Primary Market Design: Mechanisms And Markets

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Abstract

We examine the interaction of two sources of information that is needed for pricing unseasoned securities: mechanisms for eliciting information directly from investors and information revelation through when-issued trading. The analysis shows that, if when-issued trading can be counted on to always reveal information, then the issuer is typically best off not pricing an issue based on *both* a mechanism and such trading. But, if when-issued trading is not fully reliable as a source of information, then allowing such trading will typically benefit issuers who otherwise rely solely on mechanism-based information gathering.

Key words:
primary security markets; mechanism design; when-issued trading
JEL classification: G32

1 Introduction

Different primary markets employ different procedures to price and allocate securities to investors. Auctions are commonly used when issuing government debt securities. Bookbuilding procedures are most commonly used in issuing equity securities. Auctions and bookbuilding are similar in that both are mechanisms for collecting information from investors. These mechanisms differ, however, in that the outcome of a typical auction is fully determined by the participants' bids, whereas bookbuilding allows informational input beyond that of the participants. This distinction is particularly important in light of the fact that many primary markets feature an additional source of information about the value of an issue: trading in when-issued markets. This trading takes place before the securities are issued and trades are cleared when, and if, the securities are issued. Prices and quotes from when-issued markets are typically known before the primary market pricing of an issue is completed.

In the U.S. there is an active when-issued market for Treasury securities. In Germany and many other European countries when-issued trading also takes place for equity issues. Evidence indicates that information revealed through such trading is incorporated into the pricing of bookbuilt issues.[1] According to one of the largest market makers in the German when-issued market for IPO shares: "By observing when-issued trading, the underwriter can gauge the market's interest in an IPO."[2] When-issued trading of equity securities is prohibited in the U.S.[3] Equity issuers in the U.S. are thus deprived of a potential source of information for determining issue prices.

The benefits of when-issued trading are, however, not undisputed. In fact, the prohibition of such trading in U.S. IPOs seems to be motivated by concerns that the trading may interfere with the ability of issuers to raise capital. Paragraph II.F. of the Securities Exchange Act Release #38067 from December 1996 states that:[4] "Such short sales [in a when-issued market] could result in a lower offering price and reduce an issuer's proceeds." One obvious

[1] Evidence presented by Aussenegg, Pichler and Stomper (2005) is discussed in the following section.

[2] This quote was taken from the website of Schnigge AG, http://www.schnigge.de/info/service/pre-ipo-trading.html. The original quote was in German: "Der Emissionsführer kann auf Grund der Handelstätigkeit im Handel per Erscheinen das Interesse des Marktes an der Neuemission messen."

[3] These markets and the regulations are discussed in more detail in the following section.

[4] The quote was found at: http://www.sec.gov/rules/final/34-38067.txt.

reason why this could happen is that short sales may simply reveal negative information about the value of IPO shares. But, this possibility can hardly be used as an argument against when-issued trading. Instead, the case for or against such trading must hinge on the *average* effect of such trading on the proceeds of securities issues.

Our objective in this paper is to analyze the average effect of when-issued trading of unseasoned securities on the primary market pricing of the securities by means of a mechanism. We focus on direct mechanisms that allow issuers to base the issue price and allocations not only on information obtained in the mechanism, but also on information revealed by post-mechanism when-issued trading. We thus pose a mechanism design problem that differs from any that we are aware of in the literature. Rather than viewing a mechanism as an entity unto itself, we model the mechanism as a component of a financial market. We allow allocations and prices to be based both on the messages that are reported in the mechanism and on information that is revealed through trading. We answer three questions: i) Can when-issued trading hamper the collection of information from investors, resulting in lower expected issue proceeds? ii) Is it beneficial for issuers to incorporate information from when-issued trading in the issue price? iii) Will issuers benefit from the existence of a when-issued market? In answering these questions we determine how when-issued trading affects the optimal mechanism for eliciting information from investors, and also how such a mechanism may affect when-issued trading.

Our analysis consists of two main parts. In the first part, we show that when-issued trading affects the structure of the optimal mechanism for gathering information directly from potential investors. This happens because the when-issued market offers outside opportunities to all parties involved, both the investors and the issuer of unseasoned securities. For investors who are polled for their private information, the market provides an opportunity to trade on information that they hold back. For the issuer, the market reveals information that can be used to validate investors' reports.

Based only on the first part of our analysis we find that when-issued trading will, for a range of parameter values, increase the cost of using a mechanism to elicit information from investors. However, we also show that this cost can be diminished if an issuer commits to base the issue price only on information obtained in the mechanism. Without such a commitment investors have incentives to "over-bid" in order to obtain allocations. Over-bidding in the context of our analysis means that an investor pretends to value the issue more than she really does. Information released through post-mechanism when-issued trading is likely to expose any pricing errors that might result from overbidding. If the issuer, however, commits to ignore such information when setting the issue price, then investors who "over-bid" are at risk of receiving over-priced securities. This insight sheds light on the common practice in U.S. Treasury issues, i.e. that such issues are priced without any informational input from post-auction when-issued trading. Our analysis suggests that this pricing policy enhances the informativeness of Treasury auctions.[5]

In the second part of our analysis, we eliminate an assumption that was imposed in the first part: the assumption that when-issued trading can always open. We instead take into account the notion that informational asymmetries between traders may hamper the forward trading of unseasoned securities. This extension of our previous analysis captures an important feature of when-issued trading of IPO shares: such trading never opens before the filing of a preliminary offering prospectus. We interpret this filing as a "jump-start" of when-issued trading through the public release of information that the underwriters obtain in prior conversations with prospective investors. We derive the structure of the optimal mechanism for such information collection, and we compare this mechanism to the optimal mechanism in the case such that when-issued trading can always open. We find that the possibility of market failure substitutes for the above-mentioned incentive effects of disregarding the when-issued market as a source of information for pricing the issue. This is because the risk of market failure exposes over-bidders to the risk of being allocated overpriced securities.

We draw on these results in order to derive a sufficient condition such that allowing when-issued trading increases the expected proceeds of a securities issue. We find that, if when-issued trading may fail, then such trading is beneficial for issuers for a wider range of parameter values than in the absence of any risk of market failure. In fact, it is only if

[5]It may also be possible to price Treasury issues based only on information released through when-issued trading, without any mechanism-based information collection. Given the nature of the long-term relationships between the U.S. Treasury and the primary dealers who bid for these securities this may not be feasible.

nonpublic information about the issue is held by sufficiently few investors that allowing when-issued trading *may* lower an issuer's expected proceeds. Otherwise, the expected proceeds are strictly higher if such trading is permitted.

This paper extends the existing literature on the design of mechanisms for pricing unseasoned securities. The paper is most closely related to recent contributions by Biais, Bossaerts and Rochet (2002) and Maksimovic and Pichler (2006) in that we examine optimal mechanisms for eliciting information directly from informed investors. Our paper differs in that we determine the form of such mechanisms in the presence of when-issued trading of the securities.[6] In this regard our work is related to analyses of auctions for Treasury securities. Back and Zender (1993) and Viswanathan and Wang (2000) model Treasury auctions; the latter paper also allows for when-issued trading. Bikchandani and Huang (1993) and Nyborg and Sundaresan (1996) discuss concerns regarding the interaction of the when-issued market and auctions for U.S. Treasury securities. Nyborg and Strebulaev (2003) analyze the optimal design of Treasury auctions that are followed by when-issued trading. The focus of their paper is on how the potential for squeezes leads to endogenous "private values" and thus affects bidders' behavior in a symmetric information framework. Our analysis concerns the optimal design of direct mechanisms for price discovery in primary markets. We allow for asymmetric information across investors in a common values framework.

In addition, our paper is related to the literature on when-issued trading of IPO shares. Cornelli, Goldreich and Ljungqvist (2005) conduct a theoretical and empirical analysis of the relation between when-issued trading and short-run and long-run returns of IPOs, with a focus on investor sentiment. Löffler, Panther and Theissen (2002) and Aussenegg, Pichler and Stomper (2005) present empirical studies of the when-issued market for German IPOs. The first paper finds that the final prices in this market are unbiased predictors of opening prices in the secondary market. The latter paper provides evidence that bookbuilding is not used to gather information once when-issued trading commences, but may be used as a source of information prior to the trading. Dorn (2002) examines this same when-issued

[6]Busaba and Chang (2002) examine bookbuilding and aftermarket trading. When-issued trading differs from aftermarket trading in that when-issued prices are revealed prior to the setting of the primary market offer price and the allocation of securities. As such, when-issued trading affects the mechanism in ways that aftermarket trading cannot.

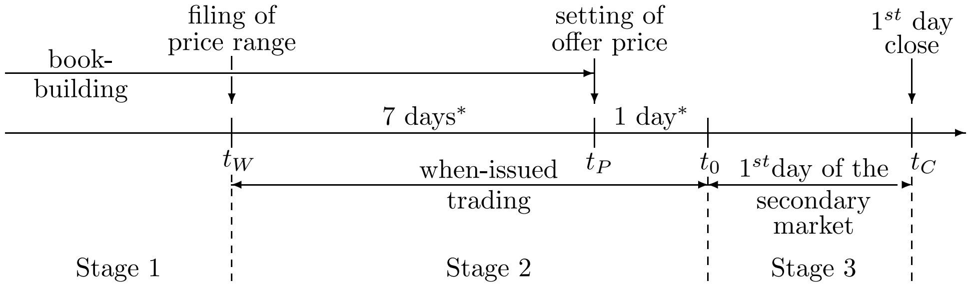
market to investigate whether sentiment drives retail participation in IPOs. Ezzel, Miles and Mulherin (2002) examine when-issued trading of shares of publicly traded subsidiaries prior to full divestiture.

The paper is organized as follows. In the next section, we provide a brief description of some existing primary markets. In the third section, we present the basic model for pricing unseasoned securities. In Section 4 we determine the optimal mechanism for eliciting information from investors, both with and without when-issued trading. In Section 5 we examine the opening of the when-issued market. In Section 6 we redo the second part of Section 4, taking into account the results of Section 5. This final analysis then enables us to answer the question: Is when-issued trading beneficial for issuers? In Section 7 we provide concluding remarks.

2 A selective survey of institutional features of primary markets

In this section, we briefly survey the structure of some primary markets, with a focus on when-issued trading. When-issued markets are forward markets for trading in not-yet-issued securities. The forward contracts represent commitments to trade when, and if, a security is issued. Net selling in these markets is, by definition, short selling. In the U.S. there is active when-issued trading of Treasury securities, but not of IPO shares. In many European markets there is when-issued trading of IPOs. In this survey we will describe one notable example, the German IPO Market.

When-issued trading of Treasury securities: Bikhchandani and Huang (1993) and Nyborg and Sundaresan (1996) describe institutional features of the primary market for U.S. Treasury securities, including the market for when-issued trading of Treasuries. The contracts in this market specify physical delivery of the underlying security. Trading of these contracts starts on the date of the announcement of a Treasury auction and continues after the auction takes place, up until the issue date. The issue price and the allocations to auction participants are determined by the bids in the auction. Information revealed by when-issued trading following the auction does not affect the issue price.



* median number of trading days during the years 1999 and 2000

Figure 1: The Neuer Markt IPO Pricing Process
Source: Aussenegg, et al. (2005)

Initial public offerings of shares: Ritter and Welch (2002), and Ritter (2002) provide surveys of the institutional structure of IPO markets. Ljungqvist, Jenkinson and Wilhelm (2003) point out that the U.S. method of IPO pricing through bookbuilding has become increasingly popular outside the U.S. Bookbuilding is similar to an auction in that information for price discovery is obtained directly from investors. In bookbuilding, however, the issuer has discretion in the pricing and allocation of securities. As such, the issue price and allocations can be based on information other than just the reports obtained from the investors in bookbuilding. This includes information revealed through when-issued trading.

When-issued trading of IPO shares: In the United States when-issued trading of IPO shares is prohibited by securities laws.[7] In contrast, IPO markets in many European countries feature when-issued trading. Many of these markets also employ bookbuilding methods, so that there are potentially two sources of information for IPO pricing: trading in the when-issued market and bookbuilding.

Aussenegg, Pichler and Stomper (2005) investigate the German IPO market which features both bookbuilding and when-issued trading. Their description of the institutional framework of this market is summarized by the timeline in Figure 1. During Stage 1 of the timeline (prior to the posting of the price range), underwriters gather information that is at least partially released when they file the preliminary offering prospectus that includes the

[7] Regulation M, Rule 105, which became effective on March 4, 1997, prohibits the covering of short positions in IPO shares that were created within the last five days before pricing, with allocations received in the IPO. This prohibition effectively prevents when-issued trading. In addition to this rule, there are also restrictions on trading in unregistered shares.

price range. When-issued trading opens at time t_W, i.e. only after the prospectus has been filed, and continues beyond the time when the underwriter sets the IPO offer price.

Aussenegg, et al. present evidence that German IPOs are priced based on information that underwriters obtain from investors in exchange for informational rents. And, they find that information about the value of IPO shares is freely available in the form of prices in the when-issued market. However, despite the informativeness of when-issued trading, it is not at all clear that such markets can be relied upon as the sole source of information for IPO pricing. For one thing, Cornelli, Goldreich and Ljungqvist (2005) show that the German IPO market stands out as the sole market in which almost all IPOs are traded on a when-issued basis; in other European markets some, but far from all, IPOs feature when-issued trading. Also, this trading never opens before the filing of preliminary offering prospectuses that are seen by practitioners as a source of information required to resolve problems of market failure.[8]

3 The Basic Model

In this section we present a simple model of security pricing as a function of the information that is available for pricing. The model captures the notion that the issuer benefits from gathering information since this reduces the discount at which the issue can be sold to retail investors. The source of the information remains unspecified for now, but it can be thought of as a mechanism and/or a when-issued market. These possibilities will be explored in later sections.

An issuer wishes to sell an exogenously given number of securities. The offering is restricted to be uniform price; that is, all investors at the offer will pay the same price. $\tilde{V}$ is the unknown secondary market value of the *total* offering: per security value times the number of securities sold. An investor who purchases securities obtains a fraction of this value. $\tilde{V}$ is given by:

$$\tilde{V} = v_0 + \tilde{s}w, \tag{1}$$

where v_0 is the prior expected value of $\tilde{V}$ and w is a positive parameter that is strictly smaller

[8] We thank Gary Beechener of Tullett & Tokyo Liberty (securities) Ltd. for providing this information.

Random variables:

$\tilde{V}$ = secondary market value $\in \{v_0 + w, v_0 - w\}$

$\tilde{s} \equiv \frac{\tilde{V} - v_0}{w} \in \{-1, 1\}$

$\tilde{\varsigma}_i$ = informed trader i's signal of $\tilde{s}$.

Exogenous parameters: (The exogenous parameters are all common knowledge)

v_0 = prior expected value of $\tilde{V}$

π_0 = prior probability that $s = 1$

w = constant (See above for $\tilde{V}$)

q = probability that $\varsigma_i = s$, i.e., that an informed investor has correct information, $1/2 < q < 1$

α = fraction of investors who are informed. $0 < \alpha < 1/2$

h_R = minimum fraction of the offering that must be allocated to retail investors

ρ = valuation parameter for liquidity traders ≥ 0

η = size of a single trade, relative to the total issue size

Other variables:

p_I = issue price

π_T = probability that $s = 1$, given all info known by issuer at time of setting price

u_{AS} = expected underpricing due to adverse selection risk

z = sum of signals reported by polled investors

$\pi(z)$ = probability that $s = 1$, given z

u^{ab} = expected underpricing, given one polled investor reports a and one reports b

h^{ab} = fraction allocated to polled investor who reports a when other reports b

w_L = impact of a lie on the expected value, without when-issued trading

w_{LT} = impact of a lie on the expected value, with when-issued trading

w_{Lb} = impact of a lie on the expected value, with when-issued trading that breaks down

ψ_L^{+b} (ψ_L^{-b}) = expected trading profit for investor who sees + (−) but reports − (+), while the other polled investor reports b

A_t (B_t) = market makers' time t quoted ask price (bid price)

$\alpha^+(z)$ = probability of an informed arrival at the open, given z and given a buyer arrived

$\alpha^-(z)$ = probability of an informed arrival at the open, given z and given a seller arrived

Table 1: Notation

than v_0. $\tilde{s}$ is a random variable that can take on one of two realizations, $s \in \{-1, 1\}$. The prior probability that $s = 1$ is $\pi_0 = 1/2$. A list of variables and their definitions is given in Table 1.

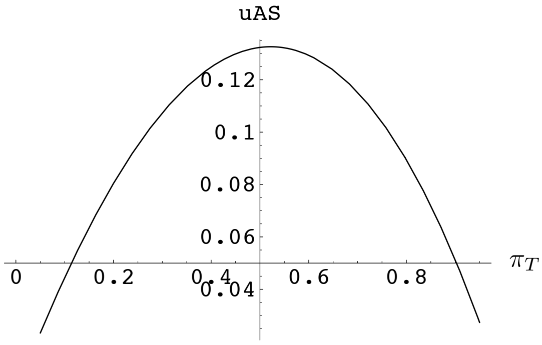
A strictly positive minimum fraction of the issue must be allocated to retail investors.[9] Retail investors include both informed and uninformed investors. Informed investors have observed noisy signals of $\tilde{s}$. The signal of investor i is a random variable $\tilde{\varsigma}_i$ that can take on one of two realizations, $\varsigma_i \in \{-1, 1\}$. Conditional on the realization of $\tilde{s}$, the signals $\tilde{\varsigma}_i$ and $\tilde{\varsigma}_j$ of any two informed investors i and j are independent of each other and identically distributed. With probability $q > 1/2$, any given informed investor has correctly observed the realization of $\tilde{s}$. For an investor who sees a positive signal, the probability that $s = 1$ is q and the probability that $s = -1$ is $1-q$, so that the expected value of $\tilde{s}$ is $q-(1-q) = 2q-1 > 0$. For an investor who sees a negative signal, the expected value of $\tilde{s}$ is $1-2q < 0$. A fraction α ($0 < \alpha < 1/2$) of all potential investors are informed. On average, a fraction $q\alpha$ of investors will have correctly observed the realization of $\tilde{s}$ and $(1-q)\alpha$ will have observed $-\tilde{s}$. Model (1) and the parameters v_0, w, α and q are all common knowledge.

All investors are risk neutral. The objective of the issuer is to maximize expected offering proceeds. We assume that the offering can only be successful if uninformed retail investors are willing to purchase securities in the primary market. This assumption implies that the issue must be underpriced since the uninformed investors are exposed to adverse selection. To see this, suppose that the securities are priced at the prior expected value, v_0. Fewer informed investors will place orders when the issue is overpriced ($s = -1$) than when it is underpriced ($s = 1$). Thus, an uninformed investor is more likely to receive an allocation if the issue is overpriced than if it is underpriced. In order to induce uninformed investors to purchase securities, the issue price, p_I, must be set so that their expected return is nonnegative:

$$p_I \leq E[\tilde{V}] - u_{AS}, \tag{2}$$

where $u_{AS} > 0$ is the a priori expected underpricing required to compensate uninformed investors for bearing adverse selection risk.

[9] Such a constraint ensures that at least some investors who do not have special relationships with the issuer are able to participate in the offering. In many primary markets there is an explicit requirement that shares be set aside for retail investors. Individual retail allocations are very small and they are awarded randomly on a first-come first-served basis.



u_{AS} versus π_T

Figure 2: Expected underpricing
$w = 1.5, \;\; q = .75, \;\; \alpha = .3$

Our model of expected underpricing due to adverse selection risk, u_{AS}, is a simplified version of the model in Rock (1986). Underpricing is a function of the information asymmetry between informed and uninformed investors, at the time of pricing. This quantity is summarized by the parameter π_T that is the probability that $s = 1$, given all of the information that is used in the primary market pricing process. The level of underpricing due to adverse selection risk, derived in the Appendix, is:

$$u_{AS} = \frac{q - 2\pi_T(1-\pi_T) - (2\pi_T - 1)^2 q}{1 - ((2\pi_T - 1)q + 1 - \pi_T)\alpha}\,\alpha w \; . \tag{3}$$

Figure 2 illustrates the relation between u_{AS} and π_T. Lemma 1 presents this relation formally. An intuitive explanation follows the lemma.

Lemma 1.

a) For all $\pi_T \leq 1/2$, u_{AS} is strictly increasing in π_T.

b) For all $\pi_T \geq q$, u_{AS} is strictly decreasing in π_T, and $u_{AS}(\pi_T) < u_{AS}(\pi_0)$.

If the issue price is based only on the prior information, then $\pi_T = \pi_0 = 1/2$. If the issue price is based on the prior information and exactly one informed investor's signal, then π_T is equal to either q ($> 1/2$) or $1 - q$ ($< 1/2$). Thus, Lemma 1 states that, if the issue is priced after obtaining information that is at least as good as that of one informed investor, then underpricing due to adverse selection risk will be lower than without the information. And, if more information is learned so that $\pi_T < 1 - q$ or $\pi_T > q$, then underpricing due to adverse selection risk will be even smaller.[10] This relation holds because, as π_T moves

[10] Note that polling two informed investors does not guarantee that the issuer will be more informed than after polling one.

closer to zero or one, there remains less asymmetry of information between informed and uninformed investors, and the latter investors are thus less exposed to adverse selection risk.

A direct implication of Lemma 1 is that gathering information prior to pricing the issue increases the expected issue proceeds, and is thus valuable for the issuer. We have up to this point, however, ignored any costs of information gathering. If a mechanism is used to elicit information directly from investors, then this may in itself lead to the issue being underpriced, due to the need to pay informational rents to investors who participate in the mechanism.

4 Optimal Mechanisms with and without When-Issued Trading

The purpose of this section is to answer the first two questions in the Introduction: Can when-issued trading hamper the collection of information from investors by means of a mechanism, resulting in lower expected issue proceeds? Is it beneficial for issuers to incorporate information from when-issued trading in the issue price? We begin by determining the optimal mechanism in the absence of when-issued trading.

4.1 The optimal mechanism without when-issued trading

We invoke the Revelation Principle and only consider mechanisms that induce each polled investor to truthfully report her type (i.e., her signal). To keep the model simple we assume that information is elicited from only two "polled" informed investors. Shares may be allocated, however, to a large number of other investors, as well as to these two investors. There are three possible outcomes for the polled investors' reports: either both report positive information, both report negative information, or one reports positive and the other negative information. We represent these outcomes with the pair $(a, b) \in \{(++), (+-), (-+), (--)\}$, where $(++)$ indicates that both polled investors reported positive information.

Information gathered through the mechanism can also be represented with a simple sufficient statistic: the number of reported positive signals minus the number of reported negative

There is a positive probability (less than 1/2) that the investors will disagree with each other, in which case the issuer will still be uninformed. This characteristic of information gathering is addressed in the following sections.

signals. We denote this difference with the parameter z. $z = 2$ corresponds to $(++)$ and $z = -2$ to $(--)$. If the polled investors' reports are the only sources of information for pricing the issue, then $\pi_T = \pi(z)$:[11]

$$\pi(z)\Big|_{z\geq 0} = \frac{q^z}{q^z + (1-q)^z} \qquad\qquad \pi(z)\Big|_{z\leq 0} = \frac{(1-q)^{|z|}}{q^{|z|} + (1-q)^{|z|}} \ . \tag{4}$$

A zero value of z indicates that the investors' reports are contradictory ($(+-)$ or $(-+)$) and, hence, overall uninformative: $\pi(0) = \pi_0 = 1/2$. Otherwise: $\pi(2) = 1 - \pi(-2) > 1/2$.

At this point we introduce some additional notation that we will use throughout the paper. If one polled investor reports a while the other reports b, then the issue price will be:

$$p_I = E[\tilde{V}|z] - u^{ab} \tag{5}$$

where u^{ab} is the expected level of underpricing, conditioned on the reports (a, b), and the relation between z and (a, b) is as given above ($z \in \{-2, 0, 2\}$). The expected value of the issue, given the reports of the polled investors, is

$$E[\tilde{V}|z] = v_0 + \frac{(z/2)(2q-1)w}{q^2 + (1-q)^2} \ .$$

If a polled investor sees positive (negative) information, but reports a negative (positive) signal, this causes z to be lower (higher) by two. Thus, a lie on the part of a polled investor changes the expected value of $\tilde{V}$, conditioned on z, by an amount w_L:

$$w_L \equiv \text{impact of a lie } = \frac{(2q-1)w}{q^2 + (1-q)^2} \ < \ w \ . \tag{6}$$

We will throughout the paper refer to w_L as the "impact of a lie". It is important to note that this is the impact on the expected value, $E[\tilde{V}|z]$. From equation (5) we can see that a lie on the part of a polled investor may also change the level of underpricing. Thus, w_L is not the impact of a lie on the price. It is rather just one component of the impact on the price. In order to determine the full impact we must solve the mechanism design problem.

Since the issue size is exogenously given, the seller's objective of maximizing expected revenue is equivalent to minimizing expected underpricing. The mechanism design problem is to determine pricing and allocation rules that are functions of the reports, (a, b), and that

[11] See the Appendix for the derivation of $\pi(z)$.

minimize the expected underpricing, subject to incentive compatibility, participation and allocations constraints:

$$\min \; E[u^{ab}] \equiv \left(\frac{q^2}{2} + \frac{(1-q)^2}{2}\right) u^{++} + 2q(1-q)u^{+-} + \left(\frac{q^2}{2} + \frac{(1-q)^2}{2}\right) u^{--} \,, \tag{7}$$

where the weights on the u^{ab}'s are the probabilities of each outcome. The objective function may also be written as:

$$\begin{aligned}
\min \; E[u^{ab}] \;&\equiv\; Er^R + Er^+ + Er^- \,, && (8)\\
\text{where} \quad Er^+ \;&=\; \text{expected return to a polled investor who sees and reports } + \\
&=\; \left(q^2 + (1-q)^2\right) u^{++}h^{++} + 2q(1-q)u^{+-}h^{+-} \,, && (9)\\
Er^- \;&=\; \text{expected return to a polled investor who sees and reports } - \\
&=\; \left(q^2 + (1-q)^2\right) u^{--}h^{--} + 2q(1-q)u^{+-}h^{-+} \,, && (10)\\
Er^R \;&=\; \text{expected return to retail investors (nonpolled investors)} \\
&=\; \left(\frac{q^2}{2} + \frac{(1-q)^2}{2}\right) u^{++}(1-2h^{++}) + \left(\frac{q^2}{2} + \frac{(1-q)^2}{2}\right) u^{--}(1-2h^{--}) \\
&\quad\; + 2q(1-q)u^{+-}(1-h^{+-}-h^{-+}) \,, && (11)
\end{aligned}$$

and where h^{ab} is the fraction of the offering that is allocated to a polled investor who reports a while the other reports b. Writing the objective function in this way emphasizes the fact that underpricing represents wealth that is transferred from the seller to the buyer of the securities. The objective function is minimized by choosing the values of u^{ab} and h^{ab} subject to the following constraints.

Participation constraints: Investors who participate in the mechanism must earn positive expected returns:[12]

$$u^{ab} \geq 0 \qquad \forall u^{ab} \in \{u^{++}, u^{+-}, u^{--}\} \,. \tag{$PC-I$}$$

[12]Satisfying this constraint means that the seller does not overprice the securities in expected value, conditioned on the information that is learned through the mechanism. We could also introduce an a priori strictly positive participation constraint: $(Er^+ + Er^-)/2 \geq \gamma > 0$. This would increase the cost of information gathering in the absence of when-issued trading, and so would only strengthen our results.

Incentive compatibility constraints: Investors will truthfully report their information, as long as the following incentive compatibility constraints are satisfied:

$$Er^{+} \geq \left(q^2 + (1-q)^2\right)\left(u^{+-} + w_L\right) h^{-+} + 2q(1-q)\left(u^{--} + w_L\right) h^{--}\,, \qquad (IC^{+})$$

$$Er^{-} \geq \left(q^2 + (1-q)^2\right)\left(u^{+-} - w_L\right) h^{+-} + 2q(1-q)\left(u^{++} - w_L\right) h^{++}\,, \qquad (IC^{-})$$

where Er^{+} and Er^{-} are as given in (9) and (10). Referring to equation (5) and the discussion below this equation, $u^{ab}+w_L$ in (IC^{+}) is the difference between the polled investor's expected value of the asset and the issue price, if the investor gives a false negative report. If the investor instead gives a false positive report (over-bids), then $u^{ab} - w_L$ in (IC^{-}) is the difference between the polled investor's expected value of the asset and the issue price. We know from equations (6) and $(PC-I)$ that $u^{ab} + w_L$ is strictly positive, but $u^{ab} - w_L$ may be strictly negative. As such, the terms $+w_L$ in (IC^{+}) represent an incentive for investors to falsely report negative information, while the terms $-w_L$ in (IC^{-}) represent a "stick" that discourages investors from falsely reporting positive information. In writing the incentive compatibility constraints we have assumed that a polled investor cannot refuse an allocation as long as $(PC-I)$ is satisfied.[13] Thus, sending an overly positive report exposes an investor to the risk of receiving an over-priced allocation. For this reason, (IC^{-}) will not be binding. This is one aspect of the mechanism design problem that may change in the presence of when-issued trading.

Participation of retail investors: The issue must be priced so that uninformed investors are compensated for bearing adverse selection risk:[14]

$$u^{++} \geq u_{AS}(2),\;\; u^{+-} \geq u_{AS}(0),\;\; u^{--} \geq u_{AS}(-2)\,. \qquad (PC-R)$$

u_{AS}, introduced in Section 3, is the expected underpricing due to adverse selection risk. We use the notation $u_{AS}(z)$ to indicate that this expected underpricing is a function of the

[13] In Treasury auctions and in some IPO markets investors are legally bound to purchase allocations. In U.S. IPOs investors are typically not legally bound to purchase allocations, but polled investors and intermediaries who assist in issuing securities are typically engaged in repeated interactions. There are thus reputational reasons for not refusing an allocation.

[14] Investors who participate in the mechanism do not face an adverse selection risk, because their allocations are based only on the reported information, not on any information that may still reside with other investors. For this reason, the constraint $(PC-I)$, which requires only nonnegative underpricing, is sufficient to ensure the participation of the polled investors.

information obtained through the mechanism. From the proof of Lemma 1 in the Appendix:

$$u_{AS}(0) = \left(\frac{2q-1}{2-\alpha}\right)\alpha\, w \tag{12}$$

Allocation constraints: The allocation to each polled investor, h^{ab}, is constrained from below by a nonnegativity condition and from above by the requirement that the issue not be overallocated:

$$h^{ab} \geq 0\,, \qquad h^{--}, h^{++} \leq \frac{1-h_R}{2} \qquad \text{and} \qquad h^{+-} + h^{-+} \leq 1 - h_R\,,$$

where $h_R \in (0,1)$ is the minimum fraction of the issue that must be allocated to retail investors.

The optimal mechanism: It is shown in the Appendix that, without when-issued trading: 1) positive expected underpricing is required in each state, due to residual adverse selection risk (adverse selection risk remaining after the polled investors' reports are incorporated into the public information set), and 2) no further underpricing is needed in order to induce truthful reporting on the part of the polled investors.[15] Thus,

$$E[u^{ab}]\Big|_{no\ when\text{-}issued\ trading} = E[u_{AS}(z)] = \\ \left(\frac{q^2+(1-q)^2}{2}\right)u_{AS}(-2) + 2q(1-q)u_{AS}(0) + \left(\frac{q^2+(1-q)^2}{2}\right)u_{AS}(2)\,. \tag{13}$$

The allocation policy in the optimal mechanism calls for a polled investor to receive the maximum possible allocation when she reports positive information, and no allocation otherwise. This mechanism is similar to a standard auction in that more securities are allocated to the investors who report more positive information about the security value. The constraints $(PC-R)$ are strictly binding; the incentive compatibility constraints are not binding. Satisfying the $(PC-R)$ constraints results in strictly positive expected underpricing in every state. A polled investor thus expects to earn a strictly positive return when she has observed positive information, and a zero return otherwise. We will refer to the mechanism described here as the **benchmark mechanism.**

[15] This follows directly from Maksimovic and Pichler (2006). They model a mechanism without when-issued trading and show that, in the absence of constraints that require a strictly positive number of shares always be allocated to polled investors, underpricing is not needed to induce truthtelling.

4.2 The optimal mechanism with when-issued trading

We now analyze how the introduction of when-issued trading changes the mechanism-based pricing of securities issues. As outlined in Section 2, in some markets when-issued trading takes place both before and after the mechanism, whereas in others it takes place only after the mechanism. In our analysis of the optimal mechanism we will be concerned only with when-issued trading after the mechanism.[16] We assume that any information that may have been revealed by when-issued trading prior to the mechanism has been incorporated into the model parameters, such as the prior expected value (v_0) and the extent of uncertainty (w). We thus assume a sequence of events that is similar to that illustrated in Figure 1. First, the issuer elicits information directly from polled investors, and the outcome is publicly revealed.[17] After that the when-issued market opens.

IPO and Treasury markets differ in that when-issued trading can directly affect the pricing of IPOs, but not that of Treasury issues. In the analysis below we will consider both of these cases, and will address the question of whether an issuer should optimally commit to base the offer price only on information that is revealed through the mechanism.

In the first case, it will be assumed that the pricing of the issue takes place after a period of when-issued trading, as is done in European IPO markets. The trading will thus provide informational input to the pricing process, along with the outcome of mechanism-based information gathering, z. In the second case, the when-issued trading will be ignored as a source of information for pricing the issue, and the value of z (i.e., the reports supplied by the mechanism participants) will fully determine the offer price and allocations.

Case 1: In this case the retail investors will observe the when-issued prices before they agree to purchase securities. Letting J_T represent the information earned from trading in the when-issued market, we now rewrite equation (5):

$$p_I = E[\tilde{V}|z, J_T] - u^{ab}. \tag{14}$$

[16]This is sufficient since we want to establish whether when-issued trading can be detrimental for the issuer. It is clear that the issuer benefits from any publicly observable release of information through trading before mechanism-based information collection. See Milgrom and Roberts (1982) for an analysis of this effect in auction theory.

[17]The public release of information can take the form of a public announcement of the outcome of an auction or the filing of an offering prospectus.

Conditioning on J_T reduces the effect of a false report on the expected value of the issue, $E[\tilde{V}|z, J_T]$. As discussed in Section 4.1, false reporting by a polled investor changes the value of z by ± 2. We define w_{LT} as the resulting change in $E[\tilde{V}|z, J_T]$. This can be compared to the impact of a lie in Section 4.1. In general, $w_{LT} < w_L$ since, upon sending a false report, a polled investor is likely to be contradicted by information revealed through when-issued trading.

We derive the optimal mechanism under the assumption that the issue is priced after the when-issued market reveals the private information of all traders. Thus, $w_{LT} = 0$. A second effect of the assumption is that there will be no remaining adverse selection risk. Therefore, the $(PC - R)$ constraints change in that it is only necessary that $u^{ab} \geq 0$. I.e., participation of retail investors now simply requires that the issue not be overpriced.[18]

Incentive compatibility constraints: Given that when-issued trading will follow the polled investors' reports and precede the pricing of the issue, the polled investors will truthfully report their information only if the following incentive compatibility constraints are satisfied:[19]

$$Er^+ \geq \left(q^2 + (1-q)^2\right)((u^{+-} + w_{LT})h^{-+} + \psi_L^{++}) + 2q(1-q)((u^{--} + w_{LT})h^{--} + \psi_L^{+-}) \quad (IC_T^+)$$

$$Er^- \geq \left(q^2 + (1-q)^2\right)((u^{+-} - w_{LT})h^{+-} + \psi_L^{--}) + 2q(1-q)((u^{++} - w_{LT})h^{++} + \psi_L^{-+}) \quad (IC_T^-)$$

As in (IC^+) and (IC^-), Er^+ and Er^- are given in (9) and (10). The constraints (IC_T^+) and (IC_T^-) differ from (IC^+) and (IC^-) in two ways.[20] First, the impact of a lie on the expected value of the issue is lower: $w_{LT} < w_L$. Second, the right-hand side of each constraint includes the expected profit that informed investors can earn by trading on their information: ψ_L^{+b} (ψ_L^{-b}) denotes the expected trading profit for an investor who sees + (−) but reports − (+), while the other polled investor reports b. Truthful reporting deprives the polled investors of

[18] The original (PC-R) constraints required that the issue be strictly underpriced, due to adverse selection risk.

[19] The participation constraints will also change in that the right-hand-side will be strictly positive, instead of zero. Er^+ and Er^- must both be at least as large as expected trading profits, given that the investor doesn't participate. The new participation constraints will be satisfied as long as the new incentive compatibility constraints are satisfied. Thus, the participation constraints are nonbinding and can be ignored.

[20] For ease of exposition, the analysis of a third change in the incentive compatibility constraints is relegated to the Appendix. In the proof of Proposition 1 we allow underpricing in the constraints (IC_T^+) and (IC_T^-) to be conditioned on information from when-issued trading, in addition to the reports from the polled investors.

any profits they could otherwise earn by trading on private information in the when-issued market; this is a consequence of the assumption that information reported in the mechanism is publicly revealed prior to the opening of when-issued trading.

The optimal mechanism for case 1: The benchmark mechanism described in Section 4.1 does not satisfy the new incentive compatibility constraints. To see this, consider an informed investor with negative information about the value of the issue. If the investor is truthful, then she can earn no informed trading profits, and under the benchmark mechanism she receives no allocation. However, if she lies (over-bids) she can profit from trading on private information, and she receives an allocation. In addition, when-issued trading will expose any overpricing that could result from her over-bidding. Because the issue cannot be overpriced relative to information from when-issued trading, the "stick" that induced her to be truthful under the benchmark mechanism is eliminated. (This stick, described at the top of page 14, was the possibility of being allocated overpriced shares following over-bidding.)

The following proposition summarizes how when-issued trading changes the optimal mechanism. A discussion follows the proposition.

Proposition 1.

1. ***The optimal mechanism in the presence of when-issued trading*** *is qualitatively different from the optimal mechanism without when-issued trading. The optimal mechanism in the presence of when-issued trading has the following characteristics:*
   - *(a) The incentive compatibility constraints are strictly binding.*
   - *(b) Rents must be paid in order to induce truthful reporting, both to polled investors with positive and with negative information.*
   - *(c) Securities are allocated to polled investors whose reports are consistent with information revealed by the when-issued market, regardless of whether the information is positive or negative. No allocations are awarded to those whose reports are contradicted.*
2. *Allowing when-issued trading can increase the expected underpricing.*

In contrast to the benchmark case, the optimal mechanism must provide incentives for truthtelling, both to investors with positive and investors with negative information. Part

1.(c) of the proposition points out that in doing so the issuer can take advantage of the fact that the when-issued market partially reveals whether a polled investor has lied. Thus, the optimal mechanism differs from a standard auction in two ways: i) The price and allocations depend on information received from polled investors in the mechanism *and* on information revealed through when-issued trading. ii) Securities are not necessarily allocated to the investor who reported a more positive valuation.

Part 2. of the Proposition states the central result of this section: when-issued trading can increase the cost of pricing a securities issue by means of a mechanism. In the presence of such trading, informational rents must be paid in order to induce truthtelling. In our mechanism these rents are paid by allocating underpriced securities to investors whose reports are consistent with information revealed through when-issued trading. The investors can thus benefit from truthful reporting, even though this may deprive them of profits they could otherwise earn by trading on their private information in the when-issued market.

Case 2: We now consider the case in which when-issued trading is not used as a source of information for setting the issue price. That is, the issue price is based on equation (5), and investors (especially retail investors) must commit to their security purchases before when-issued trading commences.[21] This case resembles the common practice in Treasury markets where investors must commit to their primary market purchases at the time of the auction, and the issue price is based only on the bids in the auction. The following corollary reveals a rationale for this practice. If information from post-mechanism when-issued trading is not incorporated into the issue price, then investors may receive allocations that are over-priced. As discussed above, this "stick" discourages over-bidding and helps induce the polled investors to truthfully report their private information. This stick substitutes for the "carrot" of paying the investors informational rents.

Corollary 1. *If the mechanism is followed by when-issued trading, but the issue price and allocations are conditioned only on the polled investors' reports, then:*

1. *The underpricing needed to satisfy the incentive compatibility constraints is strictly lower than if the issue price is conditioned on information from when-issued trading.*

[21] This case differs from the benchmark of Section 4.1 in that the when-issued market provides profit opportunities for polled investors who misrepresent their information.

2. *Securities are allocated to investors who report positive information, and not to those who report negative information.*

3. *The expected underpricing needed to ensure the participation of retail investors is the same as in the benchmark case.*

The mechanism in Corollary 1 differs from that in Proposition 1 since it discourages investors from "over-bidding" by exposing them to the risk of receiving overpriced allocations. It may still be necessary to pay the polled investors informational rents, because truthful reporting deprives them of profitable trading opportunities in the when-issued market. However, the underpricing required to satisfy incentive compatibility is lower if the issue price is *not* conditioned on information from when-issued trading. In addition, as in the benchmark mechanism, securities are allocated only to those polled investors who report positive information.

While the first part of Corollary 1 points out a positive effect of exposing the polled investors to the risk of receiving overpriced allocations, the last part of the corollary points out a negative effect. Because we consider only uniform price offerings, the risk of receiving overpriced allocations affects the retail investors, as well as the polled investors. In fact, the retail investors are exposed to the same level of adverse selection risk as in the benchmark mechanism. Thus, the original $(PC - R)$ constraints must be satisfied. If the adverse selection risk is low, then the mechanism of Corollary 1 is the optimal one: the issuer will be better off if the issue is priced without using information revealed through when-issued trading.[22] Otherwise, the when-issued market should be utilized as a source of information for the pricing of the issue, as in the mechanism described in Proposition 1.

The results of the above analysis shed light on the observed practices of pricing Treasury issues vs. IPO pricing. Treasuries are typically priced according to strict rules, based solely on the bids received in Treasury auctions. The when-issued trading of Treasuries has no direct effect on their primary market pricing. The pricing of IPOs is vastly different. Bookbuilding does not require that the issue price be based solely on information obtained in the

[22] In more general terms, this result implies that issues should be priced based on either information collected directly from investors or information revealed through when-issued trading, but not both. In our analysis, we do not consider when-issued trading as the sole source of information for the pricing of an issue. Our objective is to analyze potential adverse effects of such trading on mechanism-based information collection.

mechanism. In fact, in IPO markets with when-issued trading the evidence indicates that information from when-issued trading is incorporated into the issue prices. Our analysis so far suggests that this is done since uninformed investors are exposed to more adverse selection risk in IPO markets than in Treasury markets.

A key result of Proposition 1 is that when-issued trading can be detrimental for issuers. In what follows we will derive a sufficient condition such that when-issued trading is beneficial for issuers. This analysis requires an extension of our model of mechanism design with when-issued trading. We have up to this point assumed that when-issued trading takes place with an exogenous probability of either zero (in Section 4.1) or one (in Section 4.2). This assumption is inconsistent with the observed variation in the incidence of when-issued trading, as described in Section 2. In the following section we will develop a model of when-issued trading that allows for the possibility of market failure: i.e., given that when-issued trading is permitted, it takes place with a probability that is strictly between zero and one. In Section 6, we will return to the mechanism design problem in order to determine a sufficient condition such that when-issued trading is beneficial for issuers. We will show in that section that the possibility of market failure ameliorates the adverse effects of when-issued trading that were identified above. Readers who are not interested in the details of the market microstructure model may move directly to Section 6.

5 A Model of When-Issued Trading

We develop a model of a dealer market, such as the when-issued market for IPO shares in Germany. The model is similar to that of Glosten and Milgrom (1985). Using this model we will determine conditions under which the when-issued market can function.

Players: The players are the same as in the model so far, with the following two exceptions: i) the issuer/issuer's intermediary does not participate in when-issued trading;[23] ii) the market is facilitated by purely competitive, risk-neutral market makers. As before, a fraction α of the investors (traders) are informed, with their information structure being the same as

[23] This assumption is consistent with common practice on the German Neuer Markt. See Aussenegg et al. (2005).

described in Section 3. The market makers have no private information. All of the players are risk neutral. The market makers have no inventory costs, or costs of trading.

Time-line: The market makers post competitive bid and ask prices. Traders arrive sequentially. Each arrival either buys at the ask price, or sells at the bid price. Market makers update their bid and ask prices after a trade takes place. All bid, ask and transaction prices are publicly observed. Because the market makers have identical information and no inventory costs, all of them post the same quotes at any given time. In what follows, we will thus refer to a single bid and a single ask price at any given point in time.

Trading: The trader who arrives at time t values the traded asset at $Y_t = E[\tilde{V}|F_t] + \rho_t$, where F_t is the time t trader's information set and ρ_t is a private value component that can be interpreted as a trader's liquidity need. Y_t represents trader t's valuation of the total offering. The size of a trade is an exogenously given fraction of the total offering size, $\eta << 1$.[24] Because the trade size is exogenous, we can ignore this parameter for now; η will be reintroduced in the following section. For simplicity, we assume that $\rho_t = 0$ for all informed traders, and for the market makers. For uninformed traders, $\rho_t \in \{-\rho, \rho\}$, $\rho \geq 0$. An uninformed trader with a valuation parameter of ρ is thus a potential buyer, while an uninformed trader with a valuation parameter of $-\rho$ is a potential seller.[25]

The trading rule is the same as in Glosten and Milgrom (1985): A trader will buy if $Y_t > A_t =$ the ask price, and sell if $Y_t < B_t =$ the bid price. If all $Y_t \in [B_t, A_t]$, then no trade occurs. Because the market makers are competitive and risk neutral they post "no regret" bid and ask prices:

$$\begin{aligned} A_t &= \text{ask price} = E[\tilde{V}|H_t, \text{ time } t \text{ arrival is a buyer}] \\ B_t &= \text{bid price} = E[\tilde{V}|H_t, \text{ time } t \text{ arrival is a seller}] \end{aligned}$$

[24]The parameter η can be interpreted as a trade size determined by the typical trade size of uninformed investors. See Dow (1998) for a model where the size of trade is determined by the hedging needs of uninformed investors.

[25]A difference between our model and that of Glosten and Milgrom (1985) is that our valuation parameter is additive, rather than multiplicative. Both types of valuation parameters have the effect that market liquidity increases when the quoted spread decreases. A multiplicative valuation parameter has the additional effect that liquidity increases (decreases) when the expected value of the asset increases (decreases). While this may be realistic, it adds a level of complexity to our analysis that is not central to our work. For this reason we choose an additive form for our valuation parameter. The effect of this additive form is that liquidity depends only on the difference between the dealers' quotes and the public expected value of the issue.

where H_t is the public information set, just before the tth arrival. H_t includes all past bid, ask and transaction prices, as well as any information that has been revealed prior to the start of when-issued trading. An informed trader's information set F_t includes H_t and the trader's signal of $\tilde{s}$.

The Possibility of Market Failure If uninformed traders are not expected to participate in when-issued trading, then the dealers' bid and ask quotes will be equal to the valuations of informed traders with negative and positive information respectively. At these prices, no trade will occur and the market will fail. If, instead, uninformed traders are expected to participate, then the dealers' bid and ask quotes will be somewhat closer to the public expected value of the issue. Suppose first that no information about the issue is publicly available other than equation (1) and the prior distribution of $\tilde{s}$. Then, the opening quotes will be:

$$\hat{B}_1 = v_0 + E[\tilde{s}|Y_1 < B_1]w = v_0 - \alpha(2q-1)w\,, \tag{15}$$

$$\hat{A}_1 = v_0 + E[\tilde{s}|Y_1 > A_1]w = v_0 + \alpha(2q-1)w\,, \tag{16}$$

since an informed trader arrives with probability α. Uninformed traders will participate at each of these quotes if and only if $\hat{A}_1 < v_0 + \rho$ and $\hat{B}_1 > v_0 - \rho$. Thus, a necessary and sufficient condition for the when-issued market to open is:

$$\alpha(2q-1)w < \rho\,. \tag{17}$$

Condition (17) consists of three components. α is the probability that the first trader to arrive is informed. $(2q-1)w$ represents the extent of the information asymmetry between informed and uninformed traders. ρ is the exogenously given liquidity parameter for uninformed traders. Thus, if the information asymmetry and the likelihood of an informed trade are large relative to the liquidity preferences of the uninformed traders, then no trade will take place.

Resolving problems of market failure: As described in Section 2, when-issued trading does seem to fail for a number of IPOs where such trading is permitted. For those IPOs that do have when-issued trading this trading opens only after the posting of a prospectus that reveals information obtained from investors. Based on these observations we now suppose that mechanism-based information gathering takes place and that z, the number of positive reports minus the number of negative reports, is publicly reported prior to the opening of when-issued trading. This change in the public information set will change both the extent of the information asymmetry and the probability of an informed arrival at the opening of the market. An uninformed trader will value the issue at $v_0 + E[\tilde{s}|z]w \pm \rho$, and the opening quotes will be:

$$B_1(z) = v_0 + \alpha^-(z)E[\tilde{s}|z-1]w + (1-\alpha^-(z))E[\tilde{s}|z]w \quad (18)$$

$$A_1(z) = v_0 + \alpha^+(z)E[\tilde{s}|z+1]w + (1-\alpha^+(z))E[\tilde{s}|z]w \quad (19)$$

where $\alpha^+(z)$ ($\alpha^-(z)$) is the probability that the first trader in the market is informed, given that a buyer (seller) has arrived at the open. The expressions for $\alpha^+(z)$ and $\alpha^-(z)$ are derived in the Appendix, and it is shown that for $z \geq 1$, $\alpha^+(z) = \alpha^-(-z) > \alpha > \alpha^-(z) = \alpha^+(-z)$. If $z = 0$, then (18) and (19) are equivalent to (15) and (16), since $\alpha^+(0) = \alpha^-(0) = \alpha$.

Uninformed traders will be willing to sell at the bid price if and only if the expected value of the issue, based on public information ($E[\tilde{V}|z]$), minus the bid price ($B_1(z)$) is strictly less than ρ. Similarly, uninformed traders will be willing to buy at the ask price if and only if $A_1(z) - E[\tilde{V}|z] < \rho$. The following proposition indicates that gathering information (so that $|z| \geq 1$) strictly increases the parameter range such that the when-issued market will open.

Proposition 2. *For all values of z, such that $|z| \geq 1$:*

$$E\left[\tilde{V}|z\right] - B_1(z) < v_0 - B_1(0) \quad (20)$$

$$\text{and} \qquad A_1(z) - E\left[\tilde{V}|z\right] < A_1(0) - v_0 \,. \quad (21)$$

Proposition 2 states that the difference between the dealers' opening prices and the public expected value of the issue narrows if information is gathered through a mechanism ($|z| \geq 1$) and made publicly available before the open. A consequence of this is that there is a range of parameter values such that: i) the when-issued market will not open without any prior information gathering, but ii) this problem of market failure can be resolved through mechanism-based information gathering, and the release of any information obtained. The size of this parameter range depends on the accuracy of the information held by informed investors, as measured by q. From equation (17) it can be seen that a larger value of q increases the parameter range for which when-issued trading may be afflicted by market failure. This is because the dealers quote a wider spread when they know that informed investors have better quality information. At the same time, however, a higher value of q makes it less likely that informed investors who are polled for their information have observed conflicting signals and so is associated with a higher expected value of $|z|$. We thus have the following corollary to Proposition 2.

Corollary 2. *The more accurate the information held by informed investors (higher value of q), the more likely it is that when-issued trading cannot open without prior information gathering <u>and</u> the more effective is this information gathering in that:*

$$\frac{E[\tilde{V}|z] - B_1(z)}{v_0 - B_1(0)} \qquad \textit{and} \qquad \frac{A_1(z) - E[\tilde{V}|z]}{A_1(0) - v_0}$$

are both decreasing in q.

6 The optimal mechanism if when-issued trading may fail

We now return to analyzing the effect of when-issued trading on the expected proceeds of a securities issue. In Section 4 it was shown that when-issued trading may reduce issue proceeds. In this section we will derive a sufficient condition for issuers to benefit from when-issued trading. In contrast to Section 4, we will assume in this section that when-issued trading cannot start before some information about the issue is publicly released (i.e., we assume that condition (17) in Section 5 is not satisfied). This assumption is consistent with stylized facts concerning European IPO markets, i.e. that the filing of a preliminary offering prospectus seems to resolve problems of market failure afflicting the when-issued trading of IPOs. The analysis below will show that the possibility of market failure eliminates some of the adverse effects of when-issued trading that were identified in Section 4.2.

The sequence of events is the same as in Section 4.2. However, the opening of the when-issued market will now hinge on the successful use of a mechanism to obtain a preliminary indication of the issue's value; when-issued trading will start upon public release of this information. If no information is obtained, then the when-issued market will fail since the spread between the opening quotes will be too wide for liquidity traders to participate in trading.

As in Section 4, the parameter z represents the sum of the signals reported by polled investors. Throughout this section we will assume that $|z| = 2$ is sufficient for the when-issued market to open and that $z = 0$ is not.[26] We also assume that the polled investors take into account the fact that the value of z depends on their reports. If a polled investor misrepresents her private information, then her report is more likely to contradict the other polled investor's report, assuming that the latter investor reports truthfully. Such a contradiction implies that $|z| = 0$, and thus, that the when-issued market cannot open.

As in Case 1 of Section 4.2 the issue price is based on equation (14). It is possible, however, that the market does not open, in which case J_T contains no information. Because of the possibility of market breakdown, we must distinguish between three cases when modeling the impact of a lie on $E[\tilde{V}|z, J_T]$: i) If the false report enables the when-issued market to open and the market later confirms the report, then the impact is w, i.e. the difference between the prior expected value of the issue, v_0, and the actual value revealed by the market. ii) If the false report enables the market to open, but trading eventually breaks down, then the impact of the lie is denoted as w_{Lb}, where $0 \leq w_{Lb} < w$. iii) If a false report prevents the when-issued market from opening, then the impact of such a report is either w or w_{Lb}, depending respectively on whether the when-issued market would have stayed open, or would have broken down.

[26] Following from the analysis of Section 5, this requires that $E[\tilde{V}|z] - B_1(z) < \rho$ and $A_1(z) - E[\tilde{V}|z] < \rho$ if and only if $|z| \geq 2$. In a more realistic model the requisite value of $|z|$ would likely be higher than 2 and the issuer would optimally determine the number of investors to poll. This would not change the qualitative results of our analysis, provided the number of polled investors is set in advance of actually polling them.

Incentive compatibility constraints: As pointed out in Section 4, the presence of a when-issued market affects the incentive compatibility constraints in two ways:[27] i) polled investors have opportunities to trade on private information they hold back, and ii) when-issued trading can reveal information that prevents pricing errors due to false reporting on the part of the polled investors. Each of these effects, however, is altered by the fact that the when-issued market may not open, or may break down after the open. As discussed below, the incentive compatibility constraints are now:

$$Er^+ \geq \Big((q^2 + (1-q)^2)u^{+-} + q^2 w + (1-q)^2 w_{Lb}\Big)\, h^{-+} \;+$$
$$q(1-q)\,\Big((u_c^{--} + w)h_c^{--} + (u_b^{--} + w_{Lb})h_b^{--} + 2\psi_L^{+-}\Big) \qquad (IC_T^{+\prime})$$
$$Er^- \geq \Big((q^2 + (1-q)^2)u^{+-} - q^2 w - (1-q)^2 w_{Lb}\Big)\, h^{+-} \;+$$
$$q(1-q)\,\Big((u_c^{++} - w)h_c^{++} + (u_b^{++} - w_{Lb})h_b^{++} + 2\psi_L^{-+}\Big) \qquad (IC_T^{-\prime})$$

These constraints can be compared to the constraints (IC_T^+) and (IC_T^-) in Section 4.2. The constraints differ in that we now allow for different allocations and underpricing in three different cases: i) the when-issued market does not open because the polled investors provide contradictory reports; ii) the market opens and stays open long enough to confirm the polled investors' reports; and iii) the market opens, but eventually breaks down because the trading does not confirm the polled investors' reports. The subscript c indicates the case in which the reports are confirmed by the market; b indicates the case in which the market breaks down. (There is no subscript for u^{+-} because in this state the market does not open at all.) Er^+ and Er^- are the same as in Section 4, apart from the difference just described.

The possibility of market breakdown affects the polled investors' incentives in two ways. First, as described above, market breakdown changes the impact that a false report has on the expected value of the security. Second, an investor who lies expects to earn profits by trading in the when-issued market. But, the possibility of market breakdown means that these expected trading profits are smaller than in Section 4.2. In particular, the above constraints exclude the terms ψ_L^{++} and ψ_L^{--} since the when-issued market will fail if both investors have observed the same signals, but one of them sends a false report.

[27]As discussed in Section 4.2, even though the participation constraints for informed investors also change, they will not be binding. We thus only concern ourselves with the changes in the incentive compatibility constraints.

Before solving for the optimal mechanism we present, in Lemma 1, a condition such that the incentive compatibility constraints are nonbinding. This condition is discussed following the Lemma.

Lemma 2. *The condition*

$$(1 - h_R) \times u_{AS}(0) \geq \psi_L^{+-} \times \left(\frac{4q}{1 + 3q} \right) \tag{22}$$

is sufficient to ensure that the incentive compatibility constraints are nonbinding.

The left-hand side of (22) is the maximum allocation that can be given to a polled investor, $(1-h_R)$, times the expected underpricing due to adverse selection risk when no information is obtained through the mechanism, $u_{AS}(0)$. This is the minimum level of underpricing required to satisfy the participation constraint for retail investors, if no information is learned in the mechanism. The right-hand side of (22) is the expected trading profit of a polled investor who gives a false report, times a factor that is slightly less than one.

Lemma 2 states that if $u_{AS}(0)$ is sufficiently high relative to the expected informed trading profit ψ_L^{+-}, then a polled investor with positive information will not expect to benefit from false reporting. To understand this, suppose that such an investor reports a negative signal hoping to profit from informed trading in the when-issued market. One of two things will happen: i) the market does not open because the other polled investor reports positive information, or ii) the other polled investor reports negative information and the market opens after the lie. In both cases the investor who has lied receives no allocation. In the first case she can make no trading profits; in the second case she can. However, in this second case, if she instead had reported truthfully, then she would have received an allocation of size $1-h_R$ that would have been underpriced by an amount $u_{AS}(0)$. Condition (22) simply requires that the expected value of this allocation be at least as large as the investor's expected informed trading profits. If this requirement is met, then it is not profitable for an investor to falsely report negative information; i.e., constraint $(IC_T^{+\prime})$ is nonbinding. In the proof of Lemma 2, we show that condition (22) is also sufficient for $(IC_T^{-\prime})$ to be nonbinding.[28]

Condition (22) will hold if the fraction of informed investors, α, is sufficiently high. As

[28] In fact, we find that $(IC_T^{+\prime})$ will always bind before condition $(IC_T^{-\prime})$ does: if (22) is satisfied with equality, then $(IC_T^{+\prime})$ is also satisfied with equality and $(IC_T^{-\prime})$ is strictly nonbinding.

indicated by expression (12), $u_{AS}(0)$ is increasing in α. Thus, the left-hand side of condition (22) is increasing in α. The right-hand side of condition (22) is decreasing in α since the expected trading profit, ψ_L^{+-}, is decreasing in α. In the Appendix we derive the expected profit of an investor who trades at the when-issued opening quotes, after lying in the mechanism. This expected profit is a decreasing function of α because the dealers in the when-issued market quote wider spreads if they believe that there is a higher probability of trading with an informed trader. If an informed investor trades later than at the open, then the negative effect of a larger α on her expected trading profit will be even greater. This happens for two reasons: i) a higher value of α means that an informed trader faces more competition to trade on private information, and ii) the dealers update their quotes more in response to trading activity when α is higher. Thus, it is clear that the expected trading profit, ψ_L^{+-}, is generally decreasing in α.

The optimal mechanism: We can now characterize the optimal mechanism for eliciting information from investors. The results are summarized in the following proposition and discussed below.

Proposition 3.

1. ***The optimal mechanism in the presence of when-issued trading that has an endogenous probability of market failure*** *has the following characteristics:*
    - *(a) The incentive compatibility constraints are strictly binding only if condition (22) does not hold.*
    - *(b) Securities are allocated to polled investors who report positive information, not to polled investors who report negative information.*
    - *(c) Only polled investors with positive information expect to receive strictly positive rents for their information.*
2. *If condition (22) is satisfied, then allowing when-issued trading lowers the expected underpricing.*

Proposition 3 can be compared directly with Proposition 1 of Section 4. The optimal mechanism of Proposition 3 has characteristics of each of the two mechanisms presented in Section 4, but is most similar to the benchmark mechanism (without when-issued trading).

As in the benchmark mechanism, only investors who report positive information receive allocations. This is true regardless of whether or not the when-issued market opens. Incentive compatibility is ensured for investors with negative information by a stick: if false positive information is reported and the when-issued market fails to open, then such investors are likely to be allocated overpriced securities.[29] For investors with positive information incentive compatibility is ensured by a carrot: if when-issued trading fails to open, then the expected underpricing is $u_{AS}(0)$ and underpriced securities are allocated to investors who reported positive information.

If condition (22) is satisfied, then when-issued trading is strictly beneficial for the issuer. In expectation, such trading will reduce the required level of underpricing by revealing information about the issue, and thus reducing uninformed investors' exposure to adverse selection risk. This benefit is obtained at no cost to the issuer since the incentive compatibility constraints are non-binding if condition (22) is satisfied. As discussed above Proposition 3, this will be the case if the fraction of informed investors, α, is sufficiently high.

It is important to note that condition (22) is a sufficient condition for the issuer to benefit from when-issued trading, but not a necessary condition. If the condition fails to hold, then when-issued trading will make it more costly to induce the polled investors to truthfully report their signals about the value of the issue. However, when-issued trading can still serve as a valuable source of information that reduces uninformed investors' exposure to adverse selection risk, and the level of expected underpricing required to compensate them for bearing this risk. As a consequence, the expected proceeds of the issue may increase, even if condition (22) is not satisfied.

7 Conclusion

We consider the role of when-issued trading in the pricing of unseasoned securities and the effect that such trading may have on the expected proceeds of securities issues. The analysis yields three main results. We first show that when-issued trading can hamper the ability of

[29]In Section 4.2 it was shown that, if the when-issued market will open independent of the mechanism, then this stick is eliminated. Here, because the when-issued market may fail, and because the probability of failure increases if a polled investor lies, the stick is reinstated.

an issuer to elicit pricing-relevant information from prospective investors. In the presence of such trading investors will try to obtain an allocation, trusting that the issue will be priced as indicated by the prices in the when-issued market. This reduces the information content of investors' indications of interest (bids).

The second result follows directly from the first. We show that, for a wide range of parameter values, the issuer should rely either on the when-issued market as a source of information to price an issue, or on a mechanism to obtain information from investors, but not on both. This result sheds light on the U.S. Treasury practice of pricing bond issues based solely on the information contained in Treasury auction bids, without any direct informational input from the when-issued market.

Finally, we present a sufficient condition for issuers to benefit from the existence of a when-issued market. In deriving this condition, we extend the analysis that led to our first two results and allow for the possibility of market failure in when-issued trading. We show that the possibility of market failure mitigates the adverse effects of when-issued trading that lead to the first two results. If such trading may fail, then investors cannot rely on it to indicate how an issue should be priced. This exposes investors to the risk of receiving over-priced allocations, and induces them to truthfully reveal their private information in their indications of interest.

In summary, our analysis shows that, if post-mechanism when-issued trading can be counted on to always reveal information, then an issuer is typically best off *not* pricing an issue based on *both* a mechanism and such trading. This provides a rationale for pricing U.S. Treasury issues solely on the basis of the auction bids. If, however, when-issued trading *cannot* be counted on to always reveal information, then any information revealed should be used in pricing an issue. This result is consistent with evidence that IPOs in Europe are priced based on information that is obtained both from bookbuilding and when-issued trading, when such trading takes place. Our results suggest that this is optimal because there have been a number of IPOs in which when-issued trading was permitted, but it did not occur.

Realization of $\tilde{s}$	$s=-1$	$s=1$
Probability of this realization	$1-\pi_T$	π_T
Expected secondary market value $\tilde{V}$	$v_0 - w$	$v_0 + w$
Allocation to informed investors	$\frac{(1-q)\alpha}{1-q\alpha}$	$\frac{q\alpha}{1-(1-q)\alpha}$
Allocation to uninformed investors	$\frac{1-\alpha}{1-q\alpha}$	$\frac{1-\alpha}{1-(1-q)\alpha}$

Table 2: Expected Value and Allocations

Appendix

Derivations for Section 3:

Underpricing due to adverse selection risk: Investors arrive randomly in the retail market. Allocations are given on a first-come first-served basis until the issue is sold. An investor who "participates in the offering" joins the queue for an allocation. If $s = 1$, then on average a fraction q of the informed investors will participate; if $s = -1$, then on average a fraction $1 - q$ will participate. Uninformed investors participate only if the security is sufficiently underpriced to make it a fair bet for them.

$$E[\tilde{V}|\pi_T] = v_0 + (2\pi_T - 1)w \tag{23}$$

Informed investor i sees a signal of $\tilde{s}$: $\tilde{\varsigma}_i \in \{-1, 1\}$.

$$prob\{s = 1|\pi_T, \varsigma_i = 1\} = \frac{q\pi_T}{q\pi_T + (1-q)(1-\pi_T)} > \pi_T,$$
$$prob\{s = 1|\pi_T, \varsigma_i = -1\} = \frac{(1-q)\pi_T}{(1-q)\pi_T + q(1-\pi_T)} < \pi_T.$$

Given these probabilities, an informed investor values the issue as follows:

$$E[\tilde{V}|\pi_T, \varsigma_i = 1] = v_0 + \frac{q\pi_T - (1-q)(1-\pi_T)}{q\pi_T + (1-q)(1-\pi_T)}w \ > \ E[\tilde{V}|\pi_T] \tag{24}$$
$$E[\tilde{V}|\pi_T, \varsigma_i = -1] = v_0 + \frac{(1-q)\pi_T - q(1-\pi_T)}{(1-q)\pi_T + q(1-\pi_T)}w \ < \ E[\tilde{V}|\pi_T] \tag{25}$$

Table 1 presents the expected value and the expected relative allocations to each group of investors (informed and uninformed), for each realization of $\tilde{s}$. The table is written assuming that $p_I > E[\tilde{V}|\pi_T, \varsigma_i = -1]$, so that investors who have observed negative signals do not participate; this is checked below.[30] Because $q > 1/2$, the uninformed will on average receive more securities if the value of these securities is low ($s = -1$).

[30] The informed participation given in Table 1 is the participation, conditioned on the realization of $\tilde{s}$. In everything that follows, we will assume that the number of investors who reveal their information, either through a mechanism or when-issued trading, is small relative to the total number of informed investors who may participate in the offering. Thus, the fraction of informed investors is not affected by information gathering.

Uninformed investors will participate in the offering only if their expected return is non-negative. When underpricing is minimized, this expected return is zero:

$$0 = (1-\pi_T)(v_0 - w - p_I)\frac{1-\alpha}{1-q\alpha} + \pi_T(v_0 + w - p_I)\frac{1-\alpha}{1-(1-q)\alpha}, \tag{26}$$

Solving equation (26) for p_I yields:

$$p_I = v_0 + \left(\frac{2\pi_T - 1 - (\pi_T + q - 1)\alpha}{1 - ((2\pi_T - 1)q + 1 - \pi_T)\alpha}\right) w. \tag{27}$$

The above expression is $> E[\tilde{V}|\pi_T, \varsigma_i = -1]$, so those who have observed negative signals do not participate. The expected underpricing due to adverse selection risk is:

$$u_{AS}(\pi_T) \;=\; E[\tilde{V}|\pi_T] - p_I \;=\; \frac{q - 2\pi_T(1-\pi_T) - (2\pi_T - 1)^2 q}{1 - ((2\pi_T - 1)q + 1 - \pi_T)\alpha}\,\alpha w, \tag{28}$$

Proof of Lemma 1. We define the following variable:

$$\bar{u}_{AS} \equiv \frac{u_{AS}(\pi)}{w\alpha} = \frac{q - 2\pi(1-\pi) - (2\pi-1)^2 q}{1 - ((2\pi-1)q + 1 - \pi)\alpha}$$

$$\frac{\partial \bar{u}_{AS}}{\partial \pi} =$$

$$(2q-1)\left(\frac{2(1-2\pi)(1-(1-q)\alpha - (2q-1)\pi\alpha) + \alpha(q - 2\pi(1-\pi) - (2\pi-1)^2 q)}{(1 - ((2\pi-1)q + 1 - \pi)\alpha)^2}\right)$$

$$= (2q-1)\left(\frac{2(1-2\pi) - 2(1-\pi)^2\alpha + (1-2\pi)^2 q\alpha + q\alpha}{(1 - ((2\pi-1)q + 1 - \pi)\alpha)^2}\right) \tag{29}$$

The denominator of (29) is strictly positive. The numerator is strictly decreasing in π and strictly positive if $\pi = 1/2$. Thus, (29) is strictly positive $\forall \pi \leq 1/2$ and part a) of the Lemma is obtained. The numerator of (29) is strictly negative if $\pi = (1-\alpha)/2 + \alpha q$. (The last result can be obtained by setting $q = 1/2 + \varepsilon$, where $0 < \varepsilon < 1/2$.) Thus, (29) is negative $\forall \pi \geq (1-\alpha)/2 + \alpha q$. In addition,

$$\bar{u}_{AS}\Big|_{z=0} = \frac{2q-1}{2-\alpha} \;>\; \bar{u}_{AS}\Big|_{z=1} = \frac{(2q-1)2q(1-q)}{1 - ((2q-1)q + 1 - q)\alpha}$$

∎

Derivations for Section 4:
Derivation of $\pi(z)$: We know that

$$\pi(0) = 1/2\,, \qquad \pi(1) = q\,, \qquad \text{and} \qquad \pi(-1) = 1 - q = 1 - \pi(1)\,.$$

We can define $\pi(z)$ as a function of all signals obtained, except i's signal, together with i's signal ς_i. For $z \geq 1$, we let $\varsigma_i = 1$:

$$\begin{aligned}\pi(z) &= \frac{prob\{\varsigma_i = 1|s = 1\}\pi(z-1)}{prob\{\varsigma_i = 1|s = 1\}\pi(z-1) + prob\{\varsigma_i = 1|s = -1\}(1 - \pi(z-1))} \\ &= \frac{q\pi(z-1)}{q\pi(z-1) + (1-q)(1-\pi(z-1))}\end{aligned} \tag{30}$$

For $z \leq -1$, we let $\varsigma_i = -1$:

$$\begin{aligned}\pi(z) &= \frac{prob\{\varsigma_i = -1|s = 1\}\pi(z+1)}{prob\{\varsigma_i = -1|s = 1\}\pi(z+1) + prob\{\varsigma_i = -1|s = -1\}(1 - \pi(z+1))} \\ &= \frac{(1-q)\pi(z+1)}{(1-q)\pi(z+1) + q(1 - \pi(z+1))} \qquad (31)\end{aligned}$$

Using these equations and the above values for $\pi(1)$ and $\pi(-1)$, we obtain

$$\pi(2) = \frac{q^2}{q^2 + (1-q)^2} \qquad \pi(-2) = 1 - \pi(2)$$

Repeating the above we obtain:

$$\pi(z)\Big|_{z\geq 0} = \frac{q^z}{q^z + (1-q)^z} \qquad (32)$$

$$\pi(z)\Big|_{z\leq 0} = \frac{(1-q)^{|z|}}{q^{|z|} + (1-q)^{|z|}} \qquad (33)$$

Because $q > 1/2$, for $z \geq 0$, $\pi(z)$ is increasing in z; for $z < 0$, $\pi(z)$ is decreasing in $|z|$.

Underpricing due to residual adverse selection risk. $u_{AS}(\pi(z))$ is written as $u_{AS}(z)$. From equations (3) and (4):

$$\frac{u_{AS}(0)}{w\alpha} = \frac{2q-1}{2-\alpha} \qquad (34)$$

$$\begin{aligned}\frac{u_{AS}(2)}{w\alpha} &= \frac{q - \frac{2q^2(1-q)^2}{(q^2+(1-q)^2)^2} - \left(\frac{2q-1}{q^2+(1-q)^2}\right)^2 q}{1 - \left(\frac{2q-1}{q^2+(1-q)^2}\right) q\alpha - \left(\frac{(1-q)^2}{q^2+(1-q)^2}\right)\alpha} \\ &= \frac{(2q-1)2q^2(1-q)^2}{(q^2+(1-q)^2)\left(q^2+(1-q)^2 - \alpha(1-3q(1-q))\right)} \qquad (35)\end{aligned}$$

$$\begin{aligned}\frac{u_{AS}(-2)}{w\alpha} &= \frac{q - \frac{2q^2(1-q)^2}{(q^2+(1-q)^2)^2} - \left(\frac{2q-1}{q^2+(1-q)^2}\right)^2 q}{1 + \left(\frac{2q-1}{q^2+(1-q)^2}\right) q\alpha - \left(\frac{q^2}{q^2+(1-q)^2}\right)\alpha} \\ &= \frac{(2q-1)2q^2(1-q)^2}{(q^2+(1-q)^2)\left(q^2+(1-q)^2 - \alpha q(1-q)\right)} \qquad (36)\end{aligned}$$

$q > 1/2 \implies 1 - 3q(1-q) > q(1-q) \implies u_{AS}(2) > u_{AS}(-2)$.
$u_{AS}(0)$ is strictly increasing in q. When q is close to $1/2$, $\partial u_{AS}(2)/\partial q$ and $\partial u_{AS}(-2)/\partial q$ are positive; when q is close to one, $\partial u_{AS}(2)/\partial q$ and $\partial u_{AS}(-2)/\partial q$ are negative.

Optimal direct mechanism, without when-issued trading. Rearranging the incentive compatibility constraints, (IC^+) and (IC^-):

$$\left(q^2 + (1-q)^2\right)\left(u^{++}h^{++} - (w_L + u^{+-})h^{-+}\right) + 2q(1-q)\left(u^{+-}h^{+-} - (w_L + u^{--})h^{--}\right) \geq 0 \qquad (37)$$

$$\left(q^2 + (1-q)^2\right)\left(u^{--}h^{--} + (w_L - u^{+-})h^{+-}\right) + 2q(1-q)\left(u^{+-}h^{-+} + (w_L - u^{++})h^{++}\right) \geq 0 \qquad (38)$$

(37) is satisfied by setting $h^{-+} = h^{--} = 0$. The $(PC - R)$ constraints are satisfied by setting $u^{+-} = u_{AS}(0)$, $u^{++} \geq u_{AS}(2)$ and $u^{--} \geq u_{AS}(-2)$. (38) is satisfied because $u_{AS}(2) < u_{AS}(0) < w_L$. (This follows directly from the above derivation and a comparison of equations (6) and (34).) The expected underpricing is determined from equation (13).

Proof of Proposition 1. We assume that the when-issued market is expected to be fully informative. Thus, $w_{LT} \to 0$ and residual adverse selection risk is expected to be zero. Allowing allocations to be conditioned on when-issued trading, the constraints (IC_T^+) and (IC_T^-) can be rewritten as:

$$\begin{aligned} q^2 \left(u_c^{++}h_c^{++} - u^{+-}h_w^{-+}\right) + (1-q)^2 \left(u_w^{++}h_w^{++} - u^{+-}h_c^{-+}\right) + \\ q(1-q)\left(u^{+-}(h_c^{+-} + h_w^{+-}) - u_c^{--}h_c^{--} - u_w^{--}h_w^{--}\right) \\ \geq \left(q^2 + (1-q)^2\right)\psi_L^{++} + 2q(1-q)\psi_L^{+-} \end{aligned} \tag{39}$$

$$\begin{aligned} q^2 \left(u_c^{--}h_c^{--} - u^{+-}h_w^{+-}\right) + (1-q)^2 \left(u_w^{--}h_w^{--} - u^{+-}h_c^{+-}\right) + \\ q(1-q)\left(u^{+-}(h_c^{-+} + h_w^{-+}) - u_c^{++}h_c^{++} - u_w^{++}h_w^{++}\right) \\ \geq \left(q^2 + (1-q)^2\right)\psi_L^{--} + 2q(1-q)\psi_L^{-+} \end{aligned} \tag{40}$$

where the subscript c (w) represents the state such that when-issued trading indicates that the investor's report was correct (wrong). We will assume that $\psi_L^{++} = \psi_L^{--}$ and $\psi_L^{+-} = \psi_L^{-+}$. (This is supported by the proof of Proposition 2.) We define:

$$\Psi_L \equiv \left(q^2 + (1-q)^2\right)\psi_L^{++} + 2q(1-q)\psi_L^{+-} = \left(q^2 + (1-q)^2\right)\psi_L^{--} + 2q(1-q)\psi_L^{-+} > 0$$

Because $q > 1-q$, the optimal mechanism calls for zero rents to be paid if the when-issued market indicates that an investor's report was wrong: $u^{ab}h_w^{ab} = 0$, $\forall$ pairs (a,b). Also, because the right-hand sides of (39) and (40) are strictly positive, and because residual adverse selection risk goes to zero, (39) and (40) are strictly binding, and can be written as:

$$q\left(qu_c^{++}h_c^{++} + (1-q)u^{+-}h_c^{+-}\right) - (1-q)\left(qu_c^{--}h_c^{--} + (1-q)u^{+-}h_c^{-+}\right) = \Psi_L \tag{41}$$

$$q\left(qu_c^{--}h_c^{--} + (1-q)u^{+-}h_c^{-+}\right) - (1-q)\left(qu_c^{++}h_c^{++} + (1-q)u^{+-}h_c^{+-}\right) = \Psi_L \tag{42}$$

The solution requires that:

$$qu_c^{++}h_c^{++} + (1-q)u^{+-}h_c^{+-} \;=\; qu_c^{--}h_c^{--} + (1-q)u^{+-}h_c^{-+} \;=\; \Psi_L/(2q-1) \tag{43}$$

An investor who truthfullly reports negative information receives the same expected rents as an investor who truthfullly reports positive information. In the optimal mechanism $h_c^{++} = h_c^{--} = (1-h_R)/2$. $h_c^{+-} = h_c^{-+} = 1-h_R$. Combining (43) and (7), the expected underpricing following bookbuilding and when-issued trading is

$$\frac{2q\Psi_L}{(2q-1)(1-h_R)}\,. \tag{44}$$

Whether or not expected underpricing is greater with when-issued trading than without depends on the relative values of expected trading profits and the underpricing due to residual adverse selection risk without when-issued trading. ∎

Proof of Corollary 1. The incentive compatibility constraints are the same as (37) and (38), except that as in (39) and (40), investors who lie expect to make trading profits.

$$\left(q^2+(1-q)^2\right)\left(u^{++}h^{++}-(w_L+u^{+-})h^{-+}\right)+2q(1-q)\left(u^{+-}h^{+-}-(w_L+u^{--})h^{--}\right) \geq \Psi_L \quad (45)$$

$$\left(q^2+(1-q)^2\right)\left(u^{--}h^{--}+(w_L-u^{+-})h^{+-}\right)+2q(1-q)\left(u^{+-}h^{-+}+(w_L-u^{++})h^{++}\right) \geq \Psi_L \quad (46)$$

We ignore the $(PC-R)$ constraints and determine the minimum Eu, such that the above (IC) constraints are satisfied. This Eu is then compared to the expression in (44) in the proof of Proposition 1. (The $(PC-R)$ constraints are strictly nonbinding in that mechanism.)
It is optimal to set $h^{-+}=u^{+-}=0$ and $2h^{++}=h^{+-}=(1-h_R)$. The above constraints can thus be written:

$$\left(q^2+(1-q)^2\right)\frac{u^{++}}{2} \;-\; 2q(1-q)(w_L+u^{--})\frac{h^{--}}{(1-h_R)} \;\geq\; \frac{\Psi_L}{(1-h_R)} \quad (47)$$

$$(1-q(1-q))w_L \;+\; \left(q^2+(1-q)^2\right)u^{--}\frac{h^{--}}{(1-h_R)} \;-\; q(1-q)u^{++} \;\geq\; \frac{\Psi_L}{(1-h_R)} \quad (48)$$

If (48) is nonbinding, then $h^{--}=0$ and $u^{++}=2\Psi_L/((1-h_R)(q^2+(1-q)^2))$. Sufficient for (48) to be nonbinding is:

$$\Psi_L/((1-h_R)\leq(q^2+(1-q)^2)(1-q(1-q))w_L \quad (49)$$

It is easy to show that if (49) doesn't hold, then the issuer is strictly better off not gathering any information. We thus assume that (49) holds. The expected underpricing is $\Psi_L/(1-h_R)$. This is strictly less than the expression in (44).
Part 2. follows directly from the fact that the issue price and allocations are conditioned only on polled investors' reports. ∎

Derivations for Section 5:
Proof of Proposition 2. **Conditional probabilities of informed arrival at the open:**

$$\alpha^+(z)=\frac{prob\{\text{informed buyer at open}\}}{prob\{\text{buyer at open}\}}=\frac{\alpha q\pi(z)+\alpha(1-q)(1-\pi(z))}{(1-\alpha)/2+\alpha q\pi(z)+\alpha(1-q)(1-\pi(z))} \quad (50)$$

$$\alpha^-(z)=\frac{prob\{\text{informed seller at open}\}}{prob\{\text{seller at open}\}}=\frac{\alpha(1-q)\pi(z)+\alpha q(1-\pi(z))}{(1-\alpha)/2+\alpha(1-q)\pi(z)+\alpha q(1-\pi(z))} \quad (51)$$

Applying equation (32), if $z\geq 1$, then:

$$\frac{\alpha^+(z)}{\alpha}=\frac{q^{z+1}+(1-q)^{z+1}}{(1-\alpha)(q^z+(1-q)^z)/2+\alpha(q^{z+1}+(1-q)^{z+1})}$$

$$
\begin{aligned}
&= 1 + \frac{(1-\alpha)(q-1/2)(q^z-(1-q)^z)}{(1-\alpha)(q^z+(1-q)^z)/2+\alpha(q^{z+1}+(1-q)^{z+1})} \\
&\equiv 1+\Delta\alpha^+ > 1 \qquad (52)\\
\frac{\alpha^-(z)}{\alpha} &= \frac{q(1-q)(q^{z-1}+(1-q)^{z-1})}{(1-\alpha)(q^z+(1-q)^z)/2+\alpha q(1-q)(q^{z-1}+(1-q)^{z-1})} \\
&= 1 - \frac{(1-\alpha)(q-1/2)(q^z-(1-q)^z)}{(1-\alpha)(q^z+(1-q)^z)/2+\alpha q(1-q)(q^{z-1}+(1-q)^{z-1})} \\
&\equiv 1-\Delta\alpha^- < 1 \qquad (53)
\end{aligned}
$$

Applying equation (33) it is easily shown that, for $z \geq 1$:

$$
\alpha^+(z) = \alpha^-(-z) > \alpha > \alpha^-(z) = \alpha^+(-z) \qquad (54)
$$

Conditions for market opening:

$$
\begin{aligned}
E[\tilde{V}|z] &= v_0 + (2\pi(z)-1)w \qquad (55)\\
A_1(z) &= v_0 + (2\pi(z+1)-1)w\alpha^+(z) + (2\pi(z)-1)w(1-\alpha^+(z)) \qquad (56)\\
B_1(z) &= v_0 + (2\pi(z-1)-1)w\alpha^-(z) + (2\pi(z)-1)w(1-\alpha^-(z)) \qquad (57)
\end{aligned}
$$

$$
\begin{aligned}
&(v_0 - B_1(0))/w = (A_1(0)-v_0)/w = \alpha(2q-1) \qquad (58)\\
&(E[\tilde{V}|z] - B_1(z))/w = 2\alpha^-(z)(\pi(z)-\pi(z-1)) \qquad (59)\\
&(A_1(z) - E[\tilde{V}|z])/w = 2\alpha^+(z)(\pi(z+1)-\pi(z)) \qquad (60)
\end{aligned}
$$

To prove equation (20) we need to show that for $|z| \geq 1$:

$$
\alpha^-(z)(\pi(z)-\pi(z-1)) < \alpha(q-1/2) \qquad (61)
$$

Assume first that: $z \geq 1$. Applying equation (30) and letting $q = 1/2+\delta$, where $0 < \delta < 1/2$:

$$
\begin{aligned}
\pi(z)-\pi(z-1) &= \frac{(2q-1)\pi(z-1)(1-\pi(z-1))}{(2q-1)\pi(z-1)+1-q} \qquad (62)\\
&= \delta \times \frac{\pi(z-1)(1-\pi(z-1))}{\delta\pi(z-1)+1/4-\delta/2} \qquad (63)
\end{aligned}
$$

$\pi(z-1) \geq 1/2$ and $\pi(z-1)(1-\pi(z-1)) \leq 1/4 \implies$ the above is $\leq \delta$ and $\pi(z)-\pi(z-1) \leq q-1/2$. From (54) we know that $\alpha^-(z) < \alpha$. Thus, equation (61) holds for $z \geq 1$.
Assume now that: $z \leq -1$. Applying equations (50), (54) and (31), and letting $q = 1/2+\delta$:

$$
\begin{aligned}
\frac{\alpha^-(z)}{\alpha}\Big(\pi(z)-\pi(z-1)\Big) &= \frac{(2q-1)\pi(-z)+1-q}{(1-\alpha)/2+\alpha((2q-1)\pi(-z)+1-q)} \times \frac{(2q-1)\pi(z)(1-\pi(z))}{(1-2q)\pi(z)+q} \\
&= \delta \times \frac{2\delta\pi(-z)+1/2-\delta}{(1-\alpha)/2+\alpha(2\delta\pi(-z)+1/2-\delta)} \times \frac{2\pi(z)(1-\pi(z))}{-2\delta\pi(z)+1/2+\delta} \\
&= \delta \times \frac{2\pi(z)(1-\pi(z))}{(1-\alpha)/2+\alpha(2\delta\pi(-z)+1/2-\delta)} \qquad (64)
\end{aligned}
$$

The last equality holds because, by equations (32) and (33), $2\pi(-z) - 1 = 1 - 2\pi(z)$.
We know that $2\pi(z)(1 - \pi(z)) < 1/2$. Also, because $z \leq -1$, $\pi(-z) > 1/2$ and $2\delta\pi(-z) + 1/2 - \delta > 1/2$. Thus, the expression in (64) is $< \delta$, and equation (61) holds for $z \leq -1$.
To prove equation (21) of the Proposition we need to show that for $|z| \geq 1$:

$$\alpha^+(z)(\pi(z+1) - \pi(z)) < \alpha(q - 1/2) \tag{65}$$

Assume first that: $z \geq 1$. Applying equations (50) and (30), and letting $q = 1/2 + \delta$:

$$\begin{aligned} \frac{\alpha^+(z)}{\alpha}\Big(\pi(z+1) - \pi(z)\Big) &= \frac{(2q-1)\pi(z) + 1 - q}{(1-\alpha)/2 + \alpha((2q-1)\pi(z) + 1 - q)} \times \frac{(2q-1)\pi(z)(1-\pi(z))}{(2q-1)\pi(z) + 1 - q} \\ &= \delta \times \frac{2\pi(z)(1-\pi(z))}{(1-\alpha)/2 + \alpha(2\delta\pi(z) + 1/2 - \delta)} \end{aligned} \tag{66}$$

Because $z \geq 1$, $\pi(z) > 1/2$ and $2\delta\pi(z) + 1/2 - \delta > 1/2$. Thus the above is $< \delta$, and equation (65) holds for $z \geq 1$.
Assume now that: $z \leq -1$. Applying equation (31) and letting $q = 1/2 + \delta$:

$$\pi(z+1) - \pi(z) = \frac{(2q-1)\pi(z+1)(1-\pi(z+1))}{(1-2q)\pi(z+1) + q} \tag{67}$$

$$= \delta \times \frac{\pi(z+1)(1-\pi(z+1))}{-\delta\pi(z+1) + 1/4 + \delta/2} \tag{68}$$

$\pi(z+1) \leq 1/2$ and $\pi(z+1)(1-\pi(z+1)) \leq 1/4 \implies$ the above is $\leq \delta$. From (54) we know that $\alpha^+(z) < \alpha$. Thus, equation (65) holds for $z \leq -1$. ∎

Proof of Corollary 2. Let $q = 1/2+\delta$, where $0 < \delta < 1/2$. From equations (32) and (33) it is clear that as δ increeases $|\pi(z)-1/2|$ also increases. Thus, $\pi(z)(1-\pi(z))$ is decreasing in δ, $\forall z$. The denominators of (63), (64), (66) and (68) are all increasing in δ. $\alpha^-(z)$ is decreasing in δ. Thus, for $|z| \geq 1$: $(E[\tilde{V}|z] - B_1(z))/(v_0 - B_1(0))$ and $(A_1(z) - E[\tilde{V}|z])/(A_1(0) - v_0)$ are decreasing in q. ∎

Derivations for Section 6:
Proof of Lemma 2. The incentive compatibility constraints $(IC_T^{+\prime})$ and $(IC_T^{-\prime})$ were written under the simplifying assumption that if the polled investors agree and are correct, then with probability one the when-issued market will confirm their reports, and if the polled investors agree and are wrong, then with probability one the when-issued market will break down and the state of information will be the same as if nothing had been learned (state $+-$). This simplification helps with the exposition, but is technically inconsistent. In this proof we eliminate the simplification and solve the problem consistently. We continue to assume that if the polled investors are wrong, then with probability one the market will break down. But, we assume that if the polled investors agree and are correct, then with probability y ($1/2 \leq y < 1$) the market will confirm their reports; with probability $1 - y$

the market will breakdown. Thus, a market breakdown does not mean for certain that the polled investors were wrong. The IC constraints are now written as:

$$Er^{+} \geq \Big((q^2+(1-q)^2)u^{+-} + q^2yw + (q^2(1-y)+(1-q)^2)w_{Lb}\Big)\, h^{-+} \; + $$
$$q(1-q)\,\Big(y(u_c^{--}+w)h_c^{--} + (2-y)(u_b^{--}+w_{Lb})h_b^{--} + 2\psi_L^{+-}\Big) \qquad (IC_T^{+\prime}-A)$$
$$Er^{-} \geq \Big((q^2+(1-q)^2)u^{+-} - q^2yw - (q^2(1-y)+(1-q)^2)w_{Lb}\Big)\, h^{+-} \; + $$
$$q(1-q)\,\Big(y(u_c^{++}-w)h_c^{++} + (2-y)(u_b^{++}-w_{Lb})h_b^{++} + 2\psi_L^{-+}\Big) \qquad (IC_T^{-\prime}-A)$$

Substituting in the values of Er^+ and Er^-, and as in Section 4, assuming that $\psi_L^{+-} = \psi_L^{-+}$, the IC constraints are:

$$yq^2u_c^{++}h_c^{++} + \Big((1-y)q^2+(1-q)^2\Big)\, u_b^{++}h_b^{++} \; -$$
$$\Big((q^2+(1-q)^2)u^{+-} + q^2yw + (q^2(1-y)+(1-q)^2)w_{Lb}\Big)\, h^{-+} + 2q(1-q)u^{+-}h^{+-} \; -$$
$$q(1-q)\,\Big(y(u_c^{--}+w)h_c^{--} + (2-y)(u_b^{--}+w_{Lb})h_b^{--}\Big) \geq 2q(1-q)\psi_L^{+-} \quad (69)$$
$$yq^2u_c^{--}h_c^{--} + \Big((1-y)q^2+(1-q)^2\Big)\, u_b^{--}h_b^{--} \; -$$
$$\Big((q^2+(1-q)^2)u^{+-} - q^2yw - (q^2(1-y)+(1-q)^2)w_{Lb}\Big)\, h^{+-} + 2q(1-q)u^{+-}h^{-+} \; -$$
$$q(1-q)\,\Big(y(u_c^{++}-w)h_c^{++} + (2-y)(u_b^{++}-w_{Lb})h_b^{++}\Big) \geq 2q(1-q)\psi_L^{+-} \quad (70)$$

We next insert into the above constraints the values of underpricing that exactly satisfy the participation constraints for retail investors $(PC-R)$ and determine the condition such that the above constraints are satisfied without any further underpricing. The constraints $(PC-R)$ are exactly satisfied if: $u^{+-} = u_{AS}(0)$ and $u_c^{++} = u_c^{--} = 0$. The values of u_b^{++} and u_b^{--} that exactly satisfy $(PC-R)$ are greater than zero and possibly less than $u_{AS}(0)$. The IC constraints are thus:

$$\Big((1-y)q^2+(1-q)^2\Big)\, h_b^{++}u_b^{++} \; -$$
$$\Big((q^2+(1-q)^2)u_{AS}(0) + q^2yw + (q^2(1-y)+(1-q)^2)w_{Lb}\Big)\, h^{-+} \; +$$
$$2q(1-q)h^{+-}u_{AS}(0) - q(1-q)\,\Big(ywh_c^{--} + (2-y)h_b^{--}(u_b^{--}+w_{Lb})\Big) \; \geq 2q(1-q)\psi_L^{+-} \quad (71)$$
$$\Big((1-y)q^2+(1-q)^2\Big)\, h_b^{--}u_b^{--} \; -$$
$$\Big((q^2+(1-q)^2)u_{AS}(0) - q^2yw - (q^2(1-y)+(1-q)^2)w_{Lb}\Big)\, h^{+-} \; +$$
$$2q(1-q)h^{-+}u_{AS}(0) + q(1-q)\,\Big(ywh_c^{++} + (2-y)h_b^{++}(w_{Lb}-u_b^{++})\Big) \; \geq 2q(1-q)\psi_L^{+-} \quad (72)$$

The optimal mechanism clearly calls for $h^{-+} = h_c^{--} = 0$ and $h_c^{++} = (1-h_R)/2$. From equation (6) and the assumption that $\alpha < 1/2$ we know that $u_{AS}(0) < (2q-1)w/3$. Thus, $y \geq 1/3$ is sufficient for $h^{+-} = 1-h_R$ (the largest feasible allocation) to be optimal. The IC constraints become:

$$2q(1-q)(1-h_R)u_{AS}(0) \; + \; \Big((1-y)q^2+(1-q)^2\Big)\, h_b^{++}u_b^{++} \; -$$

$$q(1-q)(2-y)h_b^{--}(u_b^{--}+w_{Lb}) \geq 2q(1-q)\psi_L^{+-} \quad (73)$$

$$\left(q^2yw+(q^2(1-y)+(1-q)^2)w_{Lb}-(q^2+(1-q)^2)u_{AS}(0)\right)(1-h_R)+$$
$$q(1-q)\left(yw(1-h_R)/2+(2-y)h_b^{++}(w_{Lb}-u_b^{++})\right)+\left((1-y)q^2+(1-q)^2\right)h_b^{--}u_b^{--}$$
$$\geq 2q(1-q)\psi_L^{+-} \quad (74)$$

If (74) (IC for an investor with negative information) is nonbinding, then it is also optimal to set $h_b^{--}=0$ and $h_b^{++}=(1-h_R)/2$, so that the constraints become:

$$2q(1-q)u_{AS}(0) + \left((1-y)q^2+(1-q)^2\right)u_b^{++}/2 \geq 2q(1-q)\psi_L^{+-}/(1-h_R) \quad (75)$$

$$q^2yw+(q^2(1-y)+(1-q)^2)w_{Lb}-(q^2+(1-q)^2)u_{AS}(0)$$
$$+q(1-q)\left(yw+(2-y)(w_{Lb}-u_b^{++})\right)/2 \geq 2q(1-q)\psi_L^{+-}/(1-h_R) \quad (76)$$

We know that $u_b^{++} \leq u_{AS}(0) < (2q-1)w/3$. Thus, $y \geq 1/2$ is sufficient such that the left hand side of (76) is greater than the left hand side of (75), so that (76) is nonbinding. Condition (22) in the Lemma is equivalent to (75) with $y=1$. Thus, (22) is sufficient such that the incentive compatibility constraints are nonbinding. ■

Informed trading profits. Suppose polled investor i observes a positive signal, but reports negative information. If the other polled investor also reports a negative signal, then z will be -2, and when-issued trading will open. If i buys at the opening ask price, then the expected profit on this trade is $(v_0 - A_1|_{z=-2})\eta$, where v_0 is i's expected value of the issue, $A_1|_{z=-2}$ is the opening ask price, given $z=-2$, and η is the (exogenously given) fraction of the issue that can be traded in a single trade. If instead, i observes a negative signal and reports positive information, then the market will open if the other polled investor reports a positive signal. If i sells at the opening bid price, then the expected profit on the trade is $(B_1|_{z=2} - v_0)\eta$, where $B_1|_{z=2}$ is the opening bid price, given $z=2$.

From the proof of Proposition 2:

$$A_1|_{z=-2} = v_0-(2q-1)w\alpha^+(-2)-\frac{2q-1}{q^2+(1-q)^2}w(1-\alpha^+(-2)) \quad (77)$$

$$B_1|_{z=2} = v_0+(2q-1)w\alpha^-(2)+\frac{2q-1}{q^2+(1-q)^2}w(1-\alpha^-(2)) \quad (78)$$

$\alpha^-(2)=\alpha^+(-2)$, thus

$$\begin{aligned}(B_1|_{z=2}-v_0)\eta &= (v_0-A_1|_{z=-2})\eta \\ &= (2q-1)\left(\frac{1-2q(1-q)\alpha^-(2)}{q^2+(1-q)^2}\right)w\eta \\ &= \left(1-2q(1-q)\alpha^-(2)\right)w_L\eta \quad (79)\end{aligned}$$

where w_L is given by equation (6). Let $\psi_0 \equiv B_1|_{z=2}-v_0$ and $\hat{\alpha} \equiv \alpha^-(2)$.

$$\frac{\partial \psi_0}{\partial \hat{\alpha}} = -2q(1-q)w_L \qquad \text{and} \qquad \frac{\partial \hat{\alpha}}{\partial \alpha} > 0 \qquad \Longrightarrow \qquad \frac{\partial \psi_0}{\partial \alpha} < 0$$

$$\begin{aligned}
\frac{\partial \psi_0}{\partial q} &= 2(2q-1)\hat{\alpha} w_L + (1-2q(1-q)\hat{\alpha})\frac{\partial w_L}{\partial q} - 2q(1-q)w_L\frac{\partial \hat{\alpha}}{\partial q} \\
\frac{\partial w_L}{\partial q} &= \frac{4q(1-q)w}{(1-2q(1-q))^2} > 0 \\
\frac{\partial \alpha'}{\partial q} &= \frac{-\alpha(1-\alpha)(2q-1)/2}{((1-\alpha)(q^2+(1-q)^2)/2+\alpha q(1-q))^2} < 0 \qquad \Longrightarrow \qquad \frac{\partial \psi_0}{\partial q} > 0
\end{aligned}$$

Proof of Proposition 3. Part 1.(a) and parts 1.(b) and (c) for the case such that (22) is satisfied are proved above. Suppose condition (22) is not satisfied. (69) is satisfied with equality. It will be necessary to increase u_c^{++}, u_b^{++} and/or u^{+-}, but the optimal allocations will be the same as above when (22) is satisfied.
From equation (13), expected underpricing without when-issued trading is:

$$2q(1-q)u_{AS}(0) + \left((q^2+(1-q)^2)/2\right)(u_{AS}(2)+u_{AS}(-2)) \tag{80}$$

With when-issued trading, if condition (22) is satisfied, then expected underpricing is at most:

$$2q(1-q)u_{AS}(0) + (1-q)^2 u_{AS}(0) \tag{81}$$

Comparing equations (34), (35) and (36), sufficient for the expression in (81) to be less than the expression in (80) is: $(1-q)^2 u_{AS}(0) \le (q^2+(1-q)^2)u_{AS}(-2)$, or

$$\frac{1}{2-\alpha} \le \frac{2q^2}{q^2+(1-q)^2-\alpha q(1-q)} \tag{82}$$

The LHS above is < 1 and the RHS is > 1, so that the inequality in (82) is correct. Thus, if condition (22) is satisfied, then the expected underpricing is lower with when-issued trading than without. ∎

Expected underpricing with a mechanism and when-issued trading.
If a mechanism is used with when-issued trading and condition (17) *is not* satisfied (Proposition 3), then expected underpricing is given by:

$$Eu = q^2/2\left(u_c^{++}+u_c^{--}\right) + (1-q)^2/2\left(u_b^{++}+u_b^{--}\right) + 2q(1-q)u^{+-} \tag{83}$$

If condition (22) is satisfied, then (83) is equal to (81).
If (22) is not satisfied, then the IC constraints (69) and (70) can be written as:

$$q^2 u_c^{++}/2 + (1-q)^2 u_b^{++}/2 + 2q(1-q)u^{+-} = 2q(1-q)\psi_L^{+-}/(1-h_R) \tag{84}$$

$$q(1-q)\left(yw-u_c^{++}-u_b^{++}\right)/2 + \left(q^2+(1-q)^2\right)(w_L-u^{+-}) \ge 2q(1-q)\psi_L^{+-}/(1-h_R) \tag{85}$$

(85) is not strictly binding. (This could occur only if both α and ψ_L^{+-} are very large.) Thus, expected underpricing when (22) is not satisfied is determined by (83) and (84):

$$Eu = \frac{2q(1-q)\psi_L^{+-}}{1-h_R} + (1-q)^2 u_{AS}(0)/2 \tag{86}$$

The first term in (86) is the amount of underpricing needed to satisfy (84). The second term is due to the fact that $u_b^{--} = u_{AS}(0)$. ($u_c^{--} = 0$.)
If a mechanism is used with when-issued trading and condition (17) *is* satisfied (Proposition 1), then expected underpricing is given by equation (44). In order to determine a value for ψ_L^{++}, we follow the same procedure as in Section 6.1 where we modeled ψ_L^{+-}. The difference is that the investor who lied knows that $z = 2$, but the dealers believe that $z = 0$.

$$A_1|_{z=0} = v_0 + \alpha(2q-1)w \qquad E[\tilde{V}|z=2] = v_0 + w_L$$
$$\psi_L^{++} = x\left(E[\tilde{V}|z=2] - A_1|_{z=0}\right) = x(1 - \alpha(q^2 + (1-q)^2))w_L$$

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