Litigation Risk, Intermediation, and the Underpricing of Initial Public Offerings

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We formally examine the role of litigation risk in initial public offering (IPO) pricing. The underwriter's pricing decision trades off current revenue against expected future litigation costs, both of which are increasing in the IPO price. Given a time-consistency constraint and rational expectations on the part of investors, however, the "standard" litigation risk argument does* not *lead to equilibrium underpricing. We develop a richer model that provides sufficient conditions under which there is equilibrium underpricing. The issuer's choice of employing an underwriter versus floating the IPO on its own is examined, and various testable implications of the model are developed.

The purpose of this article is to develop a model in which the risk of future litigation can induce an underwriter to purposely sell an initial public offering

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(IPO) at a discount relative to the value assessed by the underwriter. While Ibbotson (1975) and Tinic (1988) have conjectured that underpricing is a form of insurance against future litigation, there has been no formal analysis of this conjecture.

In our analysis, the underwriter is an intermediary between the issuer and the capital market and makes pricing decisions that maximize his own welfare. The underwriter sets the issue price knowing that he will be sued in the future if there is evidence that the courts will judge as indicative of overpricing. There is a perfect sequential equilibrium in which some issues are overpriced, some are underpriced, there is underpricing *on average,* and there exists a positive probability of successful litigation against the underwriter.

The contributions of our analysis are fourfold. First, we show that the mere existence of litigation risk does not suffice to produce underpricing when all agents are rational. Second, we derive conditions under which IPO underpricing does emerge as an equilibrium phenomenon. The intuition lies in a particular interaction between the manner in which the IPO price influences the probability of a future price decline and the manner in which the ex ante equilibrium pricing strategies of underwriters affect ex post beliefs about whether the price decline is attributable to "bad luck" or to *overpricing.* We attempt to capture important features of the legal and regulatory environment of IPO's in this interaction. Third, we show that our analysis is consistent with Ritter's (1991) evidence that, in the long run, IPO's underperform the market. Fourth, in addition to explaining underpricing, our analysis generates several other testable predictions.

While private information interacts with litigation risk in our model, it is *not* a signaling model. The basic idea behind our analysis is as follows. When a firm is coming to the market for the first time (and infrequently thereafter) to raise equity capital, it may lack sufficient reputation for certifying the value of its future cash flows. On the other hand, an underwriter involved in many previous security offerings is more likely to have the requisite reputation. In our use of the term *reputation,* we distinguish between underwriters who maximize over the long run and therefore care about future litigation costs, and those who maximize over the short run. The firm may find it optimal to employ an underwriter with a "good" reputation, as represented by a high prior belief by investors that the underwriter is not myopic.[1]

The underwriter may be inclined to overprice the security if his compensation is positively linked to the issue price, as is observed

[1] Other services provided by the investment banker are distribution effort, insuring the proceeds, and reducing transactions costs. Examples of articles that analyze these services are Baron (1979), Baron and Holmstrom (1980), and Baron (1982).

in practice. This inclination may be alleviated, however, if the probability of future litigation depends, as in practice, upon future price declines. The underwriter's a priori reputation influences the beliefs of investors about the relation between the IPO price and the "intrinsic" value of the security. After the IPO, investors learn more about the firm through observation of the cash flow for the period and the interim stock price, and update their prior beliefs. If this evidence induces them to believe that the likelihood that the issue was overpriced is "sufficiently high," they will sue the underwriter. Since successful legal action is costly for the underwriter, the threat of such action may lead to underpricing.

However, while the link between litigation risk and IPO underpricing may appear obvious, it is not. The tenuousness of this link is highlighted in Section 3, where we analyze Tinic's (1988) "underpricing due to litigation risk" model and show that there is a time-consistency problem with that argument. When this problem is corrected, litigation risk becomes irrelevant and there is no underpricing. We then present a somewhat richer litigation model in which suing is ex post efficient and the equilibrium involves some issues being overpriced and others being underpriced. Yet there is *no* underpricing on average, despite the fact that equilibrium pricing strategies generate a positive probability of successful litigation against the underwriter. The key here is that investors are assumed to have *rational expectations* about the equilibrium pricing strategies of underwriters, and issues are priced to *clear the market.* This clarifies that to have underpricing on average, the IPO price must be set below the (Walrasian) market-clearing price. The challenge then is to craft a model, constrained by time-consistency and rational expectations requirements, in which the equilibrium IPO price generates an excess demand for the issue. This is our objective.

The main implications of our analysis are summarized below.

(1) There may be equilibrium underpricing on average, even under universal risk neutrality, regardless of whether the issuing firm goes directly to the capital market or indirectly through an underwriter. However, there may also be no average underpricing.

(2) Since the compensation of the underwriter and the equilibrium probability of litigation are increasing in the issue price, the lower the underwriter's compensation schedule, the greater the degree of underpricing.

(3) The riskier the issuing firm's cash flows, the greater is the degree of IPO underpricing.

(4) On average, there will be greater underpricing when the IPO is offered directly by the firm than when an underwriter is used.

(5) The better the reputation of the underwriter, the smaller is the amount of underpricing.

(6) If, in addition to the underwriter, the firm itself is also liable for damages, then the model can also explain why IPO's may underperform the market in the long run.

The rest of the article is organized as follows. In Section 1, we review the literature. In Section 2, we illustrate the irrelevance of litigation risk under rational expectations and market clearing constraints. In Section 3, we present a richer model that permits a litigation-risk-based explanation for IPO underpricing. The analysis is contained in Section 4. We conclude in Section 5.

1. Review of Related Literature

1.1 The empirical evidence

Examples of the vast empirical literature documenting that unseasoned IPO's are, on average, underpriced are Ibbotson (1975), Manegold (1987), Ritter (1984, 1987), and Beatty (1989). The one-day abnormal return earned from the offering to the close of trade on the day of issue has been measured as 22.1 percent during 1975–1984 [Beatty (1989)] and as 16.37 percent for 8668 new issues during 1960–1987 [Ibbotson, Sindelar, and Ritter (1988)]. Balvers, McDonald, and Miller (1988) find that underpricing was significantly reduced for issues underwritten (audited) by high reputation bankers (auditors), a conclusion supported also by the evidence of Carter and Manaster (1990). Tinic (1988) *describes* links between potential liability under securities laws, underpricing, and investment banker reputation. He compares underpricing from pre-1933 to that from post-1933 and finds greater underpricing in the latter period during which SEC-mandated changes in the regulatory environment resulted in greater ambiguity in the application of the "due diligence" concept. Ritter (1991) examines the long-run performance of IPO's and finds it to be below that of the market.

1.2 Earlier theoretical work

Baron (1982) attributes IPO underpricing to asymmetric information between the security issuer and the investment banker about market conditions.[2] Muscarella and Vetsuypens (1989) examine a sample of

[2] When the effort-averse investment banker has private information about market demand and provides only distribution services, he underprices in order to minimize his unobservable distribution effort. When the issuer procures pricing advice from the banker, it must compensate the banker for the private information through an underpriced offering.

IPO's of 38 investment bankers who took their own securities to market in the period 1970–1987, and find underpricing, contrary to Baron's prediction. Rock (1986) assumes the existence of both informed and uninformed traders and shows that underpricing emerges to encourage participation by uninformed traders who would otherwise suffer the "winner's curse" in trading with the informed. It is crucial to Rock's model that both the issuer and investment banker are less well informed than the aggregate market. There is no role, however, for the investment banker since, when the investment banker has no informational advantage over the issuer, it is the issuer who effectively sets the price and bears the risk of an undersubscribed issue.

Signaling models [Allen and Faulhaber (1989), Grinblatt and Hwang (1989), and Welch (1989)] have recently provided an interesting possible reason for underpricing. In these models, the intrinsically higher-valued firms underprice to deter mimicking by lower-valued cohorts in a separating equilibrium. In a related article by Chemmanur (1989), high-valued firms are underpriced in order to encourage information production by investors that will then be revealed in the secondary market price. These models involve firms dealing directly with investors, rather than through an investment banker. An economic role for the underwriter as an intermediary appears in Benveniste and Spindt (1989), who show that risk-averse issuing firms may underprice in order to induce some investors to reveal information about market conditions. Under these circumstances, the existence of underwriters improves the economic efficiency of the IPO market.[3]

1.3 Litigation risk

Section 11(a) of the Securities Act of 1933 defines the civil liability for public offerings as follows: if a registration statement (i.e., prospectus), at the time it became effective, "contained an untrue statement of a material fact or omitted to state a material fact . . . any person who acquired any security covered by the registration statement can sue certain specific persons to recover the difference between the price he paid for the security (but not more than the public offering) and the price at which he disposed of it or (if he still owns it) its value at the time of suit." The purchaser must demonstrate only that there was a material misstatement or omission in the prospectus and that he lost money. Section 11(b) states that the purchaser can

[3] Models that deal with IPO's but do not explain underpricing are developed by Spatt and Srivastava (1991), who explain the price rigidity feature of IPO's, and Gale and Stiglitz (1989), who examine the informational content of insider holdings in IPO's when insiders can also sell equity later.

sue every person who signed the registration statement, including the underwriters. But underwriters are relieved of civil liability under the "due diligence" defense if they can demonstrate that they had a reasonable ground for believing the truth of the statement. Despite this, litigation risk exists even for issuers who are not fraudulent because a sufficiently unfavorable ex post outcome may create the suspicion of fraud. The following quotes are from *Venture*, April 1987:

> *For a company about to go public, the best palliative against a possible stockholder lawsuit is for earnings to thrive after the offering. If a company's stock price plunges by 50% or more, it's likely to be the target of a suit. (p. 52)*
>
> *But if stock you bought in an IPO suffers a sudden, precipitous drop within a year of the offering, it's certainly worth a consultation with a securities lawyer, which is normally free.*
>
> *Virtually all major IPO cases to date have been settled rather than tried before a jury . . . among major cases filed during the last three years, defense and plaintiffs' lawyers concur, investors have gained some restitution about 75% of the time. A principal reason is that companies don't want to gamble on the cost of a jury trial, which can run up to $1 million in legal fees alone, or on an uncertain outcome. Defense attorneys fear juries won't understand complex financial issues and are predisposed to favor plaintiffs, whom they view as underdogs. (p. 55)*
>
> *The upshot, according to defense lawyers, is that what companies do or don't put in their prospectuses is less important than whether they're able to maintain their stock prices later on. Says . . ., a defense attorney: "If your company heads south, you're likely to get sued." (p. 57)*

An example of the link between underpricing, future performance, and litigation is provided by Ritter's (1984) empirical analysis of the 1980 IPO "hot issue" market. He finds a mean return on the first day of trading of 48.4 percent for 650 offerings in the 1980 hot issue period, due in large part to natural resource issues, and subsequent price increases until November 1980. In 1981 and 1982, oil prices fell, and many of the underwriters went bankrupt after the SEC charged them with price manipulation. Ritter (1991) investigates the long-run performance of 1526 firms that went public during 1975–1984, and finds that despite their high initial returns, IPO's significantly underperformed a sample of matched firms in the three-year post-issue period. This evidence clearly illustrates litigation risk. There was considerable underpricing, subsequent security price declines ostensibly unrelated to information disclosed at the time of issue, and then charges of fraud that resulted in bankruptcy of the underwriters.

Direct evidence on the importance of litigation risk appears in Jones (1980), who examines 348 shareholder derivative and class action lawsuits during 1971–1978 for which the mode of resolution is known. Plaintiffs received some relief in 75.3 percent of the suits, 75 percent (not the same 75 percent) did not go to court, and 95 percent of the cases not going to trial were settled. Jones' explanation for this settlement proclivity is that, "A case taken to trial always presents the possibility of a verdict of fraud, for which indemnification or insurance coverage is less likely."[4] Alexander (1991) describes an IPO share as two securities: a share of stock and a "litigation put" entitling investors to recover a portion of any ensuing market losses if the stock price falls sufficiently. She studied 17 computer-related IPO's issued in the first half of the 1983 hot issues market; 12 suffered stock price declines in the second half of 1983, which was a period of general collapse in the prices of high technology stocks. Class action suits alleging securities violations followed in 9 of these 12 cases, the three exceptions being cases in which the lowest potential recovery fell short of attorneys' fees. All cases were settled prior to going to trial. In a recent article, Selz (1992) cites data reported by *Class Action Reports,* a Washington newsletter, which indicate that, in 1990 and 1991, 614 class action suits were filed in federal courts, a number exceeding that for the previous five years combined. About a quarter of these suits were related to IPO's. Finally, Romano (1991) hypothesizes that the risk of shareholder litigation may align managerial and shareholders' interests.

2. Litigation Risk Does Not Necessarily Imply Underpricing

A potential link between IPO underpricing and legal liabilities under the Securities Act of 1933 and the Securities Exchange Act of 1934 was first suggested by Ibbotson (1975), and since has received empirical support by Tinic (1988). The message of this earlier research appears to be that the mere threat of litigation suffices to produce underpricing. We first show that this is not true. This is done in this section with the help of two simple examples in which the threat of future litigation exists, but there is no underpricing on average.

[4] It is not only auditors and underwriters who prefer settlement to going to trial. Directors and Officers (D&O) policies also exclude coverage for fraud. Beatty (1990) finds that auditing, legal, and underwriting fees in IPO's are all positively related to the estimated maximum damages that can be assessed under the 1983 SEC act. He also finds a significantly positive relation between audit fees and subsequent bankruptcy and delisting.

2.1 Tinic's (1988) model

Tinic presents a model in which (using mostly his notation) the probability of settlement of judgment against the underwriter/issuer, $f(P_t/P_0)$, is monotonically decreasing in P_t/P_0, where P_t is the post-offering price of the stock at time t and P_0 is the IPO price, Moreover, the legal damages suffered by the underwriter have a pecuniary value of $g(P_0 - P_t)$, where g is an increasing function of its argument and is positive when $P_0 > P_t$ and zero otherwise. Suppose P^* is the fair market value of the stock when it is initially offered to investors, and $q(\cdot)$ is the density function of P_t (a random variable at the time of issuance of the IPO). Then the underwriter's expected legal liability at the issuance date, if the IPO is sold at P^*, is

$$E(\mathcal{L}_t \mid P^*) = \int f\left(\frac{P_t}{P^*}\right) \times g(P^* - P_t)q(P_t)\, dP_t. \tag{1}$$

Tinic argues that $E(\mathcal{L}_t \mid P^*) > 0$, and that this could induce the underwriter to set $P_0 < P^*$.

Embedding this intuition in an equilibrium framework, however, presents a time-consistency problem. Given the usual "common knowledge of equilibrium strategies" requirement of a Nash equilibrium, investors *know* at time t that the IPO was priced at $P_0 < P^*$, in which case it is *not ex post efficient* for them to sue; it would be irrational for the court to judge overpricing when it is common knowledge that there was underpricing. That is, investors recognize that there is no chance of obtaining a settlement when $P_0 < P^*$. Of course, the underwriter will anticipate this ex ante, so that he will perceive $f(P_t/P^*) = 0$, and price the security at P^*. The threat of litigation is, therefore, not a credible inducement for underpricing.

2.2 A model without time-consistency problems

We can eliminate this shortcoming of Tinic's model by replacing it with a model in which, despite litigation risk, some *overpricing* persists in equilibrium, so that it is time consistent to sue the underwriter following a price decline.

We assume universal risk neutrality and an interest rate of zero. There are two types of firms: one with mean cash flow μ_L, and the other with mean cash flow μ_H, with $\mu_H > \mu_L$. The underwriter knows the firm's mean cash flow, but investors cannot distinguish the μ_L firms from the μ_H firms. Let the probability of γ represent the investors' prior beliefs that the mean cash flow (the only relevant pricing parameter with risk neutrality) is μ_L. In this setting, there can be at most two IPO prices: "high" and "low." The reason for this is that the only relevant pricing parameter is the mean cash flow and there are only two means. To see why this implies just two equilibrium prices, suppose there is a high equilibrium price and a low equilibrium price, and a firm chooses a third price between these two prices. Since mixed strategies can be readily ruled out in this setting, this firm will either be identified as a low-mean firm or as a high-mean firm. Incentive compatibility then dicates that only two out of these three prices can be part of the equilibrium: if the firm were identified as a low-mean firm at the intermediate price, all low-mean firms would choose the intermediate price, contradicting the supposition that the low price is an equilibrium price; and if the firm were identified as a high-mean firm at the intermediate price, it would strictly prefer to be at the high equilibrium price.

There are two types of underwriters: those who are myopic and those who are nonmyopic. The myopic underwriters ignore litigation risk and overprice whenever possible, whereas the nonmyopic underwriters price in a way that trades off their immediate gain from the issue price and their expected future litigation cost. Investors' prior beliefs are that the probability is π that an underwriter is myopic. We now assume that litigation risk induces the nonmyopic underwriters to offer their μ_L firms as well as a fraction of $f \in (0, 1)$ of their μ_H firms at the low price; they offer a fraction of $1 - f$ of their μ_H firms at the high price. The myopic underwriters offer all of their firms at the high price. Note that, unlike Tinic's model, some issues are overpriced in equilibrium, so that it is ex post efficient to sue the underwriter following a price decline. Even in this scenario, however, litigation risk does not suffice to produce underpricing *on average* because investors have rational expectations. Assume that the market-clearing mechanism is such that anything offered at its expected value can be sold in any quantity. Then, if the equilibrium is as we have described, the high and low IPO prices that will clear the market are, respectively,

$$P_L = \{Z_L\mu_L + [1 - Z_L]\mu_H\} \in (\mu_L, \mu_H),$$

and

$$P_H = \{Z_H\mu_L + [1 - Z_H]\mu_H\} \in (P_L, \mu_H),$$

where

$$Z_L \equiv \Pr(\mu = \mu_L \mid P_L) = \frac{\gamma}{\gamma + f[1 - \gamma]},$$

$$Z_H \equiv \Pr(\mu = \mu_L \mid P_H) = \frac{\gamma\pi}{\gamma\pi + [1 - \gamma][1 - f\{1 - \pi\}]}.$$

For there to be underpricing on average, the expected price in the after-market should be higher than the IPO price. However, since P_L

and P_H are set equal to the expected values of the firms in their respective groups, the expected after-market price is exactly the same as the IPO price in each case. To see this, consider the firms priced at P_L. Since $P_L \in (\mu_L, \mu_H)$, all the μ_L firms in this group are overpriced and all the μ_H firms are underpriced. Expected overpricing equals

$$\Pr(\mu = \mu_L \mid P_L)[P_L - \mu_L] = Z_L[P_L - \mu_L]$$

and expected underpricing equals

$$\Pr(\mu = \mu_H \mid P_L)[\mu_H - P_L] = [1 - Z_L][\mu_H - P_L].$$

It is easy to see now that $Z_L[P_L - \mu_L] = [1 - Z_L][\mu_H - P_L]$. A similar argument holds for the firms priced at P_H. Hence, the expected underpricing equals the expected overpricing. With investors having rational expectations *and* IPO's being priced to clear the market, litigation risk merely causes some mean-μ_H firms to be priced "as if" they were mean-μ_L firms, without creating underpricing on average. If one retains the rationality assumption, then the task is to explain why the non-myopic underwriter would set the IPO price such that there is excess demand for the issue. The model in the next section is designed to achieve this objective.

3. The "Underpricing" Model and the Conjectured Equilibrium

The model is set in a single-period, risk-neutral market for IPO's in which cash flow of all firms is known to be normally distributed. There are two possible values of the mean cash flow: μ_L and μ_H, where $0 < \mu_L < \mu_H < \infty$. For each firm with mean μ_i ($i = L,H$), there are two possible values of the variance: σ_L^2 and σ_H^2, where $0 < \sigma_L^2 < \sigma_H^2 < \infty$. Consequently, there are four types of firms whose cash flow densities we denote as $\phi(x \mid \mu_i, \sigma_j^2)$, $i = L,H$; $j = L,H$, where $\phi(\cdot)$ is the normal density function. The mean and the variance are independently distributed across firms.

Information about firm type is not available to either investors or the issuing firm at the time of issue. The commonly held prior beliefs of investors are that the probability that a firm has a mean of μ_L is γ and that the probability that a firm with a given mean has a variance of σ_L^2 is ρ.[5] Therefore, in the absence of additional information, and assuming a riskless rate of zero, the market value for a firm in the IPO market will be $P_0 = \gamma\mu_L + [1 - \gamma]\mu_H$.

At the beginning of the initial period, the owner of the firm can sell the firm to investors directly, or can purchase the services of an

[5] While the variance of cash flows is not relevant to risk-neutral investors in pricing securities, an important role for the variance is created by litigation risk.

investment banker who can acquire information about the firm's type, price the security, and provide flotation services. In reality, the investment banker, who will be referred to as an "underwriter" henceforth, acquires this information through a "due diligence" investigation; we interpret the assumption that the issuing firm is uninformed as suggesting that firm type can only be learned through a due diligence investigation. We assume that there are two types of underwriters: the nonmyopic type who maximizes long-run profits, and the myopic type who maximizes short-run profits.[6] Investors and issuers cannot observe underwriter type, but believe that the probability that an underwriter is myopic is π. One can view π as an index of the underwriter's reputation; the lower the π, the better is the underwriter's reputation. For reputational effects to matter in the model, even a very small π suffices.[7] The underwriter acquires information that perfectly reveals firm type $\phi(x|\mu_i, \sigma_j^2)$.

Formally, we have a game in which the informed underwriter moves first by announcing an IPO price at $t = 0$. The uninformed market's response is either to buy the IPO at the announced price or reject the IPO.[8] If investors buy the securities, they can later decide at $t = 1$ whether the observed realization of the firm's cash flow warrants initiating litigation for fraud against the underwriter. We assume that it is necessary to have the issue fully subscribed, so that "excess supply" situations are ruled out.

Lawsuits are meaningful in our context because the myopic underwriters knowingly overprice their IPO's in equilibrium.[9] We assume that investors learn the issuer's variance, but not its mean prior to $t = 1$.[10] They then take into account the IPO price, the variance, and the market price and realized cash flow at $t = 1$ in determining whether to sue. To model the litigation game in a simple and realistic way, we assume that a lawsuit will be undertaken if investors and the courts infer ex post that there is a "sufficiently" high probability that the IPO was "overpriced." Since investors always decide rationally and we assume that the courts make inferences in the same Bayesian

[6] An alternative way of interpreting this assumption is that it is the limiting case of a situation in which underwriters have different discount rates.

[7] That is, even the slightest suspicion that the underwriter may be myopic is enough to generate strong reputational effects. See Kreps et al. (1982).

[8] We rule out mixed strategy responses.

[9] We could not justify litigation if there was not some likelihood of overpricing. In the absence of overpricing, a poor outcome is known to be merely due to bad luck, as in the Tinic model.

[10] It is not important to our model whether or not investors eventually learn the variance, but it is important that they not know it when the IPO is sold; the reason for this is explained after the equilibrium is derived. If investors do not discover σ^2 prior to making their litigation decision, the analysis is much more complicated.

framework as investors, a lawsuit is always successful when it is pursued.[11]

In successful real-world IPO litigation, two conditions generally appear to hold: (i) the stock price in the after-market falls below the issue price, and (ii) earnings are below expectations, leading to a "sufficiently" high probability that the firm was overpriced in the IPO. We model the above institutional conditions as follows. Condition (i) is met if the observed future cash flow results in a future price that is less than the offering price P. Let $\hat{P}$ denote the future stock price and $\bar{x}(P, \sigma^2)$ the cash flow such that $\hat{P} < P$ if $x < \bar{x}(P, \sigma^2)$. Condition (ii) is satisfied if x is low enough that investors can reject the null hypothesis that the firm's mean cash flow is μ_H. We later discuss how the critical cash flow, $x^*(\mu, \sigma^2)$, related to this is determined. Since both conditions must hold, investors initiate successful litigation whenever x is less than a critical cash flow, $x_c(P, \mu, \sigma^2) = \min\{x^*(\mu, \sigma^2), \bar{x}(P, \sigma^2)\}$. It is now seen that, although the variance is not useful to risk-neutral investors in pricing risky securities, it is useful to them in determining ex post whether there is a "reasonable" doubt that the security was correctly priced.

The underwriter's compensation from the issuer is a fraction $\alpha(P, \pi)$ of the IPO issue price, P.[12] We assume, without loss of generality, that there is only one share of stock in the IPO, so that the stock price represents the IPO proceeds. We assume that the penalty resulting ex post from a lawsuit is borne dissipatively by the underwriter. The pecuniary equivalent of this penalty is $D > 0$ and, for tractability, we assume that legal settlement costs are linear in the "shortfall" (the amount by which the realized cash flow falls below x^*). Although we are assuming for now that D is a cost for the underwriter that is not a payment to investors, in reality investors receive at least a portion of D. Thus, our present interpretation is that D subsumes the underwriter's loss of reputation and cost of legal fees if there is a lawsuit. Later, we examine the implication of the legal penalty including a

[11] This assumption is reasonable in light of the overwhelming evidence that these cases are settled prior to going to trial.

[12] This is essentially equivalent to a firm commitment underwritten offering. To see this, let F be the fixed price the underwriter offers the firm and let P be the proceeds from the IPO, so that the underwriter gets $P - F$, which when equated to αP implies $F = [1 - \alpha]P$. If this were a "best efforts" offering, the underwriter would *not* have an incentive to *overprice* to increase his compensation. Since greater underpricing would imply a greater ease with which the issue can be sold, there would be an incentive to underprice even in the absence of litigation risk, to the extent that the underwriter's future compensation is predicated on his current success in selling "best efforts" offerings. The issuer would then wish to use a firm commitment underwritten offering to counter this moral hazard. This suggests that if the underwriter is highly reputable, the issuer would be less reluctant to use a "best efforts" contract. However, in this case, our model implies lower litigation risk with a firm commitment contract, which means that contract is more attractive as well.

payment from the firm to investors. The underwriter can now be viewed as choosing the IPO price P to solve the problem

$$\max_{P} \xi(\pi, \mu, P, \sigma^2)$$

$$= \alpha(P, \pi)P - \delta \int_{-\infty}^{x_c(P)} D[x^* - x]\phi(x \mid \mu, \sigma^2)\, dx, \qquad (2)$$

where

$$\delta = \begin{cases} 1, & \text{for the nonmyopic underwriter,} \\ 0, & \text{for the myopic underwriter,} \end{cases}$$

$\xi(\pi, \mu, P, \sigma^2)$ is the underwriter's expected utility, and we have written $x_c(P)$ as the shorthand version of $x_c(P, \mu, \sigma^2)$.

We view the firms as delegating the IPO pricing decision to the underwriter and the latter making the decision to maximize (2). Investors are aware of (2) and buy the IPO only if its price is no greater than the expected value of the firm's cash flow. This expectation is conditional on their priors, π, about the underwriter's type because they know that myopic underwriters are insensitive to legal penalties and will overprice whenever possible.

A summary of the events and actions in the model is

$t = 0$: The firm's owner employs the underwriter. The underwriter identifies firm type, sets the issue price, and takes the security to market. Investors purchase the security if the issue price does not exceed expected value.

$t = 1$: Investors have learned σ_j^2 and observed cash flow x. They then decide whether to pursue litigation if the current security price is less than the original issue price. If litigation is initiated by investors, it is successful.

We now provide an intuitive description of the equilibrium, which we will then formally derive. We denote the equilibrium IPO prices for the firms as P_L and P_H. Of course, under symmetric information, these prices would be $P_L = \mu_L$ and $P_H = \mu_H$. In the equilibrium with asymmetric information, however, P_L and P_H will be conditional expectations and may therefore diverge from μ_L and μ_H, respectively.

In the conjectured equilibrium, intentional underpricing by some underwriters occurs because of potential litigation, and the existence of potential litigation is due to purposeful overpricing by other underwriters. The myopic underwriter is maximizing only current compensation and therefore prices the IPO at P_H regardless of his private information about firm type. Underpricing then must be attributed to

Table 1
Conjectured pricing strategies of underwriters

Underwriter type	Firm type μ_L, σ_L^2	Firm type μ_L, σ_H^2	Firm type μ_H, σ_L^2	Firm type μ_H, σ_H^2
Myopic	P_H	P_H	P_H	P_H
Nonmyopic	P_L	P_L	P_H	P_L

the nonmyopic underwriter who balances current compensation and expected future litigation costs, both of which are increasing in the IPO price.

The nonmyopic underwriter never overprices and therefore prices all μ_L firms at P_L. If he prices all firms at P_L, he will never be sued, but also forgoes current compensation. The optimal balance between litigation risk and current revenue may, therefore, induce him to price some μ_H firms at P_H. Since litigation is triggered by low cash flows, the probability of litigation for firms priced at P_H depends upon the variance of cash flows and consequently this variance becomes important to the nonmyopic underwriter. For a given mean, expected litigation costs are lower for the low variance firm than for the high variance firm. Therefore, we conjecture that the nonmyopic underwriter will price the (μ_H, σ_L^2) firm at P_H, and the (μ_H, σ_H^2) firm at P_L. Consequently, investors use acquired information about the variance in the decision to sue.

4. Analysis and Results

4.1 Characterization of the critical cash flow to determine if firm was overpriced

Investors and the courts use the observed cash flow at $t = 1$ to determine whether to reject the hypothesis that the firm has a high expected cash flow. Recall that $x^*(\mu_H, \sigma^2)$ is the value of x such that the null hypothesis $\mu = \mu_H$ is rejected, conditional on variance σ^2, if $x < x^*(\mu_H, \sigma^2)$. In this subsection, we discuss how x^* is determined. We summarize the conjectured pricing strategies of the underwriters in Table 1.

We turn now to beliefs. After observing the IPO price and σ^2, investors use their prior beliefs about the firm and underwriter types, γ and π, respectively, to form the posterior probability γ_p that the mean is μ_L. First, consider firms priced at P_L. If σ_H^2 is observed, investors know that the underwriter is nonmyopic and the mean is μ_L or μ_H. Thus, $\gamma_p = \gamma$. If σ_L^2 is observed, investors know that the underwriter is nonmyopic and the mean is μ_L for sure, and therefore set $\gamma_p = 1$.

Table 2
Posterior beliefs of investors after observing variance

IPO price	Variance	Beliefs of investors about underwriter type	Posterior belief of investors about probability (γ_P) that firm has mean μ_L
P_L	σ_L^2	Nonmyopic for sure	1
P_L	σ_H^2	Nonmyopic for sure	γ
P_H	σ_L^2	Nonmyopic or myopic	$\pi\gamma$
P_H	σ_H^2	Myopic for sure	γ

If the IPO is priced at P_H, the underwriter is myopic (with probability π) or nonmyopic (with probability $1 - \pi$). If σ_H^2 is observed, investors know that the underwriter is myopic and the mean is μ_L (with probability γ) or μ_H (with probability $1 - \gamma$), and set $\gamma_p = \gamma$. For a variance of σ_L^2, investors know that the underwriter is myopic or nonmyopic and that the mean is μ_H for sure for the nonmyopic underwriter, and μ_L (with probability γ) or μ_H (with probability $1 - \gamma$) for the myopic underwriter, thereby inferring that $\gamma_p = \pi\gamma$. We summarize how investors use their information about the issue price and variance to update their beliefs about underwriter and firm types in Table 2.

Investors use their posterior belief γ_p to determine x^*. We model the determination of x^* as a problem of statistical inference in which investors infer the mean of the cash flow distribution from one observed cash flow.[13] An underwriter will be sued if the IPO was priced at P_H, there was a price decline by the end of the period, and investors (knowing σ^2) use Bayesian statistical inference to reject the null hypothesis that $\mu = \mu_H$, given the observed σ^2. The precise inference process is the *Bayes test,* which is described in detail in Mood, Graybill, and Boes (1974). We present a summary here. In what follows, the null hypothesis is that $\mu = \mu_H$.

We assume that there are "social losses" related to incorrect inferences. Let $l(d_i; \mu_j)$ denote the social loss when the decision is d_i (i.e., the inferred mean is μ_i) and the true mean is μ_j, with $l(d_i; \mu_j) > 0$ for $i \neq j$ and $l(d_i; \mu_j) = 0$ for $i = j$. If the court infers ex post that the mean is μ_H, when the true mean is μ_L (a type-II error), then $l(d_H; \mu_L)$ represents the loss of investors who unknowingly purchased the overpriced security of the low-valued firm.[14] Likewise, if the court infers

[13] It is straightforward to generalize this analysis to the case in which investors arrive at their inference after observing numerous cash flows.

[14] By this we mean the economic loss to investors in terms of misallocation of resources when investors have unknowingly purchased the overpriced security. As the court becomes more prone to make this kind of error, underwriters become increasingly emboldened to overprice. Thus, $l(d_H; \mu_L)$ can be viewed as the present value of future resource misallocations due to mispricing induced by type-II errors.

that the mean is μ_L, when the true mean is μ_H (a type-I error), then $l(d_L; \mu_H)$ represents the loss to the high-valued firm that has been mistakenly identified as a low-valued firm.[15] The magnitudes of these losses, which are the costs of type-I and type-II errors, are exogenous to our model.[16] Given the null hypothesis $\mu = \mu_H$ and taking investors' beliefs as being given by γ_p, their posterior probability after observing σ^2 but before observing the cash flow, the expected social loss with the Bayes test is

$$[1 - \gamma_p] \Pr(\text{decision} = d_L \mid \mu_H) \ell(d_L; \mu_H) + \gamma_p \Pr(\text{decision} = d_H \mid \mu_L) \ell(d_H; \mu_L). \tag{3}$$

The Bayes test determines $\Pr(\text{decision} = d_i \mid \mu_j)$ by providing a critical testing region $C(\gamma_P)$, so that the null hypothesis can be rejected if the observed cash flow falls in this critical region. This critical testing region is arrived at by minimizing the expected loss in (3). For the Bayes test, this critical region is

$$C(\gamma_p) = \left\{ x\colon \lambda < \frac{\gamma_p l(d_H; \mu_L)}{[1 - \gamma_p] l(d_L; \mu_H)} \right\}, \tag{4}$$

where λ is the likelihood ratio and is given by

$$\lambda = \phi(x \mid \mu_H, \sigma^2) / \phi(x \mid \mu_L, \sigma^2). \tag{5}$$

We now show that $C(\gamma_p) = \{x\colon x < x^*\}$ is the critical region.

Proposition 1. *For a given σ^2, the null hypothesis that $\mu = \mu_H$ should be rejected if $x < x^*(\mu_H, \sigma^2)$, where*

$$x^*(\mu_H, \sigma^2) = \frac{\mu_L + \mu_H}{2} + \left\{ \frac{\sigma^2}{\mu_H - \mu_L} \right\} \log \left\{ \frac{\gamma_p l(d_H; \mu_L)}{[1 - \gamma_p] l(d_L; \mu_H)} \right\}, \tag{6}$$

where $\gamma_p = \pi\gamma$ for $\sigma^2 = \sigma_L^2$ and $\gamma_p = \gamma$ for $\sigma^2 = \sigma_H^2$.

The behavior of x^* with respect to σ^2 depends on the prior beliefs of investors about the relative proportions of the μ_L and μ_H firms, as well as on the costs of the two types of errors. In particular, the legal standard x^* is set relatively high when the courts favor investors because the expected loss due to a type-II error exceeds the expected

[15] Although we have thus far ignored the impact of legal sanctions on the firm itself, in practice, firms suffer costs when the courts decide against them. We can view $l(d_L; \mu_H)$ as the present value of these costs, as well as the costs incurred if the firm is forced to shut down because of legal sanctions.

[16] The essential role played by $l(d_i; \mu_j)$ in the analysis is in the determination of the relative weights assigned to type-I and type-II errors. The model explicitly recognizes that the court's decision is error-prone, so that the chosen trade-off between type-I and type-II errors is germane to the damage-award decision. The approach we follow here is standard in (Bayesian) statistical inference theory.

loss due to type-I error. This may represent the case in the United States where shareholder lawsuits proliferate. The relative magnitudes of these costs might explain the institutional differences across countries: for example, the infrequency of shareholder litigation in the United Kingdom may be due to low standards.[17]

4.2 Characterization of the critical cash flow below which there is a price decline

The preceding discussion was devoted to the determination of x^*, the cutoff such that cash flow realizations below that result in the courts rejecting the hypothesis that $\mu = \mu_H$. However, since a price decline in the after-market is a prerequisite to initiating litigation, we also need to compute $\bar{x}(P, \sigma^2)$, the cutoff such that the post IPO price will fall if $x < \bar{x}(P, \sigma^2)$.

When the cash flow x is realized at $t = 1$, investors again update their beliefs about firm type and determine a new market price. In doing this, they will use γ_p (based on the issue price and the previously observed σ^2) as their priors and compute a Bayesian posterior using x. For any realized cash flow x, variance σ^2, and IPO price P, the end-of-period price, $\hat{P}$, is given by

$$\hat{P} = \Pr(\mu = \mu_L \mid x)\mu_L + \Pr(\mu = \mu_H \mid x)\mu_H, \tag{7}$$

where

$$\Pr(\mu = \mu_L \mid x) = \frac{\phi(x \mid \mu_L, \sigma^2)\gamma_p}{\phi(x \mid \mu_L, \sigma^2)\gamma_p + \{1 - \gamma_p\}\phi(x \mid \mu_H, \sigma^2)}. \tag{8}$$

For a given IPO price P and variance σ^2, let $\bar{x}(P, \sigma^2)$ be the critical value of the cash flow such that $\hat{P} < P$ for $x < \bar{x}(P, \sigma^2)$ and $\hat{P} > P$ for $x > \bar{x}(P, \sigma^2)$. That is, $\bar{x}(P, \sigma^2)$ is a solution to

$$\hat{P} = \Pr(\mu = \mu_L \mid x = \bar{x}(P, \sigma^2))\mu_L + \Pr(\mu = \mu_H \mid x = \bar{x}(P, \sigma^2))\mu_H. \tag{9}$$

It is clear that $\partial\bar{x}(P, \sigma^2)/\partial P > 0$.

4.3 Equilibrium IPO prices

Given the existence of a two-price equilibrium, there are restrictions on these prices that arise endogenously. In particular, equilibrium prices cannot exceed market-clearing prices because no investor would be willing to pay more for a group of firms than their average value,

[17] Indeed, as Jenkinson (1990) reports, U.K. firms and their advisers are seldom sued for inaccurate pricing because the Companies Act of 1985 stipulates that defenses that can be used for defendants are (1) that the defendant was unaware of any matter not disclosed, (2) that the defendant honestly and mistakenly failed to comply with or contravened the disclosure requirements, or (3) that the failure to comply or the contravention was in respect of an immaterial matter or ought in the opinion of the court reasonably to be excused. In our model, this may be interpreted as a low x^*.

conditional on the equilibrium beliefs of investors and the equilibrium strategies of firms. In our next proposition, we obtain these restrictions on IPO prices.

Proposition 2. *Suppose we have a Conjectured Equilibrium that involves only two prices, P_L and P_H, with $P_L < P_H$. Then, $P_L = P_L^b$ and $P_H \leq P_H^b$, where the superscript "b" refers to "breakeven" and*

$$P_L^b \equiv \mu_L \theta_L + \mu_H[1 - \theta_L], \tag{10}$$

$$P_H^b \equiv \mu_L \theta_H + \mu_H[1 - \theta_H], \tag{11}$$

with

$$\theta_L \equiv \Pr(\mu = \mu_L \mid P_L) = \frac{\gamma}{1 - \rho[1 - \gamma]},$$

$$\theta_H \equiv \Pr(\mu = \mu_L \mid P_H) = \frac{\gamma\pi}{\gamma\pi + [1 - \gamma][\pi + \{1 - \pi\}\rho]}.$$

Our definition of the "breakeven" prices is that, given the strategies of the two types of underwriters, these are the prices that will clear the market. They key to demonstrating underpricing is to show that P_H may be strictly less than P_H^b, generating an excess demand for the IPO that the underwriter chooses not to satisfy.

4.4 Incentive compatibility conditions for IPO prices

Since the myopic underwriter always sets the issue price at P_H, we need to consider only the nonmyopic underwriter. We need to ensure that the mean-μ_L firms will all be priced at P_L by this underwriter and the mean-μ_H firms will be priced at P_L if $\sigma^2 = \sigma_H^2$ and at P_H if $\sigma^2 = \sigma_L^2$. The sufficiency conditions for this are given below and discussed a little later.

The first condition for sufficiency is

$$\begin{aligned} &DG(\sigma_H^2)\phi(\bar{x}(P_L, \sigma_H^2) \mid \mu_H, \sigma_H^2)\frac{\partial \bar{x}(P_L, \sigma_H^2)}{\partial P_L} \\ &\quad > \alpha + P_L \frac{\partial \alpha(P_L, \pi)}{\partial P_L} \\ &\quad > DG(\sigma_L^2)\phi(\bar{x}(P_L, \sigma_L^2) \mid \mu_H, \sigma_L^2)\frac{\partial \bar{x}(P_L, \sigma_L^2)}{\partial P_L}. \end{aligned} \tag{S1}$$

There exists a global maximum in (2), $P_H < P_H^b$, satisfying

$$\alpha + P_H \frac{\partial \alpha(P_H, \pi)}{\partial P_H} = DH(\sigma_L^2)\phi(\bar{x}(P_H, \sigma_L^2) \mid \mu_H, \sigma_L^2) \frac{\partial \bar{x}(P_H, \sigma_L^2)}{\partial P_H},$$

$$\text{such that } \bar{x}(P_H, \sigma_L^2) < x^*(\mu_H, \sigma_L^2). \qquad \text{(S2)}$$

Moreover, $\forall\ \sigma^2 \in \{\sigma_L^2, \sigma_H^2\}$ and $\forall\ P \in [P_L, P_H^b]$,

$$\alpha(P_L, \pi)P_L > \alpha(P, \pi)P - \int_{-\infty}^{\bar{x}(P,\sigma^2)} D[x^*(\mu_H, \sigma^2) - x]\phi(x \mid \mu_L, \sigma^2)\, dx, \qquad \text{(S3)}$$

where

$$G(\sigma_i^2) \equiv x^*(\mu_H, \sigma_i^2) - \bar{x}(P_L, \sigma_i^2), \qquad i \in \{L, H\},$$

$$H(\sigma_L^2) \equiv x^*(\mu_H, \sigma_L^2) - \bar{x}(P_H, \sigma_L^2).$$

We now have our next result.

Proposition 3. *Suppose (S1), (S2), and (S3) hold. Then it is incentive compatible for the nonmyopic underwriter to follow the IPO pricing strategies stipulated in the Conjectured Equilibrium, with $P_H < P_H^b$.*

The intuition behind this proposition rests on the two necessary conditions for successful litigation: (i) there should be a price decline in the after-market ($x < \bar{x}$), and (ii) there should be a "sufficiently strong" suspicion that this price decline was not just due to "back luck" [i.e., that the underwriter overpriced the IPO ($x < x^*$)]. Since $x < \min\{\bar{x}, x^*\}$ is required to litigate with success, the interaction of these two effects is the key. We begin by observing that a necessary condition for litigation risk to lead to underpricing, involving an ex ante rationing equilibrium, is that $\bar{x} < x^*$. To see why, suppose that $\bar{x} \geq x^*$. Then, since $x < x^*$ is necessary for successful litigation, the *difference* $\bar{x} - x^*$ has *no* impact on litigation risk, under our supposition that $\bar{x} \geq x^*$. Thus, the underwriter, whose compensation is positively linked to P_H, will wish to raise P_H to its maximum feasible value, which, given the "no excess supply" constraint, is P_H^b; this will raise $\bar{x}$ to its maximum since $\partial\bar{x}/\partial P_H > 0$. Hence, if it is optimal for the underwriter to set P_H high enough so that $\bar{x} \geq x^*$, then such a pricing strategy must be a component of an equilibrium that involves Walrasian market clearing and *no* underpricing on average. When $\bar{x} < x^*$, the underwriter knows that his choice of P_H *directly* affects the cutoff cash flow below which he can be successfully sued. Holding α invariant, the higher the litigation cost D to the underwriter, the lower is his preferred $\bar{x}$ and consequently the lower is P_H.

Of course, $\bar{x} < x^*$ is merely necessary, but not sufficient, to generate underpricing on average. Even when the optimal P_H implies $\bar{x} < x^*$, it is possible for $P_H = P_H^b$ since the market-clearing conditions that determine P_H^b do not involve the factors that impinge on the underwriter's privately optimal trade-off between his explicit remuneration and litigation risk. Thus, for "on average" underpricing to arise, two conditions must be contemporaneously satisfied: namely, that the underwriter's expected utility must peak at a $P_H < P_H^b$, and this P_H must be such that $\bar{x}(P_H, \sigma_L^2) < x^*(\mu_H, \sigma_L^2)$. The sufficiency condition (S2) restricts exogenous parameters for this to be true. It should be noted that x^*, while not explicitly stated as a function of the equilibrium IPO prices, *depends* on the equilibrium pricing behavior of underwriters through the dependence of investors' posterior beliefs on this equilibrium behavior [see (6)].

Another essential feature of the equilibrium is that the nonmyopic underwriter segregates the μ_H firms by risk, with the riskier firms being underpriced more. Such a pricing strategy is pivotal to the viability of a *two-price* equilibrium involving ex ante rationing. To see this, suppose that all the μ_H firms were priced alike, either at P_L or at P_H. If they are priced at P_L, then they are pooled with the μ_L firms sold by the *nonmyopic underwriters.* Given this, it is impossible for the myopic underwriters to sell their IPO's at a higher price because doing so unambiguously identifies their type and is unsustainable in equilibrium. Hence, we have an uninteresting single-price equilibrium with Walrasian market clearing and no litigation risk if the nonmyopic underwriter does not segregate the μ_H firms by risk. On the other hand, if *all* the μ_H firms are offered at P_H, then it must be the case that the nonmyopic underwriter's expected utility peaks at P_H for either the (μ_H, σ_L^2) or the (μ_H, σ_H^2) firms, but *not for both.* If P_H is an optimum for (μ_H, μ_L^2), then the underwriter's expected utility would be enhanced by selling the (μ_H, σ_H^2) firms at $P_H' < P_H$, because of the positive association between cash flow variance and the likelihood of realizing a cash flow below $\bar{x}$. Likewise, if P_H is an optimum for (μ_H, σ_H^2), then the underwriter would be better off offering the (μ_H, σ_L^2) firms at $P_H'' > P_H$.

Within the class of "segregation of means by risk" pricing equilibria, which arise naturally as explicated above, we have chosen to focus on a *two-price* equilibrium involving the (μ_H, σ_H^2) firms being pooled with the mean-μ_L firms at P_L and the (μ_H, σ_L^2) firms being offered at the higher price P_H by the nonmyopic underwriters. It is also possible to have a *three-price* equilibrium in which the nonmyopic underwriter offers the μ_L firms at P_L, the (μ_H, σ_H^2) firms at $P_H > P_L$, and the (μ_H, σ_L^2) firms at $P_H^* > P_H$. One could generate "on average" underpricing in such equilibria, but the qualitative aspects of the analysis, particularly the testable predictions, would be the same as in our simpler two-price equilibrium. A similar remark applies to equilibria involving four prices. The sufficiency conditions (S1) and (S3) restrict exogenous parameter values such that our two-price equilibrium obtains. Condition (S1) says that, for the μ_H firms, it is better for the nonmyopic underwriter to increase the price above P_L when the variance is σ_L^2, but not when the variance is σ_H^2 (i.e., higher cash flow variance makes litigation risk more onerous through its impact on $\bar{x}$). Condition (S3) asserts that it is optimal for the nonmyopic underwriter to price a μ_L firm at P_L.

This proposition has numerous implications. First, IPO underpricing will occur if all of the sufficiency conditions stated in the proposition are satisfied, so that $P_H < P_H^b$. In that case, the average value of all firms sold is higher than the cross-sectional average of P_L and P_H, and there will be an immediate price adjustment after the issue. Second, underpricing is *not* an inevitable equilibrium outcome even if there is litigation risk (i.e., there could be many instances in which not all of the sufficiency conditions in the proposition are satisfied). It is possible that $\bar{x}(P_H, \sigma_L^2) > x^*(\mu_H, \sigma_L^2)$, in which case $P_H = P_H^b$ and there is no underpricing. Third, even though a price decline in the after-market is necessary for litigation risk, it is *not* sufficient. In our model, even firms priced at P_L may experience a price decline; this will happen whenever their realized cash flow falls below $\bar{x}(P_L, \sigma^2)$. However, there is no litigation in this case. Fourth, not surprisingly, there can be litigation even without underpricing. This happens when $P_H = P_H^b$ and $x < x_c(P_H)$.

4.5 The equilibrium

Define $P_{\max}$ as the maximum price at which the IPO can be sold, given the presence of the myopic underwriters. Clearly, when the nonmyopic underwriter prices all the μ_H firms at $P_H = P_{\max}$, then

$$P_{\max} = \pi[\gamma\mu_L + \{1 - \gamma\}\mu_H] + [1 - \pi]\mu_H. \tag{12}$$

Suppose

$$\begin{aligned}&\alpha(P_L, \pi)P_L \\ &\quad > \alpha(P, \pi)P - \delta D \int_{-\infty}^{\bar{x}(P,\sigma_H^2)} [x^*(\mu_H, \sigma_H^2) - x]\phi(x \mid \mu_H, \sigma_H^2)\, dx, \\ &\quad \forall\ P \in (P_L, P_{\max}].\end{aligned} \tag{S4}$$

We can now characterize the equilibrium.

Proposition 4. *There exist exogenous parameter values such that the sufficiency conditions (S1)–(S4) hold. Given the satisfaction of these sufficiency conditions, the following is a sequential equilibrium that* *survives the Grossman–Perry (1986) perfect sequential equilibrium (PSE) refinement.*

(i) A nonmyopic underwriter will offer the IPO at P_L if the cash flow density function is $\phi(x \mid \mu_H, \sigma_H^2)$, at $P_H < P_H^b$ if the density function is $\phi(x \mid \mu_H, \sigma_L^2)$, and at P_L if the density function is $\phi(x \mid \mu_L, \sigma^2)$ for $\sigma^2 \in \{\sigma_L^2, \sigma_H^2\}$.

(ii) A myopic underwriter offers the IPO at P_H regardless of the density function.

(iii) Investors buy all of the shares of any firm whose announced price is P_L or P_H. They successfully sue any underwriter that sold the IPO at P_H and realized a cash flow $x < x_c(P_H)$.[18] *In this equilibrium, the posterior beliefs of investors, formed prior to observing x but after discovering σ^2, are as described in Table 2 in Section 4.1.*

(iv) For any out-of-equilibrium IPO price $P \notin \{P_L, P_H\}$, investors' beliefs are guided by the PSE criterion.

Most of the intuition for this proposition has been given in the discussion of Proposition 3. The additional sufficiency condition (S4) is closely related to (S3), which asserts the optimality of P_L for the μ_L firms priced by nonmyopic underwriters, *conditional* on pricing choices being limited to the *equilibrium* prices. Condition (S4) asserts that the nonmyopic underwriters should find it optimal to choose P_L for the μ_L firms even when *out-of-equilibrium* price choices are allowed.

4.6 A numerical example with underpricing

In this subsection, we provide a numerical example that illustrates the determination of the endogenous parameters of the model. The exogenous parameter values are $\mu_L = 2$, $\mu_H = 6$, $\sigma_L^2 = 4$, $\sigma_H^2 = 9$, $\gamma = 0.5$, $\pi = 0.5$, $\rho = 0.5$, $l(d_L; \mu_H) = 0.08$, $l(d_H; \mu_L) = 1$, $\alpha(P, \pi) = 0.0012 \times \pi^2\sqrt{P}$, and $D = 1$. To determine the endogenous parameters, using (6) we first determine x^*. For σ_L^2, we know from Table 2 that $\gamma_p = \gamma\pi = 0.25$; and for σ_H^2, we know that $\gamma_p = \gamma = 0.5$. Thus,

$$\log\left[\frac{\gamma_p l(d_H; \mu_L)}{[1 - \gamma_p] l(d_L; \mu_H)}\right] = \begin{cases} 1.4271164, & \text{for } \sigma_L^2, \\ 2.5257286, & \text{for } \sigma_H^2. \end{cases}$$

Note that $\gamma_p l(d_H; \mu_L) > [1 - \gamma_p] l(d_1; \mu_H)$ for σ_L^2 and σ_H^2, so that the expected loss to investors (of the type-II error) exceeds the expected loss to firms (of the type-I error). Given the SEC's concern with protecting investors, this seems a plausible configuration of exoge-

[18] We have assumed that there is no ex post monetary gain to investors from suing; there is no loss either. To make it an ex post strictly preferred strategy for them to sue, we can think of a portion of the penalty as a monetary transfer to them, so that the penalty is not *purely* dissipative as we have assumed. We examine the implication of this later.

nous parameter values. We now have all the values to substitute into (6) to obtain $x^*(\mu_H, \sigma_L^2) = 5.4271164$ and $x^*(\mu_H, \sigma_H^2) = 9.6828894$. Next, we use (10) and (11) to obtain $P_L^b = 3.33$ and $P_H^b = 4.4$. And, using (9), we obtain $\bar{x}(P_L^b, \sigma_L^2) = 5.199$ and $\bar{x}(P_L^b, \sigma_H^2) = 2.4396$. It can now be checked that (S1) is satisfied.

The next step is to find the P_H that satisfies (S2). Solving the first-order condition implicit in (S2), we obtain $P_H = 3.53$. Note that $P_H < P_H^b$. Moreover, using (9), we get $\bar{x}(P_H, \sigma_L^2) = 5.35$. Note that $\bar{x}(P_H, \sigma_L^2) < x^*(\mu_H, \sigma_L^2)$.

Tedious calculations reveal that (S3) is also satisfied. As for (S4), we first use (12) to obtain $P_{\max} = 5$. And using (9), we get $\bar{x}(P_{\max}, \sigma_H^2) = 6.5$. We can now verify that (12) holds for $P \leq P_{\max}$. This concludes verification of the sufficiency conditions.

Finally, we compute the (expected) underpricing. The expected value of all firms being sold is $\gamma\mu_L + [1 - \gamma]\mu_H = 0.5 \times 2 + 0.5 \times 6 = 4$. Now, $\Pr(\mu = \mu_L | P_L) = \frac{2}{3}$ and $\Pr(\mu = \mu_H | P_H) = 0.4$. The unconditional probabilities assigned by investors are given below. The probability that a randomly chosen firm will be priced at P_L is

$$\Pr(P_L) = [1 - \pi][\Pr(\mu = \mu_L) + \Pr(\mu = \mu_H \text{ and } \sigma = \sigma_H^2)] = 0.375,$$

and the probability that a randomly chosen firm will be priced at P_H is

$$\Pr(P_H) = [1 - \pi][\Pr(\mu = \mu_H \text{ and } \sigma = \sigma_L^2)] + \pi = 0.625.$$

The expected price paid by investors is

$$\begin{aligned}&\Pr(P_L) \times P_L + \Pr(P_H) \times P_H \\ &\quad = 0.375 \times 3.33 + 0.625 \times 3.53 = 3.456.\end{aligned}$$

Thus, the average underpricing as a percentage of the expected value of securities sold is

$$\frac{4 - 3.456}{4} \times 100 = 13.6\%.$$

4.7 A numerical example with no underpricing

We can also provide an example in which there is no underpricing on average. Consider the same exogenous parameter values as in the previous example, except that $l(d_L; \mu_H)$ is now 0.02 instead of 0.08, $\sigma_L^2 = 3.6$ instead of 4.0, and $\alpha(P, \pi) = 0.6\pi^2\sqrt{P}$ instead of $\alpha(P, \pi) = 0.0012\pi^2\sqrt{P}$. The choices of these parameter values are motivated by the desire to highlight the key roles played by the cash flow variance and the underwriter's compensation in the pricing decision. Recall that a nonmyopic underwriter prices only a high-mean and a low-variance firm at the higher of the two equilibrium prices, and on-average underpricing occurs when the high equilibrium price is set below the market-clearing level. Thus, the intuition of the model suggests that if this variance were low enough, the risk of future litigation would be sufficiently low to ensure that there would be no underpricing. Similarly, an increase in the dependence of the underwriter's compensation (α) on the issue price reduces his inclination to underprice. On the other hand, a lower $l(d_L; \mu_H)$ means that the courts become stricter [see Equation (6)]. This means that x^* becomes higher. We need this because the change we have made in σ_L^2 raises x^*, and we still require $\bar{x} < x^*$ to make underpricing a possibility.

Proceeding as before, we can now establish

$$\log\left[\frac{\gamma_p l(d_H; \mu_L)}{[1 - \gamma_p] l(d_L; \mu_H)}\right] = \begin{cases} 2.8134107, & \text{for } \sigma_L^2, \\ 3.912023, & \text{for } \sigma_H^2. \end{cases}$$

Note that $\gamma_p l(d_H; \mu_L) > [1 - \gamma_p] l(d_L; \mu_H)$ for σ_L^2 and σ_H^2. Further, $x^*(\mu_H, \sigma_L^2) = 6.5320696$ and $x^*(\mu_H, \sigma_H^2) = 12.802052$. Next, we obtain $P_L^b = 3.33$, $P_H^b = 4.4$, $\bar{x}(P_L^b, \sigma_L^2) = 5.07926$, $\bar{x}(P_L^b, \sigma_H^2) = 2.4396$, $\bar{x}(P_H^b, \sigma_L^2) = 5.83655$, and $\bar{x}(P_H^b, \sigma_H^2) = 5.0065$. It can be verified that (S1), (S3), and (S4) are satisfied. As for (S2), note first that $\bar{x}(P_H^b, \sigma_L^2) < x^*(\mu_H, \sigma_L^2)$. Moreover, at $P_H = P_H^b$, the left-hand side of the inequality representing the first-order condition in (S2) is 0.4719639, and the right-hand side of that inequality is 0.4696996. Hence, the underwriter would like to set $P_H > P_H^b$ because his expected utility is increasing in P_H at $P_H = P_H^b$. But P_H^b is the highest price at which the IPO can be sold. Since $P_L = P_L^b$ and $P_H = P_H^b$, there is no underpricing on average.

4.8 The role of the underwriter and additional implications of the model

To develop additional implications of the model, we need to examine the impact of π on the degree of underpricing. To do this, we will treat $\alpha(P, \pi)$ as an exogenously given compensation function. Now, from (7)–(9), we know that $\partial \bar{x}/\partial \pi > 0$. Since $\bar{x} < x^*$ in the underpricing equilibrium, it follows that a larger π leads to a larger set of realized cash flows for which successful litigation can proceed. Further, if we assume that $\partial^2 \alpha(P_H, \pi)/\partial P_H\, \partial \pi \leq 0$ and that, at a given π, underpricing exists, then it follows from the first-order condition in (S2) that an increase in π will diminish P_H.[19] The reason is that, holding fixed P_H, an increase in π increases the underwriter's expected

[19] The condition $\partial^2 \alpha(P_H \pi)/\partial P_H \partial \pi \leq 0$ is economically reasonable. It says that the rate at which the compensation of a high-reputation (low-π) underwriter increases with the IPO price is no less than the rate at which the compensation of a low-reputation underwriter increases with the IPO price.

legal liability without increasing the rate at which his compensation rises with P_H.

This observation by itself does not guarantee, however, that an increase in π causes greater underpricing. This is because (ii) implies that $\partial P_H^b/\partial\pi < 0$, so that an increase in π leads to reductions in both P_H and P_H^b. If we define greater underpricing as a greater relative divergence between the market-clearing and IPO prices, then we need a condition under which P_H declines relatively more than P_H^b as π increases. To obtain this condition, let us continue to assume that the IPO is underpriced at a given π, so that (S2) determines P_H.[20] Therefore, since P_H depends on the penalty D, but P_H^b does not, an increase in π from the given level will reduce P_H relatively more than P_H^b if D is sufficiently large.[21] In the implications discussed below, we will maintain the three assumptions under which an increase in π implies greater underpricing: (i) $\partial^2\alpha/\partial P_H\partial\pi \leq 0$, (ii) the IPO is underpriced, and (iii) D is "sufficiently" large.

The first implication we develop is related to the role of the underwriter. One service that the underwriter provides is purely transactional. Because of his specialization as a broker, the underwriter may be able to sell the IPO at a lower cost to the issuing firm than that which would be incurred if the firm were to float the issue on its own. A more interesting service provided by the underwriter is *reputational.* The issuing firm, which is bringing its security to the market for the first time, is likely to be less reputable for "accurate" certification of its security's value than an underwriter who has been involved in possibly many previous IPO's and is more concerned about his reputation for future IPO's. Thus, if π_u and π_f are the reputation indices of the underwriter and the issuing firm, respectively, then we would expect $\pi_u < \pi_f$. Defining $1 - [P_H/P_H^b]$ as the degree of underpricing, we have the following result.

Implication 1. If $\pi_u < \pi_f$ and $\partial\alpha/\partial P_H \geq 1$ for all π, then there is more underpricing with the firm issuing securities itself than with an underwriter.

The intuition for this is as follows. The poorer the ex ante reputation of the agent setting the IPO price (be it the underwriter or the issuing firm), the more likely it is that the Bayes test will reject the null

[20] P_H will not be determined by (S2) when there is no underpricing. It is then difficult to make statements about the impact of π on P_H. For instance, if the "unconstrained" P_H exceeds P_H^b, then $P_H = P_H^b$, and an increase in π will reduce P_H^b, so that $P_H = P_H^b$ again, but at a lower level. The absence of underpricing will be sustained.

[21] From (S2) it follows that as D becomes higher, $|dP_H/d\pi|$ increases. The assumption that D is sufficiently large is reasonable since D must be large enough for IPO underpricing to exist as well.

hypothesis that $\mu = \mu_H$, for any given cash flow realization. Moreover, given an IPO price of P_H and an observed variance of σ_L^2, the end-of-period price is also affected by the IPO price setter's reputation index. Again, the better its ex ante reputation (the lower the π), the higher is the after-market price for any given x. These two effects imply that the risk of litigation for the price setter is decreasing in its reputation. So, if the underwriter is more reputable than the issuing firm, he will set the IPO price higher than would the firm operating on its own, under the assumption ($\partial\alpha/\partial P_H \geq 1$, $\forall\pi$) that the rate at which the underwriter's compensation increases with P_H is at least as great as 1 (the rate for the issuing firm itself).[22] This implication is empirically supported by Muscarella and Vetsuypens (1989), who find that self-marketed issues are underpriced more than underwritten issues. Similar reasoning leads to the next implication.

Implication 2. The degree of underpricing in an IPO is decreasing in the underwriter's reputation. The better the underwriter's reputation, the lower is the underpricing.

Empirical support is provided by Tinic (1988), who finds that underpricing is greater for "nonranked" investment bankers and that this relation is stronger in the post-SEC period than in the pre-SEC period. See also Balvers, McDonald, and Miller (1988) and Carter and Manaster (1990).

Our result that the nonmyopic underwriter may underprice if $\sigma^2 = \sigma_H^2$ but not if $\sigma^2 = \sigma_L^2$ follows from the dependence of x^* on σ^2 [Equation (6)] and the dependence of $\bar{x}$ on σ^2 [Equation (9)]. This result can be generalized to the result that underpricing is more likely when there is more risk, which we delineate as another implication of our model.

Implication 3. The greater the variance of cash flows, the greater is the underpricing.

This implication of our model is consistent with the empirical evidence provided by Ritter (1984), who documents a positive relation between underpricing and the standard deviation of the after-market return. We next examine the impact of the underwriter's compensation function on underpricing. If we interpret "higher compensation" to imply an upward shift in the entire α schedule, with

[22] Note that this result holds in the *absence* of differences in preferences. Differential underpricing will be greater if the underwriter is risk neutral and the firm is risk averse. Hensler (1990) considers a litigation-based model of underpricing by a risk-averse entrepreneur in which the subgame perfection requirement for litigation is not imposed.

no change in its slope, then it follows from (S2) that a higher α will lead to a higher P_H, without affecting P_H^b.

Implication 4. The greater the compensation of the underwriter, the lower is the degree of underpricing, *ceteris paribus.*

This implication has also recently received empirical support.[23] Beatty (1990) finds a highly significant (t-statistic of 86) relation between underwriter fee and gross proceeds of the issue.[24]

4.9 An extension of the model to explain the long-term underperformance of IPO's

Our focus thus far has been on explaining the underpricing that obtains with IPO's. There is, however, another feature of IPO's that is noteworthy. Ritter (1991) has documented that IPO's underperform the market by a significant amount in the long run. In this subsection, we show that such an empirical regularity can be explained within the context of our model.[25]

We have assumed so far that the entire legal penalty in the event of successful litigation is borne by the underwriter. In reality, though, the issuing firm is also liable.[26] Let us suppose that, in addition to a penalty of D on the underwriter, a penalty of D_F is also imposed on the issuing firm in the event of successful litigation. This penalty of D_F is not just purely dissipative like D. Rather, it represents a payment that the (purchasing) shareholders can expect to receive from the firm if they sue successfully. The expected value of this payment should be initially capitalized in the price of the stock (i.e., P_H^b will

[23] Of course, one needs to be cautious in relating the empirical evidence to this implication of our model since we take α as exogenous, whereas in practice it will be determined through a competitivity condition that accounts for the underwriter's distribution costs and his expected legal liability, among other things.

[24] There may be factors other than those identified by our model that contribute to this evidence. We have assumed that the IPO price is set by the underwriter, independently of the issuing firm. In reality, there is considerable bargaining over the price between the underwriter and the issuing firm (e.g., the Microsoft IPO). The underwriter may, therefore, yield partially to pressure by the firm to increase the IPO price even though it increases his litigation risk. For such compliance, however, the underwriter will need to receive a higher compensation.

[25] We are grateful to the referee for suggesting this to us.

[26] Selz (1992) reports that some settlements are very costly for the companies involved. For example, Software Toolworks, Inc., a computer-software firm, paid two million shares of stock and $6.5 million in cash to settle a suit related to its 1990 stock offering. Former and current officers and directors of the company had to provide $2 million of the cash portion of the deal. These individuals are also liable for up to an additional $10 million if the stock fails to reach a certain value and if the plaintiffs fail to collect a certain total sum from other defendants in the suit, such as underwriters.

Selz quotes Vincent O'Brien of Law & Economics Consulting Group in California, "Every hot IPO market has been followed by a spate of lawsuits. Many of the owners of these companies don't realize that if they get sued, the probability that they'll have to pay a significant amount of money is very high."

reflect this future expected payment). An altered version of (11), which accounts for this payment, is given below:

$$P_H^b = \mu_L\theta_H + \mu_H[1 - \theta_H] + \{\hat{\theta}_{HH}\,\epsilon_{HH} + \hat{\theta}_{HL}\,\epsilon_{HL} + \hat{\theta}_{LL}\,\epsilon_{LL} + \hat{\theta}_{LH}\,\epsilon_{LH}\}, \tag{13}$$

where

$$\hat{\theta}_{HH} \equiv \Pr(\mu = \mu_H, \sigma = \sigma_H^2 \mid P_H),$$

$$\hat{\theta}_{HL} \equiv \Pr(\mu = \mu_H, \sigma = \sigma_L^2 \mid P_H),$$

$$\hat{\theta}_{LL} \equiv \Pr(\mu = \mu_L, \sigma = \sigma_L^2 \mid P_H),$$

$$\hat{\theta}_{LH} \equiv \Pr(\mu = \mu_L, \sigma = \sigma_H^2 \mid P_H).$$

In Equation (13), ϵ_{ij} is the expected litigation payment to investors by a firm with mean μ_i and variance σ_j^2. These expected litigation payments depend on $\bar{x}$ and x^*. Explicit expressions for these expected payments as well as the related posterior probabilities are given in the Appendix. We continue to assume that $\bar{x}(P_H, \sigma^2) < x^*(\mu_H, \sigma^2)$ for every σ^2. Underpricing is possible in this case, and will obtain if the equilibrium price $P_H < P_H^b$. Since P_H^b is affected by possible future penalties on the firm, P_H will also be affected by these penalties. That is, even with underpricing, P_H will reflect at least a fraction of the terms in the curly braces in (13).

If the firm is indeed sued after its cash flow is realized, shareholders will receive D_F. If this extra "dividend" received by the shareholders is not taken account of properly in empirical studies, it will appear that the stock underperforms the market when in fact its performance is comparable to that of the market.[27]

While it would be interesting to examine the average magnitude of settlements as a fraction of the firm's equity, such data are hard to come by because out-of-court settlements are common and are often not made public. Our model, however, does point to one possible reason for the documented long-run "underperformance" of IPO's.

5. Conclusion

We have formally examined litigation risk as a factor in inducing underpricing of IPO's. The primary features of our analysis are as

[27] Our explanation of long-term underperformance is analogous to the "peso problem," where a low-probability event, devaluation, leads an econometrician to overestimate the rate of return on the currency. In our model, the low probability event is an "extra" dividend payment, so it results in underestimation. We are grateful to the editor for pointing out this analogy.

Note that this view of the long-run underperformance of IPO's does not imply that there are unexploited arbitrage opportunities, since the stock price does capitalize the value of future dividends; it is purely a measurement problem from the empiricist's standpoint.

follows. First, the role of the underwriter as an intermediary between the issuing firm and the market is prominent in our analysis. Second, the fact that the IPO is a new issue, rather than a seasoned issue, matters in our analysis because of the significant role for learning by investors. Third, the legal environment is a key consideration in the deliberate decision to underprice. Fourth, when time consistency and rational expectations are accounted for, litigation risk does not inevitably lead to underpricing on average. Finally, because reputational considerations are relevant, the extent of underpricing depends on whether the firm is issuing its own securities or is doing so through the underwriter, and in the latter case on the reputation of the underwriter himself.

While we have provided a theoretical link between litigation risk and IPO underpricing, we do not claim that litigation risk is the sole cause of underpricing. Underpricing occurs even in countries where litigation risk is not a factor. Ibbotson and Ritter (in press) summarize evidence of IPO underpricing in 15 countries other than the United States, whereas Jenkinson (1990) documents IPO underpricing in the United Kingdom and Japan. There are two points worth noting about this. First, the costs to the underwriter of ex post inferences by investors that the issue may have been overpriced include potential damage to the underwriter's reputation as well as litigation costs. It should, therefore, not be surprising that underpricing exists even when there is little or no litigation risk. Second, there may be institutional factors besides litigation risk in other countries that contribute to underpricing. For example, Ibbotson and Ritter (1991) report an average initial return of 9.7 percent during 1965–1975 and 12.2 percent during 1985–1988 for U.K. IPO's, as opposed to 16.4 percent for the United States during 1960–1987. Although litigation risk is not an important consideration in the United Kingdom, there is a key difference in the timings of the setting of the issue price in the United Kingdom and the United States. The issue price is set on the day of the issue in the United States, whereas it is set about 10 days before trading begins in the United Kingdom. The U.K. underwriter bears all the risk of a market decline, so that underpricing may be an attempt to secure some insurance against this risk.[28]

We believe that the predictions generated by our model permit one to potentially distinguish our explanation from the signaling explanations currently available. Moreover, our analysis suggests reputation as an important explanatory variable in understanding the

[28] An example of this kind of risk was the sale of British Petroleum stock in the United States in 1987. The selling price was fixed just before the October stock market crash, and the underwriters were left with most of the stock.

underpricing phenomenon. Thus, in addition to providing a rational explanation for underpricing, our theory suggests possible avenues for further empirical scrutiny. Such empirical research may reveal possibly interesting regularities about the pervasiveness as well as the cross-sectional and intertemporal variability in IPO underpricing.

Appendix

Proof of Proposition 1

The likelihood ratio in (5) can be written as

$$\lambda(x) = \exp(-[x - \mu_H]^2/2\sigma^2)/\exp(-[x - \mu_L]^2/2\sigma^2),$$

which simplifies to

$$\lambda(x) = \exp([\mu_H - \mu_L][2x - \{\mu_L + \mu_H\}]/2\sigma^2). \tag{A1}$$

Thus, the critical region is defined by values of $x < x^*(\mu_H, \sigma^2)$, where

$$\lambda(x = x^*) = \gamma_p l(d_H; \mu_L)/[1 - \gamma_p]l(d_L; \mu_H). \tag{A2}$$

Substituting (A1) in (A2) and solving yields the desired result.

Q.E.D.

Proof of Proposition 2

We have defined P_i^b as the "breakeven" price (i.e., it is equal to the expected value of firms in that price group). These expected values are computed at $t = 0$. Thus,

$$P_L^b = \Pr(\mu = \mu_L | P = P_L)\mu_L + \Pr(\mu = \mu_H | P = P_L)\mu_H, \tag{A3}$$

where P_L is the lower of the two IPO prices. Using Bayes rule, we see that

$$\Pr(\mu = \mu_L | P = P_L) = \theta_L \quad \text{and} \quad \Pr(\mu = \mu_H | P = P_L) = 1 - \theta_L.$$

Similarly,

$$P_H^b = \Pr(\mu = \mu_L | P = P_H)\mu_L + \Pr(\mu = \mu_H | P = P_H)\mu_H. \tag{A4}$$

Again, using Bayes rule, we see that

$$\Pr(\mu = \mu_L | P = P_H) = \theta_H \quad \text{and} \quad \Pr(\mu = \mu_H | P = P_H) = 1 - \theta_H.$$

Thus, we get (10) and (11).

Now, since there will not be a lawsuit if the firm was priced at the lowest IPO price, in a two-price equilibrium the firm will not get sued if it sets $P = P_L$ in the IPO. Thus, to maximize (1), even the type N underwriter will set P_L at the maximum value at which investors will buy the issue. Given the Conjectured Equilibrium, this value is

P_L^b. The higher IPO price has a maximum value of P_H^b. However, P_H may be set lower than P_L^b to reduce litigation risk. Q.E.D.

Proof of Proposition 3

If (S1) holds, then the firm with cash flow mean μ_H and variance σ_L^2 is better off being sold at an IPO price exceeding P_L. This follows from the fact that, given (S1), we have $\partial\xi(\pi, \mu_H, P, \sigma_L^2)/\partial P > 0$ at $P = P_L$. Moreover, given (S2), the price at which the type N underwriter's utility is at a stationary point is less than P_H^b *and* is such that $\bar{x}(P_H, \sigma_L^2) < x^*(\mu_H, \sigma_L^2)$. Note that $\bar{x}(P_H, \sigma_L^2) < x^*(\mu_H, \sigma_L^2)$ is *necessary* (but not sufficient) to ensure that $P_H < P_H^b$. To see this, suppose counterfactually that $\bar{x}(P_H, \sigma_L^2) < x^*(\mu_H, \sigma_L^2)$. Since the underwriter can be successfully sued only if $x < x^*(\mu_H, \sigma_L^2)$, the underwriter can, starting from a point at which $\bar{x} > x^*$, increase $\bar{x}(P_H, \sigma_L^2)$ to any feasible level above $x^*(\mu_H, \sigma_L^2)$ without further increasing the expected litigation payment. That is, P_H can be increased to its maximum feasible value. Thus, if it is optimal to set P_H such that $\bar{x}(P_H, \sigma_L^2) \geq x^*(\mu_H, \sigma_L^2)$, then it must be optimal to set $P_H = P_H^b$.

Further, given (S1), the firm with mean μ_H and variance σ_H^2 finds that $\partial\xi(\pi, \mu_H, P, \sigma_L^2)/\partial P < 0$ at $P = P_L$, and would like to reduce its IPO price below P_L if that will reduce the expected litigation cost. However, since a firm that sets its IPO price at P_L is never sued, it is optimal for this firm to sell its IPO at P_L.

Finally, (S3) ensures that no μ_L firm will be priced at P_H by the type N underwriter. Note that, given (S1) and (S2), it follows that $P_H > P_L$. Q.E.D.

Proof of Proposition 4

We have already established incentive compatibility. So all that we need to consider is out-of-equilibrium moves. The underwriter is setting a price, so the response of the uninformed capital market is twofold: (i) at $t = 0$ they must decide whether to buy the IPO at the offered price, and (ii) at $t = 1$ they must decide whether to sue the underwriter. The out-of-equilibrium moves are (a) $P < P_L$, (b) $P \in (P_L, P_H)$, and (c) $P > P_H$.

First, consider $P < P_L$. Clearly, the equilibrium we have is sustained as a PSE since, regardless of the market's beliefs, no one wants to defect. This is because the most favorable best response of the market is to view the defector as a type-μ_H firm and never to sue the underwriter. This implies that all the offered securities will be purchased at $P < P_L$ and there will be no litigation. But this is dominated by each type's equilibrium allocation.

Now consider $P \in (P_L, P_H)$. Since $P_L = P_L^b$, the only way the underwriter can sell the IPO at a price exceeding P_L is if investors believe that the fraction of μ_H firms in the defection group exceeds that fraction in the equilibrium group selling at P_L. Note first that, according to the PSE criterion, we can eliminate the type M underwriter as a defector (this underwriter loses by defecting with $P < P_H$). Thus, the "most generous" belief the market can have is that the defector has mean μ_H. In this case, the IPO can be issued at $P \in (P_L, P_H)$, but there would be no reason to sue the underwriter if $x < x_c(P_H)$ since investors "know" with probability 1 that the mean is μ_H. Given this, however, it pays even the type N underwriter with mean μ_L to defect, and thus the investor's beliefs are not "rationalized." Let $\gamma^* = \Pr(\mu = \mu_L) > 0$ represent a belief that "supports" the IPO price of $P \in (P_L, P_H)$. For a mean-μ_L firm, a type N underwriter's expected utility is

$$\alpha(P, \pi)P - \int_{-\infty}^{\hat{x}(P,\sigma^2)} D[x^*(\mu_H, \sigma^2) - x]\phi(x \mid \mu_L, \sigma^2)\, dx,$$

which is less than $\alpha(P_L, \pi)P_L$ by (S3) since $P \in (P_L, P_H^b)$. Thus, no type N underwriter with a type-μ_L firm defects and this shows that no belief $\gamma^* > 0$ can be rationalized as per the PSE requirement.

Now consider $P > P_H$. The only sustainable out-of-equilibrium price is $P \in (P_H, P_{\max})$. By the PSE criterion, the type M underwriter cannot be ruled out as a defector. Indeed, this underwriter will wish to defect. Now (S4) guarantees that the type N underwriter will not defect if the firm has mean μ_H and variance σ_H^2. Thus, the potential defectors are the type N underwriters with mean μ_H and variance σ_L^2 and the type M underwriters.

We now need to consider two cases: (i) $P \in (P_H, P_H^b)$, and (ii) $P \in (P_H^b, P_{\max})$. If $P \in (P_H, P_H^b)$, then the type N underwriters with mean μ_L do not defect, given (S3). Thus, investors must believe that $\Pr(\mu = \mu_L) = \pi\gamma$. This is the same belief that leads the type N underwriters to price the firm with cash flow density function $\phi(x | \mu_H, \sigma_L^2)$ at P_H. Hence, the type N underwriters do not defect. This means that only the type M underwriters defect and $\Pr(\mu = \mu_L) = \gamma$, in which case the IPO can only be sold at $P < P_L < P_H$. Hence, the IPO will fail. If $P \in (P_H^b, P_{\max})$, either the type N underwriter with a μ_L firm does not defect and the earlier arguments apply, or, if it does defect, the market's belief is that

$$\Pr(\mu = \mu_L) = \gamma + [1 - \gamma][1 - \rho][1 - \pi] > \gamma,$$

and hence the IPO cannot be sold at $P > P_H^b$.

All that remains is to show that there are exogenous parameter values for which (S1)–(S4) are satisfied. These conditions are satisfied in the numerical example provided in Section 4.6. Q.E.D.

Posterior probabilities and expected litigation payments in Equation (13)

We have

$$\hat{\theta}_{HH} = \pi[1 - \gamma][1 - \rho]/\text{DEN},$$

$$\text{DEN} \equiv \pi[1 - \gamma][1 - \rho] + [1 - \gamma]\rho + \pi\gamma[1 - \rho] + \pi\gamma\rho,$$

$$\hat{\theta}_{HL} = [1 - \gamma]\rho/\text{DEN},$$

$$\hat{\theta}_{LL} = \pi\rho\gamma/\text{DEN},$$

$$\hat{\theta}_{LH} = \pi\gamma[1 - \rho]/\text{DEN},$$

$$\epsilon_{HH} = \int_{-\infty}^{\bar{x}(P_H,\sigma_H^2)} D_F[x^*(\mu_H, \sigma_H^2) - x]\phi(x \mid \mu_H, \sigma_H^2)\, dx,$$

$$\epsilon_{HL} = \int_{-\infty}^{\bar{x}(P_H,\sigma_L^2)} D_F[x^*(\mu_H, \sigma_L^2) - x]\phi(x \mid \mu_H, \sigma_L^2)\, dx,$$

$$\epsilon_{LL} \equiv \int_{-\infty}^{\bar{x}(P_H,\sigma_L^2)} D_F[x^*(\mu_H, \sigma_L^2) - x]\phi(x \mid \mu_L, \sigma_L^2)\, dx,$$

$$\epsilon_{LH} \equiv \int_{-\infty}^{\bar{x}(P_H,\sigma_H^2)} D_F[x^*(\mu_H, \sigma_H^2) - x]\phi(x \mid \mu_L, \sigma_H^2)\, dx.$$

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