<th>Proportion of IPOs Not Using 180 Day Lockups</th>
<th>Market Share of High Quality Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>491</td>
<td>297</td>
<td>0.6049</td>
<td>0.1670</td>
</tr>
<tr>
<td>1994-</td>
<td>551</td>
<td>301</td>
<td>0.5463</td>
<td>0.1089</td>
</tr>
<tr>
<td>1997</td>
<td>116</td>
<td>63</td>
<td>0.5431</td>
<td>0.0603</td>
</tr>
<tr>
<td>1998-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>32</td>
<td>18</td>
<td>0.5625</td>
<td>0.0625</td>
</tr>
<tr>
<td>2001-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Table 4
Correlations Between Key Variables, by Subsample

Panel A: Correlation of Lockup Length and Underpricing

<table>
<thead>
<tr>
<th>Subsample</th>
<th>N</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-Ranked</td>
<td>1600</td>
<td>-0.013</td>
<td>0.299</td>
</tr>
<tr>
<td>VC-Backed</td>
<td>1374</td>
<td>-0.02</td>
<td>0.233</td>
</tr>
<tr>
<td>Neither</td>
<td>1052</td>
<td>0.187</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Panel B: Correlation of Lockup Length and Insider Holdings

<table>
<thead>
<tr>
<th>Subsample</th>
<th>N</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-Ranked</td>
<td>1394</td>
<td>0.053</td>
<td>0.023</td>
</tr>
<tr>
<td>VC-Backed</td>
<td>1279</td>
<td>-0.065</td>
<td>0.010</td>
</tr>
<tr>
<td>Neither</td>
<td>1055</td>
<td>0.016</td>
<td>0.303</td>
</tr>
</tbody>
</table>
Table 5
This table presents the coefficients, and associated t-statistics of an ordinary least-squares regression. The dependent variable is the number of days in the lockup period and the independent variables of interest are the percent of underpricing at the end of the first trading day and the holdings of firm insiders measured as a percent of outstanding equity, or as the natural log of dollar value. We use as control variables the offer price, a dummy variable set to 1 if the issuing firm is a high tech firm, and a dummy variable set to 1 if the underwriter ranking is greater than or equal to 8 (not included in the final 2 regressions) or if the IPO is backed by a venture capitalist. The superscripts ***, **, * represent statistical significance at the 1%, 5% and 10% levels, respectively.

### Determinants of Lockup Length

<table>
<thead>
<tr>
<th></th>
<th>All Firms</th>
<th>VC-Backed</th>
<th>VC-Backed</th>
<th>High-Rep Underwriter</th>
<th>High-Rep Underwriter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>523.8***</td>
<td>462.7***</td>
<td>368.5***</td>
<td>330.9***</td>
<td>163.7***</td>
</tr>
<tr>
<td>(27.87)</td>
<td>(35.95)</td>
<td>(17.71)</td>
<td>(11.30)</td>
<td>(12.14)</td>
<td>(10.96)</td>
</tr>
<tr>
<td>Underpricing</td>
<td>.572***</td>
<td>.502***</td>
<td>.118*</td>
<td>.096*</td>
<td>.024</td>
</tr>
<tr>
<td>(7.36)</td>
<td>(7.70)</td>
<td>(1.77)</td>
<td>(1.76)</td>
<td>(.602)</td>
<td>(.170)</td>
</tr>
<tr>
<td>Inside</td>
<td>*</td>
<td>-.034***</td>
<td>*</td>
<td>-2.23*</td>
<td>*</td>
</tr>
<tr>
<td>(2.95)</td>
<td>(-2.70)</td>
<td>(-1.76)</td>
<td>(-1.76)</td>
<td>(<strong>-1.76</strong>)</td>
<td>(1.76)</td>
</tr>
<tr>
<td>Ln(Insider $)</td>
<td>-8.26***</td>
<td>*</td>
<td>-12.73***</td>
<td>*</td>
<td>.483</td>
</tr>
<tr>
<td>(-2.71)</td>
<td>(-4.07)</td>
<td>(-.407)</td>
<td>(-.281)</td>
<td>*</td>
<td>(-1.10)</td>
</tr>
<tr>
<td>Price</td>
<td>-3.68***</td>
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### Asymmetric Information Sample

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Model (1) (2) (3) (4) (5) (6) (7) (8)
Appendix: Proofs of the Propositions

Proof of Proposition 1:
The uninformed investors in the IPO market face an informational disadvantage and will lose money if the price is set at the \( \text{ex ante} \) expected value of the shares. The uniformed investors must at least breakeven on their investments in the IPO market for it to be rational for them to participate in the market. Set the uninformed investors expected profit equal to zero 
\[
0 = \varphi X + (1 - \varphi)0 - p(\varphi X + (1 - \varphi))
\]
(where \( \varphi \) is the proportion of good firms in the market as specified by the particular semi-separating equilibrium) and rearrange to find the price function \( p(u, \varphi, X) \) in proposition 1. Note that there is underpricing relative to the \( \text{ex ante} \) expected value of the shares. The informed investors invest only in the good offerings and derive rents from their superior information. Uninformed investors invest in all issues, receiving all of the bad offerings and the portion \( u \) of the good offerings, and make zero profits at the offer price. Good firms have no further way of separating themselves from bad firms in the model so sell underpriced equity rather than accept the value zero alternative. Bad firms must mimic good firms in the publicly observable choices (the unobservable effort decision is the exception) or they will not get funded.

Proof of Proposition 2
The proof has three steps: first we show that \( T_{AI} \) and \( T_{MH} \) are well-defined, we then show that the capital constraint is binding, and finally we derive the inequalities in the proposition.

Step 1: Define 
\[
T_{\text{max}} \equiv \arg \max \{Q(T)X\delta^T\}.
\]
The first-order condition implied by this definition is 
\[
Q\delta^T + Q\delta^T \ln(\delta) = 0,
\]
which has a unique solution if \( Q = -Q \ln(\delta) \) does. The left hand side of this last equation is a decreasing function of \( T \) by the assumed concavity of the function \( Q \), while the right hand side is an increasing function of \( T \).

The lockup length that solves the asymmetric information problem, \( T_{AI} \), is defined as 
\[
T_{AI} = \arg \max \{[Q(T)X + (1 - Q(T))EV]\delta^T \text{ st } (1 - Q(T))EV\delta^T \leq V\}.
\]
The first order condition implied by this condition can be written:
\[
Q(T) = -(\ln(\delta))[\frac{(1 - \lambda)\varphi}{(1 - \varphi + \lambda\varphi)} + Q(T)],
\]
where \( \lambda \) is the Lagrange multiplier for the non-mimicry constraint. The left-hand side of this equation is a decreasing function of \( T \) while the right-hand side of this equation is an increasing function of \( T \). Thus \( T_{AI} \) is uniquely defined. The proof for \( T_{MH} \) follows similarly by writing the IC constraint as an equality.

Step 2: We establish that, in each version of the solution, the optimal \( \alpha, \alpha^* \), satisfies the equation \( \alpha^* p = I \). For the Asymmetric Information Case (when the IC constraint does not bind) the manager’s objective function is 
\[
\alpha p - I + (1 - \alpha)[Q(T)X + (1 - Q(T))EV]\delta^T + \lambda[V - (1 - \alpha)(1 - Q(T))EV\delta^T].
\]
The choice of \( \alpha \) therefore is based on a comparison of the equilibrium IPO price \( p \) and the quantity 
\[
(1 - \alpha)[Q(T)X + (1 - Q(T))EV]\delta^T + [V - (1 - \alpha)(1 - Q(T))V\delta^T]
\]
which we label \( M(T) \).
Evaluating $M(T)$ at $T = 0$ we can see that $M(0) = EV = \phi X + (1 - \phi)0 > p$ due to the underpricing of IPO shares. Because the optimal lockup length in the Asymmetric Information Case is chosen to maximize $M(T)$ it is clear that $M(T_{AI}) > M(0) > p$ which implies that the minimal $\alpha$ is optimal. Because in the solution to the Moral Hazard Case the optimal lockup length $T_{MH} > T_{AI}$ the argument is not as simple as in the Asymmetric Information Case. In particular, it may be beneficial to select an $\alpha > \alpha^*$ and a smaller $T$ to increase the incentives for managerial effort. This can easily be shown not to be an optimal strategy. The problem in the Moral Hazard Case, by assumption, can be written with the IC constraint binding:

$$\max_{\alpha, \delta} \alpha p(u, \varphi, X) - I + (1 - \alpha)[Q(T)X + (1 - Q(T))EV]\delta^T$$

s.t.

$$(1 - \alpha)Q(T)X\delta^T = C_L \quad (IC)$$

$$(1 - \alpha)([1 - Q(T)]EV)\delta^T \leq V \quad (NM)$$

$$\alpha p(u, \varphi, X) \geq I \quad (CC)$$

Solving the IC constraint for $\alpha$ and substituting this into the maximand provides:

$$(p - I) + \left[\frac{C_L}{Q(T)X}\right]\{[Q(T)X + (1 - Q(T))EV]\delta^T - p\}$$

Noting that both terms involving $T$ are decreasing in the relevant range implies the optimal choice will always involve the minimum $T$ that satisfies the IC constraint. Therefore, the optimal $\alpha$ in the Moral Hazard Case will also be $\alpha^*$ (defined by $\alpha^* p = I$ or $\alpha^* = I \frac{\varphi u + (1 - \varphi)}{\varphi u X}$).

**Step 3:** Note that the objective function above takes a constrained maximum at $T_{AI}$, where the constraint is the non-mimicry constraint (NM).

If $Q(T_{AI})\delta^{T_{AI}} \geq \frac{C_L}{(1 - \alpha)X}$ then the incentive compatibility constraint must be slack at the optimum and $T_{AI}$ is the solution to the design problem. If $Q(T_{AI})\delta^{T_{AI}} < \frac{C_L}{(1 - \alpha)X}$ then the incentive compatibility constraint binds at the optimum. The lockup is of insufficient length to resolve the moral hazard problem and the solution must involve $T > T_{AI}$. Because the objective function is decreasing over this range (by definition of $T_{AI}$) the firm prefers the shortest lockup satisfying the incentive compatibility constraint. Thus $T_{MH}$ defined by $Q(T_{MH})\delta^{T_{MH}} = \frac{C_L}{(1 - \alpha^*)X}$ solves the design problem.

**Proof of Corollary 2:**

First we derive the comparative static properties of $T_{MH}$. Recall that $Q(T)\delta^T$ takes a unique maximum at some value $T_{Max}$; see step 1 of the proof of Proposition 2. Since this lockup length maximizes the incentive to put forth effort, it follows that
\[ T_{MH} \leq T_{Max} \]. Hence the function \( Q(T)\delta^T \) is increasing over the relevant range, and the comparative static results \( \frac{\partial T_{MH}}{\partial X} < 0 \) and \( \frac{\partial T_{MH}}{\partial \phi} = 0 \) follow immediately from the definition of \( T_{MH} \).

Next, as above, define
\[
M(T) = (1 - \alpha)[Q(T)X + (1 - Q(T))EV]\delta^T + \lambda[V - (1 - \alpha)(1 - Q(T))EV\delta^T]
\]
and let
\[
N(T) = \frac{\partial M(T)}{\partial T}
\]
be the derivative with respect to \( T \) and
\[
R(T) = \frac{\partial M(T)}{\partial \lambda}
\]
be the derivative with respect to \( \lambda \).

\[ N(T) = (1 - \phi + \lambda\phi)[Q'(T)X\delta^T + Q(T)X\delta^T \ln(\delta)] + (1 - \lambda)\phi X \delta^T \ln(\delta) \]
and is zero when evaluated at \( T_{AI} \) by definition. Similarly
\[ R(T) = V - (1 - \alpha)(1 - Q(T))\phi X \delta^T \]
and is also equal to zero when evaluated at \( T_{AI} \). Using the implicit function theorem on \( N(T_{AI}) = 0 \) and \( R(T_{AI}) = 0 \) allows us to derive the comparative static characteristics for \( T_{AI} \).

By the implicit function theorem,
\[
\frac{\partial T_{AI}}{\partial X} = \frac{\frac{\partial N}{\partial \lambda}}{\frac{\partial R}{\partial \lambda}} \cdot \frac{\frac{\partial R}{\partial \lambda} - \frac{\partial N}{\partial T}}{\frac{\partial N}{\partial \lambda} - \frac{\partial R}{\partial T}}
\]
Note that \( \frac{\partial R(T_{AI})}{\partial \lambda} = 0 \), which simplifies the derivation.

\[ \frac{\partial N}{\partial \lambda} > 0 \] since \( \alpha \) is independent of \( \lambda \) and \( T_{AI} \leq T_{Max} \). The result
\[ \frac{\partial R}{\partial \lambda} < 0 \] can be seen from examination of \( R(T) \) and noting that as \( X \) rises \( \alpha \) drops. Finally, direct examination also indicates that
\[ \frac{\partial R}{\partial T} > 0 \] Thus \[ \frac{\partial T_{AI}}{\partial X} > 0 \] .

Similarly the implicit function theorem indicates that
\[
\frac{\partial T_{AI}}{\partial \phi} = \frac{\frac{\partial N}{\partial \phi} \frac{\partial R}{\partial \lambda} - \frac{\partial N}{\partial \lambda} \frac{\partial R}{\partial \phi}}{\frac{\partial N}{\partial \lambda} - \frac{\partial R}{\partial T}}
\]
The denominator is the same as above (negative). The only new term is
\[
\frac{\partial R}{\partial \phi} = (1 - \alpha)(1 - Q(T))X\delta^T - \frac{\partial \alpha}{\partial \phi} (1 - Q(T))\phi X \delta^T \]
which is positive since \( \frac{\partial \alpha}{\partial \phi} < 0 \), see step 2 of the proof of proposition 2 above. Therefore \[ \frac{\partial T_{AI}}{\partial \phi} < 0 \] .