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Voluntary disclosure and strategic stock repurchases ☆

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ABSTRACT

We study the choice of disclosure and share repurchase strategies of informed managers using a model that captures how they differentially impact short and long-term stock value. We identify a partial disclosure equilibrium in which firms in the lowest value region *neither* disclose *nor* repurchase, firms with intermediate values disclose but do not repurchase, and firms in the highest value region induce undervaluation by not disclosing and buy back shares. In particular, the well known unraveling result when the manager is always informed (and when disclosure is costless)—the typical upper-tailed disclosure region in classic voluntary disclosure models—need not obtain when informed managers can use repurchases to extract information rents. We offer a new perspective on open-market share repurchases—the most common form of share repurchases—when chosen optimally with disclosure. Our analysis indicates that the equilibrium disclosure region shrinks as the firm's stock trading liquidity increases.

1. Introduction

Managers with private information can strategically control information flow to financial markets through multiple mechanisms. They can make credible direct disclosures to influence valuations (Dye, 1985; Jung and Kwon, 1988; Verrecchia, 1983); and they can also make strategic financial policy choices to extract information rents. Specifically, the literature suggests that informed managers of undervalued firms engage in share repurchases—through open-market repurchase programs—to exploit their information advantage.[1] Importantly, informed managers can strategically choose to engage in credible direct disclosures, or repurchase shares, or do both simultaneously. Given this choice, it is natural to examine

☆ “A U.S. firm buying and selling its own shares in the open market can trade on inside informationmore easily than its own insiders because it is subject to less stringent trade disclosure rules.” (Fried, 2014, page 801).

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[1] See Stephens and Weisbach (1998), Grullon and Ikenberry (2000), Ikenberry and Vermaelen (1996), Isagawa (2002), Buffa and Nicodano (2008), Barclay and Smith (1988), Brennan and Thakor (1990), Barth and Kasznik (1999), Core et al. (2006), Gong et al. (2008), Fried (2014). CFOs cite undervaluation as one of the primary motives behind repurchases (Brav et al. (2005)), but there are other motives as well. For instance, some papers have emphasized the use of a repurchase plan to influence the stock price through signaling (Vermaelen, 1981; Ofer and Thakor, 1987), or through its impact on earnings per share (Bens et al., 2003; Hribar et al., 2006). In Section 6, we present a discussion of these other motives for share repurchases to place our analysis in perspective.

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managers' optimal choice of information dissemination mechanisms between credible disclosures and open-market share repurchases.[2]

Motivated by this issue, we analyze the *joint* determination of disclosure and repurchase strategies by informed managers. Our analysis builds on the insight that these strategies differently impact short and long-term stock value. Repurchasing *undervalued* shares transfers wealth from short-term shareholders selling their shares at a discount, to long-term investors holding on to the stock.[3] On the other hand, credible direct disclosure corrects underpricing by revealing the true equity value to the market, benefiting short-term shareholders at no direct expense to long-term shareholders (as long as there are no direct disclosure costs). However, long-term shareholders suffer the opportunity cost of the foregone repurchase of undervalued stock. We show that this trade-off shapes equilibrium disclosure and repurchase strategies in important ways not hitherto identified in the literature. In particular, we show that when an informed manager can also repurchase shares, *both* direct disclosure and share repurchase can emerge in equilibrium.[4]

The equilibrium disclosure and repurchase regions depend in an important way on the relative weights a manager places on the welfare of short-term vs. long-term investors. The novel result of our analysis is that when a manager is motivated by a *long-term price focus*—that is, her interests are relatively more aligned with long-term investors—the optimal disclosure policy is *two-tailed* in the following sense. The manager will disclose only when her firm value is in some intermediate range, but she will not repurchase. In contrast, the manager will *neither* disclose *nor* repurchase when her firm value is in the lowest region. However, the manager whose firm value is in the highest region will increase value for long-term investors by first inducing under-valuation by *not disclosing* favorable news, and then by repurchasing shares.[5] That is, firms that stand to benefit greatly from repurchasing shares have the weakest incentives to disclose voluntarily.[6] Two properties of this equilibrium are especially noteworthy. First, it is optimal for a perfectly informed manager to withhold information (unlike Grossman (1981), Milgrom (1981)). Second, the upper-tailed disclosure region in classic voluntary disclosure models —such as those analyzed by Verrecchia (1983) and Dye (1985)—does not obtain in the presence of the repurchase option.

Strikingly, the equilibrium disclosure and repurchase regions are markedly different if the manager's interests are relatively more aligned with those of short-term investors. In this case, the manager is willing to repurchase *overvalued* stock in order to boost short-term stock price. As a result, the manager's optimal disclosure strategy is necessarily upper-tailed—that is, she discloses information for higher firm values. In turn, this upper-tailed disclosure strategy implies that a perfectly informed manager *always* discloses in equilibrium, consistent with the received literature (Grossman, 1981; Milgrom, 1981).

Our analysis highlights the role stock liquidity plays in a manager's relative propensity to disclose vs. repurchase. We find that a “long-term price focused” manager would repurchase rather than disclose in equilibrium when her firm's stock is more *liquid* (Kyle, 1985)—the equilibrium disclosure region shrinks as liquidity increases. Indeed, the manager will *never* disclose for sufficiently high levels of liquidity when there is some cost associated with disclosure (Verrecchia, 1983). Instead, there is a valuation threshold above which informed managers repurchase shares, but below which they neither disclose nor repurchase. The higher the cost of disclosure, the narrower is the optimal disclosure range. Indeed, for disclosure costs above a threshold level, the equilibrium disclosure region disappears. In this sense, our analysis suggests that stock liquidity has the same impact as disclosure cost. These results yield novel empirical predictions on the relative likelihood of using disclosure or repurchases in relation to firms' stock liquidity (see, e.g., Amihud, 2002), the cost associated with disclosure, and short-term price focus of managers.

While we assume the manager is privately informed of the value of her firm in our main analysis—consistent with the disclosure and informed trading literatures—we show that the equilibria we derive are robust to introducing some uncertainty with respect to the manager's information endowment (Dye, 1985; Jung and Kwon, 1988).

To our knowledge, there is no prior work on optimal information communication by firms when considering joint disclosure and share repurchase policies. We offer a framework that integrates disclosure and information-theoretic share repurchase literatures (Verrecchia, 1983; Dye, 1985; Chowdhry and Nanda, 1994; Lucas and McDonald, 1998). In particular, the “disclosure only” and “repurchase only” strategies that are considered in different literature streams emerge endogenously as special cases of our framework. Furthermore, while an equilibrium analysis of stock prices with informed trading has been widely considered (Glosten and Milgrom, 1985; Kyle, 1985), in our setting the informed trader is the manager conducting open market share repurchases.

Our analysis focuses on a particular motive underlying share repurchases that has been highlighted in the literature—as a way for informed managers of undervalued firms to transfer wealth from short-term investors to long-term shareholders. The literature has highlighted other motives for repurchases, distinct from that based on informed trading, including:

[2] We focus on share repurchase because corporations world-wide undertake major share repurchases routinely. Indeed, share repurchases have increased in the last few decades (Fama and French, 2001; Grullon and Michaely, 2002), and in the U.S., repurchases have replaced dividends as the main cash payout instrument. In 2013, share repurchases accounted for 60% of cash equity returns of U.S. corporations.

[3] An important structural aspect of our model is that the manager of an undervalued firm has the discretion to *time* the market i.e., repurchase shares whenever the stock is undervalued–especially in a way that the market-maker cannot always distinguish between repurchases and uninformed trading. See Section 2 for a detailed discussion of the veracity of this structure in light of the regulatory environment and reporting requirements for stock repurchases.

[4] Note if direct disclosure were the only avenue available (i.e., absent the repurchase option), then with a perfectly informed manager the standard unraveling result holds, i.e., there will only be full disclosure in equilibrium (Grossman, 1981; Milgrom, 1981).

[5] Other papers deriving disclosure equilibiria in which favorable information is not disclosed include Wagenhofer (1990) and Suijs (2007).

[6] We thank an anonymous referee for pointing out this implication of the two-tailed disclosure repurchase equilibrium.

boosting earnings per-share to beat analyst forecasts (Hribar et al., 2006); offsetting dilution from employee stock option plans (Bens et al., 2003); benefiting from equity mispricing by informed managers (Barth and Kasznik, 1999), or perceived under-valuation by over-optimistic managers (Fischer and Verrecchia, 2004); inducing stock mispricing (Core et al., 2006; Gong et al., 2008); and tax-based incentives (Aboody and Kasznik, 2008). We present a discussion of these other motives in Section 6 following our analysis. Empirical tests of our model should consider the impact of these other motives for repurchasing.

The paper proceeds as follows. Section 2 reviews the regulatory environment and related literature. Section 3 describes the model. In Section 4.1, we derive our main disclosure-repurchase equilibrium when the manager focuses on the long-run stock price, while in Section 4.2 we analyze the case of the short-run price focus. Section 4.3 presents a summary of the main results. In Section 5, we extend our analysis by considering the case of costly disclosures and examine the robustness of our results to a more general liquidity shock and to the case in which there is some uncertainty with respect to the manager's information endowment. In Section 6, we present a discussion of related papers in the disclosure literature and of other motives underlying share repurchases. We also present some empirical implications of our analysis. We conclude in Section 7.

2. Open-market repurchases: relevant background

Most share repurchase transactions by U.S. firms—in fact, about 90% of them—are done through an open-market repurchase program.[7] Our model will therefore consider the strategic disclosure by privately informed managers when the firm undertakes an open-market repurchase program. Prior to this analysis, it is useful to briefly describe the regulatory environment and informational implications of open-market repurchase programs.

2.1. Regulatory environment

In an open-market repurchase program (henceforth, 'open-market program'), the firm first announces its intention to buy back stock, and then starts repurchasing shares in the market at its *discretion*. While there is no regulatory requirement relating to the announcement of open-market programs, most firms typically announce the intended size of the program (number of shares or dollar value) and its horizon (generally 1–3 years).[8] The average fraction of shares sought in a repurchase program is about 5–8% of the firm value (Vermaelen, 1981; Peyer and Vermaelen, 2009). However, there is great variation in terms of the horizon: Many firms announce a program only in order to be "in the market", and follow up with an announcement every year for several years (Jagannathan and Stephens, 2003); but some firms announce programs with horizons that are several years long or even unlimited.

Importantly, firms are not required to follow through with the announced objectives of open-market program (see, e.g., Brockman et al., 2008). Some firms start repurchasing right after announcing; others wait several months or even years before starting to repurchase, and some do not repurchase at all (Stephens and Weisbach, 1998; Cook et al., 2004). Thus, the program announcement only discloses that the firm is "granting itself" the option to repurchase shares in the open market. For example, it is not unusual for firms to announce that they "will repurchase shares whenever the stock is undervalued," and often state that "the repurchase program may be suspended or discontinued at any time without prior notice" (Brav et al., 2005).[9] In particular, while program execution is regulated in terms of some trading restrictions (see below), there is no regulatory requirement that firms make prior disclosure of their market transactions for share repurchases. Hence, financial markets generally do not have prior information on whether and if the firm will actually execute its open-market program.

Unlike announcements of open-market programs which are not regulated, the execution of open market programs is regulated by rule 10-18b of the SEC (the Safe Harbor Act). This rule, adopted in 1982, provides a voluntary "safe harbor" from liability for manipulation, when an issuer (or its affiliated purchaser) bids for or purchases its common stock, if they follow the rule's timing, price, and volume restrictions.[10] It is important to note, however, that these restrictions do not require any prior, or even immediate disclosure of repurchasing or trading intent by open-market program firms. Indeed, the market can learn about actual repurchases only from the firm's *subsequent* (or *ex post*) disclosures or reports. Since 2004 the SEC requires that firms report their actual repurchases in their *next* quarterly financial statements (see, e.g., Atkins and Korff, 2013).[11] For our context, the important implication here is that firms still keep their informational advantage in terms of

[7] According to Banyi et al. (2008), since 1996 open-market repurchase programs account for 88% of all announced repurchases for U.S. firms and the announced value of these programs is over 93% of the total reported value of repurchases. Similar evidence is provided in Ikenberry and Vermaelen (1996) and Grullon and Ikenberry (2000). The other common methods are self-tender offers and privately negotiated transactions (about 5% of all buybacks each).

[8] Most firms do announce, probably to avoid law suits about stock price manipulation and use of private information (see Atkins and Korff (2013)).

[9] For example, Microsoft initially announced a 4-year repurchase program of $30 billion back in July 2004. Two years later, in July 2006, it announced a 5-year $20 billion program, before completing its first program. Then in September 2008 it announced a 5-year $40 billion program, and a $40 billion program with no expiration date in 2013. Microsoft did not complete a program before announcing a subsequent program. It only extended its authorization to repurchase from time to time.

[10] Specifically, there are four conditions: (a) In any single day the firm may repurchase stock through only one broker (b) the firm will not repurchase stock in the last 1/2 h of trade (c) The firm's bid cannot be higher than the last independent bid, and (d) In any day non-block repurchase must not exceed 25% of the average daily trading volume in the security or 0.05% of outstanding shares.

[11] Since 2004, firms have to disclose the number of shares repurchased per month in the open market and the average price per share the firm had

their trading presence because, on average, they still have several months to use private information before it is disclosed in the financial reports.

There exists considerable empirical evidence that open-market program firms retain their informational advantage over financial markets in executing their repurchases. Several studies find insignificant announcement effects of the open-market program announcements (Comment and Jarrell, 1991; Ikenberry et al., 2000). On the other hand, Ben-Rephael et al. (2014) find that the market reaction to the eventual or ex post disclosure of actual repurchase data is positive and significant. Moreover, there is evidence that the long-run market performance of program-announcing firms is positive and significant (Bartov, 1991; Ikenberry et al., 2000; Peyer and Vermaelen, 2009), suggesting that the financial markets under-react to the program announcement. Taken together these facts support the argument that firms maintain their information advantage over financial markets when executing their open-market programs through the ex ante non-disclosure of their market participation.

2.2. Informational implications

The information content and implied commitment of open-market programs are notably distinct from the self-tender method of share repurchases. In the announcement for a self-tender offer, the firm offers to purchase a certain amount of outstanding equity at a fixed price or a Dutch auction. The existing repurchase literature argues that the commitment or credible aspect of self-tender offers is consistent with the requirements of signaling theory (Spence, 1973; Riley, 1979) and suggests that firms use repurchases (through self-tender offers) to credibly disclose positive inside information—that is, signal under-valuation (Vermaelen, 1981; Ofer and Thakor, 1987).

However, the credibility or commitment of self-tender offers does not apply to open-market programs where firms may or may not follow through their announcement.[12] A number of papers in the literature theoretically analyze open-market repurchase programs where the firm has an informational advantage and executes repurchases *anonymously* in the financial markets; that is, the other market participants, such as uninformed traders and market makers, do not have prior information on the firm's trading posture. For example, Brennan and Thakor (1990) consider an open-market program in an auction environment where informed large investors anonymously take advantage of stock mispricing that evolves after the open-market program announcement through the firm's repurchase trades. In their model, the uninformed traders are not aware of the informed trade when it occurs and hence lose to the informed investors. Other papers that model execution of open-market programs with anonymous trading include Ikenberry and Vermaelen (1996), Isagawa (2002), Oded (2005), and Buffa and Nicodano (2008). None of these papers examine the *joint* implications of informational advantage of firms on disclosures and open-market repurchases, however.

We now construct a model where a firm that has an ongoing open-market program becomes privy to cash flow related information. The informed manager can subsequently strategically disclose (or not disclose) this information and/or repurchase shares. That is, the informed manager can put in repurchase trading orders without prior disclosure of their trades, which is consistent with the usual practice and regulatory requirements. Following our analysis, in Section 6, we relate our results to the existing literatures on disclosure and other motivations for share repurchases, and highlight some salient empirical implications.

3. The model

3.1. Preliminaries

Consider a firm with a single terminal cash flow x, with the support, $\mathcal{X} \equiv [x_{\min}, x_{\max}] \subset R^{+}$. The firm is controlled by a manager who privately observes x *perfectly* —i.e., an information event occurs.[13] The manager can credibly disclose this signal at no cost (Grossman, 1981). As we know from the voluntary disclosure literature, if credible disclosure is the manager's only option to eliminate information asymmetry (i.e., when we do not consider the repurchase option), the standard unraveling results and the manager *always* discloses in equilibrium (Grossman, 1981; Milgrom, 1981). However, as our ensuing analysis reveals, such is not the case in the presence of repurchase option.

In particular, the manager can also withhold this information from markets and trade on her private information by repurchasing shares: We assume that the firm has an open-market repurchase plan in place prior to the information event.

We consider a simple model with four dates: $t \in \{0, 1, 2, 3\}$. The shares of an all equity firm—with the total number of

(*footnote continued*)
paid during the reporting period on a monthly basis. Prior to 2004, the reporting requirements were very loose. For example, a firm that issued stock to employees or managers could offset the shares issued from the repurchased shares, thus making it difficult to infer how many shares were actually repurchased. Such estimates based on available data were very inaccurate (see Stephens and Weisbach (1998), Banyi et al. (2008)).

[12] Indeed, there is significant positive average announcement return of about 15% on tender offers (Vermaelen, 1981; Comment and Jarrell, 1991). But, for open-market programs the average announcement return is substantially lower at 2% or less, and, as mentioned above, is often insignificant (Comment and Jarrell, 1991; Ikenberry et al., 2000).

[13] In Section 5.2, we extend our analysis to the case in which the manager is imperfectly informed about terminal cash flow in the sense of Dye (1985).

outstanding shares normalized to 1—are traded at times $t=0$, 2, and 3. At the initial date $t=0$, there is symmetric information regarding the value of the firm and the market price is denoted by P_0. In addition to the current shareholders, other agents can also trade in the stock. (Henceforth, the shareholders and these agents will be referred to as "investors.") The firm also announces an open-market repurchase program that gives the firm the option to repurchase up to $0 < z < 1$ outstanding shares prior to $t=3$.

At $t=1$, the manager becomes privately informed regarding the value of the firm or the realized cash flow x. At this date, the manager can choose to disclose this information to the market. At $t=2$, following the manager's choice of disclosure, trade occurs and the so-called *short-term* stock price P_2 is determined. Market participants are rational and prices satisfy $P_0 = E(P_2)$ (ignoring the time value of money).

For simplicity, we utilize a binary representation of the Kyle (1985) market mechanism (e.g., Bernhardt et al., 1995; Maug, 1998). Specifically, at the beginning of $t=2$, shareholders receive an uninsurable *liquidity* shock and must sell $q \in \{l, h\}$ shares $0 = l < h \leq z$. The liquidity shock q is low (high) with probability α $(1-\alpha)$ for some $\alpha \in (0, 1)$ and is independent of the value x. The manager does not observe the liquidity shock, but can repurchase shares $z \geq r \geq 0$. Consistent with the open-market repurchase program, the manager is not required to disclose r prior to trading. Hence, the aggregate order flow in the stock is

$$F \equiv r - q. \tag{1}$$

The market maker is risk neutral and only observes the aggregate order flow because r and q are not directly observable. Thus, the offered price P_2 is the time-2 expected value of terminal price P_3 conditional on the aggregate order flow; we write this price as $P_2(F) \equiv P_2(r-q)$. We assume free entry in market making (Kyle, 1985). Therefore, prices are set so that the market maker breaks even on average as we explain below.

At the beginning of $t=3$—the next period following the share repurchase—the firm reveals r, which is consistent with the reporting requirements for open-market programs (cf. Atkins and Korff, 2013). We can now calculate the terminal stock price (i.e., at $t=3$) following cash flow realization of x and given a repurchase of r shares at price P_2. Note that the value of shares after trade depends on both the terminal value x and any gains or losses in the case that the manager repurchases shares; a repurchase of r shares at price P_2 will cost the firm rP_2, resulting in a net asset value of $x - rP_2$ spread over $1-r$ outstanding shares. Therefore, the price per share following repurchase is,

$$P_3(r, x, P_2) = \frac{x - rP_2}{1-r} = x + \frac{r}{1-r}(x - P_2). \tag{2}$$

Note that purchasing undervalued equity (i.e., $x > P_2$) *increases* this terminal stock price, while the reverse is true for overvalued equity.

We suppose that the manager cares about the price at which shareholders sell their equity (in case a liquidity shock occurs) as well as the price of equity held by investors until the long-term cash flow is realized. Thus, the manager cares both about the *short-term* (P_2) and the *long-term* (P_3) stock prices. Let $\beta \in (0, 1)$ be the welfare weight the manager places on short-term stock performance:[14]

$$V^m = \beta P_2 + (1-\beta)P_3. \tag{3}$$

The sequence of events is as follows:

$t=0$	The manager observes the information event
$t=1$	The manager discloses or withholds information x
$t=2$	The manager and the liquidity traders place orders simultaneously and the market maker sets the short-term price P_2 as a function of the order flow
$t=3$	Cash flow x becomes public and long-term price P_3 is realized

3.2. Equilibrium concept

We analyze the Perfect Bayesian equilibrium (PBE) of the game set up by the time line above. The PBE consists of:

The Manager's disclosure strategy: The manager's disclosure strategy is denoted by s: $x \to \{D, ND\}$, with D denoting voluntary disclosure of information x by the manager, and ND denoting non-disclosure.

Repurchase strategy: The manager's repurchase r is optimal given her information x and her Bayes-consistent beliefs about the market maker's pricing function $P_2(F)$.

Market maker: The short-term price $P_2(F)$ is set such that the market maker breaks even on average, given her Bayes-consistent beliefs about the manager's disclosure and repurchase strategies.

A PBE, then, is the profile $\mathcal{S}^* = \langle s, r, P_2(F)\rangle$ where the manager's disclosure strategy and repurchase strategy are optimal given the competitive prices $\langle P_2(F), P_3\rangle$, and the market maker's pricing is optimal given the manager's strategy.

[14] See also Einhorn and Ziv (2007) and Langberg and Sivaramakrishnan (2010) for a similar payoff structure.

We begin by analyzing the trading game that takes place at $t=2$. Of course, all adverse selection is removed from the market following disclosure of x by the manager. In this case, prices reflect this information and $P_2 = P_3 = x$ regardless of the order flow. It is then, without loss of generality, optimal for the manager not to repurchase shares (i.e., $r=0$).

Following non-disclosure, however, the market maker does not know the firm value and must base his expectations on his beliefs on the disclosure strategy of the manager. In turn, the manager will choose whether to repurchase shares and disclose information while taking into account the pricing schedule of the market maker and the true value of the firm.

3.3. The manager's disclosure and repurchase strategy

In modeling the manager's repurchase strategy, we note that if the manager repurchases shares in a way that perfectly reveals her private information, she cannot gain from trading against the uninformed. Consequently, we consider a binary version of the classic Kyle (1985) model (Maug, 1998; Bernhardt et al., 1995) in which the market maker cannot always (perfectly) identify informed trading by the manager by observing the order flow if the manager repurchases either $r=h$ or $r=0$. This structure is supported by our discussion in Section 2 that even though a firm might have an open-market repurchase program in place, no *prior* disclosure of the actual repurchase of shares is required—the market can learn about actual repurchases only from *subsequent* (or *ex post*) disclosures or reports. Thus, the manager repurchase of shares is camouflaged by uninformed trading in some states, allowing her to benefit from her information advantage.

We look for a pure-strategy equilibrium in which the manager either repurchases $r=h$ or does not repurchase at all *following non-disclosure*. Three possible levels of order flow stem from this strategy of the manager:

$$F|_{r=0} = \begin{cases} -h & \text{when } q = h \text{ w. p. } 1-\alpha \\ 0 & \text{when } q = 0 \text{ w. p. } \alpha \end{cases}, \quad F|_{r=h} = \begin{cases} 0 & \text{when } q = h \text{ w. p. } 1-\alpha \\ h & \text{when } q = 0 \text{ w. p. } \alpha \end{cases}.$$

The market maker faces uncertainty regarding the level of trading by the manager *only* when order flow is intermediate—i.e., $F=0$. Whenever $F = -h$, the manager would not have repurchased shares; when $F=h$, the manager would have repurchased shares. The market maker will use this order flow information together with her beliefs regarding the manager's disclosure and repurchase strategy. Note that the order flow's information content does not relate to the size of the liquidity shock, h, but rather to the uncertainty associated with the shock, α.

Let the following price levels correspond to the three order flows:

- $P_2(h) \equiv P^H$ when the manager repurchases h and there is no liquidity shock;
- $P_2(0) \equiv P^M$ when the manager repurchases h and the liquidity traders sell h, or when the manager does not repurchase and the liquidity traders do not sell;
- $P_2(-h) \equiv P^L$ when the manager does not repurchase shares and the liquidity trader sells h.

We establish an equilibrium in which these prices are monotone in order flow (equilibrium condition **C1)**:

[**Condition C1**]: $P^H \geq P^M \geq P^L$ [Prices are monotone in order flow]

At the time the manager submits her order to purchase shares she is committed to trade but does not know the actual price of her transaction (Kyle, 1985). Similarly, when the manager does not place an order, she does not know the future stock price as it fluctuates with the order flow. Thus, the manager bases her disclosure and her repurchase decisions on the expected price following repurchase (non-repurchase) given by $\overline{P}$ ($\underline{P}$):

$$\overline{P} \equiv E(P_2|_r = h) = \alpha P^H + (1-\alpha)P^M, \quad \text{and} \tag{4}$$

$$\underline{P} \equiv E(P_2|_r = 0) = \alpha P^M + (1-\alpha)P^L \tag{5}$$

When repurchasing shares and/or disclosing information, the manager takes into account the benefits from trade to long-term investors (reflected in the realized price P_3) and the benefits from higher price to short-term investors selling their shares at price P_2. In particular, the manager can increase the long-term share price by repurchasing undervalued shares, and can improve the price at which short-term shareholders sell their holdings by disclosing favorable information.

The expected payoff to a manager of type x from a repurchase of $r=h$ shares given market prices $\langle P^H, P^M, P^L \rangle$ is given by

$$E(V^m|ND, r=h, x) = E\left[\beta P_2 + (1-\beta)P_3|ND, r=h, x\right] = \beta\overline{P} + (1-\beta)\frac{x - h\overline{P}}{1-h} = \left(\frac{1-\beta}{1-h}\right)x - \left(\frac{h-\beta}{1-h}\right)\overline{P}. \tag{6}$$

As one would expect, the expected payoff to the manager from repurchasing shares increases in the realized value of cash flows x, and more so when (i) the manager puts less weight on the short-term price (i.e., lower β), and (ii) when the liquidity shock h is higher (because the manager can then repurchase more shares without being fully detected by the market maker). In particular, we can conveniently write the above expression as

$$E\left(V^m|ND, r=h, x\right) = x + \left(\frac{h-\beta}{1-h}\right)\left(x - \overline{P}\right).$$

From this expression, it is clear that for $\beta < h$, the manager's expected payoff is increasing in the level of under-valuation, $x - \overline{P}$. Because a lower value of β corresponds to a greater weight on the terminal price P_3, the manager of an undervalued firm has a more pronounced incentive to repurchase shares as long as $\beta \in (0, h)$. In other words, if the size of the liquidity shock is sufficiently large ($h > \beta$), then the manager benefits by repurchasing shares and propping up the terminal price P_3.

On the other hand, if the liquidity shock is small—i.e., $h \leq \beta$, then over-valuation will not deter the manager from repurchasing shares and the manager has an incentive to focus on the short-run stock price (as we will see below). It is worth emphasizing that it is *not* the magnitude of β *per se* that triggers this short-run focus in our context—rather, it is the magnitude of β *relative* to that of the liquidity shock h.

In light of the fact that the manager's behavior is markedly different in the two regions characterized by $\beta \in (0, h)$ and $\beta \in (h, 1)$, we analyze them separately.[15]

4. Main analysis

4.1. Long-run price focus/high liquidity shock

4.1.1. The manager's strategies

In the previous section, we have established that when $\beta \in (0, h)$ (i.e., the weight the manager places on short-term stock performance is low relative to the size of the liquidity stock), the manager potentially benefits from repurchasing shares to prop up the terminal price, P_3. For this behavior to obtain in equilibrium, we need to compare her expected payoffs from repurchasing shares with her expected payoffs from disclosing her information directly, and from withholding information *and* not repurchasing shares. These expected payoffs are

$$\begin{aligned} &E(V^m|D, x) = x, \quad \text{and} \\ &E(V^m|ND, r=0, x) = \beta\underline{P} + (1-\beta)x. \end{aligned} \tag{7}$$

Once the manager discloses information, no information asymmetry exists between the market maker, investors, and the manager. Thus, following disclosure, whether the manager repurchases shares or not has no implication for prices.

Following non-disclosure, the benefit from repurchasing shares as opposed to not doing so is,

$$E(V^m|ND, r=h, x) - E(V^m|ND, r=0, x) = \left(\frac{h(1-\beta)}{1-h}\right)x - \left(\frac{h-\beta}{1-h}\right)\overline{P} - \beta\underline{P}.$$

It follows immediately that the manager prefers share repurchase over non-repurchase when the firm value x exceeds a certain threshold, which turns out to be a weighted average of the market prices $\langle \underline{P}, \overline{P} \rangle$:

$$x > \frac{(h-\beta)}{h(1-\beta)}\overline{P} + \frac{\beta(1-h)}{h(1-\beta)}\underline{P} \;[\langle ND, R\rangle \text{ dominates } \langle ND, NR\rangle]. \tag{8}$$

Intuitively, the manager will not find it optimal to repurchase shares (following non-disclosure) if the value of the firm is below the price $\underline{P}$, and will repurchase shares if the value is above $\overline{P}$. The repurchase cutoff in (8) lies between the expected price following repurchase and that following non-repurchase.

To see this, recall that $\beta \in (0, h)$. At its upper bound $\beta = h$, and the above condition simply reduces to the inequality $x > \underline{P}$, while at the other extreme, $\beta = 0$, a higher firm value is required in order for repurchase to dominate—i.e., $x > \overline{P}$. This is because the greater is the manager's focus on short-run price, the more she will care about the short-term shareholders, and hence will repurchase not only for values of x above $\overline{P}$ but even for lower valuations within the range $\underline{P} < x < \overline{P}$. It also follows from (8) that the repurchase cutoff is increasing in the size of the liquidity shock.

In order for it to be optimal for an informed manager to repurchase, she must not only prefer repurchase over non-repurchase, but also prefer non-disclosure over disclosure. Therefore, we compare the payoff x (following disclosure by the informed manager) to the expected payoff from non-disclosure followed by repurchase of shares $E(V^m|ND, r=h, x)$, and show repurchase and non-disclosure is preferred over disclosure by an informed manager (for $\beta \in (0, h)$) when,

$$E(V^m|ND, r=h, x) \geq x \Leftrightarrow \beta\overline{P} + (1-\beta)\frac{x - h\overline{P}}{1-h} \geq x, \;\text{ or }\; x \geq \overline{P}[\langle ND, R\rangle \text{ dominates } D]. \tag{9}$$

While both conditions (9) and (8) must be satisfied for the manager to repurchase shares in equilibrium, it is easy to

[15] Because a fraction h of investors are hit with a liquidity shock with probability $1-\alpha$, the manager's payoff will represent that of the *average* shareholder at the time of disclosure/repurchase if the weight she places on the short-term price is set to $\widehat{\beta} = (1-\alpha)h$. We thank Raghu Venugopalan for pointing this out to us.

verify that condition (9) binds. Thus, we define the repurchase cutoff as,

$$\bar{x} = \bar{P}. \tag{10}$$

Next, we explore whether non-repurchase that yields expected payoff to the manager of $\beta\underline{P} + (1-\beta)x$ dominates disclosure that yields a payoff of x. Since the long-term share value is not affected when shares are not repurchased, the manager will choose non-disclosure for relatively low value realizations. Formally,

$$x \le \underline{P}\left[\langle ND, NR\rangle \text{ dominates } D\right]. \tag{11}$$

Now, since condition (8) follows directly from condition (11), the cutoff below which the manager does not disclose information and does not repurchase shares is,

$$\underline{x} = \underline{P}. \tag{12}$$

The analysis above leads to the manager's best response strategy. The manager's best response to prices $\left\langle P^H, P^M, P^L\right\rangle$ satisfying equilibrium condition (**C1**) (prices are monotone in the order flow)—in terms of her disclosure and repurchase strategies—is summarized as follows (all proofs are in Appendix A):

Lemma 1 (*Two - Tailed Disclosure and Repurchase Strategy*). *In any candidate equilibrium in which prices following non-disclosure* $\left\langle P^H, P^M, P^L\right\rangle$ *satisfy conditions C1 and* $\beta \in (0, h)$, *the manager will withhold information and not repurchase shares for sufficiently low cash flow realizations,* $x \le \underline{x}$; *will disclose information for intermediate realizations,* $x \in (\underline{x}, \bar{x})$; *and will withhold information and repurchase shares otherwise,* $x \ge \bar{x}$.

A noteworthy implication of Lemma 1 is that the upper-tailed disclosure outcome that typically emerges in traditional disclosure equilibria (Dye, 1985; Verrecchia, 1983) does not obtain in the presence of the repurchase option. While higher cash flow realizations do give rise to an incentive to disclose information, the incentive to withhold information *and* repurchase shares to secure a better long-term price is even stronger in the upper tail of the cash flow distribution. These strategies are illustrated in Fig. 1.

4.1.2. Market prices

The market maker's beliefs about the strategy of the manager in equilibrium—i.e., her disclosure and repurchase cutoffs $\langle \underline{x}, \bar{x}\rangle$—determine the market prices, as a function of order flow and or disclosure, that are consistent with competitive markets (i.e., zero expected profits to the market maker).

The prices following extreme order flows—i.e., $P^H = P_2(h)$, and $P^L = P_2(-h)$—precisely reflect the manager's repurchase action. In particular, given the market maker's conjecture $\langle \underline{x}, \bar{x}\rangle$, these prices must satisfy the following:

$$P^H = E(x|r = h) = E(x|x \ge \bar{x}), \quad \text{and}$$
$$P^L = E(x|r = 0) = E(x|x \le \underline{x}).$$

When a repurchase takes place and is identified as such by the market maker, then by selling h shares at the price $P^H = E(x|r = h) = E(x|x \ge \bar{x})$, the market maker's expected payoff is

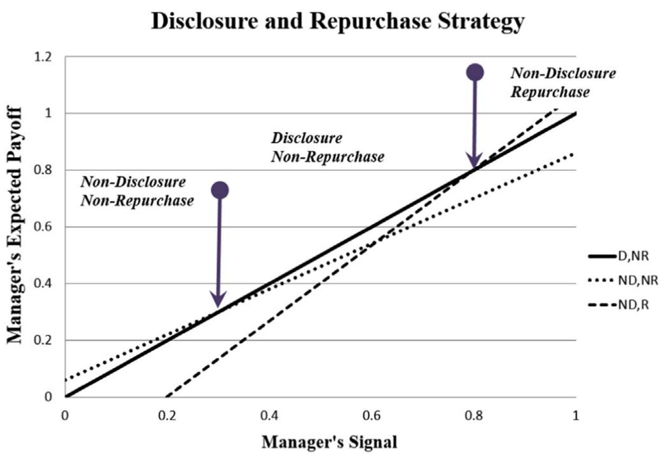

Fig. 1. The figure depicts the manager's payoffs from disclosure and repurchase when the expected prices following repurchase and non-repurchase are given by 0.8 and 0.3, the weight the manager places on the short-term price is β=0.2, the likelihood of no liquidity shock is α=0.7, and the size of the liquidity shock is h=0.4.

$$P^H - E\left[\frac{x - hP^H}{1 - h}|x \geq \bar{x}\right] = 0.$$

When order flow is intermediate, however, the market maker does not know whether the manager repurchased shares and liquidity traders do not sell or vice versa. Therefore, the conditional probability that the manager repurchased shares given the observation of intermediate order flow (of course, following non-disclosure) is of interest. Thus, we define:

$$\theta \equiv \Pr(r = h|F = 0).$$

Given this posterior probability, the market maker's expected payoff is

$$P^M - \left(\theta E\left[\frac{x - hP^H}{1 - h}|x \geq \bar{x}\right] + (1 - \theta)P^L\right).$$

Therefore, in order to obtain zero expected profit given intermediate order-flow, the following condition must hold

$$P^M = \theta P^H + (1 - \theta)P^L.$$

Lemma 2 (*Market prices and order flow*). *In any candidate equilibrium with disclosure and repurchase cutoffs* $\langle \underline{x}, \bar{x} \rangle$ *and* $\beta \in (0, h)$, *the prices* $\left\langle P^H, P^M, P^L \right\rangle$ *satisfy condition C1 and are given by*:

$$P^H = E(x|x > \bar{x}), \quad P^L = E(x|x < \underline{x}) \text{ and } P^M = \theta P^H + (1 - \theta)P^L,$$
$$\text{where } \theta = \frac{\Pr(x > \bar{x})(1 - \alpha)}{\Pr(x > \bar{x})(1 - \alpha) + P(x < \underline{x})\alpha}. \tag{13}$$

Therefore, in any equilibrium, the disclosure and repurchase cutoffs $\langle \underline{x}, \bar{x} \rangle$ and market prices $\left\langle P^H, P^M, P^L \right\rangle$ are a solution to (4), (5), and (13).

4.1.3. Equilibrium

We begin by briefly commenting on the case in which the manager has no option to repurchase. As we noted earlier, the standard unraveling result holds in this case given a *perfectly* informed manager (Grossman, 1981; Milgrom, 1981)—i.e., a full disclosure equilibrium results.[16] The reason is that in our model, there is neither a proprietary cost to disclosure (Verrecchia, 1983), nor any uncertainty as to whether the manager is informed (Dye, 1985), to prevent unraveling and support a partial disclosure equilibrium.

However, as the following equilibrium establishes, non-degenerate disclosure and non-disclosure regions obtain in equilibrium even with a perfectly informed manager when she also has an option to repurchase. We are able to construct this equilibrium which considers the manager's best response to prices set by the market maker based on order flow (Lemma 1) and the market maker's best response (Lemma 2).

Theorem 1 (*Two - Tailed Disclosure and Repurchase Equilibrium*). *For* $\beta \in (0, h)$, *there exists an equilibrium with monotone prices in which the manager does not disclose information but repurchases shares when* $x > \bar{x}$, *does not disclose information and does not repurchase shares when* $x < \underline{x}$, *and discloses her private information when* $x \in (\underline{x}, \bar{x})$. *The cutoffs* $\underline{x}, \bar{x}$ *satisfy* $x_{\min} < \underline{x} < \bar{x} < x_{\max}$ *and are implicitly given by*,

$$\underline{x} = \alpha\theta E(x|x > \bar{x}) + (1 - \alpha\theta)E(x|x < \underline{x}),$$
$$\bar{x} = (\alpha + \theta - \alpha\theta)E(x|x > \bar{x}) + (1 - \alpha)(1 - \theta)E(x|x < \underline{x}). \tag{14}$$

The market prices set by the market maker are,

$$P^H = E(x|x > \bar{x}), \quad P^L = E(x|x < \underline{x}), \quad \text{and } P^M = \theta P^H + (1 - \theta)P^L$$
$$\text{where } \theta \equiv \frac{(1 - \alpha)\Pr(x > \bar{x})}{(1 - \alpha)\Pr(x > \bar{x}) + \alpha\Pr(x < \underline{x})}.$$

Thus, full disclosure does not obtain in equilibrium when a perfectly informed manager can repurchase shares i.e., there does not exist an equilibrium in which the disclosure region is the full support $\mathcal{X}$. Instead, there is partial disclosure in equilibrium since the manager can hide behind, so to speak, the uncertainty regarding market demand for the firm's stock. In particular, the uncertainty about the liquidity needs of shareholders allows informed managers to withhold adverse information from markets or, alternatively, to trade on this information without being detected by the market maker. Without

[16] See also, Viscusi (1978), Grossman and Hart (1980), Milgrom and Roberts (1986).

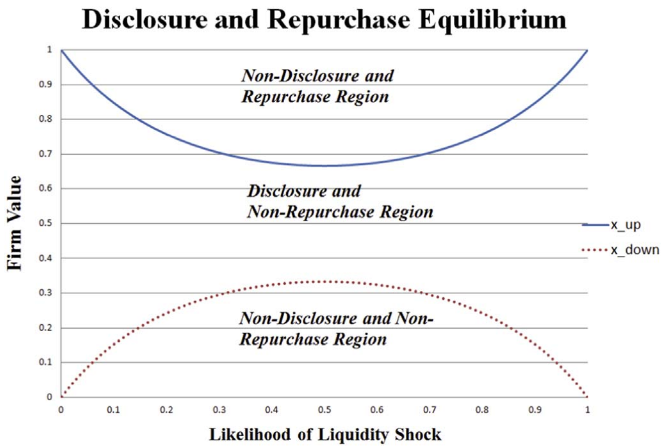

Fig. 2. The figure depicts the disclosure and repurchase regions as a function of the likelihood of the liquidity shock α when the weight the manager places on the short-term price is β=0.1, the size of the liquidity shock is h=0.4, and firm value x is a draw from the Uniform distribution over the unit interval.

such uncertainty, the market maker can perfectly identify trade by the manager and the unraveling argument holds, which leads to full-disclosure. In essence, it is the ability to buy undervalued shares that keeps high-value firms from disclosing.

We illustrate this partial disclosure and repurchase equilibrium in Fig. 2 using a closed-form solution corresponding to the case in which firm value is a draw from the Uniform distribution, $x \sim U(0, 1)$.[17] Notice that the manager is more likely to disclose her private information and less likely to repurchase shares when the level of uncertainty α is lower. The disclosure region expands when the uncertainty regarding the liquidity shock, α, is reduced. Intuitively, the manager, while being completely informed, exploits this uncertainty faced by the market maker to hide information. However, once this uncertainty diminishes, the manager will be compelled to disclose more information in equilibrium. At the limit, when the liquidity shock is completely predictable—i.e., $\alpha = 0$ or $\alpha = 1$ —the equilibrium converges to a full disclosure equilibrium. The following corollary formally states this result with respect to the liquidity shock.

Corollary 1 (*Disclosure and liquidity shock*). *The equilibrium approaches that of full disclosure* (*with no repurchase*) *as uncertainty on the liquidity shock diminishes to zero, that is,* $\langle \underline{x}, \overline{x} \rangle \to \langle x_{\min}, x_{\max} \rangle$ *as* $\alpha \to 0$ *or* 1.

Interestingly, when we subsequently consider the case of costly disclosures, we show the intermediate disclosure region *need not* exist in equilibrium for all illiquidity levels and the aforementioned limiting case will no longer yield full disclosure. Moreover, when disclosures are costly, the equilibrium behavior of the manager also depends on the size of the liquidity shock and the weight she places on the short-term price.

4.2. Short-run price focus/low liquidity shock

Next, we consider the case in which the size of the liquidity shock (h) is small relative to the weight the manager places on the short-term price in her objective function (β). As we noted earlier, the expected payoff to the manager from repurchasing shares is

$$E(V^m|ND, r = h, x) = x + \left(\frac{h - \beta}{1 - h}\right)(x - \overline{P}).$$

With $h \le \beta$, the manager does not benefit from repurchasing undervalued shares as her expected payoff would be less than the value of her private information (x). In this case, the manager might as well disclose x directly and benefit from propping up the short-term price. Consequently, it turns out that in any candidate equilibrium, the manager's disclosure strategy is necessarily upper-tailed. Moreover, given that the manager is *perfectly* informed, once again the standard unraveling result holds, and the only equilibrium is one in which the manager *always* discloses.

Proposition 1 (*Equilibrium: high short-term price focus*). *When* $\beta \in (h, 1)$, *the only equilibrium that exists is one of full disclosure. Off-equilibrium-path prices following non-disclosure are set to be* $P^H = P^M = P^L = x_{\min}$.

4.3. Summary

Table 1 summarizes the main equilibrium results derived in this section in a succinct manner.

[17] Detailed derivations corresponding to the Uniform distribution is available with the authors upon request. We refer to this special case throughout the paper to illustrate our results.

Table 1
Two-tailed disclosure and repurchase equilibrium regions.

Firm value	Alignment with long-term shareholder interests			
	HIGH		LOW	
	Disclose	Repurchase	Disclose	Repurchase
Low	No	No	Yes	Indifferent
Intermediate	Yes	Indifferent	Yes	Indifferent
High	No	Yes	Yes	Indifferent

5. Extensions

In this section, we present some extensions that address certain key structural aspects of our model. First, we examine how our main equilibrium is affected when disclosures are costly. Second, we discuss an endogenous level of managerial long-term price focus and the value implications of the existence of a repurchase plan. Finally, we show that the upper-tailed repurchase strategy result (Lemma 1), which we established using a binary representation of the liquidity shock, is robust to more general specifications.

5.1. Costly disclosures

The introduction of costly disclosure $c \in (0, \beta)$ alters the long-term price focused manager's best response to market prices, set by the market maker. In particular, we assume that following disclosure of x the value of the firm is $x(1-c)$, or that the value c represents the percentage lost in the event of disclosure.[18] Relative to the case with no disclosure cost, the manager is willing to repurchase shares for lower valuations and to choose non-disclosure for higher valuations. In addition to the incentive to repurchase undervalued stock, the manager will now also repurchase stock that is overvalued as long as the loss due to this over-valuation does not exceed the cost of disclosure (keeping in mind that repurchasing overvalued stock transfers wealth from long-term investors to short-term investors). Or formally, the manager will repurchase shares for

$$x \geq \overline{x} = \overline{P}\frac{h-\beta}{h-\beta+(1-h)c}\left[\textbf{Repurchase is optimal}\right].$$

Notice that when the disclosure cost is zero, the above condition coincides with our previous analysis and the manager repurchases only undervalued stock. However, since $\frac{h-\beta}{h-\beta+(1-h)c} < 1$ for $c > 0$, it follows that the manager repurchases overvalued stock as well. Similarly, the manager will prefer non-disclosure over disclosure for higher value realizations due to the cost associated with disclosure. Formally, non-disclosure is optimal when,

$$x \leq \underline{x} = \underline{P}\frac{\beta}{\beta-c}\left[\textbf{Non}-\textbf{disclosure and non}-\textbf{repurchase is optimal}\right].$$

Notice that a manager with a short-run price focus (a higher β) is more willing to disclose information and bear the disclosure cost relative to a manager with a long-run price focus.

Of course, in an equilibrium with partial disclosure, the upper cutoff must be higher than the lower cutoff, or formally (where $\Delta \equiv \frac{\beta}{\beta-c}\frac{h-\beta+(1-h)c}{h-\beta}$),

$$\underline{x} \leq \overline{x} \Leftrightarrow \Delta\underline{P} \leq \overline{P}.$$

If instead the prices set by the market maker satisfy $\Delta\underline{P} > \overline{P}$, then the manager's best response is to never disclose information as in the benchmark case when disclosure is not possible, i.e., repurchase above a cutoff, and not repurchase otherwise. Indeed, the higher the cost of disclosure the higher is the value of Δ.

Theorem 2 (*Equilibrium with costly disclosure*). *When disclosure is costly and the manager is long-term focused i.e., $\beta < h$, the equilibrium can be one of two types*:

No-Disclosure *For a sufficiently high disclosure cost, a non-disclosure equilibrium emerges. The manager repurchases shares only for $x > \overline{x} = \underline{x} \equiv \check{x}$ and expected prices satisfy $\overline{P} < \Delta\underline{P}$;*
Partial disclosure *For a sufficiently small disclosure cost, a two-tailed repurchase and disclosure equilibrium similar to that presented in Section 1 emerges. Namely, the manager does not disclose and does not repurchase shares for sufficiently low cash*

[18] Note that when $c > \beta$, the manager will always prefer non-disclosure over disclosure due to the relatively high cost associated with disclosure. Therefore, we restrict attention in this section to the case of lower disclosure costs.

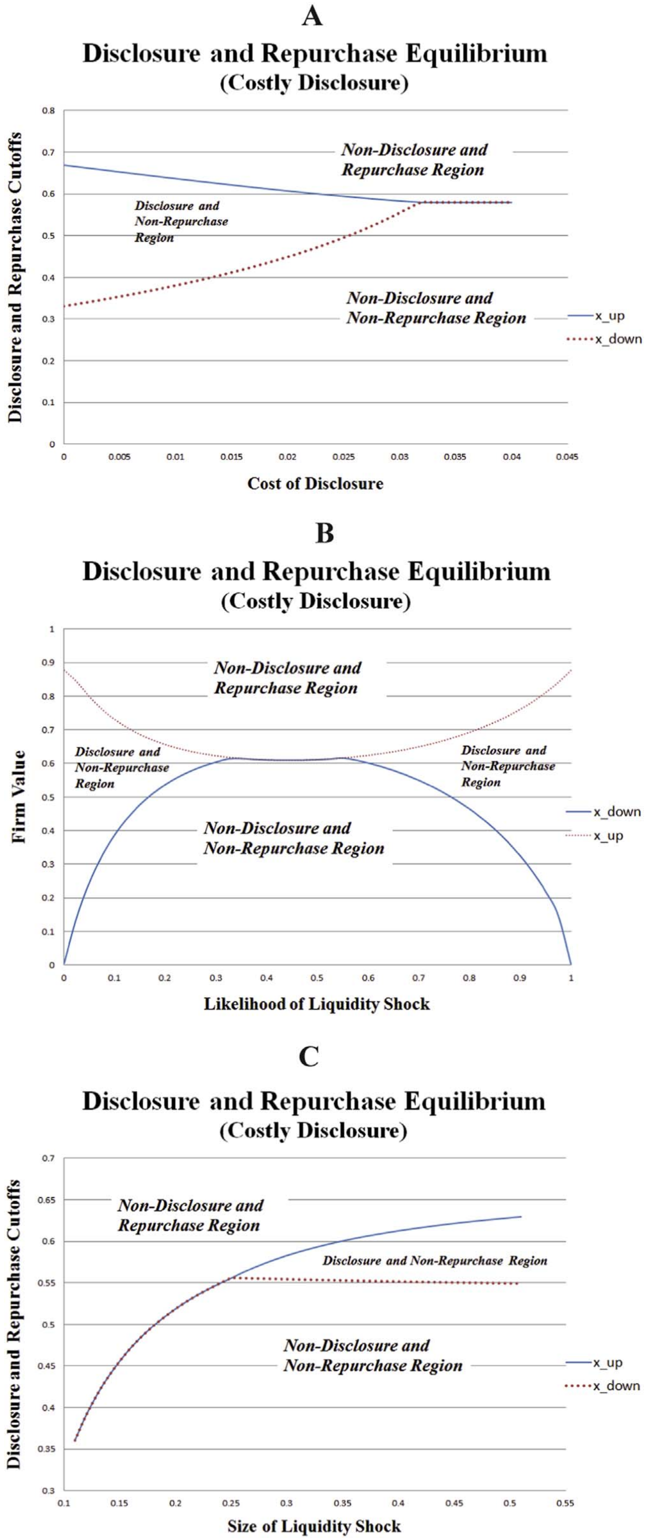

Fig. 3. (A) The figure depicts the disclosure and repurchase regions as a function of the cost of disclosure when the likelihood of the liquidity shock is $\alpha=0.45$, the weight the manager places on the short-term price is $\beta=0.1$, the size of the liquidity shock is $h=0.3$, and firm value x is a draw from the Uniform distribution over the unit interval. (B) The figure depicts the disclosure and repurchase regions as a function of the likelihood of the liquidity shock α when the weight the manager places on the short-term price is $\beta=0.1$, the size of the liquidity shock is $h=0.4$, the cost of disclosure is $c=0.035$, and firm value x is a draw from the Uniform distribution over the unit interval. (C) The figure depicts the disclosure and repurchase regions as a function of the size of the liquidity shock h when the cost of disclosure is $c=0.03$, the likelihood of the liquidity shock is $\alpha=0.45$, the weight the manager places on the short-term price is $\beta=0.1$, and firm value x is a draw from the Uniform distribution over the unit interval.

flow realizations, $x \le \underline{x} = \underline{P}\frac{\beta}{\beta - c}$; discloses information for intermediate realizations, $x \in \left(\underline{x}, \bar{x}\right)$; and otherwise withholds information and repurchase shares, $x \ge \bar{x} = \overline{P}\frac{h-\beta}{h-\beta+(1-h)c}$ and expected prices satisfy $\overline{P} > \Delta\underline{P}$; where $\left\langle \underline{P}, \overline{P}\right\rangle$ are given by (4)–(5), $P^H = E(x|x > \bar{x})$, $P^L = E(x|x < \underline{x})$, $P^M = \theta P^H + (1-\theta)P^L$, and $\theta \equiv \frac{(1-\alpha)\Pr(x > \bar{x})}{(1-\alpha)\Pr(x > \bar{x}) + \alpha \Pr(x < \underline{x})}$, $\Delta \equiv \frac{\beta}{\beta - c} \times \frac{h-\beta+(1-h)c}{h-\beta}$.

To illustrate this partial disclosure and repurchase equilibrium, we return to our Uniform distribution example where $x \sim U(0, 1)$. Fig. 3A plots the equilibrium cutoffs as a function of the cost of disclosure. As one might expect, there is less disclosure of unfavorable or middle-level news as the cost of disclosure increases (Verrecchia, 1983). However, one can also see that as a result of an increase in the cost of disclosure, there is less disclosure of good news, since the manager instead prefers to repurchase shares for these valuations.

The level of uncertainty regarding the liquidity shock, as captured by α, has implications for the equilibrium outcome that are distinct from those implied by the *size* of the liquidity shock h. As we explain below, the size of the liquidity shock affects the gains (or losses) from repurchasing stock and, thus, the behavior of the manager in equilibrium. Initially, we consider in Fig. 3B how the disclosure and repurchase equilibrium strategies of the manager vary with the likelihood of a liquidity shock. As can be seen, the equilibrium is one of no-disclosure when there is utmost uncertainty regarding the liquidity shock. As the level of uncertainty increases, or the likelihood of a liquidity shock approaches one-half, the upper disclosure cutoff decreases and the lower disclosure cutoff increases, that is, less information is disclosed. Intuitively, as the level of uncertainty increases, the manager can, with a higher probability, hide her trades from the market maker, which reduces the disclosure region. Note that while the manager's best response to a given pricing schedule as a function of order flow—set by the market maker—does not depend on the likelihood of the liquidity shock, in equilibrium, the market maker sets prices while facing less uncertainty when α is extreme, and this, in turn, affects the equilibrium outcome.

Next, we consider in Fig. 3C the disclosure and repurchase cutoffs as a function of the size of the liquidity shock h. As shown in the plot, the equilibrium contains an intermediate disclosure region in which the size of the liquidity shock is above a cutoff level and the region increases in the size of the liquidity shock afterwards. The reason is that the manager starts to repurchase shares instead of disclosing information when the stock is not yet undervalued (due to the alternative of costly disclosure) and the effective cost from repurchase in terms of long-term value is increasing in the number of shares repurchased. Consequently, the higher the number of shares repurchased, the more costly is the repurchase transaction and the higher is the equilibrium upper cutoff.

Corollary 2. *If firm value is uniformly distributed over the unit interval, then in equilibrium the following lead to a lower likelihood of disclosure (and possibly no-disclosure): (i) higher uncertainty about the liquidity shock—i.e., α closer to $\frac{1}{2}$, (ii) smaller size of the liquidity shock, h, and (iii) higher disclosure costs. Moreover, the relation between the likelihood of disclosure and the level of the manager's short-term price focus is inverted U-shaped, in the interval $\beta \in \left(c, h\right)$.*

We note that in establishing the above Corollary we have abstracted away from other forces that are known in the literature to affect the relation between disclosure and liquidity (that we discuss later).

5.2. Manager's information endowment

One of the main results of this paper is that partial disclosure emerges even when there is no cost to disclosure or when the manager is perfectly informed. In other words, the presence of the repurchase option is enough to support partial disclosure in equilibrium, unlike in Dye (1985) and Jung and Kwon (1988), where it is the uncertainty regarding the manager's information endowment (the manager can either be informed or uninformed with a certain probability) that gives rise to partial disclosure. In this section, we examine the impact of introducing such uncertainty on our results.

As in Dye (1985) and Jung and Kwon (1988), we assume that the manager is privately informed about terminal cash flow x with probability λ $(0 < \lambda < 1)$, and there is therefore uncertainty regarding the information endowment of the manager. As regards the informed manager, the best-response disclosure and repurchase cutoffs to prices $\left\langle P^L, P^M, P^H\right\rangle$ are exactly as derived earlier, i.e.,

$$\bar{x} = \alpha P^H + (1-\alpha)P^M, \quad \text{and } \underline{x} = \alpha P^M + (1-\alpha)P^L. \tag{15}$$

However, we must now consider the trade-off faced by the uninformed manager—choosing between repurchasing shares (i.e., pooling with the informed manager with favorable information) or not repurchasing shares (i.e., pooling with the informed manager with unfavorable information). Given anticipated market expected prices following repurchase and non-repurchase $\overline{P} \equiv \bar{x}$ and $\underline{P} \equiv \underline{x}$, respectively, the uninformed manager will prefer non-repurchase over repurchase when,

$$E(x) < \gamma\bar{x} + \left(1-\gamma\right)\underline{x} \ [\langle ND, NR\rangle \text{ dominates } \langle ND, R\rangle \text{ for uninformed manager}], \tag{16}$$

where $\gamma = \frac{h-\beta}{h(1-\beta)}$. In equilibrium, the market prices must be consistent with whether the uninformed manager repurchases shares or not. Thus, we add the equilibrium condition that the uninformed manager optimally chooses between repurchasing shares or not, as in (16). While considering the manager with a long-term price focus, Fig. 4A and B depict the equilibrium cutoffs as a function of the likelihood of an information event λ assuming the Uniform distribution in the unit

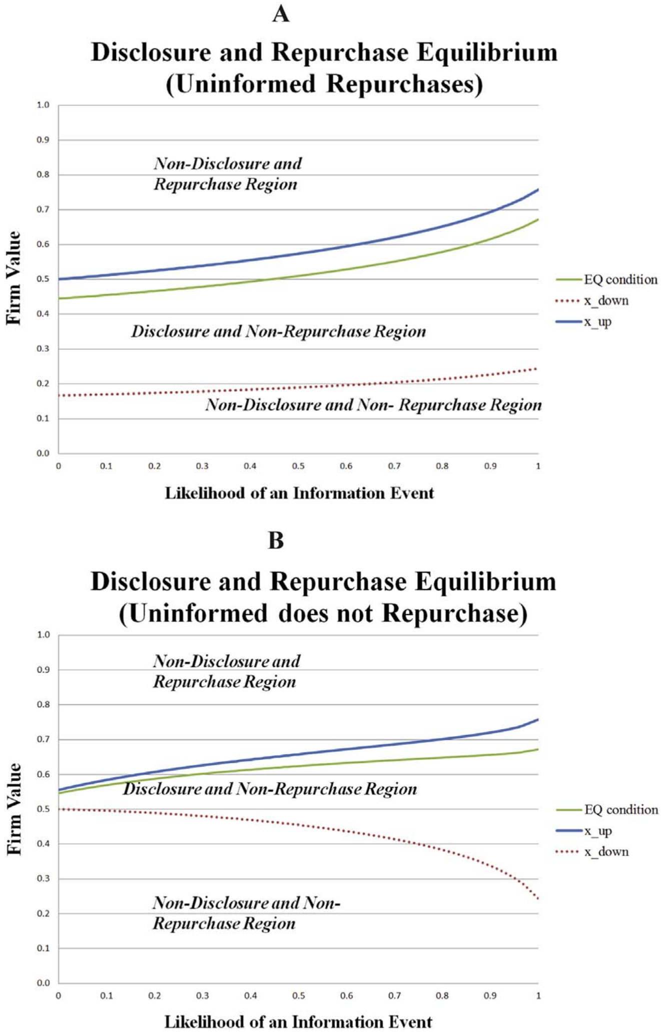

Fig. 4. (A) The figure depicts the disclosure and repurchase regions as a function of the likelihood of an information event when the uninformed manager repurchases shares, for parameters α=0.2, β=0.1, h=0.4, and when firm value x is a draw from the Uniform distribution over the unit interval. This equilibrium (in which the uninformed manager *repurchases*) exists only for sufficiently small likelihood values, when the green line that represents equilibrium condition (16) is *below* the average firm value of 0.5. (B) The figure depicts the disclosure and repurchase regions as a function of the likelihood of an information event when the uninformed manager does not repurchase shares, for parameters α=0.2, β=0.1, h=0.4, and when firm value x is a draw from the Uniform distribution over the unit interval. This equilibrium (in which the uninformed manager *does not repurchase*) exists for all likelihood values as the green line that represents equilibrium condition (16) is always *above* the average firm value of 0.5.

interval for firm value. The equilibrium outcome in which the uninformed manager *repurchases* (*does not repurchase*) shares is examined in Fig. 4A (4B). To appreciate the above choice of the uninformed manager, the green line in the figures represents the right-hand side of condition (16). An examination of Fig. 4A shows that the equilibrium outcome in which the uninformed manager repurchases shares exists only for sufficiently small values of the likelihood that the manager is informed (when the green line is below the expected value of one-half). On the other hand, Fig. 4B reveals that the equilibrium outcome in which the uninformed manager does not repurchase shares exists for all values of the likelihood $\lambda \in (0, 1)$, as the green line is always above one-half.

In Appendix B, we show that the results obtained in the case of the fully informed manager with a longer-term price focus (i.e., $\beta \in (0, h)$) are robust to the case in which there is uncertainty surrounding the manager's information endowment. In particular, we show that for sufficiently small λ there exists both an equilibrium in which the uninformed manager repurchases shares and one in which she does not repurchase shares. However, for sufficiently large λ there only exists one of these two types of equilibria depending on the informed manager's level of short-term price focus, $\beta \in (0, h)$, which affects the ratio γ in inequality (16) above. However, our qualitative inferences regarding the nature of these equilibria remain substantively similar to those in our main analysis.

5.3. General distribution of liquidity shock

In this section, we examine the generalizability of the result in Lemma 1 in which we consider a more general distribution of the liquidity shock with continuous support. In particular, suppose the shareholders receive a liquidity shock to sell $q \backsim Q$ with support $[0, 1]$. As before, we denote the pricing rule determined by the market maker that is based on the observed order flow by $P(F)$. The manager's strategy then is to repurchase shares at rate $r(x)$ and the consequent order flow is given by $F = r(x) + q \in [r(x) - 1, r(x)]$. The zero expected profit condition for the market maker implies that the pricing rule following non-disclosure satisfies $P(F) = E(x|r(x) + q)$.

Our intention here is to show that an upper-tailed cutoff disclosure strategy—i.e., that the manager discloses information for $x > x'$ for some cutoff x'—cannot be part of an equilibrium. To this end, it suffices to establish that in any such suggested cutoff equilibrium, the manager has an incentive to deviate from her disclosure strategy and instead repurchase shares while not disclosing information.

We therefore assume by contradiction that in equilibrium the manager discloses all information above the proposed cutoff x'. It then follows that the prices set by the market maker following non-disclosure and order flow $F = r(x) + q$ satisfy the property $P(r(x) + q) = E(x|r(x) + q) \le x'$. Note that given the above pricing rule, the manager has an incentive to withhold information and repurchase shares for all $x > x'$, thus contradicting the proposed cutoff disclosure strategy. In particular, the payoff from repurchasing $r(x) > \beta$ shares for the manager of type x is

$$E(V^m|ND, r(x), x) = \left(\frac{1-\beta}{1-r(x)}\right)x - \left(\frac{r(x)-\beta}{1-r(x)}\right)E(P(F)\,|r(x)),$$

while the payoff from disclosure is x. Therefore, the advantage to disclosing information is given by

$$x - E(V^m|ND, r(x), x)$$
$$= x - \left(\frac{1-\beta}{1-r(x)}\right)x + \left(\frac{r(x)-\beta}{1-r(x)}\right)E(P(F)|r(x)).$$

It then follows that the manager will find it optimal to disclose information when $x - \left(\frac{1-\beta}{1-r(x)}\right)x + \left(\frac{r(x)-\beta}{1-r(x)}\right)E(P(F)|r(x)) > 0$. Or, if simplified, disclosure is optimal only if $E(P(F)|r(x)) > x$. However, since $E(P(F)|r(x)) \le x'$, as established above, disclosure cannot be optimal for $x > x'$, which leads to a contradiction. We formally state this result in the following proposition.

Proposition 2 (*Impossibility of cutoff disclosure strategy*). *If the liquidity shock is distributed according to the general distribution function Q with support* $[0, 1]$, *there does not exist a cutoff disclosure equilibrium in which disclosure occurs for all* $x \ge x'$ *for some* $x' \in \mathcal{X}$.

Recall from our earlier analysis that the upper-tailed cutoff disclosure shown to emerge in equilibrium in the literature (Verrecchia, 1983; Dye, 1985), cannot be part of any equilibrium for a binary distribution of the liquidity shock (Lemma 1). Proposition 2 implies that the upper-tailed cutoff disclosure strategy does not emerge in equilibrium *even* when we consider a more general distribution of the liquidity shock. Thus, while we have used a binary structure for the liquidity shock for tractability reasons, the intuition underlying the full disclosure and repurchase equilibrium remains intact when we relax the binary structure of the liquidity shock to accommodate a more general distribution with continuous support.

6. Related literature and empirical implications

In this section, we first present a discussion of related papers in the disclosure and share repurchase literature to provide a context for our analysis and results. Second, we present some empirical implications of our work.

6.1. Related literature

6.1.1. Disclosure

In the classic disclosure literature, the equilibrium disclosure region is typically "upper-tailed." That is, firms with sufficiently good news, disclose; others do not (Verrecchia, 2001; Dye, 2001). In this paper, however, we identify a disclosure equilibrium in which firms with both extreme good and bad news do not disclose. While this equilibrium disclosure strategy emerges from a joint analysis of direct disclosure and repurchase decisions, the literature has shown that the strategy of withholding extreme good news can arise as equilibrium behavior in other settings as well.

For instance, in Wagenhofer (1990), a firm's manager endowed with private proprietary information wishes to promote the firm's stock price by strategically sharing this information with markets. The information disclosed, however, not only influences the beliefs of market participants but also may trigger a rival firm to act (e.g., entry by a potential entrant). The more favorable is the news disclosed, the more likely it allows the rival firm to benefit at its own expense. Wagenhofer (1990) shows that in equilibrium, the manager may withhold extreme news as shaped by the trade-off between deterring the rival firm and influencing stock price.

In Suijs (2007) a financially constrained firm approaches an investor for funds to finance funding for an investment opportunity. The investor can allocate her limited wealth between the firm and an alternate investment opportunity. The firm is privately informed about the value of the investment opportunity while the investor is privately informed about her outside option. Disclosure of good news need not lead to more investment allocated to the firm in so far as the investor, with some probability, values her outside option at an even greater value in light of the disclosure. Thus, the firm is uncertain of the investor's response. Suijs (2007) shows that this uncertainty induces a partial disclosure equilibrium in which extreme news is withheld from markets.

While the nature of the equilibrium disclosure strategies identified in these papers is *prima facie* similar to what we derive here, the forces that drive them are markedly different. Specifically, in these studies, *who* uses information (Wagenhofer, 1990), and *how* information is used (Suijs, 2007), play an important role. In contrast, in our analysis, the *manner* in which information is conveyed and incorporated into market price (direct disclosure vs. share repurchases)—in conjunction with the manager's disposition toward short-term and long-term investors—shapes equilibrium disclosure strategies in an important way. In particular, we show that the existence of a repurchase plan induces longer-term oriented managers with extreme good information to increase long-term shareholder value by withholding favorable information to strategically induce under-valuation, and at the same time, repurchasing shares. Our analysis also highlights a novel link between managers' equilibrium disclosure strategies and the level of market liquidity.

6.1.2. *Other motives for share repurchases*

Share repurchases need not always reflect attempts by informed corporate executives to raise equity valuation from the perspective of long-term investors. As the literature shows, share repurchases can also be triggered by earnings management incentives and by incentives to avoid adverse short-term market reactions.

Evidence suggests that failure to meet market earnings per share expectations evokes a negative market response (Bartov et al., 2002; Lopez and Rees, 2002); share repurchases are one way of boosting or obfuscating the calculation of earnings per share (EPS) and avoiding this market penalty. Indeed, Bens et al. (2003) show that firms often resort to repurchases to offset the dilutive effects of employee stock options (ESOs) on EPS. They also find that the frequency of stock repurchases is higher among firms whose EPS levels would otherwise not be sufficient to sustain desired earnings growth rates. In a similar vein, Hribar et al. (2006) find that firms repurchase shares to manage reported EPS for beating market benchmarks such as analyst expectations. However, the literature also suggests that the use of repurchases to manipulate earnings-per-share (EPS) may have negative real and investment consequences for the firm. For instance, Almeida et al. (2016) document that, all else equal, firms that use cash to repurchase and manipulate EPS have lower capital investment and employment.[19]

In addition, repurchases may be used by informed corporate executives to benefit from stock mispricing at the expense of less informed investors. For example, Barth and Kasznik (1999) find that the probability of initiating repurchase programs is positively related to the fraction of intangible assets. Because information asymmetry is generally considered to be positively related to the firm's intangible assets and to stock mispricing, Barth and Kasznik (1999) interpret this result as evidence that firms repurchase shares to exploit mispricing. Furthermore, Core et al. (2006) and Gong et al. (2008) show that firms sometimes manipulate financial information to create mispricing that can then be exploited through repurchases.

A common thread underlying these studies is the notion that repurchases are a mechanism by which managers—who know their firms are undervalued—exploit their information advantage. However, as Fischer and Verrecchia (2004) observe, it is not necessary that managers possess private information in order to engage in such actions; it is enough if they merely believe they have private information. That is, managers may *believe* their firms are undervalued not based on Bayesian processing of private information, but based on non-Bayesian (behavioral) heuristic reasons, which could indeed trigger repurchases.[20]

As this discussion suggests, there can be many motives behind share repurchases. Our objective is to examine how the option to repurchase stock affects the incentive of an informed manager to engage in direct disclosures. We therefore limit ourselves to the classic disclosure setting in which an informed manager faces the decision of whether or not to make credible disclosure in order to generate a favorable valuation effect (Verrecchia, 1983; Dye, 1985), and we ask how the alternative avenue of exploiting private information via stock repurchases affects equilibrium disclosure strategies. Specifically, we focus on one known aspect of share repurchases—as a mechanism that corporate executives of undervalued firms may use to transfer wealth from short-term investors to long-term shareholders (see, e.g., Stephens and Weisbach, 1998; Grullon and Ikenberry, 2000). In the context of disclosure models, this aspect brings to light an interesting trade-off because direct disclosures is a way of alleviating such wealth expropriations. Thus, we do not consider either earnings management driven incentives or behavioral heuristics in this paper.

6.2. *Empirical implications*

Our study yields a number of empirical implications comparing firms with and without a repurchase plan; regarding

[19] There are other motivations for repurchases as well, such as tax-based incentives (e.g., Aboody and Kasznik, 2008). See Allen and Michaely (2003) and Farre-Mensa et al. (2016) for useful surveys of the motivations for repurchases.

[20] We sincerely thank a referee for enlightening us in this respect.

firms with different levels of stock liquidity within the group of firms with a repurchase plan; regarding the costs associated with voluntary disclosure, and regarding the effects of managerial short-term price orientation. We note that these empirical implications pertain to the specific motive for share repurchases that we consider in this paper, namely, share repurchases as a mechanism that informed managers may use to effect wealth transfers from short-term investors to long-term investors.

The literature by and large suggests that managers either voluntarily disclose all credible information (unraveling result) or withhold bad news and only reveal favorable signals (Dye, 1985; Verrecchia, 1983). Our study suggests that the disclosure behavior of firms with a repurchase plan is quite different as they withhold extreme news (both good and bad) and only reveal intermediate signals. From an empirical point of view, one should observe lower frequencies of good news disclosures among firms with a repurchase plan relative to those without a plan, or for the same firm before the adoption of a repurchase plan vs. after the adoption.

The likelihood of a liquidity shock α plays an important role in shaping the equilibrium outcome. This uncertainty captures the notion of liquidity: higher levels of stock liquidity correspond to more uncertainty regarding the trades of the liquidity traders. Intuitively, when the uncertainty about the liquidity shock is higher (or α is closer to one half), one can trade with a low price impact—i.e., the level of liquidity is high. In our setting, the informed manager can better exploit her private information by repurchasing shares when the market is more liquid. This view is consistent with the approach in Kyle (1985) and Krishnan (1992).

Adopting this notion of liquidity, our results suggest that within the group of firms that have a repurchase plan, the level of stock liquidity impacts firms' disclosure and repurchase behavior. In particular, when the level of liquidity is high, the manager can more easily hide, so to speak, behind the trades of the liquidity traders and is more likely to exploit her private information by repurchasing undervalued stock. This is consistent with empirical evidence that documents a positive association between the tendency of firms to repurchase shares and the level of liquidity (Ben-Rephael et al., 2014; Cook et al., 2004). When the manager can also disclose information, we show that when liquidity is high, the manager is more likely to withhold good information in order to induce under-valuation and then trade; consequently, there is less disclosure. Moreover, when disclosure is costly, the equilibrium can be one of non-disclosure (by a completely informed manager) if the level of liquidity is sufficiently high.

Thus, our analysis suggests that lower levels of stock liquidity *absent* disclosure can induce the manager to disclose *more*. One empirical implication here is that following a reduction in the level of liquidity, firms with a repurchase plan are likely to respond by disclosing information (repurchasing shares) more (less) frequently. The hypothesis that managers respond to reductions in liquidity by disclosing more information receives some empirical support in Balakrishnan et al. (2014). Similar evidence is found by Healy et al. (1999) while examining the relation of stock liquidity to firm disclosure proxies.[21] They find that firms that realize an increase in their disclosure rankings, as determined by analysts, had experienced significantly lower stock-liquidity as measured by higher bid-ask spreads relative their industry peers prior to the disclosure change. For these firms, after the increase in disclosure ranking, the bid-ask spreads narrowed back to the level of their industry peers. These findings are consistent with the view that disclosure of information leads to increased liquidity and at the same time managers strategically respond to low levels of stock liquidity (e.g., high bid-ask spreads) by disclosing more information.

Our model predicts that a sufficiently low level of managerial short-term price focus is required in order to support an equilibrium in which the manager repurchases shares (otherwise there is full disclosure). In other words, managers motivated by a long-term price focus will repurchase shares more frequently and disclose information less frequently. In addition to being consistent with the notion that share repurchases benefit the long-term investors (Ikenberry et al., 1995; Peyer and Vermaelen, 2009), we offer a new perspective by showing that these managers are less likely to engage in voluntary disclosures.

Finally, when considering costly disclosures, we find that, as in previous literature, higher disclosure costs lead to less disclosure of bad news—i.e., the manager with bad signals can better support a high stock price by choosing not to disclose information in equilibrium. However, we also find that there is less disclosure of good news for these firms since the manager wishes to induce under-valuation. Thus, our analysis suggests that low disclosure cutoff increase, while high disclosure cutoff decreases, in the cost of disclosure.

7. Conclusion

In the voluntary disclosure literature, it has been shown that an informed manager's incentive to withhold bad news may actually lead to the unraveling of information or full disclosure in equilibrium. However, informed managers have other avenues through which to exploit their private information given their incentives. For instance, managers of undervalued firms often repurchase shares to the extent they care about long-term shareholders. In this paper, we model a manager's choice to either directly disclose her private information or to engage in repurchasing. While the *unraveling* result suggests that informed managers cannot exploit their private information - as all information is disclosed - we show that the ability of the manager to repurchase stock, together with the stochastic need of some investors to liquidate shares, lead to a partial

[21] See also Healy and Palepu (2001) for a survey of the empircial literature.

disclosure strategy in equilibrium.

This partial disclosure strategy emerges because the repurchase of undervalued stock dominates the disclosure of information for sufficiently favorable realizations as long as the manager cares about the long-term equity valuation gains from purchasing undervalued stock—a realistic assumption given the prevalence of stock repurchases. As we have shown, the manager can exploit her information advantage over the market maker in two important ways: first, the manager can withhold information from the market maker by choosing not to disclose information (Dye, 1985; Verrecchia, 1983); and second, the manager can privately trade or repurchase shares because the market maker must set prices based on aggregate order flow (Kyle, 1985).

We derive a two-tailed disclosure and repurchase equilibrium. For sufficiently high valuations the manager repurchases stock to the benefit of long-term investors; for sufficiently low valuations, the manager withholds her information from markets in order to sustain a favorable short-term price and also chooses not to repurchase shares because the stock would be overvalued. For intermediate value realizations that are still below the expected short-term market price following repurchase, the manager discloses information to increase the short-term price. This strategy is sustained in equilibrium because the market maker cannot perfectly infer the manager's repurchase strategy based on aggregate order flow. Indeed, we show that the level of uncertainty faced by the market maker plays a crucial role in determining the disclosure and repurchase cutoffs. The more uncertain the market maker, the less the manager discloses information, the more she repurchases shares, and consequently the intermediate disclosure region shrinks.

The level of managerial short-term price orientation relative to the amount of shares required to be repurchased also plays a role in equilibrium. In particular, for any given level of such short-termism, the manager will prefer to repurchase shares for highly undervalued stock to prop up terminal price as long as the amount of shares traded exceeds that level of short-term price focus; otherwise the manager would prefer to disclose this information to advance the short-term price. Indeed, we show that when the manager is overly focused on the short-term price (a level beyond the realization of the liquidity shock), the equilibrium is one of full disclosure.

We extend our analysis in two ways to provide robustness of our results and broaden the scope. First, we extend our analysis to include a cost associated with disclosure. As one would expect, in the Uniform distribution case, more costly disclosures lead to a reduction in the intermediate disclosure region. Eventually, if disclosure costs are high enough, a non-disclosure equilibrium results. From a robustness point of view, our analysis confirms that the introduction of a disclosure cost does not alter the main properties of our equilibrium, as long as the disclosure cost is sufficiently low. We also show that incorporating uncertainty regarding the information endowment of the manager (Dye, 1985) does not qualitatively change the manager's disclosure and repurchase strategy in equilibrium.[22] Finally, we show that the result that favorable information is not disclosed, but instead leads to repurchase, is not driven by the simple binary representation of the liquidity shock we used in our main analysis; but extends to a general distribution as well.

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Appendix A

Proof of Lemma 1. For any given expected prices following repurchase and non-repurchase $\left\langle \underline{P}, \overline{P} \right\rangle$ such that $\underline{P} \le \overline{P}$ and for $\beta \in \left(0, h\right)$ the manager's expected payoff from repurchasing shares (together with non-disclosure) dominates the two alternatives of (i) disclosure, and (ii) not repurchasing shares (together with non-disclosure) for sufficiently high value realization. Formally, for $x > \overline{P}$ we have,

$$E\left(V^m | ND, r = h, x\right) > \max\left[E\left(V^m | D, x\right),\ E\left(V^m | ND, r = 0, x\right)\right],$$

or, more precisely,

$$x + \left(\frac{h - \beta}{1 - h}\right)\left(x - \overline{P}\right) > \max\left[x,\ \beta\underline{P} + (1 - \beta)x\right] \text{ for all } x > \overline{P} \ \left(\text{when } \beta \in \left(0, h\right)\right).$$

[22] In such a setting, however, an issue arises as to whether the uninformed manager would repurchase shares or not. This strategy of the uninformed manager will in turn have implications for the pricing mechanism of the market maker and for the equilibrium thresholds.

One can also verify that non-disclosure and non-repurchase is the manager's best response when $x < \underline{P}$;

$$E\left(V^m|ND, r = 0, x\right) > \max\left[E\left(V^m|D, x\right),\ E\left(V^m|ND, r = h, x\right)\right] \text{ for all } x < \underline{P} \ (\text{when } \beta \in (0, h)).$$

And finally, that disclosure is optimal for the intermediate range of $x \in \left(\underline{P}, \overline{P}\right)$. **Q.E.D.**

Proof of Lemma 2. The market prices set by the competitive market maker follow directly from the manager's equilibrium disclosure and repurchase cutoffs $\langle \underline{x}, \bar{x} \rangle$ and the requirement of zero expected rents to the market maker; that is, prices reflect the expected value of the firm from the perspective of the market maker that observes order flow but does not directly observe the trading behavior of the firm or the liquidity traders. When order flow is extreme, the market maker can perfectly infer the amount of shares repurchased by the manager and $P^H = E\left(x|x > \bar{x}\right)$, $P^L = E\left(x|x < \underline{x}\right)$; however, when order flow is intermediate, the market maker sets the price based on the likelihood θ that the manager repurchased shares, $\theta = \Pr\left(r = h|F = 0\right)$. Namely,

$$\theta = \Pr\left(r = h|F = 0\right) = \frac{\Pr\left(r = h, F = 0\right)}{\Pr\left(F = 0\right)} \tag{17}$$

$$= \frac{\Pr\left(r = h\right)\Pr\left(F = 0|r = h\right)}{\Pr\left(r = h\right)\Pr\left(F = 0|r = h\right) + \Pr\left(r = 0\right)\Pr\left(F = 0|r = 0\right)}, \tag{18}$$

$$= \frac{\Pr\left(r = h\right)\Pr\left(q = h\right)}{\Pr\left(r = h\right)\Pr\left(q = h\right) + \Pr\left(r = 0\right)\Pr\left(q = 0\right)}$$
$$= \frac{\Pr\left(x > \bar{x}\right)(1 - \alpha)}{\Pr\left(x > \bar{x}\right)(1 - \alpha) + P\left(x < \underline{x}\right)\alpha}. \tag{19}$$

Therefore, $P^M = \theta P^H + (1 - \theta)P^L$. **Q.E.D.**

Proof of Theorem 1. Using Lemmas 1, and 2, we can derive the equilibrium cutoffs $\langle \underline{x}, \bar{x} \rangle$; namely, $\underline{x} = \underline{P} = \alpha P^M + (1 - \alpha)P^L$ and $\bar{x} = \overline{P} = \alpha P^H + (1 - \alpha)P^M$ where:

$$P^H = E\left(x|x > \bar{x}\right), \quad P^L = E\left(x|x < \underline{x}\right), \quad \text{and } P^M = \theta P^H + (1 - \theta)P^L$$
$$\theta = \frac{(1 - \alpha)\Pr\left(x > \bar{x}\right)}{(1 - \alpha)\Pr\left(x > \bar{x}\right) + \alpha\Pr\left(x < \underline{x}\right)}. \tag{20}$$

Thus,

$$\bar{x} = \alpha E\left(x|x > \bar{x}\right) + (1 - \alpha)\left(\theta E\left(x|x > \bar{x}\right) + (1 - \theta)E\left(x|x < \underline{x}\right)\right), \tag{21}$$

and

$$\underline{x} = \alpha\left(\theta E\left(x|x > \bar{x}\right) + (1 - \theta)E\left(x|x < \underline{x}\right)\right) + (1 - \alpha)E\left(x|x < \underline{x}\right). \tag{22}$$

A direct application of the Fixed Point Theorem establishes the existence of a solution to the above two equations—i.e., existence of the cutoffs $\langle \underline{x}, \bar{x} \rangle$. In particular, this follows from the compactness of the support of firm value $\mathcal{X} \equiv \left[x_{\min}, x_{\max}\right] \subset R^+$, the fact that $E\left(x|x \in A\right) \in \mathcal{X}$ for all $A \subset \mathcal{X}$, and the continuity in $\langle \underline{x}, \bar{x} \rangle$ of the functions at hand. **Q.E.D.**

Proof of Corollary 1. As uncertainty about the liquidity shock diminishes to zero, that is, $\alpha \to 0$, the conditional likelihood of a repurchase of shares by the manager upon observation of intermediate order flow by the market maker is given by

$$\lim_{\alpha \to 0^+} \theta = \lim_{\alpha \to 0^+} \frac{(1 - \alpha)\Pr\left(x > \bar{x}\right)}{(1 - \alpha)\Pr\left(x > \bar{x}\right) + \alpha\Pr\left(x < \underline{x}\right)} = 1 \text{ for any } \langle \underline{x}, \bar{x} \rangle \subset \mathcal{X}. \tag{23}$$

Now, since the cutoffs also depend on α we obtain that they are given by the solution to the following two equations at the limit:

$$\bar{x} = \theta E\left(x|x > \bar{x}\right) + (1 - \theta)E\left(x|x < \underline{x}\right) \to E\left(x|x > \bar{x}\right), \quad \underline{x} = E\left(x|x < \underline{x}\right). \tag{24}$$

Therefore, the solution $\langle \underline{x}, \bar{x} \rangle$ converges to $\langle \bar{x}, \underline{x} \rangle \to \left\langle x_{\min}, x_{\max} \right\rangle$ as $\alpha \to 0$. **Q.E.D.**

Proof of Proposition 1. Proceeding as before, let $\overline{P} \equiv E\left(P_2|r = h\right)$ and $\underline{P} \equiv E\left(P_2|r = 0\right)$; the manager's payoffs are:

$$E\left(V^m|ND, r=h, x\right) = x - \left(\frac{\beta-h}{1-h}\right)\left(x-\overline{P}\right)$$
$$E\left(V^m|ND, r=0, x\right) = x + \beta\left(\underline{P}-x\right)$$
$$E\left(V^m|D, x\right) = x,$$

which implies that,

$$E\left(V^m|ND, r=h, x\right) - E\left(V^m|ND, r=0, x\right) = \left(\frac{h(1-\beta)}{1-h}\right)x + \left(\frac{\beta-h}{1-h}\right)\overline{P} - \beta\underline{P},$$
$$E\left(V^m|D, x\right) - E\left(V^m|ND, r=h, x\right) = \left(\frac{\beta-h}{1-h}\right)\left(x-\overline{P}\right),$$

Since $\beta \in (h, 1)$, disclosure is the manager's best response for sufficiently high valuations and is dominated otherwise,

$$x \geq \overline{P} \equiv E\left(P_2|r=h\right) \Leftrightarrow \text{Disclosure is optimal.}$$

However, since all information above $\overline{P}$ is disclosed by the manager, the market maker's valuation following non-disclosure for a given order flow must be lower than this cutoff. Moreover, it must be *strictly* lower if $\overline{P} > x_{\min}$, as $ND \Rightarrow x \in \left(x_{\min}, \overline{P}\right)$. Therefore, for any $\overline{P} > x_{\min}$, the expected price P_2 following non-disclosure and repurchase $E\left(P_2|r=h\right)$ must also be strictly lower than this cutoff. Therefore, the cutoff $\overline{P}$ is not consistent with zero profits for the market maker and we reach a contradiction. Consequently, the only equilibrium that exists is one in which $\overline{P} = x_{\min}$, i.e., a full disclosure equilibrium. **Q.E.D.**

Proof of Theorem 2. First, we start with the case of no-disclosure—i.e., there is a single cutoff that refers to the manager's repurchase strategy. This cutoff $\breve{x}$ is formally provided by

$$\breve{x} = \frac{(h-\beta)}{h(1-\beta)}\overline{P} + \frac{\beta(1-h)}{h(1-\beta)}\underline{P}, \quad \text{and } \langle \underline{P}, \overline{P} \rangle \text{ are given by } (4) \text{ and } (5). \tag{25}$$

The difference between the expected prices $\left\langle \underline{P}, \overline{P} \right\rangle$ shall be sufficiently small for this equilibrium to hold—i.e., condition $\overline{P} \leq \Delta\underline{P}$. Thus, we require that

$$\Delta \geq \frac{\left(\alpha + (1-\alpha)\theta\right)E\left(x|x>\breve{x}\right) + (1-\alpha)(1-\theta)E\left(x|x<\breve{x}\right)}{\alpha\theta E\left(x|x>\breve{x}\right) + (1-\alpha\theta)E\left(x|x<\breve{x}\right)}.$$

Since the solution $\breve{x}$ does not depend on the cost of disclosure and Δ is increasing in c, we establish that the above equilibrium condition $\overline{P} \leq \Delta\underline{P}$ holds for sufficiently high cost of disclosure $c < \beta$.

In a candidate equilibrium with two distinct cutoffs $\langle \underline{x}, \overline{x} \rangle$ we have:

$$\overline{x}\left[1 + \frac{c(1-h)}{h-\beta}\right] = (\alpha + (1-\alpha)\theta)E\left(x|x>\overline{x}\right) + (1-\alpha)(1-\theta)E\left(x|x<\underline{x}\right),$$

and

$$\underline{x}\left[1 - \frac{c}{\beta}\right] = \alpha\theta E\left(x|x>\overline{x}\right) + (1-\alpha\theta)E\left(x|x<\underline{x}\right).$$

A solution to the above equations exists for $c=0$ and can be shown to exist for sufficiently small values of c due to continuity. **Q.E.D**.

Proof of Corollary 2. The likelihood of disclosure is given by the probability that the manager's private information x lies in the intermediate disclosure region, i.e., the interval $(\underline{x}, \overline{x}) \subseteq (0, 1)$. Under the Uniform distribution, $x \sim U(0, 1)$, this probability equals $\Pr\left(x \in (\underline{x}, \overline{x})\right) = \overline{x} - \underline{x}$ for any $0 \leq \underline{x} \leq \overline{x} \leq 1$. Thus, we proceed by deriving the closed-form solution for the equilibrium cutoffs $(\underline{x}, \overline{x})$ for the Uniform distribution case and disclosure cost $c > 0$ (for $\beta \in (c, h)$) first, note that it follows from the above that $\left(\text{where, } \tau_1 \equiv \left[1 + \frac{c(1-h)}{h-\beta}\right] \text{ and } \tau_2 \equiv \left[1 - \frac{c}{\beta}\right]\right)$:

$$\overline{x}\tau_1 = \alpha P^H + (1-\alpha)P^M \Leftrightarrow P^M = \frac{\overline{x}\tau_1 - \alpha P^H}{1-\alpha} = \frac{\overline{x}(2\tau_1 - \alpha) - \alpha}{2(1-\alpha)}$$

and,

$$\underline{x}\tau_2 = \alpha P^M + (1-\alpha)P^L = \alpha\left(\frac{\overline{x}(2\tau_1-\alpha)-\alpha}{2(1-\alpha)}\right) + (1-\alpha)\frac{\underline{x}}{2} \Leftrightarrow \underline{x}(2\tau_2 - 1 + \alpha) = \alpha\left(\frac{\overline{x}(2\tau_1-\alpha)-\alpha}{1-\alpha}\right) \Leftrightarrow$$

$$\underline{x} = \frac{\alpha}{1-\alpha}\left(\frac{\overline{x}(2\tau_1-\alpha)-\alpha}{2\tau_2-1+\alpha}\right). \tag{26}$$

Now, the best response of the market maker P^M is given by,

$$\begin{aligned} P^M &= \frac{\overline{x}(2\tau_1-\alpha)-\alpha}{2(1-\alpha)} \\ &= \frac{(1-\alpha)\Pr(x>\overline{x})E(x|x>\bar{x})}{(1-\alpha)\Pr(x>\overline{x})+\alpha\Pr(x<\underline{x})} + \frac{\alpha\Pr(x<\underline{x})E(x|x<\underline{x})}{(1-\alpha)\Pr(x>\overline{x})+\alpha\Pr(x<\underline{x})} \\ &= \frac{1}{2}\left(\frac{(1-\alpha)\left(1-\overline{x}^2\right)+\alpha\underline{x}^2}{(1-\alpha)\left(1-\overline{x}\right)+\alpha\underline{x}}\right). \end{aligned}$$

This implies that,

$$\frac{\overline{x}(2\tau_1-\alpha)-\alpha}{2(1-\alpha)} = \frac{1}{2}\left(\frac{(1-\alpha)\left(1-\overline{x}^2\right)+\alpha\underline{x}^2}{(1-\alpha)(1-\overline{x})+\alpha\underline{x}}\right).$$

If simplified we have,

$$\left[\overline{x}(2\tau_1-\alpha)-\alpha\right]\left((1-\alpha)(1-\overline{x})+\alpha\underline{x}\right) = (1-\alpha)\left[(1-\alpha)\left(1-\overline{x}^2\right)+\alpha\underline{x}^2\right].$$

The left-hand side equals

$$\begin{aligned} LHS &= \left[\overline{x}(2\tau_1-\alpha)-\alpha\right]\left((1-\alpha)(1-\overline{x})+\alpha\underline{x}\right) \\ &= \overline{x}2\tau_1(1-\alpha) - \alpha(1-\alpha) - \overline{x}^2(2\tau_1-\alpha)(1-\alpha) + \alpha\underline{x}\overline{x}(2\tau_1-\alpha) - \alpha^2\underline{x}, \end{aligned}$$

and the right-hand side equals

$$RHS = (1-\alpha)\left[1-\alpha-(1-\alpha)\overline{x}^2+\alpha\underline{x}^2\right].$$

By equating the two and dividing by $(1-\alpha)$,

$$\begin{aligned} RHS &= 1-\alpha-(1-\alpha)\overline{x}^2+\alpha\underline{x}^2 \\ LHS &= \overline{x}2\tau_1 - \overline{x}^2(2\tau_1-\alpha) - \alpha - \frac{\alpha^2}{1-\alpha}\underline{x} + \frac{\alpha\underline{x}\overline{x}(2\tau_1-\alpha)}{1-\alpha}. \end{aligned}$$

Thus,

$$(2\tau_1-1)\overline{x}^2 - 2\overline{x}\tau_1 + 1 = -\frac{\alpha^2}{1-\alpha}\underline{x} + \frac{\alpha\underline{x}\overline{x}(2\tau_1-\alpha)}{1-\alpha} - \alpha\underline{x}^2.$$

Now, noticing that $\underline{x} = \frac{\alpha}{1-\alpha}\left(\frac{\overline{x}(2\tau_1-\alpha)-\alpha}{2\tau_2-1+\alpha}\right)$,

$$\begin{aligned} LHS &= (2\tau_1-1)\overline{x}^2 - 2\overline{x}\tau_1 + 1 \\ RHS &= \frac{\alpha\underline{x}\left[\overline{x}(2\tau_1-\alpha)-\alpha\right]}{1-\alpha} - \alpha\underline{x}^2 \\ &= \underline{x}^2\left[2\tau_2-1\right] = \left[2\tau_2-1\right]\left[\frac{\alpha}{1-\alpha}\left(\frac{\overline{x}(2\tau_1-\alpha)-\alpha}{2\tau_2-1+\alpha}\right)\right]^2. \end{aligned}$$

Using $z = \frac{\alpha^2}{[1-\alpha]^2}\frac{[2\tau_2-1]}{[2\tau_2-1+\alpha]^2}$, we obtain,

$$(2\tau_1-1)\overline{x}^2 - 2\,\overline{x}\tau_1 + 1 = z\left(\overline{x}(2\tau_1-\alpha)-\alpha\right)^2.$$

This yields the quadratic equation,

$$\left(2\tau_1 - 1 - z(2\tau_1 - \alpha)^2\right)\bar{x}^2 + \bar{x}\left(-2\tau_1 + 2z\left(2\tau_1 - \alpha\right)\alpha\right) + 1 - z\alpha^2 = 0. \tag{27}$$

The above Eq. (27) implicitly defines $\bar{x}$ together with Eq. (26) for $\underline{x}$ and allows one to derive comparative statics numerically. Fig. 3 shows numerically how the equilibrium cutoffs $\left(\underline{x}, \bar{x}\right)$ vary with the parameters of the model $\langle\alpha, h, c\rangle$. As discussed above, a smaller interval $\bar{x} - \underline{x}$ implies a lower probability of disclosure. While the relation of the likelihood of disclosure with the weight the manager places on the short-term price is not depicted, one can verify that it is first increasing and then decreasing in β in the interval $\beta \in \left(c, h\right)$.

Now, consider the equilibrium with no disclosure. The conditions for prices in equilibrium when there is no disclosure simplifies to:

$$P^H = \frac{1 + \breve{x}}{2}, \quad P^L = \frac{\breve{x}}{2}, \quad \text{and } P^M = \theta P^H + \left(1 - \theta\right)P^L$$
$$\text{where } \theta = \frac{\left(1 - \alpha\right)\left(1 - \breve{x}\right)}{\left(1 - \alpha\right)\left(1 - \breve{x}\right) + \alpha\breve{x}}. \tag{28}$$

From the manager's best response function, the cutoff must satisfy $\left(\text{where } \gamma = \frac{\left(h - \beta\right)}{h\left(1 - \beta\right)}\right)$

$$\breve{x} = \underline{P}\left(1 - \gamma\right) + \bar{P}\gamma \Leftrightarrow \langle ND, R\rangle = \langle ND, NR\rangle, \tag{29}$$

which implies the following average prices following repurchase and no-repurchase:

$$\bar{P} = \alpha\left(\frac{1 + \breve{x}}{2}\right) + \left(1 - \alpha\right)P^M \quad \text{and } \underline{P} = \alpha P^M + \left(1 - \alpha\right)\frac{\breve{x}}{2} \tag{30}$$

and therefore,

$$\underline{P} = \alpha\left[\theta P^H + \left(1 - \theta\right)P^L\right] + \left(1 - \alpha\right)P^L = \frac{\breve{x}}{2} + \alpha\theta\frac{1}{2}. \tag{31}$$

This implies that,

$$\breve{x} = \left[\alpha P^M + \left(1 - \alpha\right)\frac{\breve{x}}{2}\right]\left(1 - \gamma\right) + \left[\alpha\left(\frac{1 + \breve{x}}{2}\right) + \left(1 - \alpha\right)P^M\right]\gamma \tag{32}$$

$$= \frac{\breve{x}}{2}\left(\left(1 - \alpha\right)\left(1 - \gamma\right) + \alpha\gamma\right) + \frac{\alpha\gamma}{2} + P^M\left[\gamma\left(1 - \alpha\right) + \left(1 - \gamma\right)\alpha\right]. \tag{33}$$

Now, since $\theta = \frac{\left(1 - \alpha\right)\left(1 - \breve{x}\right)}{\left(1 - \alpha\right)\left(1 - \breve{x}\right) + \alpha\breve{x}}$, we have,

$$P^M = \theta P^H + \left(1 - \theta\right)P^L = \theta\left[\frac{1 + \breve{x}}{2} - \frac{\breve{x}}{2}\right] + \frac{\breve{x}}{2} \tag{34}$$

$$= \frac{\left(1 - \alpha\right)\left(1 - \breve{x}\right)}{2\left[\left(1 - \alpha\right)\left(1 - \breve{x}\right) + \alpha\breve{x}\right]} + \frac{\breve{x}}{2}. \tag{35}$$

This leads to the equality,

$$\left[\breve{x} - \alpha\gamma\right]\left[1 - \alpha - \breve{x} + 2\alpha\breve{x}\right] = \left(1 - \alpha\right)\left(1 - \breve{x}\right)\left[\gamma + \alpha - 2\gamma\alpha\right]. \tag{36}$$

The solution $\breve{x}$ satisfies the following condition (37) and must belong to the unit interval,

$$A\breve{x}^2 + B\breve{x} + C = 0, \tag{37}$$

where the constants $\langle A, B, C\rangle$ are given by,

$$A = -1 + 2\alpha,$$
$$B = 1 + \gamma - 2\gamma\alpha - \alpha^2,$$
$$C = \left(1 - \alpha\right)\left(\gamma\alpha - \gamma - \alpha\right).$$

In the non-disclosure equilibrium, the solution $\breve{x}$ represents the cutoff above which the manager chooses to repurchase shares and below which the manager chooses not to repurchase. As demonstrated in Fig. 3A–C, greater uncertainty regarding the liquidity shock, or a higher cost of disclosure, or a lower size of the liquidity shock can lead to the non-disclosure equilibrium. **Q.E.D.**

Appendix B

B.1. Imperfectly informed manager

As in Dye (1985), we assume that the manager is privately informed about terminal cash flow x with probability λ $(0 < \lambda < 1)$, and there is therefore uncertainty regarding the information endowment of the manager. It is useful to first establish the augmented market prices following non-disclosure. As mentioned earlier, there are two possibilities for the strategy of the uninformed manager to consider: repurchase or non-repurchase.

For example, when the uninformed manager *does not repurchase* shares, the market maker, observing low order flow, does not know whether the manager is uninformed (value of $E(x)$) or whether she is informed with adverse information (value of $E(x|x < \underline{x})$). Thus, the conditional probability that the manager is informed upon the observation of low order flow is, $\tilde{\lambda} \equiv \Pr(\text{Informed}|NR) = \frac{\lambda \Pr(x < \underline{x})}{\lambda \Pr(x < \underline{x}) + 1 - \lambda}$. Similarly, the probability that the manager had repurchased shares when intermediate order flow is observed takes into account the behavior of the non-informed manager. Alternatively, it could be the case that the uninformed manager repurchases shares in equilibrium. Thus, we obtain the two sets of equilibrium conditions:

Uninformed Manager does not Repurchase: In any equilibrium in which the uninformed manager *does not repurchase* shares, condition (16) in the text is satisfied, the cutoffs are given by the solution to condition (15) in the text, and:

$$P^H = E(x|x > \bar{x}), \quad P^L = \lambda_{nr} E(x|x < \underline{x}) + (1 - \lambda_{nr})E(x), \quad P^M = \theta_{nr} P^H + (1 - \theta_{nr})P^L$$
$$\text{where } \lambda_{nr} = \frac{\lambda \Pr(x < \underline{x})}{\lambda \Pr(x < \underline{x}) + 1 - \lambda}, \quad \text{and } \theta_{nr} = \frac{\lambda \Pr(x > \bar{x})(1 - \alpha)}{\lambda \Pr(x > \bar{x})(1 - \alpha) + [1 - \lambda + \lambda P(x < \underline{x})]\alpha}.$$

Uninformed Manager Repurchase. In any equilibrium in which the uninformed manager *repurchases* shares, condition (16) is violated, the cutoffs are given by the solution to condition (15), and:

$$P^H = \lambda_r E(x|x > \bar{x}) + (1 - \lambda_r)E(x), \quad P^L = E(x|x < \underline{x}), \quad P^M = \theta_r P^H + (1 - \theta_r)P^L$$
$$\text{where } \lambda_r = \frac{\lambda P(x > \bar{x})}{\lambda P(x > \bar{x}) + 1 - \lambda}, \quad \text{and } \theta_r = \frac{[1 - \lambda + \lambda \Pr(x > \bar{x})](1 - \alpha)}{[\lambda \Pr(x > \bar{x}) + 1 - \lambda](1 - \alpha) + \lambda P(x < \underline{x})\alpha}.$$

The following proposition presents the equilibria that arise when there is uncertainty surrounding a long-term oriented manager's information endowment.

Proposition 3 (*Uncertain information endowment*). *When there is uncertainty regarding the information endowment of the manager, i.e.,* $\lambda \in (0, 1)$, *then in any pure strategy equilibrium, the manager with* $\beta \in (0, h)$ *follows the strategy identical to that specified in Section 4.1.3. For sufficiently small* λ *there exists both an equilibrium in which the uninformed manager repurchases shares and one in which she does not repurchase shares, while for sufficiently large likelihood of an information event there only exists one type of equilibrium.*

When the likelihood of an information event is sufficiently close to 1 the equilibrium cutoffs are, at the limit, given by the solution to (14). From the perspective of the uninformed manager, she will repurchase according to condition (16) in the text. Whether the uninformed manager repurchases shares depends on whether $\beta \in (0, h)$. Notice that while the equilibrium cutoffs are not affected by this level of short-term orientation or the size of the liquidity shock h, the uninformed manager's strategy is potentially affected by the ratio $\gamma = \frac{h - \beta}{h(1 - \beta)}$:

$$E(x) > \gamma \bar{x} + (1 - \gamma)\underline{x} \Leftrightarrow \text{Repurchase is Optimal.}$$

On the other extreme, when $\lambda \sim 0$, one can explicitly derive the two possible equilibrium outcomes. In particular, if the uninformed manager *does not repurchase* shares in equilibrium (i.e., (16) is satisfied) then prices and cutoffs satisfy,

$$P^H = E(x|x > \bar{x}), P^L = P^M = E(x) \ (\tilde{\lambda} = 0, \quad \text{and } \theta = 0)$$
$$\bar{x} = \bar{P} = \alpha E(x|x > \bar{x}) + (1 - \alpha)E(x), \quad \text{and } \underline{x} = \underline{P} = E(x).$$

If, alternatively, the uninformed manager *repurchases shares* in equilibrium (i.e., (16) is not satisfied) then,

$$P^H = P^M = E(x), \quad P^L = E(x|x < \underline{x})(\tilde{\lambda} = 0, \quad \text{and } \theta' = 1)$$
$$\bar{x} = \bar{P} = E(x), \quad \text{and } \underline{x} = \underline{P} = \alpha E(x) + (1 - \alpha)E(x|x < \underline{x}).$$

One can verify that both equilibrium outcomes are feasible by examining condition (16).

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