# Investment Banks as Information Providers in IPOs

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**Abstract**

Financial intermediaries are known to have access to privileged information on firm value, potentially providing important services by revealing it to uninformed investors. An important issue that arises is whether Investment Banks have an incentive to distort prices by communicating biased information on the firms they are underwriting in IPOs. Reputation acquisition may mitigate this problem as intermediaries may lose credibility by incorrectly forecasting the profitability of firms. We argue that the introduction of reputation may not suffice to eliminate all scope for misreporting, allowing less talented intermediaries to profit from not revealing their private information to the market.

## 1 Introduction

The role of information providers in reducing the informational asymmetries in financial markets has received considerable attention. In this paper, we consider the incentives of Investment Banks (IBs) as information providers in the underwriting process of IPOs. Within the context of IPOs, IBs intermediate the interaction between new issuers and public investors. Almost by definition, new issuers lack a public history upon which investors can rely to infer the quality of the offering. Thus, IPOs are inherently characterized by a high degree of information asymmetry between corporate insiders and outside investors. Furthermore, a firm goes public only once, and only infrequently engages in subsequent offerings, with the consequence that it can hardly build a reputation for being a credible and disinterested provider of information. Accordingly, an essential part of the intermediation that IBs perform in the IPO market involves playing the role of a third party provider of information. Indeed, unlike the firm they underwrite, IBs interact in the IPO market repeatedly and are thus in a position to build a reputation for being reliable and skilled providers of quality certification. Ultimately, the credibility of IBs in providing information is based on the reputational capital that these intermediaries put at stake whenever they evaluate a new issue. We show that reputation acquisition might not suffice to eliminate all the scope for untruthful information revelation.

We address this question in a signalling game with three classes of players: Investment Banks, Firms and Investors. Firms sell shares in an equity market with asymmetric information either directly or through investment banks. Investment banks have better information on firm profitability than the market (although still incomplete) and interact with the equity market, evaluate entrepreneurs' projects and report to investors in return for a fee that is paid by the issuer. In line with what is observed in the IPO market, we assume that the firm that goes public pays the IB an underwriting fee equal to a fixed fraction of the proceedings of the IPO.

IBs differ for having a different "evaluation technology". By "evaluation technology" we mean the ability of the IBs in acquiring accurate information about the true state of the firm whose equity is eventually underwritten. We assume that the information technology is exogenously determined by nature and cannot be changed by the IB. The belief held by the market about the ability (i.e. the type of evaluation technology) of an IB represents its reputation and we assume that it affects the IB's payoffs. Therefore, the payoff structure of the IB is ultimately characterized by an underwriting fee component and by a reputational component, to reflect the incentives that IBs face in actual IPO markets.

In such a framework, we investigate the firm's decision to go public either through an IB or directly, and the IBs' decisions to underwrite and report their private information to the market.

Since the compensation of the IB for the underwriting activity is a fixed fraction of the proceedings of the IPO, the IB faces a strong incentive to inflate the offering price through distorted reports in order to enhance the short term profits from the underwriting fee.

In fact, these incentives are limited by the IB's concerns about its own reputation. Indeed, since the IB interacts with the IPO market repeatedly, biased reports may cause a loss of reputation, which may in turn lead to a loss of future profits. Thus, investment banks trade off the short term gains (in underwriting fees) from over-reporting their private signals about firm value against the reputational losses incurred by reports that are revealed to be ex post incorrect.

We show that whenever the prior on firm profitability is either very high (boom markets) or very low (bust markets) and the uncertainty on firm profitability is relatively small, the reputational mechanism fails to provide all IBs with the correct incentives to fully reveal their private information. Indeed, when public information on firm profitability is quite precise, IBs with the worst evaluation technology believe that any contrarian signal they receive is probably incorrect. Being worried about the adverse impact of ex-post incorrect evaluations on their reputation, they distort their private information to agree with the prior. Thus, misreporting takes the form of conformist behavior on the part of less talented IBs. We define such equilibria as informationally inefficient because less talented IBs always have superior information relative to outside investors. Thus, reputational concerns and conformist behavior prevent the flow of valuable information from IBs to the capital market. Rather unexpectedly, we obtain that informational inefficiency is actually driven by reputational incentives.

The role of IB reputation in the IPO market has been the subject of several academic studies. On an empirical ground, two strands of literature have emerged analyzing the relationship between underwriter reputation and IPO performance. On the one hand, a first group of studies has focused on the effects of IB reputation on the pricing and the performance of IPOs (Beatty and Ritter (1986), Carter, Dark, and Singh (1998), Carter and Manaster (1990), Beatty and Welch (1996), Cooney et al. (2000) and Loughran and Ritter (2004)). On the other hand, a second group of studies has examined the effects of IPO past performance on underwriter reputation (Beatty and Ritter (1986)), Nanda and Yun (1995, Dunbar (2000)).

Prior studies belonging to the first strand of literature showed that during the 1980s IPOs managed by more prestigious underwriters were associated with less underpricing and a lower long-run underperformance (Beatty and Ritter (1986), Carter, Dark, and Singh (1998), Carter and Manaster (1990)). Subsequent research has shown that the negative relationship between underwriter reputation and IPO underpricing disappeared in the 1990s. Beatty and Welch (1996), Cooney et al. (2000) and Loughran and Ritter (2004) document how during the 1990s this pattern actually reversed into a positive one, with more reputable IBs associated with more underpricing. Logue et al. (2002) provides evidence that underwriter reputation has only an indirect effect on the IPO underpricing and no impact on the IPO long-run performance.

Studies belonging to the second strand of literature have provided more consistent findings through time. Generally, underwriters that systematically misprice IPOs subsequently are found to lose reputation, as measured by the underwriter market share (Beatty and Ritter (1986)), and by the underwriter market value (Nanda and Yun (1995)). A more recent study by Dunbar (2000) confirms these initial findings, but also documents that the negative impact of mispricing on underwriter reputation is significant only for well established underwriters, suggesting that the relationship is sensitive to the initial level of reputation that is put at risk.

On a theoretical ground, the role of IBs' reputation in IPOs has been explicitly considered by Chemmanur and Fulghieri (1994). However, they focus on the impact that reputation has on the incentives of IBs to improve their evaluation technology, and do not address the issue of information transmission, which is the main object of our analysis.

In this respect, our model is closely related to the burgeoning literature on reputational cheap talk and in particular to the papers by Benabou and Laroque (1992) and Ottaviani and Sorensen (2006). In Benabou and Laroque (1992), insiders perform the joint actions of speculating and spreading information at no intrinsic cost, managing to manipulate prices repeatedly, without being fully discovered. Insiders do not differ in their forecasting abilities (i.e., they all receive an equally informative signal), but rather in their degree of honesty in reporting private information. In particular, some types of insiders are constrained to provide truthful reports, while others are allowed to act strategically. In our model, IBs are characterized by different forecasting abilities and the reporting strategies of all types of IBs are determined endogenously.

Ottaviani and Sorensen (2006) study information transmission by a privately informed expert concerned about being perceived to have accurate information. They characterize the expert's incentives to deviate from truthtelling in a setup in which the expert is solely concerned about the receivers' perception of his forecasting ability. We draw upon their model and adapt the information transmission analysis to the context of the IPO underwriting activity. The institutional setup we consider allows us to analyze the issue of information reporting in an economic setup in which the expert is not exclusively concerned about his reputation. Indeed, the expert's concern for being perceived to have accurate information is entwined with the concern for the impact that his report has on the decision of the firm and eventually on the price of the firm's stock.

Trueman (1994) considers a model where analysts with different forecasting abilities are concerned about building a good reputation for their forecasting accuracy. He finds that analysts display herding behavior, whereby they disregard their private information and release forecasts similar to those previously announced by other analysts in order to maximize their expected reputation. His finding is in line with Sharfstein and Stein (1990) where managers exhibit herding behavior in a framework in which the expert has to make an investment decision as opposed to reporting his private information to a third party. In these papers, experts choose their actions sequentially and, as in Ottaviani and Sorensen (2006), are solely concerned about their reputation.

Our work is also related to the recent literature on analysts' conflict of interests. On an empirical ground, Michaely and Womak (1999) show that underwriters' analysts tend to release over-optimistic recommendations in the attempt to inflate the stock price of the firm taken public by their IB. Morgan and Stocken (2003) present a theoretical model that analyzes the informational content of stock reports when investors are uncertain about an analyst's incentives. Analyst incentives may be aligned with those of investors or misaligned. They find that any investor uncertainty about incentives makes full revelation of information impossible. Under certain conditions, analysts with aligned incentives can credibly convey unfavorable information, but can never credibly convey favorable information. The first difference with respect to our work is that in their model analysts do not differ in the degree informativeness of their signals, but in the degree of divergence of their preferences with respect to those of investors. Basically, as in Benabou and Laroque

(1992), the analyst is not concerned about being perceived as having accurate information, but about being perceived as honest. Furthermore, though our model is suited to study analysts' conflict of interests, it is nevertheless thought to address the issue of information production and transmission in the period preceding the offer date, when the IB's role of information producer and provider affects not only the decisions of the investors, but also those of the firm candidate to go public.

The main departure of our paper from the previous literature comes from recognizing that poorly informed underwriters may refrain from truthfully revealing their private information in IPOs, thus adopting a conformist behavior precisely because they fear they will suffer a reputational "punishment". Thus in "booms" or "busts", when there is less uncertainty on firm profitability, some valuable information on firm profitability may never reach the financial market.

The paper is organized as follows. In section 2, we introduce the general setup of the model. In section 3, we analyze the conditions under which truthtelling by IBs is possible and highlight the incentives that IBs may have to deviate from truthtelling. We characterize a family of "partial pooling" equilibria where talented IBs transmit truthful evaluations while untalented IBs transmit untruthful evaluations to the market and manage to influence prices of firms. In section 4 we compare the relative informational efficiency of different market scenarios as defined by the relevant parameters. In section 5 discuss the empirical implications of the model. Section 6 concludes.

# 2 The Model

We consider a financial market populated by a large pool of firms that want to go public, a large pool of investment banks (IBs) that possibly underwrite their shares and a large pool of investors interested in buying the firms' shares. Firms differ in their fundamental values. IBs differ in their ability to recover information about the true value of the firm that they possibly underwrite.

Firms can issue their shares either directly to the market or through an IB. While hiring an IB comes at the cost of paying a fee to the underwriting IB, firms that go public directly bear no fees.

We assume that there is only one period of time $t$. At the beginning of $t$, a firm and an IB are randomly selected from their respective pools and matched.[1] The IB *privately* evaluates the firm and proposes its underwriting conditions, which consist of: 1) an evaluation of the firm to be *publicly* communicated to the market; 2) a fee that the firm must pay to the IB. The firm observes both the fee and the proposed evaluation and chooses either to be underwritten by the investment bank or to go public directly.

If the IPO occurs through an IB's services, the IB's evaluation reaches the market and, based on this evaluation, investors determine the price of the firm's shares. If the firm goes public directly, investors determine the value of its shares based on the observation that the firm has refused to use the IB.

At the end of $t$, the true value of the firm is revealed and observed by all market participants. Thus, every player in the market can compare the true value of the firm with the actions taken by the IB and the firm, and accordingly form her own belief about the IB's ability for recovering information on the true value of a firm that is about to go public. We interpret this belief as the IB's reputation for ability and assume that all IBs care about their own reputation.

The rest of the section is devoted to explaining the model just described in greater detail.

[1] The analysis of how the firm chooses the IB is out of the scope of the present paper.

## 2.1 Agents

### 2.1.1 Firms

We assume that there are two types of firms. High profit firms, whose true value is 1 and low profit firms, whose value is 0. Let $F$ denote the value of a firm operating at $t$ and assume that $F \in \{0, 1\}$. Let $\theta$ be the fraction of high type firms and $1 - \theta$, the complementary fraction of low type firms. Notice that $\theta$ can be interpreted as the prior probability at time $t$ that the firm is worth 1. Formally, $\theta = \Pr(F = 1)$. We assume that $\theta$ is common knowledge and that firms do not know their own type.[2]

A firm can choose either to accept $(A)$ or refuse $(R)$ to be underwritten by an IB. This choice is taken after the IB has assessed the quality of the firm and revealed to the firm the evaluation that it commits to send to the market in case the firm accepts to go public through the intermediation of the IB. If the firm were to refuse to be underwritten by the IB, it has the outside option of going public directly.

### 2.1.2 Investment Banks (IBs)

Although IBs do not know firms' types, they receive a private signal about the true type of the firm. This signal is binary and can be either high or low. Let $S_h$ and $S_l$ respectively denote the events that the IB receives a high or low signal in period $t$.

We assume that there are two types of IBs, good $(G)$ and bad $(B)$. Let $IB$ denote a generic investment bank active at $t$, so that $IB \in \{G, B\}$. Good IBs receive a more informative signal[3] about the true state of the firm than

[2] This seemingly implausible assumption is without loss of generality. Furthermore, notice that in reality, most of the firms that aim to go public do not have accurate information about the way the market will to react to the IPO. One reason to hire an IB for the IPO is exactly that of getting some help in determining how the market perceives the offer.

[3] We assume that signals are private and non-verifiable. Accordingly, a court cannot distinguish whether the analyst received the high or low signal. This prevents a contract

bad IBs, as described by the following probability distributions:

$$\Pr(S_h \mid IB = G, F = 1) = \Pr(S_l \mid IB = G, F_t = 0) = p,\ p \in (1/2, 1] \quad (1)$$
$$\Pr(S_h \mid IB = B, F = 1) = \Pr(S_l \mid IB = B, F_t = 0) = z,\ z \in (1/2, p] \quad (2)$$

This information structure allows each type of IB receiving a signal to update the prior on the firm's type and thus form its own belief about the fact that the firm is good.

Let $\alpha$ represent the fraction of good IBs, while $(1-\alpha)$ is the complementary fraction of bad IBs, where $\alpha$ can be interpreted as the prior probability that an IB is good, that is $\alpha = \Pr(IB = G)$. We assume that $\alpha$ is common knowledge and that an IB knows its own type.

Once the signal is received, the IB chooses which evaluation to publicly release in the form of a binary message $s_j \in \{s_l, s_h\}$.[4] The evaluation is observed by the firm, but it reaches the market if and only if the firm accepts to be underwritten by the IB. For every $i, j \in \{h, l\}$, $\sigma_{IB}(s_j \mid S_i)$ denotes the behavioral strategy of the IB, indicating the probability that an IB of type $IB$ sends evaluation $s_j$ given that it has received signal $S_i$.

**IBs' reputation.** We assume that at the end of period $t$ the true value of the firm $F$ can be observed. Thus, every player in the market can compare it with the observable actions taken by the IB and the firm and update his own belief about the ability of the IB accordingly. We interpret the updated belief about the IB's ability as the new level of reputation acquired by the IB at the end of period $t$ and we denote it with $\widehat{\alpha}$. Formally, in the case in which the firm accepts to be underwritten and evaluation $s_j$ eventually reaches the

from being written with payment contingent on the analyst truthfully reporting the private signal.

[4]Notice that we use $S$ for the private signal recieved by the IB and $s$ for the message sent by the IB. While the first is determined exogenously by the IB's type, the latter is a choice variable for the IB.

market, we have that:

$$\widehat{\alpha} = \Pr(IB = G \mid F, s_j)$$

On the other hand, in the case in which the firm refuses to be underwritten and no evaluation reaches the market, we have that:

$$\widehat{\alpha} = \Pr(IB = G \mid F, R)$$

The value of $\widehat{\alpha}$ is endogenous, since it depends on the equilibrium strategies of firms and IBs and on the equilibrium beliefs held by investors, in a way that will be clear soon.

To ease notation, let us define

$$\widehat{\alpha}_{F,s_j} \equiv \Pr(IB = G \mid F, s_j) \text{ in case the firm accepts}$$
$$\widehat{\alpha}_{F,R} \equiv \Pr(IB = G \mid F, R) \text{ in case the firm refuses}$$

### 2.1.3 Investors

There is a large pool of risk neutral investors interested in buying the shares of the firm that goes public. We assume that whenever a firm goes public through the intermediation of an IB, investors observe the IB's evaluation and then bid à la Bertrand in order to obtain the firm's shares. This implies that the stock price of the firm, $v$ is set equal to its expected value given all publicly available information.[5] Hence, if the firm accepts to be underwritten, the IB's message reaches the market and

$$v = \Pr(F = 1 \mid s_j)$$

On the other hand, if the firm refuses to be underwritten, no IB evaluation reaches the market. The only information available to the market is the

[5] This implies that the IPO market is semi-strong efficient.

refusal of the firm, and therefore:

$$v = \Pr(F = 1 \mid R)$$

It is important to stress that in both cases the price of the firm $v$ is determined endogenously in equilibrium since it depends on the equilibrium strategies of the IBs and on the equilibrium (and out of equilibrium) beliefs of the investors. This further implies that the stock price of the firm depends on the prior reputation of the underwriter. Accordingly, from now onwards we let $V(s_j, \alpha) \equiv \Pr(F = 1 \mid s_j)$ and $d(\alpha) \equiv \Pr(F = 1 \mid R)$. In words, $V(s_j, \alpha)$ denotes the value of a firm that is underwritten by an IB with prior reputation $\alpha$ sending evaluation $s_j$. On the other hand, $d(\alpha)$ denotes the value that the market assigns to a firm that chooses to go public directly (refusing to be underwritten by an IB).

## 2.2 The underwriting fee

A firm that goes public through an IB has to pay an underwriting fee to the IB. In line with Chemmanur and Fulghieri (1994), we assume that the firm pays an underwriting fee equal to a fraction $k \in (0, 1)$ of the surplus value that the IB assures to the firm by underwriting its shares. This surplus value is the difference between the value of the firm that emerges when the firm goes public through the IB, and the value of equity when it goes public directly. Formally, the IB's compensation is given by $k[V(s_j, \alpha) - d(\alpha)]$.[6] We assume that $k$ is is the same for all investment banks, exogenous, and common knowledge. However, since the surplus value generated by the underwriter is endogenous, the underwriting fee is also endogenous. It is important to bear in mind that the fee is paid only by firms that choose to go public through the intermediation of an IB (i.e., by firms that accept to be underwritten by

[6] In a very simplified way, this linear fee structure bears some of the essential features present in the contractual arrangements used in practice (see Chemmannur Fulgheri, 1994).

an IB).

## 2.3 Payoffs

**Firms** The payoff of a firm that goes public at time $t$ is assumed to be given by the following function:

$$\pi^F = \begin{cases} V(s_j, \alpha) - k[V(s_j, \alpha) - d(\alpha)] & \text{if the firm accepts} \\ d(\alpha) & \text{if the firm refuses} \end{cases} \tag{3}$$

**Investment Banks.** The underwriting activity is typically characterized by the presence of both explicit and implicit incentives. The explicit incentives are those related to the direct compensation that the IB gets for assisting the firm along the IPO process, that is, the underwriting fee. The implicit incentives are those related to the reputation that the IB acquires about its ability in providing correct information to the market. Usually, these incentives work in opposite directions. Indeed, since the compensation the IB gets from the firm is usually proportional to the success of the IPO, the IB has an incentive to inflate the value of the firm. On the other hand, this incentive is mitigated by the fear of building up a bad reputation. Indeed, a bad reputation would translate into a loss of market share in the underwriting market (and hence in a loss of future fees), since no firm would use an IB with a bad reputation. Accordingly, we assume that the payoff of an investment bank of type $IB$ sending a message $s_j$reads:

$$\pi^{IB} = \begin{cases} k[V(s_j, \alpha) - d(\alpha)] + \widehat{\alpha}_{F,s_j} & \text{if the firm accepts} \\ \widehat{\alpha}_{F,R} & \text{if the firm refuses} \end{cases} \tag{4}$$

In words, if the firm accepts to be underwritten with evaluation $s_j$, the IB's payoff consists of the fee component $k[V(s_j, \alpha) - d(\alpha)]$ and the reputational component $\widehat{\alpha}_{F,s_j}$. If instead the firm chooses to go public directly, the IB's payoff is only made of the reputational component $\widehat{\alpha}_{F,R}$ because no fee has to be paid by the firm in case it refuses to be underwritten by an IB.[7,8] Notice that $\widehat{\alpha}$ is the investors' belief about IB's ability at the end of period $t$ and can be interpreted as the new level of reputation acquired by the IB once the true value of the firm has been observed and used to assess the ability of the IB.[9]

The previous reduced form is meant to represent the trade-off that is typically faced by an IB while producing and reporting information for the market during the IPO process, where the effects of the evaluation activity persist well beyond the immediate benefits of providing untruthful information to the market.[10] In the next section we analyze how the interaction between the reputational and the fee component in the IB payoff shapes the incentives of IBs to report their private information. In this respect, our analysis introduces an additional element to the reputational cheap talk model presented by Ottaviani and Sorensen (2006) that focuses on the case in which an expert is solely concerned about his reputation.

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[7] Qualitatively, the results we derive under (4) hold for a more general payoff function that put weights on the reputational and fee components:

$$\pi^{IB} = \begin{cases} \beta k \left(V(s_j, \alpha) - d\right) + (1-\beta)\,\widehat{\alpha}_{F,s_j} & \text{if the firm accepts} \\ (1-\beta)\,\widehat{\alpha}_{F,R} & \text{if the firm refuses} \end{cases}$$

with $\beta \in [0, 1)$. Further, for our results to hold it is suficient that the payoff of the IB be a non-decreasing function of $\widehat{\alpha}$.Using (4) allows us to greatly simplify algebra without loss of generality.

[8] From the point of view of an IB, $V(s_j, \alpha)$ is a non-stochastic value. Indeed, $V(s_j, \alpha)$ depends on $s_j$, which is decided by the IB, and on $\alpha$, which is a given value at the beginning of the period in which the IB makes its evaluation. On the other hand, $\widehat{\alpha}_{F,\cdot}$ is a stochastic value, since at the moment in which evaluation $s_j$ is proposed (and eventually sent to the market), the IB does not know $F$.

[9] From a technical point of view, since the payoff of the IB (the sender) depends on the belief of investors (the receivers), our game belongs to the class of psycological games. See Battigalli and Dufwenberg (2005) for an analysis of extensive-form psychological games.

[10] This reduced form is widely adopted in many studies that model experts and managers' reputation or career concerns (see for example Holmstrom 1982, Sharfstein and Stein 1990, Dasgupta and Prat 2004 and Jackson, 2005)

# 3 Equilibrium Analysis

The equilibrium concept we use is that of perfect Bayesian equilibrium. We show that truthtelling on the part of *both* IBs is not always guaranteed and that the most informative equilibrium contains elements of both truthtelling and misreporting. It turns out that the equilibrium behavior of IBs depends crucially on the prior on firm profitability $\theta$.

We consider equilibria in which firms accept to be underwritten by IBs when receiving a positive evaluation and go public directly when receiving a bad evaluation. This assumption is without loss of generality and greatly simplifies the analysis.[11]

## 3.1 Truthtelling

We start by analyzing whether the presence of a reputational component in the IB's payoffs may induce IBs to truthtell. In truthtelling, the strategies of the good and bad IBs are such that both types of IBs report their private signal. Formally, this implies that for $IB \in \{G, B\}$ and $j \in \{h, l\}$, $\sigma_{IB}(s_j \mid S_j) = 1$.

An investment bank of type $IB$ receiving private signal $S_j$ will truthtell if and only if the expected payoff of reporting the private signal is greater than the payoff of reporting an evaluation that is different from the private signal.

Since we consider equilibria in which firms accept to be underwritten only if they receive a high evaluation, the IB gets an underwriting fee $k[V(s_j, \alpha) - d(\alpha)]$ only when proposing $s_h$. Since in equilibrium firms always refuse when receiving $s_l$, investors infer that firms going public directly received a negative evaluation and we have that $\widehat{\alpha}_{F,R} = \widehat{\alpha}_{F,s_l}$. Let us denote $V^{TT}(s_h, \alpha)$ and

[11] We consider the equilibria in which the firm refuses after $s_l$ because this allows us to obtain a well defined value for $d$ that does not depend on out of equilibrium beliefs. Although this is an arbitrary equilibrium selection criterion we can say in terms of information transmission (which is the focus of the paper) it is wlog.

$V^{TT}(s_l, \alpha)$ as the values of the firm under truthtelling when investors observe evaluations $s_h$ and $s_l$ respectively. Given the equilibrium behavior of firms it must be that $d(\alpha) = V^{TT}(s_l, \alpha)$. Clearly, when IBs truthtell $V^{TT}(s_h, \alpha) > V^{TT}(s_l, \alpha)$.

Now, consider the reputational component of the IB's payoff, $\widehat{\alpha}_{F,s_j}$. It is easy to show that given the equilibrium behavior, $\widehat{\alpha}_{F,s_j}$ can assume only the following two values:

$$
\begin{aligned}
\widehat{\alpha}_{\min} &= \widehat{\alpha}_{0,s_h} = \widehat{\alpha}_{1,s_l} \\
\widehat{\alpha}_{\max} &= \widehat{\alpha}_{1,s_h} = \widehat{\alpha}_{0,s_l}
\end{aligned}
$$

where $\widehat{\alpha}_{\max} > \alpha > \widehat{\alpha}_{\min}$. Making a correct evaluation increases the IB's reputation from its initial level $\alpha$ to the higher level $\widehat{\alpha}_{\max}$, while making a wrong evaluation decreases the IB's reputation from $\alpha$ to $\widehat{\alpha}_{\min}$. It is important to remember that $\widehat{\alpha}_{F,s_j}$ is a random variable, because the value of the firm $F$ is unknown at the moment in which the IB proposes evaluation $s_j$. The IB uses its private signal $S_j$ to update the prior about the true state of the firm, and based on this update computes the expected reputation from truthfully reporting (or misreporting) the signal. Let us denote with $E\left(\widehat{\alpha}_{F,s_j} \mid S_i, IB\right)$ the reputation that an IB of type $IB$ expects from proposing evaluation $s_j$ when receiving signal $S_i$. Since good IBs receive more informative signals than bad IBs, $E\left(\widehat{\alpha}_{F,s_j} \mid S_j, G\right) > E\left(\widehat{\alpha}_{F,s_j} \mid S_j, B\right)$.

Based on the previous discussion, IBs truthtell if for every $IB = \{G, B\}$ the following conditions are satisfied:

$$
k[V^{TT}(s_h, \alpha) - V^{TT}(s_l, \alpha)] + E\left(\widehat{\alpha}_{F,s_h} \mid IB, S_h\right) \geq E\left(\widehat{\alpha}_{F,s_l} \mid IB, S_h\right) \quad (5)
$$

$$
E\left(\widehat{\alpha}_{F,s_l} \mid IB, S_l\right) \geq k[V^{TT}(s_h, \alpha) - V^{TT}(s_l, \alpha)] + E\left(\widehat{\alpha}_{F,s_h} \mid IB, S_l\right) \quad (6)
$$

Condition (5) says that an IB that has received a high signal will truthtell if the expected payoff of sending a high evaluation (the LHS of (5)) is higher than the expected payoff of sending a low evaluation (the RHS of (5)). Condition (6) has the same interpretation for the case in which a low signal is received. Truthtelling is the optimal strategy, if both bad and good IBs expect a higher payoff from truthfully reporting the signal received (the LHS of conditions (5) and (6)) with respect to misreporting (the RHS of (5) and (6)).

**Lemma 1** *In the class of equilibria in which a firm accepts to be underwritten by an IB only when receiving $s_h$, a necessary and sufficient condition for there to be a truthtelling equilibrium is that the truthtelling conditions are satisfied for the bad IB . (proof in appendix)*

This result follows directly from the fact that the good IB has a more informative signal and therefore it assigns greater weight to the expected reputational loss of providing an incorrect evaluation. In other words, if a bad IB has a strong enough incentive to truthtell, then, *a fortiori,* this must be true for a good IB too. The lemma above allows us to focus on the truthtelling conditions of the bad IB to determine the existence of a truthtelling equilibrium, which can be conveniently written as follows:

$$k\left[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)\right] \;\geq\; E\left(\widehat{\alpha}_{F,s_l}-\widehat{\alpha}_{F,s_h}\mid B,S_h\right) \tag{7}$$
$$k\left[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)\right] \;\leq\; E\left(\widehat{\alpha}_{F,s_l}-\widehat{\alpha}_{F,s_h}\mid B,S_l\right) \tag{8}$$

Inspection of conditions (7) and (8) leads us to the following central result.

**Proposition 1** *For $k,\alpha\in(0,1)$, $z\in(\frac{1}{2},p)$ there always exist a $\underline{\theta}\in(0,1)$ and $\overline{\theta}\in(0,1)$ with $\overline{\theta}>\underline{\theta}$, such that for any $\theta\in\left[\underline{\theta},\overline{\theta}\right]$ there exists an equilibrium in which both good and bad IBs truthfully report their private information, and firms accept to be underwritten when receiving $s_h$. (Proof in appendix)*

For an intuition of the previous result, focus on the bad IB's necessary and sufficient conditions (7) and (8). When the values of the prior on firm profitability $\theta$ are relatively extreme (so that it is ex ante very likely that the actual value of the firm is either 0 or 1), the net gain from fees of reporting a high evaluation instead of a low evaluation is very small. Indeed, when $\theta$ is very low (high), the market expects the firm to be very unprofitable (profitable), regardless of the evaluation sent. Accordingly, the LHS of conditions (7) and (8) are close to zero and the choice of the bad IB is mainly driven by reputational concerns. However, since the bad IB's signal is imprecise (though informative), when $\theta$ is relatively extreme it is less confident about a signal that contradicts what indicated by a strong prior. Consider for example the case in which $\theta$ is close to 0 and the bad IB receives $S_h$. While the net fee-gain from truthfully reporting the high signal is small, the expected reputational gain of *truthtelling* is strictly *negative*, since the bad IB (which cannot count on a very precise signal) expects the low state to be more likely than the high one. Similarly, when $\theta$ is close to 1, the bad IB expects the high state to be more likely than the low one (even if the signal received is $S_l$). Accordingly, the bad IB expects that it will be more likely to be correct and to improve its reputation when sending $s_h$ instead of $s_l$.

Proposition 1 states that a truthtelling equilibrium exists only for intermediate values of $\theta$. Whenever the prior on firm value is too extreme, truthtelling is destroyed by the incentives of the bad IB to report the signal that is more likely to be correct ex-post (that is, once the value of the firm is revealed). In words, if for example common sense (represented by the prior) suggests that a firm is very likely to be highly profitable and the IB is not too confident about its low signal, then the IB is not willing to contradict common sense. This result can be interpreted as a sort of conservative and conformist behavior by the bad IB when the prior on firm profitability is too high (or too low) relative to its signal precision. The important conclusion is that this result is driven by exactly those incentives that allow truthtelling to be sustainable in a particular region of the parameter space, namely the reputational concerns of the IB.

The previous results allow us to formulate the conjecture that for extreme values of $\theta$, bad IBs may provide a negative evaluation when $\theta$ is low and a positive evaluation when $\theta$ is high. This behavior leads to informational inefficiency as the bad IB's private information on firm profitability does not reach the market and fails to be incorporated into firm values.

## 3.2 Partial pooling

We refer to Partial Pooling ($PP$) as an equilibrium in which good IBs always truthfully report their signals while bad IBs conform to the prior disregarding their private information with positive probability. In order to define the most informative equilibrium, we analyze whether Partial Pooling exists, and for which range of the parameter space $\theta$.Notice that a partial pooling equilibrium is informationally inefficient, because we are assuming that the signal received (but disregarded) by the bad IB contains some information ($z > \frac{1}{2}$). Again, we will focus on equilibria in which the firm accepts only after receiving $s_h$.

Since we focus on mixed strategy partial pooling equilibria, a straightforward interpretation of this mixed strategy equilibrium involves considering $\alpha$ to represent the percentage of good IBs within the population and $(1-\alpha)$ as the share of bad IBs. Among the IBs with the worst evaluation technology (bad IBs) a fraction of these underwriters truthfully report the evaluation of the firm they are underwriting and the remaining fraction of these chooses to misreport.

We first analyze whether a $PP$ equilibrium exists in which bad IBs truthfully report low signals with probability $\overline{q} \in (0,1)$ and always truthfully report high signals, while good IBs always truthtell. Formally this implies:

$$\begin{aligned} \sigma_{IB}(s_j \quad &| \quad S_j, G) = 1 \; \forall j \\ \sigma_{IB}(s_h \quad &| \quad S_h, B) = 1 \text{ and } \sigma_{IB}(s_l \mid S_l, B) = \overline{q} \end{aligned}$$

We refer to this equilibrium as $PP_H$ indicating the fact that bad IBs "partially" pool around the high evaluation. As conjectured above, this case should occur when the prior on firm profitability $\theta$ is particularly high, leading less informed banks to disregard their private information and to conform to the prior on firm profitability.

Since we are focusing on equilibria in which firms accept only when receiving a high evaluation, in equilibrium only $s_h$ is actually observed by investors. As in the truthtelling equilibrium, when firms go public directly investors infer that they received a negative evaluation. Thus, as for the case of truthtelling, the payoff of an IB includes the fee component, only when it provides a positive evaluation.

In this equilibrium, sending a correct evaluation always enhances the underwriter's reputation:

$$\widehat{\alpha}_{1,s_h} > \widehat{\alpha}_{0,s_h} \; and(\alpha) \; \widehat{\alpha}_{0,s_l} > \widehat{\alpha}_{1,s_l}$$

implying that IBs always have an incentive to try to correctly evaluate the firm's profitability. This incentive is reinforced by the fact that providing a correct evaluation pays more in terms of reputation when the signal reported is $s_l$ and likewise an incorrect evaluation leads to a greater reputational punishment when the evaluation is $s_h$. Another way of saying this is that there is a greater "degree" of separation in terms of the underwriter type when the market observes a low evaluation. In other words, equilibrium strategies imply that banks with better information will tend to provide low signals more frequently. Thus observing a low evaluation commands a premium in terms of reputation. It follows that:

$$\widehat{\alpha}_{0,s_l} > \widehat{\alpha}_{1,s_h} and(\alpha) \; \widehat{\alpha}_{1,s_l} > \widehat{\alpha}_{0,s_h}$$

Let us now consider the fee component of the IB's payoff and denote with, $V_H^{PP}(s_j, \alpha)$ the equilibrium value of a firm underwritten by an investment bank of reputation $\alpha$, reporting evaluation $s_j$, in the $PP_H$ equilibrium under consideration. Given the equilibrium strategies of good and bad IBs, the market infers that there is a greater chance that $s_l$ has been proposed by a good IB that has received $S_l$ rather than by a Bad IB that truthfully reports low signals less frequently (i.e. $0 < \overline{q} < 1$). As in the truthtelling equilibrium, although only evaluation $s_h$ reaches the market since the firm refuses after $s_l$, investors correctly infer that firms that go public directly received a negative evaluation and the value of the firm is computed accordingly, $d(\alpha) = V_H^{PP}(s_l, \alpha)$. Finally, the market also discounts the fact that both types of IBs have incomplete information on firm value and can therefore make mistakes. Thus although not all information reaches the market, a positive evaluation enhances the value of the firm, since $V_H^{PP}(s_h, \alpha) > V_H^{PP}(s_l, \alpha)$.

From the previous discussion, it follows that the expected payoff of an IB of type $IB$ that sends evaluation $s_h$ is:

$$k[V_H^{PP}(s_h, \alpha) - V_H^{PP}(s_l, \alpha)] + E\left(\widehat{\alpha}_{F,s_h} \mid IB, S_i\right) \qquad i = h, l \text{ and } IB = G, B$$

and for an IB that sends evaluation $s_l$ the expected payoff is:

$$E\left(\widehat{\alpha}_{F,s_l} \mid IB, S_i\right) \qquad i = h, l \text{ and } IB = G, B$$

**Lemma 2** *In the class of equilibria in which the firm accepts to be underwritten only when receiving evaluation $s_h$, a sufficient and necessary condition for the existence of a Partial Pooling Equilibrium $PP_H$ is that the bad IB is indifferent between providing a high or low evaluation when receiving $S_l$. (proof in appendix)*

This result follows directly from the fact that the good IB has a more informative signal than a bad IB and therefore assigns greater weight to the expected reputational loss of misreporting. In other words, if a bad IB is indifferent between truthtelling and misreporting when receiving a low signal on firm profitability, then, *a fortiori, a* good IB must strictly prefer to truthtell. The lemma above allows us to focus on the binding condition of the bad IB to determine the existence of the partial pooling equilibrium.

$$k[V_H^{PP}(s_h,\alpha) - V_H^{PP}(s_l,\alpha)] + E(\widehat{\alpha}_{F,s_h} \mid B, S_l) = E(\widehat{\alpha}_{F,s_l} \mid B, S_l) \qquad (9)$$

As conjectured above, this conformist behavior that leads some bad underwriters to disregard negative signals on firm profitability, occurs in situations when the prior $\theta$ on firm profitability is particularly high. This leads to the following proposition:

**Proposition 2** *When the prior on firm profitability is above a certain threshold, $\theta > \overline{\theta}_H^{pp}$, there always exists a partial pooling equilibrium ($PP_H$) in which the firm accepts to be underwritten only when receiving $s_h$, the good IB truthtells and, the bad IB truthtells when receiving a high signal ($S_h$) and is indifferent between providing a high or low evaluation when receiving a low signal ($S_l$).*

For $\theta$ above a certain threshold we can always find a $\overline{q} \in (0,1)$ that satisfies condition (9). Intuitively, the incentives to misreport by reporting a high evaluation, increase when the prior on the firm's profitability is higher. As $\theta$ increases, the bad IB becomes less confident about its low signal and about the fact that truthfully reporting its signal will prove to be correct ex-post.

What happens when the prior on the firm's profitability tends to zero? It is possible to show that when $\theta$ is below a given threshold, there exists a partial pooling equilibrium in which the good IB always truthtells and the bad IB is indifferent between reporting a low or high evaluation when receiving a high signal. We refer to this equilibrium as $PP_L$. We formalize this result in the following proposition.

**Proposition 3** *When the prior on firm's profitability is below a certain threshold, $\theta < \underline{\theta}_L^{pp}$, there always exists a partial pooling equilibrium ($PP_L$)*

*in which the firm accepts to be underwritten only when receiving $s_h$, the good IB truthtells and the bad IB truthtells when receiving a low signal ($S_l$) and is indifferent between providing a high or low evaluation when receiving a high signal ($S_h$).*

We relegate the proof of the previous result in the appendix, since the logic of the proof follows that of the $PP_H$ equilibrium. Intuitively, proposition (3) suggests that when the prior on firm profitability is very low, the bad IB is better off disregarding its private information and conforming to the public information on $\theta$. In this case, the loss in terms of fees that the IB incurs, is less than the expected loss of reputation that it suffers by underwriting a firm that is unprofitable. In other words, when private information is not complete, the underwriter will tend to attribute less weight to its signal for extreme values of public information.

Based on the previous results, we now characterize the most informative equilibrium as follows:

**Proposition 4** *The most informative equilibrium is such that: 1) for $\theta \in (0,\underline{\theta}^{TT})$ the equilibrium behavior of IBs is Partial Pooling around the low evaluation ($PP_L$) 2) for $\theta \in [\underline{\theta}^{TT},\overline{\theta}]$ the equilibrium behavior of IBs is Truthtelling ($TT$) 3) For $\theta \in (\overline{\theta}, 1)$ the equilibrium behavior of IBs is Partial Pooling around the high evaluation ($PP_H$) (to prove in the appendix)*

This confirms the initial conjecture that for extreme values of the prior on firm profitability there will be a tendency to disregard private information and confirm to the prior. For instance if public information is such that $\theta$ is very close to 1, banks with a worst evaluation technology will be reluctant to report a negative evaluation that contradicts the prior. For these extreme regions of the parameter space the most informative equilibrium is thus informationally inefficient as some of the relevant private information never reaches the market.

Since in $PP_h$ ($PP_l$) IBs are more (less) keen on bringing firms public, we define hot (cold) periods based on whether $\theta$ is greater that $\overline{\theta}$ or less than $\underline{\theta}$. An empirical implication that this result suggests is that we should expect different market behavior based on whether we are in hot periods or in cold periods. For example, we should observe that a relatively large fraction of firms that are marketed when $\theta$ is very high will be delisted subsequently as even low profit firms are brought to the market in hot periods. On the other hand, when $\theta$ is very low the opposite should occur. Thus, the set of firms that receive a positive evaluation and are marketed in a "bust" period should generally be of higher quality than those that are marketed in a "boom".

# 4 Comparative Statics

The most informative equilibrium is thus defined based on the threshold values $\underline{\theta}$, and $\overline{\theta}$ that determine the existence of the three different types of IB behavior: $PP_L$, $PP_H$ and $TT$.

In the next section we consider how each of the parameters $\alpha$,$k$, and $z$ affect the threshold values of $\theta$ that characterize the most informative equilibrium. The purpose of this section is to identify how variations in the exogenous parameters can lead to more or less efficient equilibria. We thus identify more or less efficient equilibria based on these threshold parameters in the following way. Whenever a variation in a given parameter increases the parameter space over $\theta$ for which the truthtelling equilibrium is satisfied, we have an improvement in informational efficiency. A reduction in $\overline{\theta}$ increases the parameter space for which bad IBs misreport when receiving a low signal, $S_l$ while $\underline{\theta}$ is the maximum value of $\theta$ for which $PP_L$ is sustained. It follows that a reduction in $\underline{\theta}$ diminishes the parameter space for which the bad IB misreports when receiving a high evaluation, $S_h$. Naturally the impact on overall efficiency depends on the net effect of the variation of these threshold values. Since it is not possible to explicitly characterize a solution for this net effect, we make use of numerical simulations to derive comparative statics results.[12]

### 4.1 Variations in prior reputation ($\alpha$) and in fees ($k$)

Increases in fees have an asymmetric effect on the partial pooling equilibria. Larger fees tend to reduce the chances of having equilibria in which bad IBs pool around the low evaluation, but increase the incentive to pool around the good evaluations. The intuition for this result is that an increase in the underwriting fee, raises the benefit in terms of fees of providing a positive evaluation independently from the signal received. It follows that the incentives to misreport increase when the bad IB receives $S_l$ and decrease when it observes $S_h$. Numerical simulations indicate that the former effect dominates the latter leading to a decrease in efficiency as shown in figure 1. Thus altogether the region for which all underwriters truthfully report their evaluation tends to shrink.

**Remark 1** *An increase in the IB's underwriting fee $k$ increases the range of parameters for which partial pooling $PP_H$ is sustained ($\overline{\theta}$ decreases) and reduces that for which $PP_L$ is sustained ( $\underline{\theta}$ decreases). The net effect is a reduction in informational efficiency.*

By letting initial reputation vary we obtain a different pattern.(figure 1). As initial reputation, $\alpha$ increases both $\overline{\theta}$ and $\underline{\theta}$ follow the same concave pattern. When initial reputation is close to zero both thresholds rise when the initial level of reputation increases. However, for very high levels of initial reputation the two thresholds values will decrease rapidly as $\alpha$ increases further. This result sheds new light on the findings obtained by Ottaviani and Sorensen (2006) where variations in reputation have no effect on the parame-

[12]Unless where it is explicitly mentioned, all the results are derived for $p < 1$, which implies that the good investment bank can make honest mistakes.

ter space for which truthtelling occurs.[13] Thus when adding an endogenous fee component to the reputational cheap talk model, initial reputation plays an important role in determining informational efficiency. This leads us to the following remark:

**Remark 2** *An increase in the initial IB reputation, $\alpha$ reduces (increases) the range of $\theta$ for which $PP_H$ $(PP_L)$ is sustained for $\alpha$ below a threshold $\overline{\alpha}$ and increases (reduces) that for which $PP_H(PP_L)$ is sustained for $\alpha$ above $\overline{\alpha}$.*

More specifically we now analyze the two thresholds $\overline{\theta}$ and $\underline{\theta}$ separately. If we consider $\overline{\theta}$, the incentives to pool around the high evaluation will diminish as a greater share of Investment Banks with a better evaluation technology enter the market. Nevertheless rather counterintuitively, when the market is characterized by a very large share of Good IBs (i.e. for high $\alpha$) the incentives to misreport and market firms that received a bad evaluation will rise. The intuition for this result is that reputational concerns play a greater role when there is greater uncertainty on the ability of IBs (i.e. when $\alpha = 1/2$ there is the greatest amount of uncertainty). In fact, when uncertainty on the ability of IBs is high, providing a correct or incorrect evaluation has a larger impact on the magnitude of reputation updates. On the other hand, for extreme values of initial reputation, when there is little to learn on the ability of the bank by observing whether it made a correct evaluation or not, the fee component outweighs reputational concerns increasing the incentives to misreport.

[13] Ottaviani and Sorensen (2006) analize the incentives of an informed expert to truthfully report her private information when she is solely concerned about her reputation. It is easy to show that if IBs were solely concerned about their reputation, truthtelling would hold for $\theta \in [1 - z, z]$, and the thresholds $\underline{\theta}$ and $\overline{\theta}$ would depend solely on the information technology of the bad IB. The presence of a fee component in the IB payoff implies that the thresholds $\underline{\theta}$ and $\overline{\theta}$ are functions of the information technology of the good and the bad IB, $p$ and $z$, and of the initial repuation of the IBs $\alpha$.

The same mechanism is at work when considering the $PP_L$ threshold $\underline{\theta}$. In this case however reputational concerns play a negative role since the incentives to provide a negative evaluation grow when there is more uncertainty on the ability of the underwriters. Therefore the concave shape of the dashed curves in figure 1 illustrates that for more extreme values of reputation, $\underline{\theta}$ is lower and the incentives to truthtell by correctly communicating that the firm received a positive evaluation increase.

The previous remark highlights that the net effect on informational efficiency is ambiguous since both $\overline{\theta}$ and $\underline{\theta}$ vary in the same direction as $\alpha$ increases. As can be seen in Figure 1, when initial reputation is very high or very low, informational efficiency may actually be lower than for intermediate values of $\alpha$. To translate this result into a testable empirical implication we must consider the fact that $\theta$ and $\alpha$ represent two parameters that characterize the institutional framework: the quality of the firms and that of the IBs respectively. The previous remark implies that the same level of firm quality $\theta$ is associated to different degrees of informational efficiency depending on the specific level of IB quality $\alpha$. Furthermore, since we identify hot (cold) periods based on whether $\theta$ is greater than $\overline{\theta}$ (or less than $\underline{\theta}$), the following holds: hot (cold) periods will be more (less) frequent when the underwriting market is characterized by either many well established banks or by many small new underwriters with respect to the scenario where there is greater uncertainty on IB type. Finally, the previous remark also suggest a novel explanation of IPO waves. Unlike the existing literature that focuses on firms' characteristics (Pastor and Veronesi (2005)) or market sentiment (Ping He (2007)) as determinants of IPO waves, our result suggest an alternative explanation based on the fluctuation of IBs' reputation.

## 4.2 Variations in evaluation technology

When considering underwriter technology, we let $z$ vary such that $1/2 < z \leq p < 1$, in order to observe the impact on informational efficiency of an

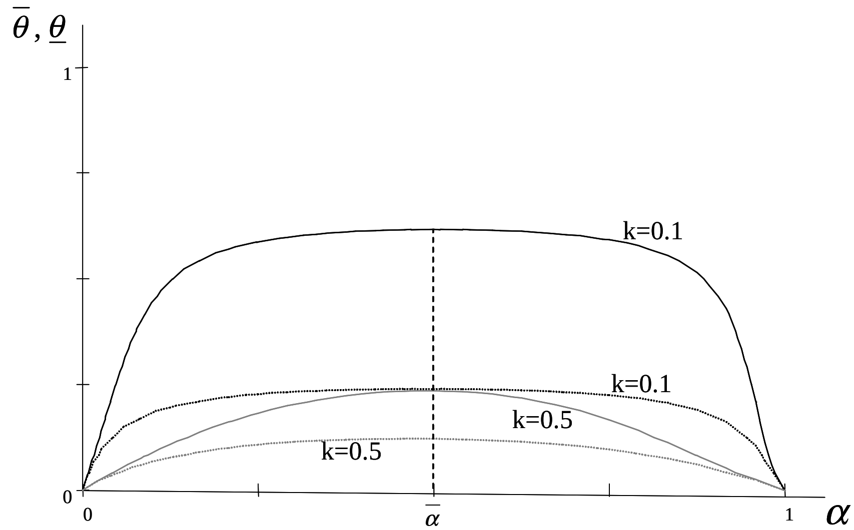


Figure 1: Relation between $\overline{\theta}$ and $\underline{\theta}$ (bold) and $\alpha$

exogenous improvement in screening technology, that reduces the ability gap between the two types of IBs.

When average firm profitability is particularly high, as the evaluation technology of the bad IB increases both: 1) the fee-benefit of providing a high evaluation increases, since it is more trusted by the market, and 2) the expected reputational gain of truthfully revealing the observed signal increases.

In the case of $PP_H$, the net effect of 1) and 2) is uncertain. As shown in figure (3), $\overline{\theta}$ initially increases indicating that the reputational gain of truthtelling is predominant. This occurs precisely because as the evaluation technology of underwriters improves they will tend to have more faith in their private information, thus assigning more weight to the fact that truthtelling may enhance reputation. Beyond a certain threshold, as the gap between the two evaluation technologies decreases, the increase in underwriter compensation offsets the increase in expected reputation of providing a correct evaluation. This occurs because as the two banks becomes similar there is less scope for reputation acquisition.

For the $PP_L$ equilibrium things are more straightforward. Both forces lead to greater incentives to truthtell and a decrease in $\underline{\theta}$. Truthfully providing a high evaluation enhances both expected reputation and underwriter compensation. These considerations lead to the following remark:

**Remark 3** *When the good IB can make evaluation mistakes ($p < 1$), reducing the distance between evaluation technologies initially increases the informational efficiency and then decreases it.*

In terms of efficiency, it is safe to say that reducing the distance between the abilities of the two types of banks initially leads to an improvement. However, after a certain threshold, as the distance between the two information technologies shrinks, $\overline{\theta}$ diminishes at a faster rate than $\underline{\theta}$ leading to a reduction in informational efficiency. Indeed, as the gap between abilities approaches zero the incentive to acquire a reputation for being a good underwriter disappears.

This suggests another empirical implication of the model, namely that for a given uncertainty on whether IBs are good or bad ($\alpha$), when the difference in ability between the good and bad banks is either very small or very large, the informational inefficiency is greater. This inefficiency should generate different empirical implications based on whether the distance between technologies is large or small.

As can be seen from figure (2) when banks have very distinct abilities (when $(p - z)$ is large) we should observe hot and cold periods to be equally likely. On the contrary, when Bad IBs have very similar evaluation technologies with respect to Good IBs (as $z \to p$) we should observe that cold periods almost never occur. Along with remark (2), this finding rather surprisingly illustrates that the occurrence of IPO waves may be influenced by the underlying structure of the underwriting market.

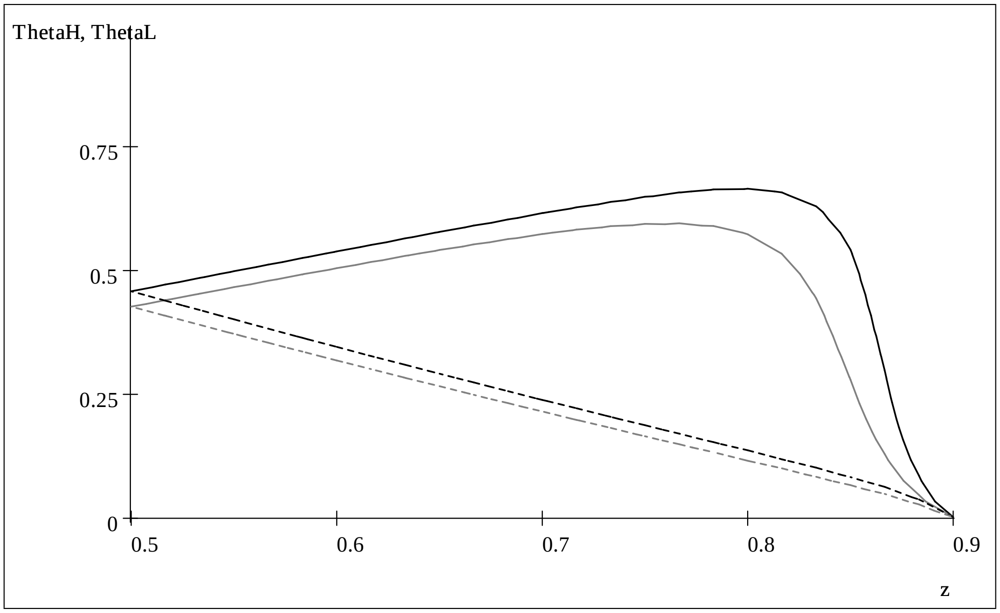

Figure (2): Relation between $\overline{\theta}$ (solid), $\underline{\theta}$ (dashed) and $z$, for $k = 0.1$ (black,) $k = 0.5$ (grey) and $p = 0.9$

## 4.3 Conclusions

In IPOs, investment banks typically have privileged information on the profitability of firms they are underwriting. They are therefore in a position to reduce the informational asymmetries between firms that are going public and investors, acting as information providers for the market. We introduce reputation to take into account of the fact that providing incorrect evaluations may hinder future profits of the underwriters by reducing their credibility. It turns out however, that in many cases IBs misreport their private information and actually profit from doing so.

Misreporting takes the form of a conformist behavior where IBs tend to disregard their private information once the public signal is extreme. Thus when investors have an ex-ante perception that firm profitability is either very high or very low, underwriters will tend to conform to the prior. In other words, hot (cold) periods occur when the prior on the profitability of firms that approach the market is high (low), leading more (less) firms to be underwritten independently of whether they are actually profitable or not.

Interestingly we obtain that the degree of heterogeneity in the ability of underwriters to evaluate firms that go public, plays a key role in determining the existence of hot and cold periods in the IPO market. More specifically our model generates the following testable empirical implications:

1) In hot periods on average we should observe a greater number of delistings since even firms that received bad evaluations are brought to the market. On the other hand, in cold periods the opposite should happen as many high quality firms may actually not be underwritten by conservative IBs. Thus, the set of firms that receive a positive evaluation and are marketed in a "bust" period should generally be of higher quality.

2) For extreme values of initial reputation, in other words when the underwriter market is characterized by either a great share of small IBs or by a great share of large well established banks we should observe more informational inefficiency with respect to market scenarios characterized by a more equal distribution of types of investment banks. This implies that hot (cold) periods will be more (less) frequent when the market is characterized by less uncertainty on the ability of the underwriters.

3) Given a certain distribution of underwriter types, when established banks and small underwriters have very distinct evaluation technologies, we should observe hot and cold periods to be equally likely. On the contrary, when Bad IBs have very similar evaluation technologies with respect to Good IBs we should observe that cold periods almost never occur.

Testing these empirical results represents an important step for future research. It is also worth noticing, that this theoretical setup may be used to analyze other markets where intermediaries play the role of information providers. In particular, the model we have presented could be extended to the real estate market, that presents very similar characteristics to the IPO market.

This theoretical framework may also be enriched to address other aspects of the IPO process. First of all, we assume that the fee structure is exogenously given. An interesting extension would be to endogenously derive underwriting fees as a contract between firms and investment banks. Furthermore in this model we have concentrated on the strategic information transmission problem faced by investment banks. Another aspect concerns the incentives firms face in disclosing information to the underwriters. Combining these aspects may provide a more complete theory of information disclosure in the IPO underwriting process.

# 5 Appendix

## 5.1 Proof of Lemma 1

**Proof.** Consider conditions (7) and (8) for the existence of a truthtelling equilibrium, rearranging terms they become:

$$\begin{aligned} k[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)] &\geq E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid G,S_h) \qquad (10)\\ k[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)] &\leq E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid G,S_l) \qquad (11)\end{aligned}$$

and

$$\begin{aligned} k[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)] &\geq E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid B,S_h) \qquad (12)\\ k[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)] &\leq E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid B,S_l) \qquad (13)\end{aligned}$$

Lemma 1 implies that (13) and (12) are necessary and sufficient conditions for the existence of a truthtelling equilibrium. Notice that the good IB has a more informative signal than the bad IB. Hence, the following inequalities hold:

$$E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid B,S_l) < E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid G,S_l)$$
$$E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid G,S_h) < E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid B,S_h)$$

This implies that conditions (11) and (10) are satisfied whenever (13) and (12) are satisfied. ■

## 5.2 Proof of Proposition 1

**Proof.** Consider conditions (13) and (12). First, consider condition (13). To ease notation, let $k[V^{TT}(s_h,\alpha)-V^{TT}(s_l,\alpha)]$ and $R^{TT}(B,s_l,S_l) \equiv E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid B,S_l)$, so that we can write this condition as follows:

$$M^{TT} \leq R^{TT}(B,s_l,S_l)$$

For every $k,\alpha \in (0,1)$ and $z \in \left(\frac{1}{2},1\right), p \in (z,1)$, the following properties are satisfied:

(i) at $\theta = 0$, $M^{TT} = 0$ and $R^{TT}(B,s_l,S_l) = \alpha_{\max} - .\alpha_{\min} > 0$ Thus, at $\theta = 0$, $M^{TT} < R^{TT}(B,s_l,S_l)$.

(ii) at $\theta = 1$, $M^{TT} = 0$ and $R^{TT}(B,s_l,S_l) = \alpha_{\min} - \alpha_{\max} < 0$. Thus, at $\theta = 1$, $M^{TT} > R^{TT}(B,s_l,S_l)$.

(iii) for $\theta \in (0,1)$, $M^{TT}$ is a continuous and strictly concave function of $\theta$, while $R^{TT}(B,s_l,S_l)$ is a continuous and strictly decreasing function of $\theta$.

(i), (ii), guarantee that there exists a value $\theta = \overline{\theta} \in (0,1)$ such that for $\theta \leq \overline{\theta}$ condition (13) is satisfied (iii) guarantees that $\overline{\theta}$ is unique.

Now consider condition (12). Again, let $M^{TT} \equiv k[V^{TT}(s_h,\alpha) - V^{TT}(s_l,\alpha)]$ and $R^{TT}(B,s_h,S_l) \equiv E(\widehat{\alpha}_{F,R}-\widehat{\alpha}_{F,s_h} \mid B,S_h)$, so that we can write this condition as follows:

$$M^{TT} \geq R^{TT}(B,s_l,S_h)$$

For every $k,\alpha \in (0,1)$ and $z \in \left(\frac{1}{2},1\right), p \in (z,1)$, the following properties are satisfied:

(iv) for $\theta = 0$, $M^{TT} = 0$ and $R^{TT}(B, s_l, S_h) = \alpha_{\max} - \alpha_{\min} > 0$. Thus, at $\theta = 0$, $M^{TT} < R^{TT}(B, s_l, S_h)$

(v) for $\theta = 1$, $M^{TT} = 0$ and $R^{TT}(B, s_l, S_h) = \alpha_{\min} - \alpha_{\max}. > 0$ Thus, at $\theta = 1$, $M^{TT} > R^{TT}(B, s_l, S_h)$

(vi) for $\theta \in (0, 1)$, $M^{TT}$ is a continuous and strictly concave function of $\theta$; $R^{TT}(B, s_l, S_h)$ is a continuous and strictly decreasing function of $\theta$.

(vi), (v), guarantee that there exists a value $\theta = \underline{\theta} \in (0, 1)$ such that for $.\theta \geq \underline{\theta}$ condition (12) is satisfied (vi) guarantees that $\underline{\theta}$ is unique.

In order to complete the proof we must show that $\underline{\theta} < \overline{\theta}$

This can easily be seen by observing that for $\theta \in (0, 1)$,for every $k, \alpha \in (0, 1)$ and $z \in \left(\frac{1}{2}, 1\right), p \in (z, 1)$, the following inequality holds:

$$R^{TT}(B, s_l, S_h) < R^{TT}(B, s_l, S_l)$$

Then, at $\theta = \underline{\theta}$ we have that

$$M^{TT} = R^{TT}(B, s_l, S_h) < R^{TT}(B, s_l, S_l)$$

Since $R^{TT}(B, s_l, S_l)$ is monotonically decreasing in $\theta$, it must be that the equality

$$M^{TT} = R^{TT}(B, s_l, S_l)$$

is satisfied for $\theta > \underline{\theta}$. ■

## 5.3 Proof of Lemma 2

**Proof.** Given the equilibrium strategies of the firm and of bad IBs, a good IB truthtells if:

$$k[V_H^{PP}(s_h, \alpha) - V_H^{PP}(s_l, \alpha)] + E(\widehat{\alpha}_{F,s_h} \mid G, S_h) \geq E(\widehat{\alpha}_{F,R} \mid G, S_h) \quad (14)$$

$$k[V_H^{PP}(s_h, \alpha) - V_H^{PP}(s_l, \alpha)] + E(\widehat{\alpha}_{F,s_h} \mid G, S_l) \leq E(\widehat{\alpha}_{F,R} \mid G, S_l)) \quad (15)$$

Since the bad IB randomizes when receiving $S_l$ we have that:

$$k[V_H^{PP}(s_h,\alpha)-V_H^{PP}(s_l,\alpha)]+E(\widehat{\alpha}_{F,s_h}\mid B,S_l)=E(\widehat{\alpha}_{F,R}\mid B,S_l) \qquad (16)$$

given the informativeness of the bad IBs signal this implies that the bad IB always truthtells when receiving $S_h$ :

$$k[V_H^{PP}(s_h,\alpha)-V_H^{PP}(s_l,\alpha)]+E(\widehat{\alpha}_{F,s_h}\mid B,S_h)>E(\widehat{\alpha}_{F,R}\mid B,S_h) \qquad (17)$$

Given the greater informativeness of the good IB's signal with respect to that of the bad IB and since (16) implies (17) it follows that (14) and (15) are both satisfied. ■

## 5.4 Proof of Proposition 2

**Proof.** Rearranging terms we can rewrite the sufficient condition (in which the bad IB always randomizes when receiving $S_l$) for the existence of the $PP_H$ equilibrium in the following way:

$$k[V_H^{PP}(s_h,\alpha)-V_H^{PP}(s_l,\alpha)]=E(\widehat{\alpha}_{F,R}\mid B,S_l)-E(\widehat{\alpha}_{F,s_h}\mid B,S_l) \qquad (18)$$

For any given values of $k,\alpha\in(0,1)$ $z\in(1/2,p),p\in(z,1)$ the following conditions hold

i) When $\theta=1$, $V_H^{PP}(s_h,\alpha)=V_H^{PP}(s_l,\alpha)=1$ and $\overline{q}=0$, $E(\widehat{\alpha}_{F,s_h}\mid B,S_l)$ $< E(\widehat{\alpha}_{F,R}\mid B,S_l)$ so the RHS is greater than the LHS

ii) When $\theta=1$, $V_H^{PP}(s_h,\alpha)=V_H^{PP}(s_l,\alpha)=1$ and $\overline{q}=1$, $E(\widehat{\alpha}_{F,s_h}\mid B,S_l)$ $> E(\widehat{\alpha}_{F,R}\mid B,S_l)$ so the LHS is greater than the RHS

iii) The RHS of (18) is continuous and strictly decreasing in $\overline{q}$

(i), (ii) and (iii) ensure that we can always find a $\overline{q}^*\in(0,1)$ such that when $\theta=1$ (18) is satisfied. In other words when $\theta=1$, if the Bad IB observes $S_l$ it will report $s_l$ with probability $\overline{q}^*$ and $s_h$ with probability $(1-\overline{q}^*)$.

At this point we are left to prove that $PP_H$ exists for values of $\theta$ above a certain threshold.

iii) at $\theta = 0$ the LHS is 0 and the RHS is $> 0$, at $\theta = 1$ the LHS is equal to 0 and the RHS is $< 0$

iv) The LHS is continuous and strictly concave in $\theta$ while the RHS is continuous and strictly decreasing in $\theta$.

v) The LHS of (18) is continuous and strictly increasing in $\overline{q}$, for $\theta \in (0,1)$ and the RHS is continuous and strictly decreasing in $\overline{q}$

(iii), (iv) and (v) imply that the lowest value of $\theta$ for which $PP_H$ exists, which we define $\overline{\theta}_H^{PP}$ corresponds to $\overline{q} \to 1$

v) Since Part 1 of the proof holds for $\overline{q} \in (\overline{q}^*, 1)$ this implies that $PP_H$ exists for all$\overline{\theta}_H^{PP} \leq \theta \leq 1$ ■

## 5.5 Proof of Proposition 3

Consider the putative (partial pooling) equilibrium in which the bad IB truthfully reports high signals with probability $\underline{q} \in (0,1)$ and always truthfully reports low signals. the good IB truthtells and the firm accepts after $s_h$ and refuses after $s_l$ . In this equilibrium, ex-post reputation $\widehat{\alpha}$ assumes the following values:

$$\begin{aligned}
\widehat{\alpha}_{0,R} &= \frac{p\alpha}{p\alpha + [z + (1-\underline{q})(1-z)](1-\alpha)} \\
\widehat{\alpha}_{1,R} &= \frac{(1-p)\alpha}{(1-p)\alpha + [(1-z) + (1-\underline{q})z](1-\alpha)} \\
\widehat{\alpha}_{1,s_h} &= \frac{p\alpha}{p\alpha + \underline{q}z(1-\alpha)} \\
\widehat{\alpha}_{0,s_h} &= \frac{(1-p)\alpha}{(1-p)\alpha + \underline{q}(1-z)(1-\alpha)}
\end{aligned}$$

Let $V_L^{PP}(s_h, \alpha)$ and $V_L^{PP}(s_l, \alpha)$ respectively denote the value of the firm when evaluation $s_h$ and $s_l$ reach the market.

In this equilibrium, since the firm accepts only after $s_h$, out of equilibrium beliefs are such that $d(\alpha) = V_L^{PP}(s_l, \alpha)$ Accordingly:

$$V_L^{PP}(s_h, \alpha) = \frac{\theta[p\alpha + \underline{q}z(1-\alpha)]}{\theta[p\alpha + \underline{q}z(1-\alpha)] + (1-\theta)[(1-p)\alpha + \underline{q}(1-z)(1-\alpha)]}$$

and

$$V_L^{PP}(s_l, \alpha) = \frac{\theta[(1-p)\alpha + (1-z)(1-\alpha)]}{\theta[(1-p)\alpha + (1-z)(1-\alpha)] + (1-\theta)[p\alpha + z(1-\alpha)]}$$

To prove the proposition we first establish the following Lemma:

**Lemma 3** *In the class of equilibria in which the firm accepts to be underwritten by an IB only after receiving $s_h$ the sufficient condition for the existence of a $PP_L$ equilibrium is*

$$kV_L^{PP}(s_h, \alpha) + E(\widehat{\alpha}_{F,s_h} \mid B, S_h) = kV_L^{PP}(s_l, \alpha) + E(\widehat{\alpha}_{F,R} \mid B, S_h)$$

**Proof.** of Lemma 3

**Good IBs' problem.** Given the equilibrium strategies of the firm and bad IBs, a good IB truthtells if:

$$k[V_L^{PP}(s_h, \alpha) - V_L^{PP}(s_l, \alpha)] + E(\widehat{\alpha}_{F,s_h} \mid G, S_h) \geq E(\widehat{\alpha}_{F,R} \mid G, S_h) \tag{19}$$
$$k[V_L^{PP}(s_h, \alpha) - V_L^{PP}(s_l, \alpha)] + E(\widehat{\alpha}_{F,s_h} \mid G, S_l) \leq E(\widehat{\alpha}_{F,R} \mid G, S_l) \tag{20}$$

Since the bad IB randomizes when receiving $S_h$ we have that:

$$k[V_L^{PP}(s_h, \alpha) - V_L^{PP}(s_l, \alpha)] + E(\widehat{\alpha}_{F,s_h} \mid B, S_h) = E(\widehat{\alpha}_{F,R} \mid B, S_h) \tag{21}$$

given the informativeness of the bad IBs signal this implies that the bad IB always truthtells when receiving $S_l$ :

$$k[V_L^{PP}(s_h, \alpha) - V_L^{PP}(s_l, \alpha)] + E(\widehat{\alpha}_{F,s_h} \mid B, S_l) < E(\widehat{\alpha}_{F,R} \mid B, S_l) \tag{22}$$

Given the greater informativeness of the good IB's signal with respect to that of the bad IB and since (21) implies (22) it follows that (19) and (20) are both satisfied. ■

Now we prove the proposition 3

**Proof.** of Proposition 3

Rearranging terms we can rewrite the sufficient condition (in which the bad IB always randomizes when receiving $S_h$) for the existence of the $PP_L$ equilibrium in the following way:

$$k[V_L^{PP}(s_h,\alpha) - V_L^{PP}(s_l,\alpha)] = E(\widehat{\alpha}_{F,R} \mid B, S_h) - E(\widehat{\alpha}_{F,s_h} \mid B, S_h) \qquad (23)$$

i) At $\theta = 0$, $V_L^{PP}(s_h,\alpha) = 0$ and $V_L^{PP}(s_l,\alpha) = 0$ when $\underline{q} = 0$, $E(\widehat{\alpha}_{F,R} \mid B, S_h) < E(\widehat{\alpha}_{F,s_h} \mid B, S_h)$ so LHS is greater than the RHS

ii) At $\theta = 0$, $V_L^{PP}(s_h,\alpha) = 0$ and $V_L^{PP}(s_l,\alpha) = 0$ when $\underline{q} = 1$, $E(\widehat{\alpha}_{F,R} \mid B, S_h) > E(\widehat{\alpha}_{F,s_h} \mid B, S_h)$ so RHS is greater than the LHS

iii) The RHS of (23) is continuous and strictly increasing in $\underline{q}$

(i), (ii) and (iii) ensure that we can always find a $\underline{q}^* \in (0,1)$ such that when $\theta = 0$ (18) is satisfied. In other words when $\theta = 0$, if the Bad IB observes $S_h$ it will report $s_h$ with probability $\underline{q}^*$ and $s_l$ with probability $(1 - \underline{q}^*)$.

At this point we are left to prove that $PP_L$ exists for values of $\theta$ below a certain threshold.

iii) at $\theta = 0$ the LHS is 0 and the RHS is $> 0$, at $\theta = 1$ the LHS is equal to 0 and the RHS is $< 0$

iv) The RHS is continuous and strictly decreasing in $\theta$ while the LHS is continuous and strictly concave in $\theta$.

v) The LHS of (23) is continuous and strictly decreasing in $\underline{q}$ and the RHS is continuous and strictly increasing in $\underline{q}$

(iii), (iv) and (v) imply the lowest value of $\theta$ for which $PP_L$ exists, which we define $\underline{\theta}_L^{PP} = \lim_{\bar{q}\to 1} \theta_L^{pp}$ corresponds to $\underline{q} \to 1$ ,

vi) Since Part 1 of the proof holds for $\underline{q}\in \left(\underline{q}^{*},1\right)$ this implies that $PP_L$ exists for $0 \leq \theta \leq \underline{\theta}_L^{PP}$ ■

## 5.6 Proof of Proposition 4

**Proof.** For any given value of $k, \alpha \in (0,1)$, $z \in (\frac{1}{2}, p)$ we have that:

(i) for every $\theta \in [\underline{\theta}, \overline{\theta}]$ truthtelling exists and by definition truthtelling is the most informative equilibrium

(ii) for $\theta \in [0, \overline{\theta}_L^{PP})$ $PP_L$ is the most informative equilibrium since pooling is the only other equilibrium in this region

(iii) $\theta \in (\overline{\theta}_H^{PP}, 1]$ $PP_H$ is the most informative equilibrium since pooling is the only other equilibrium in this region

Thus it is sufficient to prove that $\overline{\theta}_H^{pp} = \overline{\theta}$ and $\overline{\theta}_L^{pp} = \underline{\theta}$To prove this result observe that when $\overline{q} \simeq 1$ this implies that bad IBs truthtell so $V_H^{PP}(s_j, \alpha) = V^{TT}(s_j, \alpha)$ and therefore $\overline{\theta}_H^{pp} = \overline{\theta}$when $\underline{q}\simeq 1$ this implies that bad IBs truthtell so $V_L^{PP}(s_j, \alpha) = V^{TT}(s_j, \alpha)$ and therefore $\overline{\theta}_L^{pp} = \overline{\theta}$

To show that $\overline{\theta} > \underline{\theta}$ observe that $\overline{\theta}$ is the value of $\theta$ that satisfies the following condition

$$kV^{TT}(s_h, \alpha) + E(\widehat{\alpha}_{F,s_h} \mid B, S_l) = E(\widehat{\alpha}_{F,R} \mid B, S_l) \tag{24}$$

and $\underline{\theta}$ is the value that satisfies:

$$kV^{TT}(s_h, \alpha) + E(\widehat{\alpha}_{F,s_h} \mid B, S_h) = E(\widehat{\alpha}_{F,R} \mid B, S_h) \tag{25}$$

Given the informativeness of the Bad IB's signal and the fact that the RHS of both equations (24) and (25) is decreasing in $\theta$ while the LHS of both conditions is increasing in $\theta$ it follows that $\overline{\theta} > \underline{\theta}$ ■

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