Institutional Trading, Information Production, and the SEO Discount: A Model of Seasoned Equity Offerings

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We develop a model of the seasoned equity offering (SEO) process, starting from the SEO announcement, through pre-offer trading, and ending in the offering itself. We use our model to advance a new rationale for the existence of the SEO discount and SEO underpricing, and to analyze the role of institutional investors in SEOs. We show that the SEO discount is positively related to the extent of information asymmetry a firm faces, and SEOs with greater pre-offer net buying by institutional investors have higher institutional allocations, greater oversubscription, and lower SEO discounts. Furthermore, our model predicts a positive link between the pre-offer net buying by institutional investors and the magnitude of SEO underpricing and the long-run post-SEO operating performance.

1. Introduction

The discounting and underpricing of seasoned equity offerings (SEOs) have been extensively documented by the empirical literature (see, e.g., Corwin, 2003; Chemmanur et al., 2009). The SEO discount is defined as the difference between the issuing firm’s closing price on the last trading day prior to the offer day and its SEO offer price; SEO underpricing, on

For helpful comments and discussions, we thank Shan He, Gang Hu, Debarshi Nandy, Xuan Tian, participants at the 2007 European Finance Association meetings, seminar participants at Boston College, and especially two anonymous referees and a coeditor.
the other hand, is defined as the difference between the issuing firm’s SEO offer price and its closing price on the first trading day after the SEO (both are usually expressed as a percentage of the offer price). Altinkilic and Hansen (2003) report that, in the 1990s, the average SEO discount was 3.2%, which often exceeds half of the underwriting syndicate’s fee, and the aggregate SEO discounts in this period amount to $2.6 billion. Chemmanur et al. (2009) document an average 3.50% underpricing for SEOs in the 1999 to 2004 period.

SEOs are one of the most important venues for firms to raise capital: e.g., DeAngelo et al. (2007) report that without the SEO proceeds, 62.6% of issuers would have insufficient cash to implement their chosen operating and non-SEO financing decisions in the year after the SEO. The most critical decision in an SEO is the pricing of the issuing firm’s equity because it concerns the amount of financing, if any, can be raised, and thus the chance of successfully implementing managers’ business plans. Hence, SEO discounts and underpricing have important implications for firms’ business strategy. There is a large theoretical as well as empirical literature on the economic phenomenon of underpricing in initial public offerings (IPOs). In contrast, in spite of the economic significance of SEOs, theoretical analyses on them have been scarce. In particular, although the existence of SEO discounts (and underpricing) has been widely documented in the empirical literature, there have been few theoretical analyses on the discounting and underpricing of SEOs. A notable exception is Gerard and Nanda (1993), who develop a model of manipulative informed trading around SEOs in a Kyle (1985) type setting. In their manipulative equilibrium, institutional investors may sell shares in the pre-SEO market even when they have favorable private information about the firm, in an attempt to conceal such private information (i.e., informed investors with favorable private information trade in the opposite direction of their information). Such a trading strategy is profitable if institutional investors can recoup their losses in the pre-SEO trading by obtaining (and subsequently selling) share allocations in these SEOs at a reduced offer price. In the above setting, the SEO discount is a way of compensating uninformed (retail) investors for the adverse selection they face in the SEO allocation process (similar to the winner’s curse in Rock’s (1986) IPO model).  

1. Parsons and Raviv (1985) also develop a model that sheds light on the relationship between the SEO offering price and the secondary market price prior to the SEO (and therefore on the SEO discount). They assume that investors have heterogeneous valuations for the firm’s shares. In such a setting, they show that the SEO offer price is set at a discount relative to the pre-issue share price in equilibrium. This equilibrium discount arises from the fact that, because the SEO may be oversubscribed, an investor can obtain
However, there is little empirical support for Gerard and Nanda (1993). For example, in contrast to Gerard and Nanda’s (1993) prediction that institutional investors sell more shares in the pre-offer market for firms offering higher SEO discounts, Chemmanur et al. (2009) document a positive relationship between institutional net buying (institutional buy minus sell) in equity of SEO firms in the pre-offer market and SEO discounts. Moreover, whereas Gerard and Nanda (1993) predict that firms with larger SEO discounts have lower price run-up (between the SEO announcement date and offer date) in the pre-offer market, Altinkilic and Hansen (2003) find a positive relationship between SEO firms’ price run-up in the pre-offer market and SEO discounts. Finally, contradictory to the implication of Gerard and Nanda (1993) that banning short selling around SEOs reduces SEO discounts, a number of empirical studies have documented that, subsequent to the enactment of rule 10b-21 banning short sales around SEOs, SEO discounts have in fact increased rather than decreased (see, e.g., Singal and Xu, 2005; Kim and Shin, 2004).

Because of the paucity of theoretical models of SEOs, most empirical studies on SEOs rely on theoretical models of IPOs for testable hypotheses (see, e.g., Altinkilic and Hansen, 2003; Corwin 2003). However, although SEOs have some similarities to IPOs, there are important factors making SEO pricing different from that of IPOs, with the most important one being the existence of the pre-SEO market, which is absent for IPO firms (because their shares are publicly traded for the first time only after the IPO). For this reason, the most interesting puzzle related to SEOs, namely, the SEO discount, does not exist for IPOs. Further, the existence of a pre-SEO market has implications for price setting by issuers in SEOs as well, because they can extract some (noisy) information regarding the demand for SEO shares by observing the pre-SEO share prices. In sum, it is clear that IPO models cannot generate predictions for SEO discounts, the role of institutional investors in the pre-SEO market, and the relationship between institutional investors’ trading behavior in the pre-SEO market and SEO discounts.

The objective of this paper is therefore to remedy this gap by developing a theoretical analysis on the SEO offering process and the role of institutional investors in SEOs.

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a share allocation in the SEO only with a certain probability (less than one), whereas he can obtain shares with certainty by buying shares in the stock market prior to the SEO. However, although the differences in reservation prices across investors in Parsons and Raviv (1985) can be interpreted as arising from differences in information across investors, this model does not yield directly testable predictions for the role of institutional investors in SEOs.
Our model of the SEO offering process generates predictions that are significantly different from those of existing models of SEOs (e.g., Gerard and Nanda, 1993), and is able to explain many findings in the empirical literature. We consider an entrepreneur (firm insiders), who wishes to sell a certain number of shares in his firm to outsiders in an SEO. The firm can be of either high intrinsic value or low intrinsic value, with a high intrinsic value firm having a higher end of period cash flow than a low intrinsic value firm. The entrepreneur has private information about the firm’s intrinsic value: although he knows the true firm value, outsiders only observe a prior probability distribution over it. There are two kinds of investors in the equity market: institutional investors and retail investors (liquidity traders). Institutional investors can produce (noisy) information about the firm at a cost, whereas retail investors cannot do so, and their equity demand is driven entirely by liquidity considerations.

Three ingredients drive the equilibrium in our model. First, insiders of the high intrinsic value firm would find it beneficial to induce a significant extent of information production by institutional investors, because such information production can reduce the extent of their pooling with the low intrinsic value firm, thus enabling them to obtain a higher offer price in the SEO. Second, institutional investors may use the information they produce about the firm at two different venues: in the pre-offer market, and in the SEO itself. Third, firm insiders can partially infer the demand in the SEO by observing the pre-offer price. However, given that there is retail trading in the pre-offer market, the above inference by firm insiders is noisy, such that there may be a residual probability of SEO failure, during which firm insiders cannot sell all shares being offered.\(^2\) The equilibrium SEO discount, therefore, depends on the magnitude of the cost incurred by the firm in the event of SEO failure. When this cost is small, firm insiders set the SEO discount to be the same across all possible states (prices) in the pre-offer market, and this discount is just enough to cover institutional investors’ information production costs. In this case, the firm faces some probability of SEO failure. When this cost is large, firm insiders set a larger SEO discount when the pre-offer price is less informative about institutional investors’ demand in the SEO, and they set a smaller discount when the pre-offer price is more informative (to minimize the probability of SEO failure).

\(^2\) One way to reduce uncertainty about institutional demand in the SEO is through the bookbuilding procedure, in which firm insiders can extract demand information from investors. If bookbuilding can remove all uncertainty about institutional demand, firm insiders can adjust the SEO offer price accordingly to avoid SEO failure. However, as long as the residual uncertainty after the bookbuilding procedure is sufficiently large, our main results remain qualitatively unchanged.
this case, the SEO is guaranteed not to fail because the SEO offer price is set low enough that all institutional investors who have produced information about the firm bid for shares in the SEO.

Our analysis generates several testable predictions. First, our model predicts that SEOs are on average discounted. Second, our model implies that the magnitude of the SEO discount is positively related to the extent of information asymmetry a firm faces (as measured by how costly it is for institutional investors to produce information about the firm). Third, our model generates predictions regarding the relationship between the informativeness of equity price in the pre-offer market and the magnitude of the SEO discount. In particular, it predicts that firms whose pre-offer prices are more informative have smaller SEO discounts. Fourth, because more institutional investors bid for shares in the SEO when the pre-offer price is more informative, our model implies a negative relationship between the allocation of SEO shares to institutional investors and the magnitude of the SEO discount. In other words, SEOs in which institutional investors acquire larger share allocations are characterized by smaller SEO discounts. Fifth, our model generates predictions regarding the relationship between the institutional net demand in the pre-offer market, the institutional share allocation in the SEO, and the degree of oversubscription in the SEO. In particular, because the pre-offer net demand from institutional investors is positively associated with the informativeness of the pre-offer price, our model predicts that SEOs in which the net buying by institutional investors in the pre-offer market is higher have higher institutional SEO allocations and higher degrees of SEO oversubscription. Sixth, our model implies that SEOs with higher pre-offer institutional net buying have better post-issue long-run operating performance because such firms are more likely to be of high intrinsic value. Seventh, our model predicts a positive relationship between the institutional net buying in the pre-offer market and the post-SEO initial return (i.e., SEO underpricing) because institutional investors’ pre-offer net buying is positively related to the intrinsic value of the firm. Finally, our model implies a positive relationship between the institutional net buying in the pre-offer market and that in the post-SEO market: that is, SEOs with higher institutional net buying in the pre-offer market have higher institutional net buying immediately after the offering.

This paper is related to several strands in the theoretical and empirical literature. In contrast to the relative paucity of theoretical research on SEOs, there is a substantial empirical literature dealing with the SEO offering process. Corwin (2003) conducts a comprehensive analysis of the determinants of SEO discounts. He finds that the magnitude of SEO discounts has increased substantially over time, especially after
the adoption of Rule 10b-21, and that the magnitude of SEO discounts is positively related to offer size, price uncertainty, and the magnitude of pre-offer returns. Kim and Shin (2004) also conclude that Rule 10b-21 has resulted in less informative pre-offer prices and that its adoption has in fact increased the magnitude of SEO discounts. Similarly, Singal and Xu (2005) document that a higher cost of short selling (i.e., less informative pre-SEO stock prices) has led to higher SEO discounts after the enactment of Rule 10b-21. Altinkilic and Hansen (2003) decompose SEO discounts into expected and unexpected components and examine the relationship between these components and SEO stock returns. They find that the expected discounts are incorporated into stock prices when SEOs are first announced and that the unexpected discounts release information that often causes large price swings on the offer day. Mola and Loughran (2004) empirically analyze SEO discounts and the clustering of SEO offer prices. Gao and Ritter (forthcoming) examine the marketing aspects of the SEO process. In analyzing the importance of underwriters’ marketing efforts for SEOs, Huang and Zhang (2009) document a negative relation between the pre-offer institutional ownership and SEO discounts. Finally, using quarterly institutional holdings data, Gibson et al. (2004) document that SEO firms experiencing the greatest increase in institutional investment around the offer dates significantly outperform those experiencing the greatest decrease. They interpret their results as evidence that institutions have the ability to identify above-average SEO firms.

Most closely related to this paper is the empirical study by Chemmanur et al. (2009), who present direct tests on the implications of our model using a large sample of transaction-level institutional trading data that allows them to explicitly identify institutional SEO share allocations. They study whether institutional investors indeed have private information about the SEO firms, and the relationship between share allocations in SEOs to institutional investors, institutional trading before and after SEOs, and SEO discounts. They find the following: First, institutions are able to identify and obtain more allocations in SEOs with better long-term returns. Second, more pre-offer net buying of the SEO firm’s equity by institutional investors is associated with

3. Corwin (2003) documents an increase in the magnitude of SEO discounts during the 1990s. Given that both analyst coverage and institutional ownership increased substantially during this period, this finding is likely to be driven by factors outside our model. We acknowledge this limitation of our model and believe it represents an important opportunity for future research.

4. Safieddine and Wilhelm (1996) examine manipulative trading around SEOs by testing the relationship between SEO discounts and pre-offer short selling. They document unusually high levels of short interest in the pre-offer period and a positive relationship between short interests and SEO discounts.
more institutional SEO share allocations, and also more post-offer net buying. Third, greater pre-offer net buying of SEO firms’ equity by institutions and larger institutional SEO share allocations are associated with smaller SEO discounts. Fourth, institutions flip only a very small fraction of their SEO share allocations: 3.20% during the first 2 days post-SEO. However, this lack of flipping does not appear to be costly to institutional investors, because there is no significant difference between the extent of SEO underpricing and the realized profitability of institutional SEO share allocation sales. Further, institutional investors’ post-SEO trading significantly outperforms a naive buy-and-hold trading strategy in SEOs. Finally, the profitability of post-offer trading in SEOs where institutions obtained allocations is higher than that of trading in SEOs where they did not obtain allocations. Chemmanur et al. (2009) conclude that their results are consistent with the information production rationale for SEO discounts and underpricing proposed by our paper.

The rest of the paper is organized as follows. Section 2 describes the essential features of our model. Section 3 characterizes the equilibrium of the model and develops results and empirical implications. Section 4 develops an extension of the basic model allowing the market maker to reset the SEO firm’s share price on the day after the SEO, thus allowing us to study equilibrium SEO underpricing. Section 5 concludes. The proofs of all propositions are confined to the Appendix.

2. The Model

The model has four dates: time 0, time 1, time 2, and time 3. There are four types of (risk neutral) agents in the model: the entrepreneur (firm insiders), institutional investors, noise traders, and the market maker. The firm is initially set up by insiders as an all equity firm. Firm insiders hold all \( m \) shares of equity in the firm at the beginning of the game.

The firm can be of two types: type H (the “high” type) or type L (the “low” type). The type H firm generates a time 3 cash flow of \( h \), whereas the type L firm generates a time 3 cash flow of \( l \). We assume that \( h > l \): that is, the type H firm generates a higher future cash flow than the type L firm. The equity market is characterized by asymmetric information, and firm insiders have private information about the intrinsic value of the firm: although they know the true type (time 3 cash flow) of the firm, at time 0, outside investors only know a probability distribution over the firm type. Specifically, outside investors believe that with probability \( \theta \) the firm is of type H, and it is of type L with the complementary probability \( (1 - \theta) \).
In our setting, the SEO discount, which is determined in equilibrium, has two components. The first component is a “state-independent discount,” which does not vary with the share price of the firm on the day before the SEO, and depends on the extent of information asymmetry faced by the firm and outsiders’ information production cost (which, in turn, may depend upon various firm characteristics such as firm size, age, the industry the firm is in, and the characteristics of the investment banker underwriting the firm’s equity issue). The second component is a “state-dependent” discount, which depends on the firm’s share price on the day before the SEO. These two components are discussed in more detail later.

The sequence of events in the model is depicted in Figure 1. At time 0, firm insiders make an announcement that they will offer \( q \) out of their holdings of \( m \) shares in the firm to outside investors in an seasoned equity offering at time 2. The rest of insiders’ equity holdings are sold to outside investors at their intrinsic values at time 3 (when all asymmetric information is resolved). At time 0, along with the SEO announcement, firm insiders also decide on the magnitude of the state-independent discount, denoted by \( s \), to be offered to investors who bid in the SEO. After the SEO announcement, between time 0 and 1, institutional

5. Note that the SEO discount is a discount on the closing price on the last trading day prior to the SEO.
6. In practice, when firms announce SEOs, they also announce an upper limit on the offer price. We can interpret such a price limit as a signal of the state-independent discount because it allows outside investors to estimate of the minimum profits they can make from participating in SEOs.
7. In practice, firms may raise external financing in SEOs in addition to insiders liquidating a fraction of their equity holdings. For modeling simplicity, we focus on the latter aspect and abstract away from the former. Incorporating the external financing aspect of SEOs into our model adds considerable complexity without changing the qualitative nature of our results.
8. We assume this state-independent discount is enforced by an investment banker, who is a repeated player in the equity issue market and cares about his reputation.
investors choose whether or not to produce information about the firm type (i.e., the time 3 cash flow). At time 1, both institutional investors and noise traders participate in equity trading (if they choose to do so) in the pre-offer market. Based on the total demand by institutional investors and noise traders, the market maker sets the pre-offer price of the firm’s equity. At time 2, after observing the pre-offer price, firm insiders set the offer price of the SEO. Both institutional investors and noise traders can participate in the SEO. At time 3, all cash flows are realized and all information asymmetry is resolved.

2.1 Institutional Investors

After the firm’s SEO announcement (between time 0 and 1), institutional investors choose whether or not to produce information about the time 3 cash flow (intrinsic value) of the firm. This information production is costly: If an institutional investor produces information, he incurs a cost \( c \) between time 0 and 1, and receives an information signal about the firm’s true value. He can use this information either in the pre-offer trading (at time 1) or in the SEO itself (at time 2), or at both dates. If he chooses not to produce information, he invests all his wealth in the risk-free asset and participate neither in the pre-offer trading nor in the SEO. For simplicity, we normalize the risk free rate of return to zero.

Institutional investors form rational expectations about the magnitude of the state-independent discount, \( s \), upon the SEO announcement, based on which they decide whether or not to produce information

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9. This information production process is discussed in detail in Section 2.1.
10. We assume that the information production cost, \( c \), is the same for all institutional investors throughout the paper, whereas in practice, it may be different across investors. In particular, it may be less costly for institutions with existing ownership of the SEO firms’ stocks to produce information than other institutions. In this case, because the information production cost is borne by firm insiders, they are better off inducing these institutions to produce information before resorting to other institutions, which allows them to offer smaller SEO discounts. In spite of its intuitive appeal, incorporating differential costs of information production adds considerable complexity to our model, and thus is omitted for analytical simplicity.
11. Given that institutional investors face considerable adverse selection if participating as uninformed investors either in the pre-offer market or in the SEO, it is reasonable to assume that they participate in neither if they choose to remain uninformed. Further, it can be shown that uninformed institutional investors are strictly worse off participating in the pre-offer trading or in the SEO compared to investing their wealth in the risk-free asset, provided that the SEO is not heavily discounted. Although uninformed institutional investors have some incentive to participate in the SEO when the discount is very large, we assume throughout the paper that they do not do so because allowing such participation adds considerable complexity to our model without changing the qualitative nature of the results.
about the firm. Depending on the magnitude of the state-independent discount, $s$, a number $n(s)$ of institutional investors produce information about the firm.

If an institutional investor decides to produce information, he receives an informative but noisy signal $e$ about the true type of the firm. This signal has two possible realizations: “good” ($e = G$) or “bad” ($e = B$). For the type H firm, with probability $\alpha_H$, a fraction $\lambda$ of institutional investors who produce information receive good signals, whereas the remaining fraction $(1 - \lambda)$ receive bad signals; with the complementary probability $(1 - \alpha_H)$, a fraction $\delta$ of institutional investors who produce information receive good signals, and the remaining fraction $(1 - \delta)$ receive bad signals. Similarly, for the type L firm, with probability $\alpha_L$, a fraction $\lambda$ of institutional investors who produce information receive good signals, whereas the remaining fraction $(1 - \lambda)$ receive bad signals; with the complementary probability $(1 - \alpha_L)$, a fraction $\delta$ of institutional investors who produce information receive good signals, and the remaining fraction $(1 - \delta)$ receive bad signals. The structure of the information signal is summarized in Figure 2. We assume:

$$\alpha_H > \alpha_L, \text{ and } \lambda > \delta,$$

that is, on average, institutional investors who produce information are more likely to receive a good signal about the type H firm than about the type L firm. In addition, we impose the parameter restriction $(\lambda - \delta)n = d_1.12$

12. Note that our assumption on the structure of the information signal institutional investors receive is critical for the existence of the pooling equilibrium discussed in...
The above information structure implies that institutional investors’ signals from information production are informative but noisy. They are informative in the sense that they are positively correlated with the true type of the firm: that is, institutional investors are more likely to receive a good signal about the type H firm than about the type L firm. They are noisy in the sense that they do not allow institutional investors to distinguish the type H firm from the type L firm with probability 1. In other words, although the information asymmetry between firm insiders and institutional investors is lowered by institutional investors’ information production, it cannot be completely eliminated by it.\textsuperscript{13}

Based on the signal from information production, each institutional investor chooses to buy or sell a maximum of one share of the firm in the pre-offer market. Further, each institutional investor can bid for a maximum of one share in the SEO.\textsuperscript{14}

2.2 Noise Traders

In contrast to institutional investors, noise traders cannot produce information about the firm at any cost (i.e., they have an infinite information production cost). However, they participate in both the pre-offer trading of the firm’s shares and in the SEO to some degree. We assume a binomial distribution for noise traders’ (exogenous) equity demand in both the pre-offer market and the SEO. At time 1 (in the pre-offer market), the noise traders’ demand is $d_1$ shares with probability $\phi_1$, and $-d_1$ shares with the complementary probability $(1 - \phi_1)$: that is, they buy $d_1$ shares with probability $\phi_1$ and sell $d_1$ shares with probability $(1 - \phi_1)$. At time 2 (in the SEO), their demand is $d_2$ with probability $\phi_2$.

Section 3. This is because it allows for the possibility that institutional investors have the same information production result for the type H firm and the type L firm. Combined with our assumptions on noise trader demand and the parametric restriction $(\lambda - \delta)n = d_1$, this assumption is also important for a state in which the pre-offer price in not very informative to arise in equilibrium (see Section 3.1.1 for details).\textsuperscript{13}

Note that we assume the signals institutional investors receive about the firm are correlated with each other. This assumption is made for modeling simplicity. In practice, institutional investors’ signals may be independent from each other. While allowing for independent signals makes various expressions more complex, the qualitative nature of our results would remain unchanged as long as a larger fraction of institutional investors receive good signals for the type H firm than for the type L firm.\textsuperscript{13}

Note that the assumptions of institutional investors trading only one share in the pre-offer market and bidding for only one share in the SEO are not crucial for our results. As long as each institutional investor devotes only a limited amount of wealth to the pre-offer trading and to bidding in the SEO, the qualitative nature of our results does not change.\textsuperscript{14}
and zero with the complementary probability \((1 - \phi_2)\) (because they cannot sell shares in the SEO).\(^{15}\)

### 2.3 The Market Maker

At time 1, after the information production by institutional investors, a market maker observes the demand for the firm’s shares in the pre-offer market from both institutional investors and noise traders, and sets the share price according to his beliefs about the final cash flow of the firm. Note that the market maker can observe only the total demand for the firm’s shares, but not the demands from institutional investors and noise traders separately. Both firm insiders and outside investors observe the share price set by the market maker.

### 2.4 The Equity Issue Game

At time 0, firm insiders announce an SEO of \(q\) shares to outside investors at time 2. The remaining shares are retained by firm insiders at time 2, and will be sold to outside investors at their intrinsic value at time 3 (when the information asymmetry is resolved). We assume that firm insiders’ objective is to maximize the expected value of the total proceed from the above two sales, net of any costs of SEO failure. At time 0, they choose the state-independent discount, \(s\), to induce an optimal amount of information production by institutional investors for the above objective. In choosing the SEO offer price (at time 2), firm insiders not only take into account their firm’s true value, but also the pre-offer price set by the market maker (at time 1).

In the pre-offer market (at time 1), institutional investors make trading decisions (buy or sell) based on the information production signals they receive about the firm, which we characterize in detail in Section 3. In the SEO (at time 2), each institutional investor (who participates in the SEO) decides on whether or not to bid for a share based on two factors: the signal he receives from information production and the pre-offer price. Because the pre-offer price is a (noisy) aggregation of information held by institutional investors, in some cases (when the above aggregation is not very noisy), it dominates the individual signals such that institutional investors make their SEO bidding decisions entirely based on this price. On the other hand, when the information aggregation in the pre-offer market is very noisy,

\(^{15}\) Thus, similar to market microstructure models with liquidity or noise traders (see, e.g., Kyle, 1985), we assume that noise traders participate in the pre-offer market and in the SEO regardless of the potential adverse selection they face.
institutional investors take into account both their individual signals and the pre-offer price in forming bidding strategies in the SEO.

If the total demand in the SEO (by both institutional investors and noise traders) exceeds the number of shares offered \( q \), we refer to the SEO as a “success.” In this case, the SEO is oversubscribed and shares are rationed among all bidders. If the total demand in the SEO is less than the number of shares offered (i.e., there are shares left unsold in the SEO), we refer to the SEO as having failed, and the cost of SEO failure, \( K \), is imposed on firm insiders.16

3. Equilibrium

The equilibrium concept we use is that of Perfect Bayesian Equilibrium surviving the Cho–Kreps intuitive criterion.17 An equilibrium in this model consists of the following choices made by firm insiders and institutional investors: (i) Firm insiders’ choice at time 0 regarding the magnitude of the state-independent discount of the firm’s SEO, and their choice at time 2 regarding the offer price of the SEO; (ii) a decision by the institutional investors regarding whether or not to produce information about the firm between time 0 and 1, their decision regarding whether to buy or sell one share in the pre-offer market at time 1, and their decision regarding whether or not to bid for one share in the firm’s SEO at time 2. Each of the above choices satisfies the following requirements: (a) the choice of insiders of each firm type maximizes their objective, given the equilibrium behavior and beliefs of insiders of the other type of the firm, and the equilibrium behavior and beliefs of institutional investors; (b) the beliefs of insiders of both types of the firm and institutional investors are consistent with the equilibrium choices of others; further, along the equilibrium path, these beliefs are formed using Bayes’ rules; (c) any deviation from the equilibrium strategy by insiders of any firm type is met by beliefs of institutional investors that yield them a lower expected payoff compared to that obtained in equilibrium; and (d) the beliefs of the institutional investors in response

16. For analytical simplicity, we assume that the cost of SEO failure, \( K \), is imposed directly on firm insiders. However, given that insiders retain a significant fraction of the firm’s equity subsequent to the SEO, all our results go through qualitatively even if we assume that the cost \( K \) is paid from the firm’s cash flow at time 3.

17. Thus, our equilibrium definition is based on the Perfect Bayesian Equilibrium (PBE) concept, first formally defined for dynamic games with incomplete information by Fudenberg and Tirole (1991). See Milgrom and Roberts (1986), Engers (1987), or Cho and Sobel (1990) for a detailed discussion of why the notion of a PBE surviving the Cho–Kreps intuitive criterion is the appropriate equilibrium concept here.
to off-equilibrium path moves by insiders of any firm type are such that they satisfy the Cho–Kreps intuitive criterion.18

3.1 The SEO Equilibrium

This section describes the equilibrium involving information production by institutional investors in our model.19 There are two important scenarios in this equilibrium, and we discuss them separately. The first scenario involves the firm incurring a positive probability of SEO failure and arises when the cost of SEO failure, $K$, is not very large. The second scenario involves the SEO succeeding with probability 1 and arises when the cost of SEO failure, $K$, is relatively large.

**Proposition 1:** The equilibrium in the equity market can be characterized as follows:

(i) The price of the firm’s shares in the pre-offer market can be one of three possible values: high, medium, or low (to be characterized in detail below).

(ii) If the cost of SEO failure, $K$, is not too large and if outsiders’ prior probability assessment of the firm being of type H, $\theta$, is large enough, the type H firm does not offer any discount in addition to the state-independent discount, $s^*$, in the SEO. If the cost of SEO failure, $K$, is sufficiently large and if outsiders’ prior probability assessment of the firm being of type H, $\theta$, is small enough, the type H firm offers a state-dependent discount, $S^*$, in addition to the state-independent discount if the pre-offer price is medium. It does not offer such an additional discount if the pre-offer price is high or low.

(iii) The type L firm mimics the type H firm with probability 1.

(iv) $n$ institutional investors produce information about the firm. An institutional investor buys one share of the firm in the pre-offer market if he receives a good signal, and he sells one share if he receives a bad signal. Further, if the cost of SEO failure, $K$, is not too large and if outsiders’ prior probability assessment of the firm being of type H, $\theta$, is large enough, an institutional investor bids for one share in the SEO if: (a) he receives a good signal and the pre-offer price is medium, or (b) the pre-offer price is high or low. If the cost of SEO failure, $K$, is sufficiently

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19. Of course, if institutional investors’ information production cost is very large, or if the precision of the information available to them is too small, they may not produce any information. This situation is not of interest to us because the phenomena we study in this paper do not arise in absence of information production. Thus, we assume throughout this paper that sufficiently precise information is available to institutional investors at a low enough cost such that there is always some information production by institutional investors in equilibrium.
large and if outsiders’ prior probability assessment of the firm being of type H, $\theta$, is small enough, an institutional investor bids for one share in the SEO regardless of the signal he receives for all three states of the pre-offer market.

At time 0, in deciding on the magnitude of the state-independent discount, insiders of the type H firm face the following trade-off. On the one hand, setting a bigger state-independent discount induces more institutional investors to produce information about the firm, which is beneficial because in equilibrium, institutional investors who receive a good signal about the firm always bid in the SEO, and thus having more institutional investors producing information effectively increases the number of them bidding in the SEO, thereby reducing the probability of (costly) SEO failure. On the other hand, setting a bigger state-independent discount lowers the firm’s proceed in the SEO. In equilibrium, insiders of the type H firm set the level of the state-independent discount by balancing the above costs and benefits. Under the conditions specified in the Appendix, insiders of the type L firm would find it optimal to mimic the type H firm to avoid revealing their firm’s true type to outside investors.

There are three possible demand states in the pre-offer market: high, medium, and low. The pre-offer prices in the high and low sates are more informative than that in the medium state. This is because in the high (low) state, all agents infer with probability one that the institutional demand in the pre-offer market is high (low), whereas in the medium state, the per-offer demand can be driven either by a high demand by institutional investors (and a low demand by noise traders), or by a high demand by noise traders (and a low demand by institutional investors). Firm insiders do not face any probability of SEO failure for the high or low states of the pre-offer market because the pre-offer prices are informative enough for them to infer that all institutional investors (who produce information about the firm) bid in the SEO as long as they offer the state-independent discount, and the state-independent discount is set such that the number of institutional investors producing information is large enough: that is, if all of them bid in the SEO, no shares go unsold. In contrast, for the medium state of the pre-offer market, firm insiders cannot infer the number of institutional investors receiving good signals about the firm (and in turn their evaluation of the firm value) by observing the pre-offer price alone. In this case, whether firm insiders face any probability of SEO failure or not depends on the magnitude of the cost of SEO failure, $K$.

When the cost of SEO failure is small, firm insiders face a positive probability of SEO failure when the pre-offer price is medium. In this
case, whether the SEO fails or not is determined by the aggregate demand from noise traders. If their demand is high, the combined demand by institutional investors and noise traders is enough to make the SEO a success, whereas if their demands is low (zero in our setting), the demand from institutional investors would not always be enough for all \( q \) shares offered in the SEO, and the firm has to bear the cost of SEO failure with a positive probability. Firm insiders can avoid such an SEO failure by giving a state-dependent discount for the medium state in addition to the state-independent discount, but they choose not to do so because the cost of SEO failure is small.

We now turn to the scenario where the cost of SEO failure is sufficiently large. In this case, firm insiders wish to drive the probability of SEO failure to zero. Insiders of the type H firm can achieve this goal in two alternative ways. One possibility is to induce more institutional investors to produce information about the firm (and consequently bid in the SEO) by increasing the state-independent discount. The alternative is to give an additional state-dependent discount for the medium state of the pre-offer market such that institutional investors bid in the SEO regardless of their individual signals. When outsiders’ prior probability of the firm being of type H, \( \theta \), is relatively low, the number of institutional investors producing information increases at a slow rate in the increase of the state-independent discount (because institutional investors’ expected benefit from information production is smaller when \( \theta \) is smaller). Therefore, insiders of the type H firm adopt the latter strategy to eliminate the probability of SEO failure.

We now derive in detail the equilibrium strategies of firm insiders and institutional investors in the scenario with positive probability of SEO failure. The derivation of equilibrium values in the scenario with zero probability of SEO failure is very similar to that for the scenario with positive probability of SEO failure, and thus is confined to the Appendix for brevity.

### 3.1.1 Institutional Investors’ Strategies
Each institutional investor makes three decisions: whether or not to produce information about the firm (at time 0), his trading strategy in the pre-offer market (at time 1), and his bidding strategy in the SEO (at time 2). He chooses to produce information if his expected return from participating in the pre-offer trading of the firm’s equity and the corresponding SEO bidding strategy is no less than the return from investing in the risk-free asset (whose return is normalized to zero).

Based on their rational expectations on the magnitude of the state-independent discount, \( s, n(s) \) institutional investors produce information about the firm. The probability distribution of the signal
institutional investors receive from information production is depicted in Figure 2. In equilibrium, if an institutional investor receives a good signal about the firm, he buys one share in the pre-offer market, and he sells one share if his signal is bad. Noise traders buy \( d_1 \) shares with probability \( \phi_1 \) and sell \( d_1 \) shares with the complementary probability \( 1 - \phi_1 \). Hence, in the pre-offer market, there are four possible net demand states: The aggregate demand is \((2\lambda - 1)n + d_1\) if demands from both institutional investors and noise traders are high (the “high state” or “U”); it is \((2\lambda - 1)n - d_1\) if the demand from institutional investors is high but that from noise traders is low (the “high–low state”); it is \((2\delta - 1)n + d_1\) if the demand from institutional investors is low but that from noise traders is high (the “low–high state”); and it is \((2\delta - 1)n - d_1\) if demands from both institutional investors and noise traders are low (the “low state” or “D”). For analytical simplicity, we assume the aggregate demands in the two middle states are equal by imposing the parametric restriction \( (\lambda - \delta)n = d_1 \), and refer to them as the “medium state” or “M.”

The market maker sets the pre-offer price according to his beliefs about the type of the firm based on the net equity demand in the pre-offer market. We assume that the market maker is competitive and thus makes zero expected profit in setting the price. In the high state, he assesses a probability \( \alpha_H^\theta \) that the firm is of type H, and a probability \( \frac{\alpha_L^\theta}{\alpha_H^\theta + \alpha_L(1 - \theta)} \) that the firm is of type L, leading to a pre-offer price given by:

\[
p_U^1 = \frac{\alpha_H^\theta}{\alpha_H^\theta + \alpha_L(1 - \theta)} h + \frac{\alpha_L(1 - \theta)}{\alpha_H^\theta + \alpha_L(1 - \theta)} l. \tag{2}
\]

In the low state, he assesses a probability \( \frac{(1 - \alpha_H)^\theta}{(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)} \) that the firm is of type H, and a probability \( \frac{(1 - \alpha_L)(1 - \theta)}{(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)} \) that the firm is of type L, leading to a pre-offer price given by:

\[
p_D^1 = \frac{(1 - \alpha_H)^\theta}{(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)} h + \frac{(1 - \alpha_L)(1 - \theta)}{(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)} l. \tag{3}
\]

Finally, in the medium state, he assesses a probability \( \frac{(1 - \alpha_H)(1 - \theta)}{(\alpha_H(1 - \phi) + (1 - \alpha_H)(1 - \theta))} \) that the firm is of type H, and a probability \( \frac{(1 - \alpha_L)(1 - \theta)}{(\alpha_H(1 - \phi) + (1 - \alpha_H)(1 - \theta))} \) that the firm is of type L, leading to a pre-offer price given by:
If the firm is in the high or low states of the pre-offer market, firm insiders can infer the total number of institutional investors receiving good signals about the firm from the pre-offer price. In other words, this price is very “informative” and the aggregate information in it dominates institutional investors’ individual signals. Thus, in these two states, firm insiders know the number of institutional investors bidding in the SEO. In contrast, in the medium state, neither firm insiders nor institutional investors can perfectly distinguish institutional demand from noise trader demand, making it impossible to predict the number of institutional investors bidding in the SEO simply by observing the pre-offer price. In other words, for the high and low states of the pre-offer market, an institutional investor’s equilibrium SEO bidding strategy depends entirely on the pre-offer price, whereas he takes into account both the pre-offer price and his own signal from information production for the medium state.

### 3.1.2 Institutional Trading in the Pre-Offer Market

In the pre-offer market, if an institutional investor receives a good signal about the firm, he assesses a probability \( \theta \) that it is of type H, and a probability \( 1 - \theta \) that it is of type L. Thus, an institutional investor’s evaluation of the firm’s intrinsic value conditional on getting a good signal is:

\[
P^G_1 = \frac{(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta}{(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta + (\alpha_L(1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)}^H + \frac{(\alpha_L(1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)}{(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta + (\alpha_L(1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)}^I.
\]  

(4)

If he receives a bad signal, he assesses a probability \( \theta(\alpha_H + (1 - \alpha_H)\delta) \) that it is of type H, and a probability \( \theta(\alpha_L + (1 - \alpha_L)\delta) \) that it is of type L. His evaluation of the firm’s intrinsic value conditional on getting a

\[
P^G_0 = \frac{\theta(\alpha_H \lambda + (1 - \alpha_H)\delta)}{\theta(\alpha_H \lambda + (1 - \alpha_H)\delta) + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta)}^H + \frac{(1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta)}{\theta(\alpha_H \lambda + (1 - \alpha_H)\delta) + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta)}^I.
\]  

(5)
bad signal is:

\[
P_B^0 = \frac{\theta(\alpha_M(1-\lambda) + (1-\alpha_M)(1-\delta))}{\theta(\alpha_M(1-\lambda) + (1-\alpha_M)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}
+ \frac{(1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}{\theta(\alpha_M(1-\lambda) + (1-\alpha_M)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}h
\]

(6)

Because the market maker sets the pre-offer price based on the aggregate demand in the pre-offer market, there are three possible pre-offer prices for the firm’s equity: \(p_U^1\), \(p_M^1\), and \(p_D^1\) (corresponding to the high (U), medium (M), and low (D) states, respectively). If an institutional investor receives a good signal about the firm, his probability assessment of the pre-offer price being high (i.e., equal to \(p_U^1\)) is \(\text{prob}(U \mid G) = \frac{\lambda(\alpha_M + \alpha_L)}{\lambda(\alpha_M + \alpha_L) + (1-\theta)(\alpha_M + \alpha_L)}\); his probability assessment of it being low (i.e., equal to \(p_D^1\)) is \(\text{prob}(D \mid G) = \frac{\beta(\alpha_M + \alpha_L)}{\beta(\alpha_M + \alpha_L) + (1-\theta)(\alpha_M + \alpha_L)}\), and his probability assessment of it being medium (i.e., equal to \(p_M^1\)) is \(\text{prob}(M \mid G) = \frac{\lambda(\alpha_M + \alpha_L)}{\lambda(\alpha_M + \alpha_L) + (1-\theta)(\alpha_M + \alpha_L)}\).

If he receives a bad signal about the firm, his probability assessment of the pre-offer price equal to \(p_U^1\) is \(\text{prob}(U \mid B) = \frac{\lambda(1-\alpha_M + \alpha_L + (1-\alpha_M)(1-\delta))}{\lambda(1-\alpha_M + \alpha_L + (1-\alpha_M)(1-\delta)) + (1-\theta)(\alpha_M + \alpha_L)}\), his probability assessment of it equal to \(p_D^1\) is \(\text{prob}(D \mid B) = \frac{\beta(1-\alpha_M + \alpha_L + (1-\alpha_M)(1-\delta))}{\beta(1-\alpha_M + \alpha_L + (1-\alpha_M)(1-\delta)) + (1-\theta)(\alpha_M + \alpha_L)}\), and his probability assessment of it equal to \(p_M^1\) is \(\text{prob}(M \mid B) = \frac{\lambda(1-\alpha_M + \alpha_L + (1-\alpha_M)(1-\delta))}{\lambda(1-\alpha_M + \alpha_L + (1-\alpha_M)(1-\delta)) + (1-\theta)(\alpha_M + \alpha_L)}\).

At time 0, an institutional investor expects to buy one share in the pre-offer market if receiving a good signal about the firm, giving him an expected profit equal to his expectation on the firm’s intrinsic value conditional on a good signal, \(P_0^G\) (given by (5)), net of the expected pre-offer share price (again conditional on a good signal):

\[
\pi_1^G = P_0^G - \text{prob}(U \mid G)P_1^U - \text{prob}(D \mid G)P_1^D - \text{prob}(M \mid G)P_1^M.
\]  (7)

An institutional investor expects to sell one share in the pre-offer market if receiving a bad signal, giving him an expected profit equal to his expectation on the firm’s intrinsic value conditional on a bad signal, \(P_0^B\) (given by (6)), net of the expected pre-offer share price (again conditional on a bad signal):

\[
\pi_1^B = \text{prob}(U \mid B)P_1^U - \text{prob}(D \mid B)P_1^D - \text{prob}(M \mid B)P_1^M - P_0^B.
\]  (8)

20. Throughout the paper, we restrict our model parameters to be such that \(\pi_1^G\) and \(\pi_1^B\) are positive, ensuring that each institutional investor receiving a good signal from information production buys one share in the pre-offer market, and each institutional investor receiving a bad signal sells one share in the pre-offer market.
Because each institutional investor expects to receive a good signal with probability \( \theta (\alpha_H \lambda + (1 - \alpha_H) \delta) + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L) \delta) \), and a bad signal with probability \( \theta (\alpha_H (1 - \lambda) + (1 - \alpha_H)(1 - \delta)) + (1 - \theta)(\alpha_L (1 - \lambda) + (1 - \alpha_L)(1 - \delta)) \), his expected profit from trading in the pre-offer market is given by:

\[
\pi_1 = (\theta (\alpha_H \lambda + (1 - \alpha_H) \delta) + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L) \delta)) \pi^G_1 + (\theta (\alpha_H (1 - \lambda) + (1 - \alpha_H)(1 - \delta)) + (1 - \theta)(\alpha_L (1 - \lambda) + (1 - \alpha_L)(1 - \delta))) \pi^B_1. \tag{9}
\]

### 3.1.3 Bidding by Institutional Investors in the SEO

As discussed in Section 3.1.2, both firm insiders and individual institutional investors can infer the total number of institutional investors receiving good signals about the firm by observing the pre-offer prices in the high and low states. Firm insiders therefore set the equilibrium SEO offer price in these two states as the pre-offer price minus the state-independent discount, \( s \), and all institutional investors in the pre-offer market bid for shares in the SEO regardless of their individual signals (because they expect a positive profit from doing so). In these two states, \( n \) investors bid for shares in the SEO if noise traders’ demand is 0 (this happens with probability \( 1 - \phi_2 \)), and \( n + d_2 \) investors bid if noise traders’ demand is high (this happens with probability \( \phi_2 \)). An institutional investor’s expected profit is \( \frac{q}{n} s \) in the former case, and it is \( \frac{q}{n + d_2} s \) in the latter case. In sum, his expected profit from bidding for one share in the SEO conditional on the firm being in the high or low states of the pre-offer market is given by:

\[
\pi^U_2 = \pi^D_2 = \phi_2 \frac{q}{n} s + (1 - \phi_2) \frac{q}{n + d_2} s. \tag{10}
\]

The pre-offer price in the medium state, in contrast, is a noisy indicator for the number of institutional investors receiving good signals about the firm. Institutional investors therefore use both their own signals and the pre-offer price to determine their SEO bidding strategy in this case. Consequently, firm insiders cannot perfectly predict the institutional demand in the SEO from the pre-offer price. Because they wish to at least ensure that the SEO succeeds when the noise trader demand is high, firm insiders choose the state-independent discount \( s \) such that the number of institutional investors producing information and subsequently receiving good signals is larger or equal to \( q - d_2 \). In this case, if an institutional investor receives a good signal, and if the total institutional demand is indeed high, his evaluation of the firm value is \( V^M_2 (\lambda) = V^M_2 (\lambda) h + \frac{(1 - \theta) \alpha_L}{\theta \alpha_H + (1 - \theta) \alpha_L} l \), and his expected profit from bidding in the SEO is \( \frac{q}{\lambda n + d_2} (V^M_2 (\lambda) - p^M_2) \) with probability \( \phi_2 \), and
\[ \frac{q}{\lambda n} (V_2^M(\lambda) - p_2^M) \] with the remaining probability \((1 - \phi_2)\). If the total institutional demand is indeed low, his evaluation of the firm value is \(V_2^M(\delta) = \frac{\sigma(1-\alpha_H)(1-\alpha_L)}{\sigma(1-\alpha_H)+(1-\sigma)(1-\alpha_L)} h + \frac{(1-\theta)(1-\alpha_H)(1-\alpha_L)}{\sigma(1-\alpha_H)+(1-\sigma)(1-\alpha_L)} l\), and his expected profit from bidding in the SEO is \(\frac{q}{\delta n + d_2} (V_2^M(\delta) - p_2^M)\) with probability \(\phi_2\), and \((V_2^M(\delta) - p_2^M)\) with the remaining probability \((1 - \phi_2)\). The expected profit an institutional investor makes from bidding for one share in the SEO conditional on the firm being in the medium state of the pre-offer market is therefore given by:

\[
\pi_2^M = \frac{\text{prob}(M, \lambda n | G)}{\text{prob}(M | G)} \left( \phi_2 \frac{q}{\lambda n + d_2} + (1 - \phi_2) \frac{q}{\lambda n} \right) (V_2^M(\lambda) - p_2^M) \\
+ \frac{\text{prob}(M, \delta n | G)}{\text{prob}(M | G)} \left( \phi_2 \frac{q}{\delta n + d_2} + 1 - \phi_2 \right) (V_2^M(\delta) - p_2^M). \tag{11}
\]

At time 0, an institutional investor assesses a probability \((\theta \alpha_H + (1 - \theta) \alpha_L) \phi_1\) for the high state of the pre-offer market, a probability \((\theta \alpha_H + (1 - \theta) \alpha_L)(1 - \phi_1) + (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)) \phi_1\) for the medium state; and a probability \((\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L))(1 - \phi_1)\) for the low state. Therefore, an institutional investor’s expected profit from bidding in the SEO is given by:

\[
\pi_2 = (\theta \alpha_H + (1 - \theta) \alpha_L) \phi_1 \pi_2^U + ((\theta \alpha_H + (1 - \theta) \alpha_L)(1 - \phi_1) \\
+ (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)) \phi_1) \pi_2^M \\
+ (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L))(1 - \phi_1) \pi_2^D. \tag{12}
\]

The profit an institutional investor makes from producing information about the firm and using it in the pre-offer market and in the SEO is \(\pi = \pi_1 + \pi_2\), and he therefore produces information if \(\pi \geq c\).\textsuperscript{21}

### 3.1.4 SEO Pricing by Firm Insiders
Firm insiders need to make two decisions: the magnitude of the state-independent discount (at time 0) and the SEO offer price (at time 2).

For insiders of the type H firm, the state-independent discount \(s\) is a mechanism to induce information production by institutional investors. Because institutional investors receiving good signals from information production bid in the SEO, having more institutional investors producing information helps the type H firm reduce the probability of SEO failure and the associated costs. In equilibrium, insiders of the type H firm set the state-independent discount to ensure

\[\text{Note that in equilibrium, this condition holds as an equality because firm insiders have no incentive to give institutional investors a return higher than that from the risk-free asset. Thus, we can use the condition } \pi = c \text{ to solve for the number of institutional investors producing information, } n.\]
that institutional investors’ profits from producing information (and the subsequent equilibrium moves) are equal to those from investing in the risk-free asset, that is, \( \pi = c. \)

At time 2, in addition to the private information about firm type, firm insiders also observe the pre-offer price. For the type H firm with the high pre-offer price, its insiders infer that \( \lambda n \) institutional investors receive good signals about the firm, and all \( n \) institutional investors (regardless of their individual signals) bid in the SEO as long as the state-independent discount \( s \) is offered. In this case, the SEO offer price is equal to the pre-offer price minus the state-independent discount:

\[
p^U_2 = p^U_1 - s = \frac{\alpha_H \theta}{\alpha_H \theta + \alpha_L (1 - \theta)} h + \frac{\alpha_L (1 - \theta)}{\alpha_H \theta + \alpha_L (1 - \theta)} l - s. \tag{13}
\]

For the type H firm with the low pre-offer price, its insiders infer that \( \delta n \) institutional investors receive good signals about the firm, and all \( n \) institutional investors (regardless of their individual signals) bid in the SEO as long as the state-independent discount \( s \) is offered. In this case, the SEO offer price is again equal to the pre-offer price minus the state-independent discount:

\[
p^D_2 = p^D_1 - s = \frac{(1 - \alpha_H) \theta}{(1 - \alpha_H) \theta + (1 - \alpha_L)(1 - \theta)} h + \frac{(1 - \alpha_L)(1 - \theta)}{(1 - \alpha_H) \theta + (1 - \alpha_L)(1 - \theta)} l - s. \tag{14}
\]

For the type H firm with the medium pre-offer price, firm insiders cannot perfectly infer the number of institutional investors receiving good signals: it is \( \lambda n \) with probability \( \text{prob}(M, \lambda n | G) \) and \( \delta n \) with probability \( \text{prob}(M, \delta n | G) \). In this case, institutional investors bid for shares in the SEO only if they receive good signals about the firm. Because the cost of SEO failure is not very large, firm insiders rely on noise trader demand to avoid SEO failure with some probability \( \phi_2 \), and they do not offer additional discount to ensure the success of the SEO. Specifically, if the total institutional demand is indeed low and if noise traders’ SEO demand is 0 (this occurs with probability \( 1 - \phi_2 \)), the firm’s SEO fails. In

22. If firm insiders offer a state-independent discount greater than the critical value satisfying \( \pi = c \), although it induces more institutional investors to produce information (and hence reduces the probability of SEO failure), the extra profits given to institutional investors exceed the expected reduction in the cost of SEO failure, leaving firm insiders worse off from doing so. If a firm offers a state-independent discount that is less than the critical value satisfying \( \pi = c \) (an out-of-equilibrium move), institutional investors believe that it is a type L firm with probability 1, and do not produce information, generating less payoff for firm insiders than their equilibrium payoff.
sum, the SEO offer price for the medium state is equal to the pre-offer price minus the state-independent discount:

\[ p^M_2 = p^M_1 - s \]

\[ = \frac{(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta}{(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta + (\alpha_L(1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)} h \]

\[ + \frac{(\alpha_L(1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)}{(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta + (\alpha_L(1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)} l - s. \] (15)

The equilibrium payoff for insiders of the type H firm is given by their proceeds from two equity sales: the SEO (at time 2) and the final sale (at time 3), weighted by the probability of each state of the pre-offer market, net of any cost of SEO failure incurred:

\[ \pi_H = \alpha_H\phi_1 (p^U_2 q + (m - q)h) + (\alpha_H(1 - \phi_1) + (1 - \alpha_H)\phi_2)(p^M_2 q + (m - q)l) + (1 - \alpha_H)(1 - \phi_1)(p^D_2 q + (m - q)l). \] (16)

In equilibrium, insiders of the type L firm find it optimal to mimic the type H firm by choosing the same state-independent discount, enabling them to pool with the type H firm. Their expected equilibrium payoff is given by:

\[ \pi_L = \alpha_L\phi_1 (p^U_2 q + (m - q)l) + (\alpha_L(1 - \phi_1) + (1 - \alpha_L)\phi_2)(p^M_2 q + (m - q)l) + (1 - \alpha_L)(1 - \phi_1)(p^D_2 q + (m - q)l). \] (17)

Note that the probability of SEO failure is significantly greater for the type L firm than for the type H firm in equilibrium. This is because institutional investors are less likely to receive good signals about the type L firm, and therefore are less likely to bid in its SEO. Nevertheless, insiders of the type L firm is better off mimicking the type H firm because doing otherwise (and thereby revealing the true type of their firm) yields them a significantly lower expected payoff than that obtained in equilibrium.

23. The type L firm mimics the type H firm in setting the offer price in other respects as well, because deviating from the offer price set by the type H firm in any manner would reveal its true type with probability 1.
3.2 Equilibrium Characteristics and Empirical Implications

We now turn to discussions on the characteristics of the SEO equilibrium and the associated empirical implications.

**Proposition 2** (The Existence of an SEO Discount): *In the SEO equilibrium, the firm’s SEO is characterized by an SEO discount.*

In the SEO equilibrium, firm insiders always offer the state-independent discount to investors in the SEO. Further, when the cost of SEO failure is sufficiently large, they also offer an additional discount in the SEO for the medium state of the pre-offer market. Therefore, the SEO offer price is always lower than the closing price on the pre-offer day; that is, the equilibrium is characterized by an SEO discount. The existence of SEO discounts has been documented by a number of empirical studies (see, e.g., Altinkilic and Hansen, 2003; Corwin, 2003, Chemmanur et al., 2009), and our model can explain the existence of this important economic phenomenon.

**Proposition 3** (Relationship between the Degree of Information Asymmetry and the SEO Discount): *In the SEO equilibrium, the SEO discount increases in the degree of information asymmetry faced by the firm (as measured by the magnitude of the information production cost, c).*

Because the state-independent discount is a mechanism to induce information production by institutional investors, when the information production cost increases, firm insiders need to commit a higher SEO discount to induce sufficient information production. Therefore, the magnitude of the SEO discount increases in the information production cost in equilibrium. This proposition implies that on average, firms with more information asymmetry offer higher SEO discounts than those with less information asymmetry. Using firm size and other proxies for information asymmetry (such as the number of analysts following a firm, standard deviation of analyst forecasts, and analyst forecast errors), this means that a firm’s SEO discount is expected to decrease in firm size and the number of analyst following, and increase in the standard deviation of analyst forecasts and analyst forecast errors.

**Proposition 4** (Relationship between the Institutional Demand in the Pre-Offer Market and the SEO Discount): *When the cost of SEO failure, K, is sufficiently large and when outsiders’ prior probability assessment of the firm being of type H, θ, is small enough, the SEO discount decreases in the informativeness of the pre-offer price and in the institutional net demand in the pre-offer market.*
When the cost of SEO failure is sufficiently large, in addition to the state-independent discount (that is the same across all states), firm insiders also offer a state-dependent discount for the medium state of the pre-offer market (where the pre-offer price is less informative than in the other two states). Hence, in equilibrium, the total discount offered for the medium state is greater than for the high and low states. Further, when the probability of the low state is small enough (i.e., when (A24) in the Appendix is satisfied), the weighted average of institutional net demands in the high and low states is close to the institutional net demand in the high state (which is higher than that in the medium state). In this case, the institutional net demand in the medium state (where the discount is larger) is smaller than the average institutional demand in the other two states, leading to a negative relationship between the institutional net demand in the pre-offer market and the SEO discount.

This proposition implies that firms with more informative pre-offer prices offer smaller SEO discounts than their counterparts whose pre-offer prices are less informative. Evidence consistent with this prediction is provided by Singal and Xu (2005), who document that a higher cost of short selling (i.e., less informative pre-offer stock prices) leads to a higher SEO discount. This proposition also predicts that the SEO discount decreases in the pre-SEO price run-up between the SEO announcement date and offer date (recall that, higher the pre-offer price, higher the pre-SEO price run-up). Consistent with this prediction, Altinkilic and Hansen (2003) find a negative relationship between the SEO discount and the pre-SEO price run-up. Furthermore, this proposition implies that the SEO discount decreases in the institutional net demand in the pre-offer market. Consistent with this prediction, Chemmanur et al. (2009) document a negative relationship between institutional pre-SEO net buying and the SEO discount. Finally, this proposition implies that firms with more institutional investors bidding for SEO shares offer smaller SEO discounts. Consistent with this prediction, Chemmanur et al. (2009) document a negative relationship between institutional share allocations in SEOs and the magnitude of SEO discounts.

Proposition 5 (Relationship between the Institutional Demand in the Pre-Offer Market and the Degree of Oversubscription in the SEO): When the cost of SEO failure, $K$, is not too large and when outsiders’ prior probability assessment of the firm being of type $H$, $\theta$, is large enough, the

24. Singal and Xu (2005), as well as many other papers, use the term “underpricing” for both SEO discount (prior day closing price to offer price return) and SEO underpricing (offer price to next day closing price return). We translate their terminology to that used in this paper in discussing empirical predictions.
institutional demand and the degree of oversubscription in the SEO increase with the institutional net demand in the pre-offer market.

When the cost of SEO failure is not too large, only the state-independent discount is offered in the SEO for all three states of the pre-offer market. In this case, there is oversubscription in the SEO for the high and low states of the pre-offer market because, in these two states, not only the institutional investors bid for shares in the SEO, noise traders also participate with some probability. For the medium state, SEO oversubscription occurs only when the institutional demand or the noise trader demand (or both) are high. If the type distribution of the firm is such that (A24) in the Appendix holds, the institutional demand in the medium state of the pre-offer market is less than the weighted average of those in the other two states. This is because, if (A24) holds, the weighted average of institutional demands in the high and low states of the pre-offer market is close to that in the high state, which is higher than the institutional demand in the medium state. Consequently, there is a positive relationship between the institutional demand in the pre-offer market and the degree of SEO oversubscription. Moreover, because all institutional investors bid for shares in the SEO for the high and low states of the pre-market, and only those who receive good signals bid in the SEO for the medium state of the pre-offer market, there is a positive relationship between the institutional demand in the pre-offer market and that in the SEO.

This proposition implies that firms with higher institutional demand in the pre-offer market are associated with higher SEO share allocations to institutional investors and greater extents of SEO oversubscription. Evidence consistent with this prediction is provided by Chemmanur et al. (2009), who document a positive relationship between the institutional net buying in the pre-offer market and SEO share allocations to institutional investors.

**Proposition 6** (Relationship between the Institutional Demand in the Pre-Offer Market and the Long-run Post-SEO Operating Performance): In the SEO equilibrium, the firm’s long-run post-SEO operating performance increases in the institutional net demand in the pre-offer market and in the pre-offer price.

Institutional investors are more likely to receive good signals from information production for the type H firm than for the type L firm in the SEO equilibrium. Therefore, the institutional net demand in the pre-offer market is higher for the type H firm than for the type L firm. Consequently, there is a positive relationship between the institutional net demand in the pre-offer market and the post-SEO
operating performance. Further, because the noise trader demand is unaffected by the true firm type, the aggregate demand in the pre-offer market (and thereby the pre-offer price) is higher (on average) for the type H firm than for the type L firm, leading to a positive relationship between the pre-offer price and the post-SEO operating performance. This proposition implies that firms with higher institutional demand in the pre-SEO market and higher pre-SEO price run-up between the SEO announcement dates and offer dates have better long-run post-SEO operating performance.

4. An Extension to the Basic Model: SEO Underpricing

In this section, we extend our basic model to analyze SEO underpricing (the return in the first trading day after the SEO). We introduce an additional date between the SEO (time 2) and the end of the game (time 3), and call this date time $2'$. We assume that at time $2'$, the market maker resets the share price based on the aggregate demands in the pre-offer market and in the SEO.\(^{25}\) We define the SEO underpricing as the difference between the time $2'$ price and the SEO offer price.

**Proposition 7** (The Existence of SEO Underpricing): *In the SEO equilibrium, the SEO is underpriced on average.*

For the high and the low states of the pre-offer market, the market maker sets the time $2'$ price to be the same as the pre-offer price. This is because, in these two states, all agents can perfectly infer the number of institutional investors receiving good signals from information production and consequently bidding in the SEO from the pre-offer price, and thus observing the SEO demands does not give the market maker any additional information about the true firm type.

For the medium state of the pre-offer market, when the cost of SEO failure is sufficiently large, firm insiders offer an additional SEO discount (on top of the state-independent discount) to ensure that all institutional investors producing information about the firm bid in the SEO. In this case, observing the SEO demand again does not convey any additional information about the true firm type, leading the market maker to set the time $2'$ price to be the same as the pre-offer price. Because the SEO offer price is always lower than the pre-offer price, the

\(^{25}\) For analytical simplicity, we do not model the trading by institutional investors or noise traders at time $2'$. It can be shown that all our results remain qualitatively unchanged if trading is allowed at this time.
SEO is always underpriced when the cost of SEO failure is sufficiently large.

When the cost of SEO failure is not too large, firm insiders do not offer any state-dependent discount in the SEO, and there is a positive probability of SEO failure. In this case, for the medium state of the pre-offer market, the market maker obtains new information about the true firm type by observing the institutional demand in the SEO. If the institutional demand in the SEO is high, the market maker infers that a large number of institutional investors received good signals about the firm from information production (and revises his probability assessment of the firm being of type $H$ upward), and sets the time $2'$ price to be higher than the pre-offer price (which is higher than the SEO offer price): that is, there is severe underpricing in the SEO. If the institutional demand in the SEO is low, the market maker infers that a small number of institutional investors received good signals about the firm from information production (and revises his probability assessment of the firm being of type $H$ downward), and sets the time $2'$ price to be lower than the pre-offer price: that is, the underpricing is lower, or it may be even negative (the SEO is overpriced in this case). In equilibrium, the SEO underpricing (occurring for the high and low states with probability 1 and for the medium state with a positive probability) dominates the SEO overpricing (occurring only for the medium state with some probability), and the SEO is underpriced on average.

**Proposition 8** (The Relationship between the SEO Underpricing and the Institutional Demand in the Pre-Offer Market): *Let the distribution of the firm type be such that (A25) holds. Then, when the cost of SEO failure, $K$, is not too large and when outsiders’ prior probability assessment of the firm being of type $H$, $\theta$, is large enough, the SEO underpricing increases in the institutional net demand in the pre-offer market.*

When the cost of SEO failure is not too large, firm insiders do not offer any state-dependent discount in the SEO, and there is a positive probability of SEO failure. In this case, the SEO underpricing is always the same for the high and low states. There are two possibilities for the medium state: the SEO can be either severely underpriced or less so (see discussions for Proposition 7). If the distribution of the true firm type is such that (A25) in the Appendix holds, the average net institutional demand in the pre-offer market for the high state and for the subset of the medium state where institutional demand is truly high (where the underpricing is greater than in the other states) is larger than the average of net demands in the pre-offer market for the low state and for
the subset of the medium state where institutional demand is truly low (where the degree of SEO underpricing is smaller), leading to a positive relationship between the institutional demand in the pre-offer market and the SEO underpricing.

This proposition implies that SEOs with higher institutional net buying in the pre-offer market have greater SEO underpricing. Consistent with this prediction, Chemmanur et al. (2009) document a positive relationship between the institutional net demand in the pre-SEO market and the post-SEO initial return in the first trading day after the SEO. Further, our extended model also implies that the institutional net buying in the day immediately following an SEO increases in the institutional demand in the pre-SEO market. This is because, as we have shown in Proposition 5, the extent of oversubscription in the SEO increases with the pre-offer institutional demand. Because institutional investors bidding for shares in the SEO are less likely to receive share allocations when the pre-offer institutional demand is greater, they resort to the post-offer market to acquire shares.26 Consistent with this prediction, Chemmanur et al. (2009) find that, post-SEO, institutions buy more shares in firms in which they purchase more shares in the pre-SEO market and obtain larger SEO share allocations.

5. Conclusion

We have developed a model of the SEO process, starting from the SEO announcement, through pre-offer trading, and ending in the offering itself. We use our model to advance a new rationale for the SEO discount and SEO underpricing, and also to analyze the role of institutional investors in SEOs. We consider an entrepreneur (firm insiders) with private information about his firm’s intrinsic value, and who wishes to sell a certain number of shares of his equity holding to outsiders in an underwritten SEO. There are two kinds of investors in the equity market: institutional investors, who can produce (noisy) information about the firm at a cost, and retail investors, who are unable to do so, and whose demand for equity is therefore driven purely by liquidity considerations. Three ingredients drive the equilibrium in our model.

26. Although we do not model the institutional trading in the post-SEO market (date 2′), it can be shown in a more general model (with a continuum of demand states in the pre-offer market and in the SEO) that institutional investors who received good signals about the firm can profit from buying additional shares in the post-SEO market. This is because, when there is a continuum of demand states, the market maker cannot fully distinguish the case where the high SEO oversubscription is driven by high institutional demand from the case where it is driven by high noise trader demand, such that the post-SEO price does not fully reflect the number of institutional investors receiving good signals about the firm.
First, insiders of higher intrinsic value firms are better off inducing a significant extent of information production by institutional investors, because such information production enables them to obtain a higher offer price in the SEO. Second, institutional investors may use their information at two different venues: in the pre-offer market, and in the SEO itself. Third, firm insiders can partially assess the potential SEO demand from the pre-offer price. However, given the existence of retail trading in the pre-offer market, the above inference is noisy, such that there is a residual probability of SEO failure. Therefore, in equilibrium, the SEO discount depends on the magnitude of the firm’s cost of SEO failure. When this cost is small, firm insiders set the SEO discount to be same across all possible states (prices) in the pre-offer market, just enough to cover institutional investors’ information production costs. When this cost is large, firm insiders offer a larger SEO discount when the pre-offer price is less informative about the potential SEO demand, and they offer a smaller discount when it is more informative (in an effort to minimize the probability of SEO failure). Our model generates a number of testable predictions on the relationship between the institutional demand for a firm’s equity in the pre-offer market, the stock return from the SEO announcement day to the day before the offering, institutional share allocation in the SEO, and the SEO discount. In an extension to our basic model, we incorporate the post-offer market as well, thus allowing us to relate the above variables to SEO underpricing, and to the institutional demand in the post-offer market.

**Appendix**

*Proof of Proposition 1.* We first discuss the scenario where the cost of SEO failure is not too large. There are four possible net demand (ND) in the pre-offer market: (1) $ND(\lambda, -d_1) = (2\lambda - 1)\eta + d_1$ (the high state); (2) $ND(\lambda, -d_1) = (2\lambda - 1)\eta - d_1$ (the high–low state); (3) $ND(\delta, d_1) = (2\delta - 1)n + d_1$ (the low–high state); and (4) $ND(\delta, -d_1) = (2\delta - 1)n - d_1$ (the low state). We impose the parameter restriction $ND(\lambda, -d_1) = ND(\delta, d_1)$, which is equivalent to: $(\lambda - \delta)\eta = d_1$, and refer both low–high and high–low states as the medium state from now onward.

If the firm is in the high state of the pre-offer market, firm insiders infer that $\lambda\eta$ institutional investors receive $G$ from information production, and the market maker and institutional investors assess a probability $\frac{\alpha_H\theta}{\alpha_H\theta + \alpha_L(1-\theta)}$ that the firm is of type H, and a probability $\frac{\alpha_L(1-\theta)}{\alpha_H\theta + \alpha_L(1-\theta)}$ that the firm is of type L. If the firm is in the low state of the pre-offer market, firm insiders infer that $\delta\eta$ institutional investors
receive G from information production, and the market maker and institutional investors assess a probability \((1 - \alpha_H)\theta/(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)\) that the firm is of type H, and a probability \((1 - \alpha_L)(1 - \theta)/(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)\) that the firm is of type L.

If the firm is in the medium state of the pre-offer market, firm insiders cannot perfectly infer the number of institutional investors receiving G from information production. The market maker assesses a probability \((\alpha_H(1 - \phi) + (1 - \alpha_H)\phi)\theta/(\alpha_H(1 - \phi) + (1 - \alpha_H)\phi + (1 - \alpha_L)(1 - \phi)(1 - \theta))\) that the firm is of type H, and a probability \((\alpha_L(1 - \phi) + (1 - \alpha_H)\phi)\theta(1 - \alpha_L)(1 - \phi)(1 - \theta)/(1 - \alpha_H)^\theta + (1 - \alpha_L)(1 - \theta)\) that the firm is of type L. Therefore, the time 1 price in the high state is:

\[
p^H_1 = \frac{\alpha_H \theta}{\alpha_H \theta + \alpha_L (1 - \theta)} h + \frac{\alpha_L (1 - \theta)}{\alpha_H \theta + \alpha_L (1 - \theta)} l. \tag{A1}\]

The time 1 price in the low state is:

\[
p^L_1 = \frac{(1 - \alpha_H \theta)}{(1 - \alpha_H \theta) + (1 - \alpha_L)(1 - \theta)} h + \frac{(1 - \alpha_L)(1 - \theta)}{(1 - \alpha_H \theta) + (1 - \alpha_L)(1 - \theta)} l. \tag{A2}\]

The time 1 price in the medium state is:

\[
p^M_1 = \frac{(\alpha_H (1 - \phi) + (1 - \alpha_H)\phi)\theta}{(\alpha_H (1 - \phi) + (1 - \alpha_H)\phi + (1 - \alpha_L)(1 - \phi)(1 - \theta)) h} + \frac{(\alpha_L (1 - \phi) + (1 - \alpha_L)\phi)(1 - \theta)}{(\alpha_H (1 - \phi) + (1 - \alpha_H)\phi + (1 - \alpha_L)(1 - \phi)(1 - \theta)) l}. \tag{A3}\]

If an institutional investor receives G for the firm, he assesses a probability \(\vartheta(\alpha_H \lambda + (1 - \alpha_H)\delta)/(\alpha_H \lambda + (1 - \alpha_H)\delta + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta))\) that it is of type H, and a probability \(\vartheta(\alpha_L \lambda + (1 - \alpha_L)\delta)/(\alpha_H \lambda + (1 - \alpha_H)\delta + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta))\) that it is of type L. His evaluation of the firm conditional on receiving G is:

\[
P^G_0 = \frac{\vartheta(\alpha_H \lambda + (1 - \alpha_H)\delta)}{(\alpha_H \lambda + (1 - \alpha_H)\delta) + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta)} h + \frac{(1 - \vartheta)(\alpha_L \lambda + (1 - \alpha_L)\delta)}{(\alpha_H \lambda + (1 - \alpha_H)\delta) + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta)} l. \tag{A4}\]

Further, given that he receives G, he assesses a probability \(\vartheta(\alpha_H \lambda + (1 - \alpha_H)\delta)/(\alpha_H \lambda + (1 - \alpha_H)\delta + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta))\) that he needs to pay \(p^H_1\) for a share in the pre-offer market, a probability \(\vartheta(\alpha_L \lambda + (1 - \alpha_L)\delta)/(\alpha_H \lambda + (1 - \alpha_H)\delta + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta))\) that he needs to pay \(p^L_1\), and a probability \(\vartheta(\alpha_H \lambda + (1 - \alpha_H)\delta)/(\alpha_H \lambda + (1 - \alpha_H)\delta + (1 - \theta)(\alpha_L \lambda + (1 - \alpha_L)\delta))\) that he needs to pay \(p^M_1\).
Similarly, if an investor receives B from producing information, he assesses a probability \( \frac{\theta(\alpha_H(1-\lambda)+(1-\alpha_H)(1-\delta))}{\theta(\alpha_H(1-\lambda)+(1-\alpha_H)(1-\delta))+(1-\theta)(\alpha_L(1-\lambda)+(1-\alpha_L)(1-\delta))} \) that it is of type H, and a probability \( \frac{\theta(\alpha_H(1-\lambda)+(1-\alpha_H)(1-\delta))+(1-\theta)(\alpha_L(1-\lambda)+(1-\alpha_L)(1-\delta))}{\theta(\alpha_H(1-\lambda)+(1-\alpha_H)(1-\delta))+(1-\theta)(\alpha_L(1-\lambda)+(1-\alpha_L)(1-\delta))} \) that it is of type L. His evaluation of the firm conditional on receiving B is:

\[
p_B^0 = \frac{\theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta))}{\theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))} h
+ \frac{\theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}{\theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))} l.
\]

(A5)

Further, given that he receives B, he assesses that he receives \( p_B^U \) when selling one share in the pre-offer market with probability

\[
\frac{(1-\lambda)(\alpha_H(1-\phi + \alpha_L(1-\delta)}{(1-\lambda)(\alpha_H(1-\phi + \alpha_L(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}
\]

\( p_B^D \) with probability

\[
\frac{(1-\lambda)(\alpha_H(1-\phi + \alpha_L(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}{(1-\lambda)(\alpha_H(1-\phi + \alpha_L(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}
\]

\( p_B^M \) with probability

\[
\frac{(1-\lambda)(\alpha_H(1-\phi + \alpha_L(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}{(1-\lambda)(\alpha_H(1-\phi + \alpha_L(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))}
\]

An institutional investors’ expected profit from buying in the pre-offer market is:

\[
\pi_1^G = P_0^G - \text{prob}(\text{high} \mid G) P_B^U - \text{prob}(\text{low} \mid G) P_B^D - \text{prob}(\text{highlow} \mid G) P_B^M.
\]

(A6)

His expected profit from selling in the pre-offer market is:

\[
\pi_1^B = \text{prob}(\text{high} \mid B) P_B^U - \text{prob}(\text{itlow} \mid B) P_B^D - \text{prob}(\text{highlow} \mid B) P_B^M - P_0^B.
\]

(A7)

Because the equilibrium strategy for the institutional investors is to buy one share if receiving G (this happens with probability \( \theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) \)) and to sell one share if receiving B (this happens with probability \( \theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta)) \)), the expected profit for an institutional investor from trading in the pre-offer market is given by:

\[
\pi_1 = (\theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta))) \pi_1^G
+ (\theta(\alpha_H(1-\lambda) + (1-\alpha_H)(1-\delta)) + (1-\theta)(\alpha_L(1-\lambda) + (1-\alpha_L)(1-\delta)) \pi_1^B.
\]

(A8)

For the high state of the pre-offer market, firm insiders know that as long as they offer the state-independent discount \( s \), all institutional investors who produce information (and noise traders with probability
φ_2) bid in the SEO. They therefore do not give any additional discount, and set the SEO offer price at:

\[ p_U^2 = p_U^1 - s = \frac{\alpha_H \theta}{\alpha_H + \alpha_L(1-\theta)} h + \frac{\alpha_L(1-\theta)}{\alpha_H + \alpha_L(1-\theta)} l - s. \quad (A9) \]

For the low state of the pre-offer market, firm insiders know that as long as they offer the state-independent discount \( s \), all institutional investors who produce information (and noise traders with probability \( \phi_2 \)) bid in the SEO. They therefore do not give any additional discount, and set the SEO offer price at:

\[ p_D^2 = p_D^1 - s = \frac{(1-\alpha_H)\theta}{(1-\alpha_H)\theta + (1-\alpha_L)(1-\theta)} h \]
\[ + \frac{(1-\alpha_L)(1-\theta)}{(1-\alpha_H)\theta + (1-\alpha_L)(1-\theta)} l - s. \quad (A10) \]

For the medium state of the pre-offer market, the SEO fails when noise traders’ SEO demand is zero and the institutional demand is low. Firm insiders do not give any additional discount, and set the SEO offer price at:

\[ p_M^2 = p_M^1 - s = \frac{(\alpha_H(1-\phi) + (1-\alpha_H)\phi)\theta}{(\alpha_H(1-\phi) + (1-\alpha_H)\phi)(1-\theta) + (\alpha_L(1-\phi) + (1-\alpha_L)\phi)(1-\theta)} h \]
\[ + \frac{(\alpha_L(1-\phi) + (1-\alpha_L)\phi)(1-\theta)}{(\alpha_H(1-\phi) + (1-\alpha_H)\phi)(1-\theta) + (\alpha_L(1-\phi) + (1-\alpha_L)\phi)(1-\theta)} l - s. \quad (A11) \]

Institutional investors can also make profits from bidding for shares in the SEO. For the high state of the pre-offer market, when noise traders’ SEO demand is zero, \( n \) investors bid in the SEO, whereas \( n + d_2 \) investors bid when noise traders’ SEO demand is positive. In the former case, an institutional investor’s expected profit in the SEO is \( \frac{q}{n} s \), and it is \( \frac{q}{n+d} s \) in the latter case. Therefore, an institutional investor’s expected profit in the SEO conditional on the high state of the pre-offer market is:

\[ \pi_U^2 = \phi_2 \frac{q}{n+d} s + (1-\phi_2) \frac{q}{n} s. \quad (A12) \]

Following a similar argument, it can be shown that an institutional investor’s expected profit in the SEO conditional on the low state of the pre-offer market is:
\[ \pi_2^D = \pi_2^U = \phi_2 \frac{q}{n + d} s + (1 - \phi_2) \frac{q}{n} s. \]  

(A13)

For the medium state of the pre-offer market, an institutional investor bids for one share in the SEO if he receives \( G \) from information production. If the total institutional demand in the SEO is \( \lambda n \), his evaluation of the firm is 
\[ V_2(\text{highlow}) = \frac{\theta_{\alpha_{H}}}{\theta_{\alpha_{H} + (1 - \theta)\alpha_{L}}} h + \frac{(1 - \theta)\alpha_{L}}{\theta_{\alpha_{H} + (1 - \theta)\alpha_{L}}} l. \]  
In this case, he makes a profit of 
\[ \frac{q}{\lambda n + d_2} (V_2(\text{highlow}) - p_2^M) \]  
with probability \( \phi_2 \), and a profit of 
\[ \frac{q}{\lambda n + d_2} (V_2(\text{highlow}) - p_2^M) \]  
with probability \( 1 - \phi_2 \), leading to an expected profit of 
\[ \phi_2 \frac{q}{\lambda n + d_2} (V_2(\text{highlow}) - p_2^M) + (1 - \phi_2) \frac{q}{\lambda n + d_2} (V_2(\text{highlow}) - p_2^M) \]  
from bidding in the SEO. If the total institutional demand in 
the SEO is \( \delta n \), an institutional investor’s evaluation of the firm is 
\[ V_2(\text{lowhigh}) = \frac{\theta_{(1 - \alpha_{H})}}{\theta_{(1 - \alpha_{H}) + (1 - \theta)(1 - \alpha_{L})}} h + \frac{(1 - \theta)(1 - \alpha_{L})}{\theta_{(1 - \alpha_{H}) + (1 - \theta)(1 - \alpha_{L})}} l. \]  
In this case, he makes a profit of 
\[ \frac{q}{\delta n + d_2} (V_2(\text{lowhigh}) - p_2^M) \]  
with probability \( \phi_2 \), and a profit of 
\[ (V_2(\text{lowhigh}) - p_2^M) \]  
with probability \( 1 - \phi_2 \), leading to an expected profit of 
\[ \phi_2 \frac{q}{\delta n + d_2} (V_2(\text{lowhigh}) - p_2^M) + (1 - \phi_2) (V_2(\text{lowhigh}) - p_2^M) \]  
from bidding in the SEO.

For the medium state of the pre-offer market, if an institutional investor receives \( G \) from information production, he assesses a probability 
\[ \frac{\text{prob}(\text{highlow} | G)}{\text{prob}(\text{highlow} | G) + \text{prob}(\text{lowhigh} | G)} \]  
that \( \lambda n \) institutional investors bid in the SEO, and a probability 
\[ \frac{\text{prob}(\text{lowhigh} | G)}{\text{prob}(\text{highlow} | G) + \text{prob}(\text{lowhigh} | G)} \]  
that \( \delta n \) institutional investors bid in the SEO. Therefore, his expected profit from bidding in the SEO is:

\[ \pi_2^M = \frac{\text{prob}(\text{highlow} | G)}{\text{prob}(\text{highlow} | G) + \text{prob}(\text{lowhigh} | G)} \times \left( \phi_2 \frac{q}{\lambda n + d_2} (V_2(\text{highlow}) - p_2^M) + (1 - \phi_2) \frac{q}{\lambda n + d_2} (V_2(\text{highlow}) - p_2^M) \right) \]

\[ + \frac{\text{prob}(\text{lowhigh} | G)}{\text{prob}(\text{highlow} | G) + \text{prob}(\text{lowhigh} | G)} \times \left( \phi_2 \frac{q}{\delta n + d_2} (V_2(\text{lowhigh}) - p_2^M) + (1 - \phi_2) (V_2(\text{lowhigh}) - p_2^M) \right). \]

(A14)

At time 0, an institutional investor assesses a probability \( (\theta_{\alpha_{H}} + (1 - \theta)\alpha_{L})\phi_1 \) for the high state in the pre-offer market, a probability \( (\theta_{\alpha_{H}} + (1 - \theta)\alpha_{L})(1 - \phi_1) + (\theta(1 - \alpha_{H}) + (1 - \theta)(1 - \alpha_{L}))\phi_1 \) for the medium state, and a probability \( (\theta(1 - \alpha_{H}) + (1 - \theta)(1 - \alpha_{L}))(1 - \phi_1) \)
for the low state. His expected profit from bidding in the SEO is thereby given by:

\[
\pi_2 = (\theta \alpha_H + (1 - \theta) \alpha_L) \phi_1 \pi_2^U + ((\theta \alpha_H + (1 - \theta) \alpha_L)(1 - \phi_1) + (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)) \phi_1) \pi_2^M + (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L))(1 - \phi_1) \pi_2^D. \tag{A15}
\]

The total profit an institutional investor expects from trading in both the pre-offer market and the SEO is:

\[
\pi = \pi_1 + \pi_2. \tag{A16}
\]

To induce information production by institutional investors, \( \pi \) has to be equal to or greater than the information production cost, \( c \): that is, \( \pi \geq c \).

At time 2, for the high state of the pre-offer market, if firm insiders choose an offer price higher than \( p_2^U \) (it can be shown that offering at a lower price is a strictly dominated strategy), institutional investors believe that the firm is of type L with probability 1, and do not bid in the SEO (and the cost of SEO failure \( K \) is imposed on the firm). Following a similar argument, no firms in the medium or low states offer prices higher (or lower) than \( p_2^M \) and \( p_2^D \) in the SEO. Therefore, the equilibrium payoff for insiders of the type H firm is:

\[
\pi_H = \alpha_H \phi_1 (p_2^U q + (m - q) h) + (\alpha_H(1 - \phi_1) + (1 - \alpha_H) \phi_1 \phi_2) (p_2^M q + (m - q) h) + (1 - \alpha_H)(1 - \phi_1)(p_2^D q + (m - q) h) + (1 - \alpha_H)\phi_1(1 - \phi_2)(p_2^M \delta n + (m - \delta n) h - K). \tag{A17}
\]

Similarly, the equilibrium payoff for insiders of the type L firm is:

\[
\pi_L = \alpha_L \phi_1 (p_2^U q + (m - q) l) + (\alpha_L(1 - \phi_1) + (1 - \alpha_L) \phi_1 \phi_2) (p_2^M q + (m - q) l) + (1 - \alpha_L)(1 - \phi_1)(p_2^D q + (m - q) l) + (1 - \alpha_L)\phi_1(1 - \phi_2)(p_2^M \delta n + (m - \delta n) l - K). \tag{A18}
\]

For the medium state, if the pre-offer market is in the high–low state, the firm sells all \( q \) shares in the SEO even if noise traders’ demand is zero (i.e., the SEO always succeeds): the equilibrium state-independent discount \( s^* \) is such that \( \lambda n \geq q \). If the pre-offer market is in the low–high state, the firm faces SEO failure with probability \( (1 - \phi_2) \)
(when noise traders’ demand is zero): that is, \( \delta n < q \). Note that, if \( n > \frac{q}{\lambda} \), the firm can reduce the number of institutional investors producing information by lowering the state-independent discount \( s \). By doing so, firm insiders receive a higher expected payoff, while institutional investors’ information production constraint continues to be satisfied. If \( n < \frac{q}{\lambda} \), and if the noise traders’ SEO demand is zero, the firm faces SEO failure with probability 1 for the medium state of the pre-offer market. In this case, firm insiders receive a higher expected payoff if they increase \( s \). In summary, in equilibrium, \( n = \frac{q}{\lambda} \).

The proof for the scenario where the cost of SEO failure is sufficiently large is similar to the proof for the scenario where the cost of SEO failure is not too large, with the main differences summarized as follows. In this case, the firm offers an additional discount \( S \) in the SEO (in addition to the state-independent discount \( s \)) for the medium state of the pre-offer market. The above difference in equilibrium SEO pricing gives rise to differences in various equilibrium expressions. The SEO offer price for the medium state of the pre-offer market is:

\[
p_2^M = V_2(\text{lowhigh}) = \frac{\theta(1 - \alpha_H)}{\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)} h + \frac{(1 - \theta)(1 - \alpha_L)}{\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)} l, \tag{A19}
\]

where \( V_2(\text{lowhigh}) \) is an institutional investor’s evaluation of the firm for the low–high state of the pre-offer market. For the medium state of the pre-offer market, an institutional investor assesses a probability \( \frac{\text{prob}(\text{highlow})}{\text{prob}(\text{highlow}) + \text{prob}(\text{lowhigh})} \) that \( \lambda n \) institutional investors bid in the SEO, and a probability \( \frac{\text{prob}(\text{lowhigh})}{\text{prob}(\text{highlow}) + \text{prob}(\text{lowhigh})} \) that \( \delta n \) institutional investors bid in the SEO. Thus, his expected profit from bidding in the SEO conditional on the medium state is:

\[
\pi_2^M = \frac{\text{prob}(\text{highlow})}{\text{prob}(\text{highlow}) + \text{prob}(\text{lowhigh})} \left( \phi_2 \frac{q}{\lambda n + d_2} \left( V_2(\text{highlow}) - p_2^M \right) + (1 - \phi_2) \frac{q}{\lambda n} \left( V_2(\text{highlow}) - p_2^M \right) \right).
\tag{A20}
\]

At time 0, an institutional investor assesses a probability \( (\theta \alpha_H + (1 - \theta) \alpha_L) \phi_1 \) for the high state of the pre-offer market, a probability \( \theta \alpha_H + (1 - \theta) \alpha_L)(1 - \phi_1) + (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)) \phi_1 \) for the medium state of the pre-offer market; and a probability \( (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L))(1 - \phi_1) \) for the low state of the pre-offer market. There-
fore, his expected profit from bidding in the SEO is given by:
\[ \pi_2 = (\theta \alpha_H + (1 - \theta) \alpha_L) \phi_1 \pi_2^U + ((\theta \alpha_H + (1 - \theta) \alpha_L)(1 - \phi_1) \\
+ (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L)) \phi_1 \pi_2^M \\
+ (\theta(1 - \alpha_H) + (1 - \theta)(1 - \alpha_L))(1 - \phi_1) \pi_2^D. \] (A21)

In sum, the total profit an institutional investor expects from trading in both the pre-offer market and the SEO is:
\[ \pi = \pi_1 + \pi_2. \]

Further, the equilibrium payoff for insiders of the type H firm is:
\[ \pi_H = \alpha_H \phi_1 (p_2^U q + (m - q)h) \\
+ (\alpha_H(1 - \phi_1) + (1 - \alpha_H)\phi_1)(p_2^M q + (m - q)h) \\
+ (1 - \alpha_H)(1 - \phi_1)(p_2^D q + (m - q)h). \] (A22)

Similarly, the equilibrium payoff for insiders of the type L firm is:
\[ \pi_L = \alpha_L \phi_1 (p_2^U q + (m - q)l) + (\alpha_L(1 - \phi_1) + (1 - \alpha_L)\phi_1) \\
\times (p_2^M q + (m - q)l) + (1 - \alpha_L)(1 - \phi_1)(p_2^D q + (m - q)l). \] (A23)

In equilibrium, \( \pi = c, \) and \( n = q. \) In this case, the equilibrium number of institutional investors producing information, \( n = q, \) is smaller than that in the scenario where the cost of SEO failure is not too large, where \( n = q. \) In other words, the state-independent discount \( s^* \) is smaller in the current case. However, there is zero probability of SEO failure because, for the medium demand state of the pre-offer market, the firm offers an additional discount \( S^* \), ensuring that all institutional investors producing information (even those who receive bad signals) bid in the SEO. \( \square \)

**Proof of Proposition 2.** When the cost of SEO failure is not too large, there is a positive probability of SEO failure. In this case, there is an SEO discount for all three states of the pre-offer market: the state-independent discount \( s. \) Because \( s > 0, \) the SEO discount exists. When the cost of SEO failure is sufficiently large, in addition to the state-independent discount \( s, \) the firm offers an additional discount \( S \) for the medium state of the pre-offer market. In this case, the SEO discount is \( s \) for the high and low states, and it is \( s + S \) for the medium state. Because \( s > 0 \) and \( S > 0, \) the SEO discount exists in this case as well. \( \square \)

**Proof of Proposition 3.** When the cost of SEO failure is not too large, there is a positive probability of SEO failure. Because \( \pi = c, \) \[ \frac{\partial \pi}{\partial s} = \frac{\partial \pi}{\partial c} \frac{\partial c}{\partial s}. \]
Because \( \frac{\partial \pi}{\partial c} = 1 \) and \( \frac{\partial \pi}{\partial s} = \frac{\partial (\pi_1 + \pi_2)}{\partial s} = \frac{\partial \pi_1}{\partial s} + \frac{\partial \pi_2}{\partial s} \),

Because \( \frac{\partial \pi}{\partial s} = 0 \) and \( \frac{\partial \pi_2}{\partial s} > 0 \), \( \frac{\partial \pi}{\partial s} > 0 \). When the cost of SEO failure is sufficiently large, for both high and low states, the only discount offered is the state-independent discount \( s \). It can be shown that \( \frac{\partial \pi_1}{\partial s} = 0 \) and \( \frac{\partial \pi_2}{\partial s} > 0 \), \( \frac{\partial \pi}{\partial s} > 0 \). Hence \( \frac{\partial s}{\partial c} > 0 \).

Because the cost of SEO failure is sufficiently large, for both high and low states, the only discount offered is the state-independent discount \( s \). It can be shown that \( \frac{\partial \pi_1}{\partial s} = 0 \) and \( \frac{\partial \pi_2}{\partial s} > 0 \), \( \frac{\partial \pi}{\partial s} > 0 \). Hence \( \frac{\partial s}{\partial c} > 0 \).

When the cost of SEO failure is sufficiently large, for both high and low states, the only discount offered is the state-independent discount \( s \). It can be shown that \( \frac{\partial \pi_1}{\partial s} = 0 \) and \( \frac{\partial \pi_2}{\partial s} > 0 \), \( \frac{\partial \pi}{\partial s} > 0 \). Hence \( \frac{\partial s}{\partial c} > 0 \).

Proof of Proposition 4. When the cost of SEO failure is sufficiently large, the SEO discount for the high and low states is \( s \), and it is \( s + S \) for the medium state. Because \( S > 0 \), and because the pre-offer price in the medium state is less informative than those in the high and low states, the SEO discount decreases in the informativeness of the pre-offer price. The average pre-offer institutional demand for the high and low states is greater than that for the medium state if

\[
\frac{\text{Pr}(\text{high})}{\text{Pr}(\text{high}) + \text{Pr}(\text{low})} \lambda n + \frac{\text{Pr}(\text{low})}{\text{Pr}(\text{high}) + \text{Pr}(\text{low})} \delta n > D(\text{middle}),
\]

which is equivalent to:

\[
\text{Pr}(\text{low}) < \frac{\text{Pr}(\text{high})(\lambda n - D(\text{middle}))}{D(\text{middle}) - \delta n}.
\] (A24)

Proof of Proposition 5. When the cost of SEO failure is not too large, there is a positive probability of SEO failure. In this case, the degree of oversubscription is larger for the high and low states of the pre-offer market than for the medium state of the pre-offer market. In this case, if

\[
\frac{\text{Pr}(\text{high})}{\text{Pr}(\text{high}) + \text{Pr}(\text{low})} \lambda n + \frac{\text{Pr}(\text{low})}{\text{Pr}(\text{high}) + \text{Pr}(\text{low})} \delta n > D(\text{medium}),
\]

which is equivalent to

\[
\text{Pr}(\text{low}) < \frac{\text{Pr}(\text{high})(\lambda n - D(\text{medium}))}{D(\text{medium}) - \delta n},
\]

institutional demand and the degree of oversubscription in the SEO are bigger for firms with higher pre-offer institutional net demand.

Proof of Proposition 6. Institutional investors’ equilibrium trading strategy in the pre-offer market is to buy one share if receiving a signal G and to sell one share if receiving a signal B. For the high state, the number of institutional investors buying shares is \( \lambda n \). For the medium state, the number of institutional investors buying shares is \( \phi_1 \lambda n + (1 - \phi_1) \delta n \). For the low state, the number of institutional investors buying shares is \( \delta n \). Because \( \lambda n > \phi_1 \lambda n + (1 - \phi_1) \delta n > \delta n \), a firm in the high state of the pre-offer market is more likely to be a type H firm than a firm in the medium state, which is more likely to be a type H firm than a firm in the low state. Therefore, firms with more pre-offer institutional demand have better (average) long-run operating performance.
The aggregate (institutional investors and noise traders combined) pre-offer demand is \( \lambda n + \phi_1 d_1 \) for the high state, \( \phi_1 \lambda n + (1 - \phi_1) \delta n + \phi_1 d_1 \) for the medium state, and \( \delta n + \phi_1 d_1 \) for the low state. Because \( \lambda n + \phi_1 d_1 > \phi_1 \lambda n + (1 - \phi_1) \delta n + \phi_1 d_1 > \delta n + \phi_1 d_1 \), and because there is a monotonic increasing relationship between the aggregate pre-offer demand and pre-offer price, a higher pre-offer price is associated with better long-run operating performance.

**Proof of Proposition 7.** When the cost of SEO failure is not too large, there is a positive probability of SEO failure. In this case, for the high and low states of the pre-offer market, the post-SEO price is the same as the pre-offer price. For the medium state, at time \( 2' \), although the market maker sets a higher price than the pre-offer price if institutional demand in the SEO is high, and he sets a lower price than the pre-offer price if institutional demand in the SEO is low, the average post-SEO price is the same as the pre-offer price. In this case, the SEO underpricing exists for all three states because \( s > 0 \). Similarly, SEO underpricing exists in the scenario with full insurance against SEO failure because \( s > 0 \) and \( S > 0 \).

**Proof of Proposition 8.** When the cost of SEO failure is not too large, there is a positive probability of SEO failure. In this case, the SEO underpricing for the high and low states are the same. The post-offer price is

\[
V_2(\text{highlo}) = \frac{\theta_{a_H}}{\theta_{a_H} + (1 - \theta)a_L} h + \frac{(1 - \theta)a_L}{\theta_{a_H} + (1 - \theta)a_L} l
\]

for the high–low state of the pre-offer market, and it is

\[
V_2(\text{lohigh}) = \frac{\theta(1 - a_H)}{\theta(1 - a_H) + (1 - \theta)(1 - a_L)} h + \frac{(1 - \theta)(1 - a_L)}{\theta(1 - a_H) + (1 - \theta)(1 - a_L)} l
\]

for the low–high state of the pre-offer market. Thus, the SEO underpricing is

\[
\frac{Pr(\text{high}) + Pr(\text{highlo})(V_2(\text{highlo}) - p_1^M)}{Pr(\text{high}) + Pr(\text{highlo})}
\]

for firms with high institutional demand in the pre-offer market, and it is

\[
\frac{Pr(\text{low}) + Pr(\text{lowhigh})(V_2(\text{lowhigh}) - p_1^M)}{Pr(\text{low}) + Pr(\text{lowhigh})}
\]

for firms with low institutional demand in the pre-offer market. The SEO underpricing is larger for firms with more pre-offer institutional demand if:

\[
Pr(\text{high}) + Pr(\text{highlo})(V_2(\text{highlo}) - p_1^M) > Pr(\text{low}) + Pr(\text{lowhigh})(V_2(\text{lowhigh}) - p_1^M)
\]

(A25)

**References**
