

Prevention is Better than Cure: Precluding Information Acquisition in IPOs

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Abstract

We treat information acquisition by potential investors in IPOs as endogenous. With endogenous information, the critical question is why underwriters would allow investors to spend resources acquiring superior information intended solely to effect a wealth transfer. We show that institutional arrangements such as regulars, stabilization, short-selling constraints, and investment banking syndicates avoid such a wealth transfer by precluding information acquisition and the information asymmetry that would otherwise arise. We characterize the resulting outcome as one of *symmetric ignorance*.

1 Introduction

Asymmetry of information between issuers, underwriters, and investors plays a central role in the large literature on initial public offerings (IPOs) of corporate securities. Early on, Beatty and Ritter (1986) and Rock (1986) showed that asymmetric information can explain the most salient feature of IPOs, their systematic underpricing. Subsequent literature on IPO underpricing shows that it can be used to encourage informed parties to signal their information to the uninformed, that it can be used by the uninformed to screen the informed, and that it can be used to encourage the production of desirable information.¹ This literature identifies several institutional arrangements common to IPOs that reduce the extent of underpricing necessary to achieve signaling, screening, or the production of information. Examples of such arrangements include reliance on regulars, stabilization, syndication, and managing underwriters' unilateral discretion in making IPO allocations to intermediaries and investors.²

In virtually all of this literature, underpricing and related arrangements serve to *remedy* adverse selection resulting from asymmetric information. In this paper, we take information asymmetry to be a consequence of “excess search” by aggressive investors, who attempt to capture wealth from others by identifying and exploiting the errors in pricing managing underwriters inevitably make. We show that underpricing and related arrangements can be used to *preclude* the information asymmetry that would otherwise lead to adverse selection. We argue that underwriters' reliance on regulars, stabilization, syndication, and unilateral discretion over IPO allocations is consistent with information preclusion. In addition, information preclusion explains why underwriters engage in last-minute pricing and allocation, seek to impose restrictions on short-selling by both participants and nonparticipants

¹See Allen and Faulhaber (1989), Grinblatt and Hwang (1989), and Welch (1989) for signalling models of underpricing; Benveniste and Spindt (1989) and Benveniste and Wilhelm (1990) for screening models; and Sherman (2000) and Sherman and Titman (2002) for models in which information is to be produced. Related models are Benveniste, Busaba, and Wilhelm (2002) and Maksimovic and Pichler (2001).

²See Benveniste and Spindt (1989) and Sherman (2000) for an analysis of regulars; Benveniste, Busaba, and Wilhelm (1996) and Chowdhry and Nanda (1996) for that of stabilization; Chowdhry and Nanda (1996) and Pichler and Wilhelm (2001) for that of investment banking syndicates; and Benveniste and Wilhelm (1990) and Sherman (2000) for that of underwriter discretion.

in the IPO process, engage in “reciprocal participations” with syndicate members across successive IPOs, and require members of the underwriting syndicate to behave passively with respect to valuing, pricing, distributing, and stabilizing the issue.^{3,4}

To show how information asymmetry can be precluded, we consider the case of an investor who can, at a cost, acquire information about the value of a new issue. To deter the investor from doing so, the underwriter offers to sell shares at a discount. The discount is such that the investor is indifferent between i) acquiring information at a cost and then using it to “pick and choose” between over- and underpriced issues and ii) refraining from acquiring information and “buying blind” in all issues. In equilibrium, the investor acquires no information, and there is no information asymmetry. We characterize this equilibrium as one of *symmetric ignorance*.

The discount necessary to ensure the investor remains uninformed is of course costly to the issuer, and the underwriter therefore has an incentive to minimize it. The various arrangements associated with IPOs decrease the value of information to the investor by limiting his ability to profit from it. In the absence of a constraint on short selling, for example, the investor can profit by acquiring information to buy underpriced issues and short overpriced issues. With a constraint on short selling, however, the investor can only withdraw from overpriced issues and cannot profit from the inevitable downward price correction.

Our analysis of IPOs follows general work by Barzel (1977, 1982), Fama and Laffer (1971), and Hirshleifer (1971) and on the problem of “excess search” and the role of private institutions in limiting the problem.⁵ In Hirshleifer’s terms, “private foreknowledge” is information used to identify pricing errors after resource allocation is fixed. Because it results in a pure wealth transfer but is costly to

³The term reciprocal participation appears in the government’s complaint in *U.S. v. Morgan et al.* (1953), an antitrust case in which the U.S. Department of Justice sought unsuccessfully to enjoin 17 major bracket banks from monopolizing the investment banking business through this and other institutional arrangements. It refers to underwriters’ practice of regularly inviting one another to share in their offerings. See Corwin and Schultz (2004) for recent evidence of reciprocity.

⁴See Section 6 for evidence of passivity.

⁵Gondat-Larralde and James (2004) and James (2004) conduct a similar analysis. We consider Gondat-Larralde and James’s analysis of the role of regular investors in Section 4.1.

produce, it reduces social surplus. As Fama and Laffer point out, some of what can be described as “speculation” relies on private foreknowledge, and this accounts for the negative connotation sometimes given to the word “speculator.” As opposed to private foreknowledge, “discovery information” is produced prior to the time resource allocation is fixed, and because it positively affects resource allocation it generally increases social surplus. But even discovery information can be overproduced because optimal expenditures on discovery information will inevitably be subject to pricing errors that can be exploited by those who gather superior information. In cases of both fixed and variable resource allocation, then, excess search has the potential to occur, and private parties will adopt institutional arrangements to avoid the associated losses.

We proceed as follows. In Section 2, we model the maximization problem an underwriter faces when hired by an issuer to sell shares to a single investor. We begin by illustrating a simple benchmark case of “symmetric ignorance,” in which all parties have identical but imperfect information and the cost of acquiring further information is prohibitive. We then introduce adverse selection, where only the investor can acquire costly information about the after-market price of the shares.

In Section 3, we show that the parties’ joint payoff increases if the investor can commit to remaining ignorant. Even if this commitment cannot be enforced, the underwriter can ensure that the investor remains ignorant by underpricing enough to provide him with a self-enforcing rent.

In Section 4, we show that the underwriter can increase the issuer’s proceeds by adopting various institutional arrangements to raise the self-enforcing price and reduce the self-enforcing rent. These arrangements include repeat business relations with regular investors, stabilization, last-minute pricing and allocation, and short-selling constraints.

We consider the case of multiple investors and investment banking syndicates in Section 5. We note that certain investment banks are likely to be especially shrewd investors if left outside the syndicate. By inviting these rival banks to share in the offering subject to syndicate rules and

government regulations, the managing underwriter ensures they have a strong incentive to remain ignorant and to avoid spoiling the deal.

In Section 6, we discuss the available evidence in support of our analysis. A distinctive implication of our analysis is the passive behavior of non-managing syndicate participants, as the managing underwriter seeks to prevent the creation of a problem of adverse selection. This is in contrast to those authors who view syndicates as serving to remedy the problem of adverse selection. These predict that syndicate participants should be active in valuing and pricing the issue (Pichler and Wilhelm, 2001) and in stabilizing it (Chowdhry and Nanda, 1996). The available evidence clearly shows that non-managing syndicate participants are expected to behave passively.

Section 7 provides a brief discussion and some concluding remarks. The problem of excess search no doubt exists to some extent for all securities, and, in fact, for virtually all experience goods. Even in secondary security markets, where a substantial amount of the information acquired by market participants is intended to improve resource allocation, we believe many institutional arrangements can be partially explained as a response to the problem of excess search.

We would like to stress that it is not our contention that there is no information revelation in IPOs. Clearly, this is the purpose of book-building.⁶ Our contention, instead, is that where information is costly to produce and has no role in guiding investment decisions, there are benefits to devising arrangements that preclude the production of information. Thus, there should be in IPOs both information revelation and information preclusion. The information that is revealed is that produced at zero or low cost or used to guide investment decisions. The production of costly information whose sole purpose is to transfer wealth is precluded.⁷ Our argument in the present paper is that regulars, stabilization, last-minute pricing and allocation, short-selling constraints, and investment banking

⁶For extensive empirical evidence, see for example Cornelli and Goldreich (2001, 2003), Hanley (1993), and Ljungqvist and Wilhelm (2002).

⁷In an earlier version of the paper, we formalized the co-existence of information revelation and information preclusion.

syndicates may be more appropriately thought of as precluding the production of information rather than complementing book-building in inducing informed investors to reveal their information.

2 The initial setting

2.1 Simple symmetric ignorance

An issuer contracts with an underwriter to sell an issue of S shares in an IPO. Without loss of generality, we normalize S to equal one throughout most of the paper.⁸ We initially assume the underwriter approaches a single investor.⁹ We assume the issuer and the underwriter have identical incentives and that all parties are risk neutral.¹⁰

We let x denote the after-market value of the issue. We assume x ranges over the interval $[x_l, x_h]$. We further assume that x_l is the value of the issue if retained by the issuer, and normalize x_l to zero without loss of generality. Neither the issuer, the underwriter, nor the investor know x prior to the offering, although all of them know the distribution $F(\cdot)$ of x and its expectation $\bar{x} \equiv E[\tilde{x}]$.^{11,12}

With risk neutrality and symmetric ignorance, the underwriter sells the entire issue to the investor at a price $P^{si} \equiv \bar{x}$. On average, the investor receives exactly what he pays for and earns a normal return.

2.2 Asymmetric information and adverse selection

Suppose the investor can establish an informational advantage by spending c to learn the exact value of x prior to deciding whether to invest. This information provides him with a valuable option because

⁸We depart from the normalization of S in Section 4.3.

⁹We consider the case of multiple investors in Section 5.

¹⁰See Baron and Holmström (1980) and Baron (1982) for an analysis of the agency problem between issuer and underwriter.

¹¹This is the case of symmetric ignorance.

¹²We assume the cumulative distribution function $F(\cdot)$ and probability density function $f(\cdot)$ satisfy the monotone hazard property; that is, $\frac{1-F(x)}{f(x)}$ is decreasing in x .

it allows him to “pick and choose” between overpriced ($x < P$) and underpriced ($x > P$) offerings.¹³ The option to pick and choose creates a problem of adverse selection for the underwriter, who must now choose the price P to be such that,

$$\max_P [1 - F(P)] P.$$

This problem has first-order condition,

$$-f(P) P + [1 - F(P)] = 0,$$

$$\Leftrightarrow P = \frac{1 - F(P)}{f(P)}. \quad (1)$$

Denote P^{as} the solution to equation (1). The presence of adverse selection decreases the issuer’s expected proceeds, as,

$$\begin{aligned} P^{si} &= \bar{x} \\ &= \int_0^{P^{as}} x f(x) dx + \int_{P^{as}}^{x_h} x f(x) dx \\ &> \int_{P^{as}}^{x_h} P^{as} f(x) dx \\ &= [1 - F(P^{as})] P^{as}. \end{aligned}$$

Benveniste and Spindt (1989) and Benveniste and Wilhelm (1990) show that the underwriter can correct the information asymmetry by establishing a screening mechanism — book-building — to induce the investor accurately to reveal his knowledge of x . In the present context, however, screening leaves the issuer’s expected proceeds unchanged at $[1 - F(P^{as})] P^{as}$. This is because an attempt to

¹³The investor might further increase the benefit of being informed by shorting the overpriced offerings. We discuss short sales in Section 4.4.

induce the investor to reveal his knowledge of x by tying his allocation to the value of x he reveals leads to a “bang-bang” solution to the screening problem; that is, the investor buys the entire issue for values of x larger than P^{as} and nothing otherwise.¹⁴

3 Precluding information production

3.1 A commitment to symmetric ignorance

The preceding analysis has shown that the underwriter’s response to the investor’s ability to acquire information requires foregoing the sale of the issue in the cases $x < P^{as}$. The problem of adverse selection therefore prevents the parties from reaping the gains from trade that would be obtained from such sale.¹⁵ The underwriter can devise a superior arrangement, however, by offering the investor the right to buy the issue at a discount, provided the investor will commit to doing so in advance. The discount provides the investor with the same expected payoff he would receive, net of c , if he were to acquire information and pick and choose. The commitment price, P^{cm} , is such that,

$$\bar{x} - P^{cm} = E \max [x - P^{as}, 0] - c, \tag{2}$$

$$\Leftrightarrow P^{cm} = \bar{x} - E \max [x - P^{as}, 0] + c.$$

The discount, $E \max [x - P^{as}, 0] - c$, is the value of the option to pick and choose, net of search costs. As a result, the investor is indifferent between i) committing to buy at P^{cm} and ii) declining to do so, learning the exact value of x at cost c , and picking and choosing.

By precluding information production by the investor, the underwriter avoids the problem of

¹⁴For a formal analysis, see Remark 1 in the Appendix.

¹⁵This is a variant of Akerlof’s (1970) well-known result.

excess search and adverse selection. This increases the issuer's proceeds by ensuring the issue sells when $x < P^{as}$ and by avoiding c .¹⁶

3.2 A self-enforcing commitment to symmetric ignorance

The commitment solution assumes the investor can costlessly commit to buying the issue at a price of P^{cm} before spending c to learn the exact value of x . But the investor's commitment is not necessarily credible.¹⁷ In particular, suppose $P^{cm} < P^{as}$.¹⁸ From (2), this implies that,

$$E \max [x - P^{cm}, 0] - c > \bar{x} - P^{cm}. \quad (3)$$

The right-hand side of this inequality is the investor's expected payoff from honoring his commitment to buy the issue at the price P^{cm} , i.e., buying blind. The left-hand side is his expected payoff from spending c to learn x and renege on his commitment if $x < P^{cm}$, i.e., picking and choosing. The inequality indicates that the investor will prefer to learn the exact value of x and renege on his commitment if this value is low.

A remedial response by the underwriter is to make the commitment self-enforcing. This requires the issue price to be such that inequality (3) holds as an equality, making the investor indifferent between honoring the commitment, on the one hand, and spending c and renege on his commitment if x is low, on the other hand. Specifically, we define the self-enforcing price, P^{se} , to be such that the

¹⁶See Remark 2 in the Appendix.

¹⁷We assume that the underwriter's commitment to sell at a given price is made credible by its reputation. See Beatty and Ritter (1986), Beatty and Welch (1996), Booth and Smith (1986), Carter, Dark, and Singh (1998), Carter and Manaster (1990), Cooney, Singh, Carter, and Dark (1999), Habib and Ljungqvist (2001), Logue, Rogalski, Seward, and Foster-Johnson (2002), Megginson and Weiss (1991), and Nanda and Yun (1997) for an analysis of underwriter reputation.

¹⁸This would be the case if $F(x) \sim U[0, x_h]$ for example, because $P^{as} = \bar{x} > P^{cm}$ in such case.

investor's discount equals the expected value of the option to pick and choose net of search costs,

$$E \max [x - P^{se}, 0] - c = \bar{x} - P^{se}. \quad (4)$$

Note that $P^{se} < P^{cm}$ because,

$$\begin{aligned} & \frac{\partial (E \max [x - P, 0] - c - (\bar{x} - P))}{\partial P} \\ = & \frac{\partial \left(- \int_0^P (x - P) f(x) dx - c \right)}{\partial P} > 0. \end{aligned} \quad (5)$$

The investor's purchase of the issue at the price P^{se} leaves the parties' joint surplus unchanged compared to what it would be if the investor's commitment could be costlessly enforced, but it diminishes the issuer's proceeds because $P^{se} < P^{cm}$. The underwriter therefore has an incentive to increase P^{se} toward P^{cm} and decrease the self-enforcing rent $P^{cm} - P^{se}$. We discuss in Section 4 a number of arrangements that the underwriter can use for that purpose.

Before we do so, we note that there will be cases in which the production of information should not be precluded. Where c is very low, the discount that must be granted the investor to preclude him from gathering information will be so large as to favor information revelation through screening, i.e., book-building, over precluding the production of information.¹⁹ This is in line with the extensive empirical evidence on the revelation of information in book-building.²⁰ In view of such evidence, we provide testable implications to distinguish between information revelation and information preclusion in our analysis of two arrangements that have already been studied, namely regulars and stabilization.

¹⁹In the limit, when $c = 0$, the solution to (4) is $P^{se} = x_l \leq [1 - F(P^{as})] P^{as}$, where the inequality is true from the definition of P^{as} .

²⁰See for example Cornelli and Goldreich (2001, 2003), Hanley (1993), and Ljungqvist and Wilhelm (2002).

4 Self-enforcing arrangements

An important implication of the foregoing analysis is that to increase the issuer's proceeds the underwriter will adopt institutional arrangements to raise the self-enforcing price toward the commitment price. To the extent such arrangements are costly to implement and therefore imperfect we expect to find underwriters resorting to multiple complementary arrangements. In this section, we model a number of institutional arrangements common to IPOs and show that they raise the self-enforcing price. These arrangements include sale to regular investors, stabilization, last-minute pricing and share allocation, and short-selling constraints. We note that Benveniste and Spindt (1989) and Sherman (2000) provide a screening explanation for sale to regular investors and that Benveniste, Busaba, and Wilhelm (1996) provide a screening explanation for stabilization. We are unaware, however, of any prior explanation for last-minute pricing and share allocation or short-selling constraints.²¹

4.1 Regulars

Benveniste and Spindt (1989), Cornelli and Goldreich (2001), Eccles and Crane (1988), and Weiss Hanley and Wilhelm (1995) all report that sale to regular investors is a standard feature of IPOs in the U.S. and elsewhere. A regular investor is one who expects to take part in repeated IPOs and who the underwriter expects to participate whenever an invitation is extended. The expectation of repeat business permits the underwriter to spread the self-enforcing rent over the entire life of the relationship, thereby decreasing the expected rent on any given offering.

We assume the life of the relationship between the underwriter and the investor is infinite and that the investor's refusal to buy in any single offering results in termination thereafter.²² We denote the

²¹Benveniste and Wilhelm (1990) and Ljungqvist and Wilhelm (2002) provide a screening explanation for underwriter discretion. In their analysis, the underwriter exercises discretion only up to the point that it establishes a menu of prices and allocation levels to induce investors to truthfully reveal their demands. In fact, underwriters exercise unilateral discretion as to pricing and share allocation up to the moment the issue is offered for public sale.

²²Equivalently, the life of the relationship is indefinite with probability of continuation in each period equal to the per-period discount factor.

self-enforcing price to regular investors as P_{reg}^{se} and show that $P_{reg}^{se} > P^{se}$ for $\delta > 0$, where δ denotes the investor's per-period discount factor. The self-enforcing price to regulars equates the expected value of the option to pick and choose in the current period minus the cost of being informed in the current period with the present value of buying blind through all periods. The expected value of the option to pick and choose in the current period equals the greater of zero and the current-period benefit from buying an underpriced offering plus the present value of buying blind in all future periods,²³

$$E \max \left[x - P_{reg}^{se} + \frac{\delta}{1-\delta} (\bar{x} - P_{reg}^{se}), 0 \right] - c = \frac{\bar{x} - P_{reg}^{se}}{1-\delta}.$$

Using the Implicit Function Theorem, we can show,²⁴

$$\frac{\partial P_{reg}^{se}}{\partial \delta} = - \frac{\int_{P_{reg}^{se} - \frac{\delta}{1-\delta}(\bar{x} - P_{reg}^{se})}^{x_h} \left(\frac{\bar{x} - P_{reg}^{se}}{(1-\delta)^2} \right) f(x) dx - \frac{\bar{x} - P_{reg}^{se}}{(1-\delta)^2}}{- \int_{P_{reg}^{se} - \frac{\delta}{1-\delta}(\bar{x} - P_{reg}^{se})}^{x_h} \frac{1}{1-\delta} f(x) dx + \frac{1}{1-\delta}} > 0.$$

The alternative explanation for reliance on regulars is that it decreases the informational rent that must be granted informed investors to induce them to reveal information truthfully (Benveniste and Spindt, 1989). The underwriter can force the investor to subscribe to an overpriced issue by threatening to deny him participation in future IPOs. This allows the underwriter to recover part of the informational rent he grants the investor to induce him to reveal his information. Thus, Benveniste and Spindt view regulars primarily as informed investors, whereas we view them as capable of gathering information but induced to remain uninformed. The fraction of bids by regulars that take the form of "limit" bids, that is, bids that specify both price and quantity, may therefore provide the basis for a test that distinguishes between the two views.²⁵ As shown by Cornelli and Goldreich (2003), such

²³We need only consider the investor's decision to become informed in the current period. See Fundenberg and Tirole (1991, p. 159).

²⁴This is the standard result in reputational models that the per-period rent declines with the discount factor. See Klein and Leffler (1981).

²⁵Limit bids are to be contrasted with "strike" bids, which commit those placing the bids to buying a specific number of shares regardless of the issue price.

bids communicate information to the underwriter. In Benveniste and Spindt, a greater fraction of bids from regulars than non-regulars should take the form of limit bids. We predict the opposite.

Gondat-Larralde and James (2004) develop and conduct an alternative test. They combine the predictions of Benveniste and Spindt (1989) that i) shares in IPOs with zero initial returns are allocated to uninformed investors and ii) regulars are informed to obtain the testable prediction that those taking part in an offering that has zero initial returns are not regulars. They test and reject this prediction. They interpret their results as being consistent with a “block-booking” (Kenney and Klein, 1983, 2000) explanation for regulars, in which investors agree to participate in all of a bank’s IPOs as a way to commit to “remain ignorant about an [IPO’s precise] value when making their participation decision” (Gondat-Larralde and James, p. 1).

4.2 Stabilization

The underwriter can further reduce the investor’s gain from acquiring superior information and increase the owner’s expected proceeds by committing to after-market price support, or stabilization. There are two basic forms of after-market price support loosely identified in the literature as stabilization: “pure stabilization” and stabilization associated with the over-allotment of IPO shares. We model the effects of pure stabilization and discuss how they might be affected by over-allotment.²⁶

Stabilization is similar to a money-back guarantee, in which a seller agrees to repurchase its product at the original price if the product falls short of the buyer’s expectations. Specifically, a stabilized issue is one in which the underwriter repurchases the issue at the issue price, P^{se} , when the after-market value, x , is below P^{se} . We assume the underwriter then sells the repurchased issue in the stock market at the after-market value of the issue, x .

²⁶Aggarwal (2000, p. 1077) defines pure stabilization as a situation in which “an identified stabilizing bid is posted” pursuant to SEC disclosure and other requirements, not the least of which are that stabilization can continue only for a reasonable time after the offering and may not involve a price in excess of the offering price. She reports that underwriters in her data set never use pure stabilization.

Let ϕ denote the share of the issue the underwriter commits to repurchase, and let $P^{se}(\phi)$ denote the corresponding self-enforcing price with stabilization.²⁷ This price is such that the investor's option value from picking and choosing net of the cost of being informed equals the expected value of buying blind and benefiting from stabilization in the event of low after-market value, $x < P^{se}(\phi)$. Formally,

$$\begin{aligned}
& E \max [x - P^{se}(\phi), 0] - c \\
&= [1 - F(P^{se}(\phi))] E [x - P^{se}(\phi) | x \geq P^{se}(\phi)] \\
&\quad + F(P^{se}(\phi)) (1 - \phi) E [x - P^{se}(\phi) | x < P^{se}(\phi)], \\
&\Leftrightarrow -c - (1 - \phi) \int_0^{P^{se}(\phi)} (x - P^{se}(\phi)) f(x) dx = 0.
\end{aligned}$$

Using the Implicit Function Theorem, we can show that the self-enforcing price increases in the share the underwriter commits to repurchasing,

$$\frac{\partial P^{se}(\phi)}{\partial \phi} = - \frac{\int_0^{P^{se}(\phi)} (x - P^{se}(\phi)) f(x) dx}{(1 - \phi) \int_0^{P^{se}(\phi)} f(x) dx} > 0. \tag{6}$$

Stabilization raises the self-enforcing price because it reduces the loss suffered by the investor in the event of low after-market value. It thereby diminishes the investor's incentive to acquire information, which would be at least partially intended to guard against such a loss.

The increase in the self-enforcing price made possible by stabilization can be shown to dominate — at least initially — the cost of stabilization, specifically the buying at $P^{se}(\phi)$ of what has value $x < P^{se}(\phi)$.²⁸ Stabilization increases issuer expected proceeds.

When an underwriter makes stabilizing repurchases to cover an over-allotment, it transfers the repurchased shares to those investors to who were promised shares but have yet to receive them.

²⁷Equivalently, ϕ denotes the probability of stabilization where the entire issue is bought back in case stabilization does take place.

²⁸See Remark 3 in the Appendix.

Over-allotment limits the underwriter's inventory risk on repurchased shares (Hansen, Fuller, and Janjigian, 1987). From the standpoint of those investors who have their shares repurchased, the outcome is identical to pure stabilization. The two forms of stabilization would be equivalent if all investors expected to have their shares repurchased. But the underwriter discriminates between investors in making stabilizing repurchases, apparently targeting those who are in a position to acquire information, such as institutional investors (Benveniste, Erdal, and Wilhelm, 1998).

The alternative explanation for stabilization is that it commits the underwriter to communicate truthfully to investors the information he has acquired through book-building (Benveniste, Busaba, and Wilhelm, 1996). There is no benefit to the underwriter from overpricing an issue if he must buy it back from investors at the issue price. We note, however, that underwriter reputation appears to be effective at deterring underwriters from misrepresenting the information revealed in book-building, because underwriters that bring overpriced issues to market suffer both a loss in market share (Beatty and Ritter, 1986) and a decline in stock price (Nanda and Yun, 1997). The relation between underwriter reputation and stabilization may therefore provide the basis for a test that distinguishes between Benveniste et al.'s explanation for stabilization and ours. Benveniste et al. suggest that less reputed underwriters should engage in more stabilization, whereas we predict no such relation.

4.3 Last-minute pricing and allocation

One of the most curious artifacts of the IPO process is the last-minute pricing and allocation of the issue (Court Opinion, U.S. v. Morgan, p. 648; Pichler and Wilhelm, 2001; Rock, 1986).²⁹ In effect, this requires the investor to decide whether to subscribe to the issue before having been told the exact price he will pay and allocation he will receive. A decision to subscribe commits the investor

²⁹A possible explanation for the last-minute pricing of the issue is that it decreases the risk borne by the underwriter. We do not subscribe to this explanation because last-minute pricing results in the transfer of risk from the underwriter to the issuer. Surely, the issuer's ability to bear risk is lower than the underwriter's.

to accepting the price and allocation set by the underwriter as long as these do not exceed the price and quantity the investor specified in a limit bid, or the quantity the investor specified in a strike bid. By regulation, the investor has the nominal legal right to cancel an order before the end of the settlement period (Aggarwal, 2000, p. 1077) because he has not seen the final prospectus, which provides the material terms of the offer, and regulation also prohibits anyone from offering or agreeing to sell shares of a new issue prior to the effective date of the registration statement and delivery of the final prospectus. The offer price is set the night before the offer becomes effective and is stated in the final prospectus. That the underwriter can obtain the desired commitment from the investor despite such legal obstacles is due to the repeated nature of the relationship between underwriter and investor. An investor who reneges on the commitment can be excluded from further offerings. As a result, and as noted by Cornelli and Goldreich (2001, p. 2338), “it is very rare for any investor to renege on a bid.”³⁰

We show that the underwriter can increase the self-enforcing price by maintaining uncertainty about price and allocation at the time the investor decides whether to commit to the issue. This is because the investor’s decision whether to subscribe to the issue — to pick and choose — is, itself, an investment decision whose expected payoff increases with more accurate information about price and allocation.

We introduce uncertainty regarding price and allocation by assuming that the number of shares S is a random variable. The investor knows the distribution of S , $H(S)$, over the range $[S_l, S_h]$, $1 \leq S_l < S_h$, but not its exact value, which we assume is uncorrelated with x . The issuer and the underwriter know S , the allocation size. The underwriter must decide whether to adopt a policy

³⁰The investor’s ex ante commitment to participate, which is enforced by the threat of exclusion from future deals, does not violate the prohibition on offers or agreements to sell prior to the effective date because neither the solicitation of a commitment nor the commitment, itself, are legally binding. In law, to be bona fide an offer must be definite as to its material terms; otherwise, it does not give the offeree the power to bind the offeror by accepting the offer (i.e., it does not create a call option). No offer that leaves price and quantity unspecified qualifies as a bona fide legal offer. The underwriter’s attempt to induce the investor to make an unconditional commitment to buy thereby avoids giving the investor a call option. We thank the anonymous referee for alerting us and urging us to clarify this point.

of revealing S , along with the corresponding offer price, before or after the investor has made his subscription decision.

With last-minute pricing and allocation, the underwriter reveals the allocation size S and the last-minute offer price $P_{lm}^{se}(S)$ only after the investor has made his decision to subscribe to the issue. The investor must therefore form expectations of the offer price and allocation size based on his knowledge of the distribution of S when making the decision to subscribe. The expectation of the self-enforcing last-minute price, $E_S[P_{lm}^{se}(S)]$, is therefore such that,

$$E \max [E_S [S] x - E_S [P_{lm}^{se}(S)], 0] - c = E_S [S] \bar{x} - E_S [P_{lm}^{se}(S)]. \quad (7)$$

If the investor knows S when making his subscription decision, the self-enforcing price, $P^{se}(S)$, is such that,

$$E \max [Sx - P^{se}(S), 0] - c = S\bar{x} - P^{se}(S). \quad (8)$$

To explain the underwriter's preference for last-minute pricing and allocation, we show that $E_S [P_{lm}^{se}(S)] \geq E_S [P^{se}(S)]$. For that purpose, take the expectation of equation (8) to obtain,

$$E_S [E \max [Sx - P^{se}(S), 0]] - c = E_S [S] \bar{x} - E_S [P^{se}(S)].$$

Now note that,

$$\begin{aligned} & E_S [S] \bar{x} - E_S [P^{se}(S)] \\ = & E_S [E \max [Sx - P^{se}(S), 0]] - c \\ = & E [E_S \max [Sx - P^{se}(S), 0]] - c \\ \geq & E \max [E_S [S] x - E_S [P^{se}(S)], 0] - c, \end{aligned} \quad (9)$$

where the inequality is true by the convexity of $\max[\cdot]$. Combining inequalities (5) and (9) with equality (7), we find that $E_S [P_{lm}^{se}(S)] \geq E_S [P^{se}(S)]$.

4.4 Short-selling constraints

Picking and choosing is only one source of speculative gain to the investor from gathering superior information. With overpricing possible, the investor might gain further by selling short, thereby increasing the problem posed by information acquisition and reducing the self-enforcing price.³¹ To the extent the underwriter can effectively restrict short sales prior to the offering he can increase the self-enforcing price and the owner's payoff.

To see this, suppose the investor would short sell at a price P^{sh} . Absent short selling restrictions, the self-enforcing price, $P^{se}(P^{sh})$, would have to equate the investor's expected net gain from the option to buy underpriced offerings and short overpriced offerings with the expected gain from buying blind,

$$E \max \left[x - P^{se} \left(P^{sh} \right), 0 \right] + E \max \left[P^{sh} - x, 0 \right] - c = \bar{x} - P^{se} \left(P^{sh} \right),$$

$$\Leftrightarrow E \max \left[x - P^{se} \left(P^{sh} \right), 0 \right] - c - \left(\bar{x} - P^{se} \left(P^{sh} \right) \right) = -E \max \left[P^{sh} - x, 0 \right] \leq 0.$$

This inequality together with inequality (5) imply that $P^{se}(P^{sh}) \leq P^{se}$, with strict inequality for $P^{sh} > 0$. Of course, profitable short selling requires the presence of liquidity traders, because rational investors who do not know x would refuse to trade at any price $P^{sh} > 0$ (Akerlof, 1970; Milgrom and Stokey, 1982).

Short selling prior to the offering is formally restricted in several ways. First, those involved in underwriting the IPO have always been contractually prohibited from short selling by the underwriting

³¹The preceding raises the question of who will subscribe to the offering when it is overpriced. Following Rock (1986), we assume uninformed retail investors do so. Their presence constitutes an additional source of underpricing. It leaves our main results unchanged.

agreement and agreement among underwriters. Second, Mahoney (2001) reports that prior to passage of the Securities Act (1933) the Investment Bankers Association of American attempted to prevent sales in advance of public offerings and price discounting by its members even when not participating in the offering. These attempts at industry self-regulation were eventually codified into the Securities Act's statutory framework at the behest of the leading banks. The Act prohibits anyone from offering or agreeing to sell shares of a new issue prior to the effective date of the registration statement and delivery of the final prospectus. As Pichler and Stomper (2003) report, regulatory restrictions on advance trading effectively prohibit short sales prior to the issue date. Third, the New York Stock Exchange and other self-regulatory organizations require their members, which collectively include virtually all investment banks, to ensure that short sellers have the ability to deliver the security on the delivery date. This is effectively enforced by requiring the seller to borrow the share before executing the short sale agreement. Yet, borrowing shares of stock that have yet to be issued is impossible.

The managing underwriter also discourages short selling after the offering begins, among other ways by using his power to stabilize the issue to reduce the likelihood that short selling will be profitable even in the face of weaker-than-expected demand. As Harold L. Stuart of Halsey, Stuart & Co. testified in the 1953 *U.S. v. Morgan Stanley* trial, "a trading or stabilization account for a new issue is designed to protect, for one thing, against short sales by the thousands of brokers and dealers who are not members of the distribution team." Loughran and Ritter (1995) report that, even today, short selling by nonunderwriters is extremely difficult and that the amount of observed short selling is much less than for seasoned stock (Friend, Longstreet, Mendelson, Miller, and Hess, 1967, p. 228). Restrictions on flipping may also limit opportunities for short selling by restricting the supply of shares sold into the secondary market that would allow short sellers to cover their positions.

5 Multiple investors and investment banking syndicates

We now introduce multiple investors. Consider the case in which there are N investors who have costs of acquiring information $c_1 > c_2 > \dots > c_N$. Assuming the fraction of the firm sold is divided equally among the N investors, and bearing in mind that the self-enforcing price P^{se} must be such that all investors, including the investor with lowest information acquisition cost c_N , must be precluded from acquiring information, we note that the self-enforcing price is such that,

$$\begin{aligned} E \max \left[\frac{x}{N} - \frac{P^{se}}{N}, 0 \right] - c_N &= \frac{\bar{x}}{N} - \frac{P^{se}}{N}, \\ \Leftrightarrow E \max [x - P^{se}, 0] - Nc_N &= \bar{x} - P^{se}. \end{aligned} \quad (10)$$

Using the Implicit Function Theorem, we can show that $\frac{\partial P^{se}}{\partial Nc_N} > 0$. This suggests that the self-enforcing price P^{se} is maximized by selling the issue to n investors, where $n = \arg \max_{\hat{n}} \hat{n}c_{\hat{n}}$. Should $n < N$, the remaining $N - n$ investors should be prevented from taking part in the offering.

Such prevention may, however, be difficult to achieve. For example, the $N - n$ investors prevented from taking part in the offering may collude with those taking part to acquire information and share the gains from picking and choosing.³² Alternatively, the $N - n$ investors may invest through confidential nominee accounts. Picking and choosing is profitable when the offer price has been predicated on a minimum information acquisition cost of c_n , but the information acquisition cost of some investors is smaller than c_n .³³

³²The possibility for all investors to collude would change equation (10) to:

$$E \max [x - P^{se}, 0] - c_N = \bar{x} - P^{se}.$$

It reinforces the desirability of not allowing those investors with low cost of information acquisition to take part in the issue.

³³We believe it is to investors such as these that Mr. Harold L. Stuart of Halsey, Stuart, & Co. alludes to in his testimony regarding the use by underwriters of penalty bids: "... you simply had to have a [penalty] clause in order to make this business function in putting the securities on the market [because] there were many ways that shrewd people could beat the game and spoil the putting of any security on the market unless you did this." (U.S. v. Morgan Stanley, et al., 118 F. Supp. 621, 643, 1953).

Syndication has the desired effect. The managing underwriter precludes those with low costs of gathering information from participating in the offering as investors by inducing them to join the syndicate, thereby providing them with a residual share of profits from a successful offering while subjecting them to various contractual and regulatory restrictions that encourage passivity. Examples of such restrictions are the quiet period, prohibitions on pre-sale and price discounts, prospectus delivery requirements, joint-and-several liability up to each bank's pro rata share of the offering, etc.

This begs the question of why, or under what circumstances, an investor would forgo the opportunity for profitable speculation to join the syndicate and share in the underwriting residual, which is occasionally negative. For the most part, syndicate members consist of other investment banks, who clearly have expertise in valuing new issues and for whom the prospect of speculative profits is no doubt especially tempting. Our answer is that as between rival banks the speculation problem is reciprocal. All banks are in a position to manage their own offerings from time to time, in which they face the problem of excess search by outsiders. Reciprocal participation by a group of investment banks in each others' offerings is a widely recognized feature of the syndicate system (Court Opinion, *U.S. v. Morgan*, pp. 629 and 738; Corwin and Schultz, 2004). Reciprocity establishes a tit-for-tat framework to discourage speculative wealth transfers (Hoffman, McCabe, and Smith, 1998) and increase issuer proceeds.³⁴

6 Empirical evidence: Investor and underwriter passivity

We have argued that the syndicate system encourages a collective norm of symmetric ignorance, both among investors and among investment banks that act as syndicate participants. This suggests that both investors and syndicate participants are expected to behave passively when it comes to

³⁴Anand and Galetovic (2000) show that commitments of the sort can be sustained in oligopolistic markets such as investment banking.

information acquisition.

Adverse selection models predict institutional investors will acquire superior information and use it to identify and selectively participate in underpriced IPOs. Institutional investors should therefore receive large shares of such offerings, evaluated *ex post*. Consistent with our theory of symmetric ignorance and investor passivity, Weiss Hanley and Wilhelm (1995) find that institutional investors take roughly 70% of the shares in both underpriced and overpriced offerings.³⁵ What is more, Cornelli and Goldreich (2001, p. 2341) find that 80% of the bids submitted by institutional investors in book-building are strike bids, which commit those placing the bids to buying a specific number of shares regardless of the issue price. This is a clear case of institutional investor passivity.

Krigman, Shaw, and Womack (1999) report that institutions systematically flip IPOs whose future performance turns out to be poorest, suggesting that institutional investors routinely acquire costly information. The authors use the share of first-day volume sold in block trades as a proxy for flipping. Yet, underwriters view flipping more narrowly as unauthorized sales subject to penalty clauses or investor expulsion from future IPOs. Surely those shares repurchased by the underwriter as part of a price guarantee or to cover an oversold position in excess of the over-allotment option are not properly characterized as having been flipped, and the reported results may therefore be a poor reflection of information acquisition by institutional investors.

Most of the available evidence leaves little doubt that, with the exception of co-managers, syndicate members are extremely passive. The managing underwriter does not appear to solicit their input in valuing and pricing the issue.³⁶ Evidence of the passivity of non-managing syndicate participants appears in both the Brief on General Points and in the Court Opinion in *U.S. v. Morgan Stanley*. More

³⁵Aggarwal, Puri, and Prahala (2002) provide recent contrary evidence showing that institutional investors receive larger allocations where underpricing is greater. However, the “somewhat modest” (Aggarwal et al., 2002, p. 1436) 1.77% first-day return difference in favor of institutional investors suggests that any informational advantage these investors may have is correspondingly modest.

³⁶Indeed, our understanding is that, prior to the advent of book-building, the managing underwriter invited syndicate members to participate only at the last minute.

recently, Corwin and Schultz (2004, Table 4, Panel A) find that the likelihood that positive private information revealed in the book-building process is incorporated into the offer price does not depend on the number of non-managing syndicate participants.³⁷ It does, however, increase in the number of co-managers. Chen and Ritter (2000) note the passivity, or at least the non-involvement, of non-managing syndicate participants with respect to selling activity, and Ellis, Michaely, and O'Hara (2000) note the passivity of non-managing syndicate participants with respect to stabilization operations.

7 Discussion and concluding remarks

Our analysis focuses narrowly on the interests of the firm owner, the underwriter, and investors and syndicate participants. Although symmetric ignorance might be in their private interest, stock prices have welfare consequences that reach much further in the economy. One might ask why the informational problems posed by IPOs are any different than those posed by secondary market trading. Information acquisition in secondary markets is generally thought to improve resource allocation by increasing the accuracy of prices.

We have two responses to this question. First, the IPO market is somewhat unique because the firm as a going concern is being priced and sold for the first time, and information problems are therefore more acute. Unlike secondary markets, where a great deal of valuation is conditional on the most recent price, in the IPO market valuation is unconditional. This raises *ex ante* uncertainty and, at the margin, implies that the potential losses from excess search are relatively large in relation to the value of discovery information. Moreover, we believe that until an issue is properly *placed* its price is likely to be a relatively poor signal for those in the economy who hope to rely on it in making resource allocation decisions. The IPO market provides an ideal setting for studying how the problem

³⁷The results are somewhat different regarding negative private information, for which the number of non-managers appears to affect the likelihood of incorporating the information (Corwin and Schultz, 2004, Table 4, Panel B). The lack of significance of non-managers is re-established when combining positive and negative private information (Corwin and Schultz, Table 4, Panel C).

of excess search affects institutional arrangements and, more broadly, the trade-off between discovery information and private foreknowledge.

Our second response is that even if secondary securities markets are dominated by search for discovery information, the problem of excess search persists at the margin. We therefore expect our analysis to have considerable power in explaining evolved market institutions, not only for securities markets but for any experience good. For example, Barzel (1982) shows that warranties, brand names, sharing arrangements, and allocation limits preclude excess search in the market for new products.³⁸ Following Barzel (1977, 1982), Kenney and Klein (1983, 2000) show that the bygone practice of block booking first-run films by motion picture houses precluded excess search by exhibitors and facilitated self-enforcing distribution contracts. Coase (1937) argued early on that the very reason for the existence of firms is to economize on the cost of using prices, and Barzel (1982) shows in detail that organization within the firm precludes workers from inefficiently picking and choosing between sequential inputs and outputs in the production process.

We believe similar forces are at work throughout securities markets. Hansen and Khanna (1994) argue that issuers' preference for negotiated over competitive underwriting precludes redundant search in a private value setting. Cramton and Schwartz (1991) argue that corporations subject to control contests can efficiently preclude excess search in a common value setting by negotiating with a single bidder rather than by instituting an auction. More recently and more broadly, Subrahmanyam and Titman (1999) suggest that the choice between public and private financing is influenced by a trade-off between the benefits from precluding excess search where market analysts would tend to duplicate one another's efforts and the benefits from encouraging the production of serendipitous discovery information.

Mutual fund complexes have successfully lobbied the SEC for regulations that allow them to price

³⁸See Matthews and Persico (2001) for a related analysis of warranties.

and redeem mutual fund shares at “fair value,” rather than net asset value, during times of inter-market volatility. Fair-value pricing eliminates an option otherwise available to informed fund investors. Prior to the advent of fair-value pricing, informed fund investors actively exploited inter-market arbitrage opportunities that allowed them to transfer wealth from other fund investors. Because this costly information acquisition had no effect on the prices of the underlying portfolio securities, it stood to have little beneficial effect on resource allocation. Fair-value pricing helped funds avert this costly wealth transfer, in our lexicon by enforcing a group norm of symmetric ignorance.³⁹

The problem of excess search may even influence the pattern of public equity holdings between individuals and institutions. Hansen and Lott (1996) show that when two (or more) corporations’ shares are held in a common portfolio, their managers will depart from firm value maximization and will, instead, tend to maximize the utility of portfolio investors. This leads managers to mitigate externalities that would otherwise result in a costly wealth transfer between their firms. Civil lawsuits, piracy of business methods, and personnel raids are simple examples of such externalities. But along the same lines, an institutional portfolio manager committed to long-term investing will have little interest in acquiring costly information that raises the price of one portfolio security if doing so decreases the price of another portfolio security by the same or a greater amount.

In this regard, it seems plausible that the share of outstanding corporate equity held by institutions influences the relative expenditures on discovery information and private foreknowledge throughout the market. Exactly how the market achieves the optimal trade-off, if at all, is a question that must be left for further research. But the basic insight suggests that what underwriters have in mind when they emphasize the importance of properly placing an issue could have something to do with allocating IPO shares between institutional and individual investors to minimize excess search.

Finally, disclosure regulation surely influences the trade-off between discovery information and

³⁹See Chalmers, Edelen, and Kadlec (2001) for a related analysis.

private foreknowledge. Although it purports to ensure full disclosure, Mahoney (2001) shows that the Securities Act of 1933 actually prohibits certain types of disclosure that threatened the syndicate system. Two important examples were preferential price discounting and the so-called practice of “beating the gun,” in which non-managing banks disseminated information prior to the offering in an effort to pre-sell the issue. Prior to passage of the Act, rival banks apparently used discounting and pre-selling to “poach” one another’s regular investors. In the context of our analysis, both practices would have increased the option value from acquiring superior information. It is no surprise that established banking houses, whose reputations relied most heavily on survival of the syndicate system, lobbied successfully to have these practices prohibited with passage of the Act and through subsequent regulation.

Along the same lines, the SEC’s recent imposition of Regulation FD (*Fair Disclosure*) requires corporate executives to publicize all data that might move markets before disclosing it to any single analyst. This requirement has dramatically changed the nature of the relationship analysts have with corporate executives, and the anecdotal evidence suggests that it has increased the variability of earnings estimates.⁴⁰ Whether Regulation FD increases or decreases the problem of excess search on net balance is a difficult empirical question, but the analysis we present in this paper sets out a useful framework for addressing this and other important issues.⁴¹

⁴⁰See “Regulation is altering the way analysts approach their jobs,” *Wall Street Journal*, October 23, 2000.

⁴¹We note that one large issuer pending an IPO has recently sought to require independent analysts to vet their research reports with the firm prior to publicizing them. See “Orange ‘censors’ attacked,” *Financial Times*, December 21, 2000.

Appendix

Remark 1 *The screening mechanism leaves the owner's expected proceeds unchanged at $[1 - F(P^{as})] P^{as}$.*

Proof: Screening avoids adverse selection by conveying the investor's private information to the underwriter, thereby correcting the information asymmetry. The problem the underwriter faces is to offer the proper combination of allocation $\alpha(x)$ and price $P(x)$ to prevent the investor from under-reporting x to obtain an advantageous price.⁴² Formally,

$$\max_{\alpha(\cdot), P(\cdot)} \int_{x_l}^{x_h} P(x) f(x) dx, \quad (11)$$

subject to

$$x = \arg \max_{\hat{x}} \alpha(\hat{x}) x - P(\hat{x}) \quad (12)$$

and

$$\alpha(x) x - P(x) \geq 0. \quad (13)$$

Expression (12) is the investor's incentive compatibility constraint, which requires that he reveal the true value of x . Expression (13) is his individual rationality constraint, which requires that he pay no more than the value of what he receives.

The solution to such problems is well-known (Tirole, 1988; Salanié, 1997). For all values of $x > 0$, the underwriter sets the price to the investor equal to the value of what he receives less the benefit he could earn by under-reporting,

$$P^{sc}(x) \equiv \alpha^{sc}(x) x - \int_0^x \alpha^{sc}(u) du. \quad (14)$$

⁴²The remaining fraction of the issue $1 - \alpha(x)$ is retained by the issuer, to whom it has value zero.

For accurately revealing $x > 0$, the underwriter rewards the investor with an informational rent equal to,⁴³

$$\int_0^x \alpha^{sc}(u) du > 0.$$

Substituting $P^{sc}(x)$ from equation (14) into problem (11) and integrating by part, we can rewrite the underwriter's problem as,

$$\max_{\alpha(\cdot)} \int_{x_l}^{x_h} \alpha(x) \left[x - \frac{1 - F(x)}{f(x)} \right] f(x) dx.$$

The problem has solution,

$$\begin{cases} \alpha(x) = 1 \text{ for } x \geq \frac{1 - F(x)}{f(x)}, \\ \alpha(x) = 0 \text{ for } x < \frac{1 - F(x)}{f(x)}. \end{cases}$$

There is therefore “bunching,” with the price in case of sale P^{sc} equals to the lowest value of x for which a sale will take place. Thus, P^{sc} is such that,

$$P^{sc} = \frac{1 - F(P^{sc})}{f(P^{sc})}.$$

Comparing with equation (1) implies that $P^{sc} = P^{as}$.

Remark 2 *Precluding information production by the investor raises the issuer's proceeds.*

⁴³We assume the expected informational rent exceeds the cost of becoming informed; that is, $\int_0^{x_h} (\int_0^x \alpha^{sc}(u) du) f(x) dx > c$.

Proof: We have,

$$\begin{aligned}
P^{cm} &= \bar{x} - E \max [x - P^{as}, 0] + c \\
&= \bar{x} - P^{as} + P^{as} - E \max [x - P^{as}, 0] + c \\
&= E \max [x - P^{as}, 0] + E \min [x - P^{as}, 0] + P^{as} - E \max [x - P^{as}, 0] + c \\
&= F(P^{as}) E [x - P^{as} | x < P^{as}] + P^{as} + c \\
&= [1 - F(P^{as})] P^{as} + F(P^{as}) E [x | x < P^{as}] + c \\
&> [1 - F(P^{as})] P^{as}.
\end{aligned}$$

Remark 3 *The increase in the self-enforcing price made possible by stabilization dominates — at least initially — the cost of stabilization.*

Proof: The issuer's expected proceeds equal,

$$\begin{aligned}
&[1 - F(P^{se}(\phi))] P^{se}(\phi) + F(P^{se}(\phi)) [(1 - \phi) P^{se}(\phi) + \phi E [x | x < P^{se}(\phi)]] \\
&= [1 - \phi F(P^{se}(\phi))] P^{se}(\phi) + F(P^{se}(\phi)) \phi E [x | x < P^{se}(\phi)] \\
&= [1 - \phi F(P^{se}(\phi))] P^{se}(\phi) + \phi \int_0^{P^{se}(\phi)} x f(x) dx.
\end{aligned}$$

Differentiating with respect to ϕ , we obtain,

$$\begin{aligned}
&-F(P^{se}(\phi)) P^{se}(\phi) + \int_0^{P^{se}(\phi)} x f(x) dx \\
&+ [1 - \phi F(P^{se}(\phi)) + \phi P^{se}(\phi) f(P^{se}(\phi))] \frac{\partial P^{se}(\phi)}{\partial \phi}.
\end{aligned}$$

Substituting $\frac{\partial P^{se}(\phi)}{\partial \phi}$ from (6), and setting $\phi = 0$, the preceding expression becomes,

$$\begin{aligned}
& -F(P^{se}(0))P^{se}(0) + \int_0^{P^{se}(0)} xf(x)dx + \left. \frac{\partial P^{se}(\phi)}{\partial \phi} \right|_{\phi=0} \\
= & -F(P^{se}(0))P^{se}(0) + \int_0^{P^{se}(0)} xf(x)dx - \frac{\int_0^{P^{se}(0)} (x - P^{se}(0))f(x)dx}{\int_0^{P^{se}(0)} f(x)dx} \\
= & \int_0^{P^{se}(0)} (x - P^{se}(0))f(x)dx - \frac{\int_0^{P^{se}(0)} (x - P^{se}(0))f(x)dx}{\int_0^{P^{se}(0)} f(x)dx} \\
> & 0.
\end{aligned}$$

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