Disclosing Share Repurchase More Frequently? *

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Abstract

In response to the exponential increase in share repurchases, the U.S. Securities and Exchange Commission (SEC) adopted a rule in 2023 to increase the disclosure frequency of share repurchases from quarterly to daily. We demonstrate theoretically and empirically that more frequent disclosure would increase, rather than decrease, the volume of share repurchases. Increased disclosure frequency reduces information asymmetry, thereby lowering the price impact of repurchases and incentivizing firms to buy back larger amounts. However, it also triggers price jumps, raising the total cost of repurchasing despite the reduced marginal cost of additional buybacks. Analyzing a prior regulatory change that increased disclosure frequency from yearly to quarterly, we find that this adjustment led to a 1% increase in repurchase volume relative to total asset value, a 4.5 basis point reduction in price impact, and an 18% increase in repurchase price compared to cross-listed control stocks unaffected by the policy change. Our findings rationalize a "repurchase paradox": although more frequent disclosure boosts share repurchases, firms oppose such measures, even suing the SEC and eventually overturning the daily disclosure rule.

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1 Introduction

Share repurchases have grown exponentially, reaching a record high of $922.7 billion in 2022. This surge has raised concerns among regulators. In 2021, the SEC proposed that U.S. public firms should disclose their repurchases more frequently, moving from quarterly to daily reporting. The SEC adopted this rule on May 3, 2023, with revisions aimed at addressing strong opposition from firms, passing with a narrow 3-2 vote. However, the adoption of the rule intensified tensions, culminating in a lawsuit filed by the U.S. Chamber of Commerce. On December 19, 2023, the U.S. Court of Appeals for the Fifth Circuit vacated the Repurchase Rule, citing the SEC's actions as "arbitrary and capricious" for failing to conduct a proper cost-benefit analysis[1]. These unprecedented confrontations and policy reversals raise two key questions: (1) Could more frequent disclosure of share repurchases reduce repurchase volume ? (2) Why are firms opposed to this proposal?

Surprisingly, we show both theoretically and empirically that more frequent disclosure increases, rather than decreases, the volume of share repurchases. This is because disclosure reduces the information asymmetry and thereby price impact of repurchase trades, effectively lowering the marginal cost of additional share repurchases. However, more frequent disclosure also raises the total cost of share repurchases due to price jumps triggered by increased transparency, which explains why firms strongly oppose the proposal.

Our analysis begins with a multi-period model featuring a risky project and three types of participants: a firm, uninformed investors, and market makers. The firm holds superior information because it receives signals about the final cash flow of the project, and these signals become increasingly precise over time. The firm is incentivized to buy back its shares when they are undervalued. However, these repurchases generate price impacts. Although market makers do not directly observe the firm's private signal, they can infer it from the observed trading volume. The frequency of disclosure plays a key role, as it influences the information available to market makers. In the extreme case where the firm does not disclose its repurchase volume, market makers can only observe the combined volume of the firm and uninformed investors. Nonetheless, market makers can deduce that a large buy imbalance suggests positive news, leading them to adjust prices upward. This price impact constrains the firm's ability to buy back whole undervalued shares. It is optimal for the firm to make smaller repurchases to avoid moving the price significantly.

We then examine the effect of increasing disclosure frequency. With more frequent disclosure, market makers can observe not only the total trading volume in the current trading round but also the firm's exact repurchase volume in the previous round. This additional information leads to a price jump. At the same time, increased disclosure reduces information asymmetry, lowering the price impact of repurchase in the current round. Consequently, the firm is likely to increase its repurchase volume because the marginal cost of additional share purchases decreases. However, the total cost of repurchases rises due to the price jump, leading to a paradox: more frequent disclosure reduces marginal cost of repurchase and in-

[1] See The U.S. Court of Appeal, case 23-60255 here.

creases the volume of share repurchases, yet firms oppose the rule because of the higher total repurchasing cost.

This comparison between less and more frequent disclosure yields three testable predictions: (1) more frequent disclosure leads to a lower price impact of trades, (2) it increases the volume of share repurchases, and (3) it raises the repurchase price. We test these predictions using an exogenous policy shock with natural treatment and control groups. In 2004, the amendment of SEC Rule 10b-18 required U.S.-listed firms to shift from annual to quarterly disclosure of share repurchases. This policy change affected U.S. domestic firms but did not impact Canadian and British firms cross-listed in the U.S., as Canada mandates monthly and the UK mandates daily disclosures, regardless of the location of repurchases. We use these cross-listed firms as the control group and a matched sample of U.S. domestic firms as the treatment group.

Our difference-in-difference regression results are consistent with the three model predictions. First, compared with the control group, the price impact—measured by Kyle's Lambda—decreases by 3.6 basis points for U.S. domestic firms, accounting for a 19% reduction relative to pre-reform levels. Second, the repurchase payout (in dollar volume) increases by 0.99% of the total asset values for U.S. domestic firms, translating to an average annual increase of $6.28 million in repurchase volume per firm. Dividend payout reduces by 0.43% of the total asset value, which is an average annual decrease by 2.70 million for each firm. Since the decrease in dividend is less than the increase in share repurchases, probably due to the dividend stickiness (Guttman et al., 2010), the total payout increases by 0.55% of the total asset value for U.S. domestic firms, which is an annual average increase by 3.45 million per firm. This shift alters the payout structure, with U.S. domestic firms increasing their reliance on share repurchases relative to cross-listed firms. Finally, we find that the repurchase price, scaled by the average quarterly closing price, statistically increases by 18% following more frequent disclosure.

Our paper links the market microstructure and corporate finance literature by proposing the first model in which informed traders are firms themselves. The market microstructure literature has a long-standing tradition of modeling interactions between informed and uninformed traders (Kyle, 1985; Glosten and Milgrom, 1985), but it typically abstracts away from identifying who the informed traders are. We consider firms as one type of informed trader, given that they undoubtedly possess superior information about their own stocks compared to the average investor. By incorporating the information asymmetry between firms and their investors into a trading model, we provide explanations for several puzzles raised by the payout irrelevance theorem of Miller and Modigliani (1961).

First, information asymmetry offers a rationale for firms to repurchase shares, compared with the benchmark of no payout at all. Since firms have superior information compared to other investors, buying back undervalued shares can enhance the value for remaining shareholders. Second, we present the first model that explains the coexistence of dividends and share repurchases. This result also sheds light on the "dividend puzzle" (Black, 1976; Allen and Michaely, 2003): firms continue to pay cash dividends despite the tax disadvantages of dividends compared to share repurchases. While firms benefit from repurchasing undervalued shares, large repurchase amounts may reveal too much information to the market, prompting firms to opt for smaller buybacks and use dividends for the remaining payout.

A significant body of literature in behavioral corporate finance focuses on rational managers operating in irrational markets (see Baker and Wurgler (2011), for a survey). In this framework, managers lower the overall cost of capital for ongoing investors by issuing overpriced securities and repurchasing underpriced ones. However, theoretical models in this literature, such as Stein et al. (1996), typically assume an exogenous price impact to prevent managers from buying back the entire firm when it is undervalued. Our contribution to this literature is to endogenize the price impact. Furthermore, we show that the price impact decreases with greater disclosure. Our policy shocks provide opportunities to test predictions for the behavioral corporate finance literature.

One fundamental challenge in the payout literature is explaining the long-term secular increase in share repurchases over decades (Farre-Mensa et al., 2014), due to the difficulty of identifying an economic force that has consistently moved in one direction over such an extended period. For instance, agency-based models cannot account for this trend without making the implausible assumption of a long-term increase in agency costs. Farre-Mensa et al. (2014) suggest that the only realistic explanation is the growth of stock options. As the exercise of executive and employee stock options dilutes earnings per share (EPS), the increase in stock option compensation practices over time could explain the secular rise in repurchases (Kahle, 2002). However, recent studies have found that repurchases have continued to grow even as option-based compensation has declined (Ferri and Li, 2020; Li et al., 2024). Our paper show an increase in the transparency of share repurchases may provide an explanation for the increase in share repurchases beyond the sample period analyzed by (Kahle, 2002).

The existing payout literature on information asymmetry primarily focuses on signaling, where undervalued firms use dividends or repurchases to signal positive information to investors (Bhattacharya, 1979; Miller and Rock, 1985; John and Williams, 1985). In contrast, our paper highlights an economic force that operates in the opposite direction. When undervalued firms can buy back their own shares, they prefer to conceal their repurchases to exploit their private information rather than to signal it. This prediction aligns with the observed behavior of firms, which typically seldom voluntarily disclose their share repurchases as a signal to the market. Instead, they often resist mandatory disclosure requirements for share repurchases.

The paper proceeds as follows. Section 2 provides the theoretical framework for analysis. Section 3 presents our empirical strategy including the institutional background, data source, and identification methods. Section 4 reports our empirical results that verify our model predictions. Section 5 concludes the paper.

2 Theory and Empirical Predictions

This section provides a theoretical framework to analyze the potential outcomes of disclosing share repurchases more frequently. This model could also explain why firms are against the more frequent disclosures. We consider a firm with a risky investment project. An informed manager of the firm receives two increasingly precise signals. The first signal informs the firm about the firm's state. In a good state, the investment project could generate positive cash flows with a positive probability. In a bad state, the project fails. The manager can repurchase zero, small, or large shares from the stock market after receiving the first signal. After the first round of trading, the manager receives the second signal about the realization of the project's cash flows, which could be high, low, or still uncertain with equal probability. The firm enters the second round of trades upon receiving the second signal. After the two trading rounds, the state and the realized cash flows become public information. We model each round of trading with the informed manager, uninformed liquidity traders, and risk-neutral competitive market makers. The market makers only know the distribution of the states and cash flows but do not know the exact signal the firm receives. Liquidity uninformed traders face exogenous liquidity needs to sell in each trading round. This setting is similar to Kyle (1985). We model the more frequent disclosure by mandating the firm disclosing its trading quantity (and price) in the first round of trading. We then compare the equilibrium outcomes under the less and more frequent disclosure requirements. We finally summarize the model hypotheses for empirical tests. All proofs are designated to the Appendix B.

2.1 Trading Game

Times and a Firm. The model considers four time periods, denoted as $t = 0, 1, 2, 3$. At $t = 0$, nature determines the state of the firm, choosing either a good state, $S = S_G$, with probability θ, or a bad state, $S = S_B$, with probability $1-\theta$. The firm has a risky investment project that will yield cash flows at $t = 3$. In the good state, the project may generate either a high cash flow, $A = A_H$, or a low cash flow, $A = A_L$, each with an equal probability of $1/2$. In the bad state, however, the project can only produce the low cash flow, $A = A_L$. An informed manager of the firm receives two signals. First, at $t = 0$, she knows the realized state. Then, between $t = 1$ and $t = 2$, she receives a second informational update about the cash flow, which may be A_L, A_H, or a midpoint value of $\frac{1}{2}(A_L + A_H)$, each with equal probability. This structure allows the firm to gradually gain a more precise understanding of the investment's potential outcomes over time.

For the algebraic simplicity, we normalize $A_H = 1$ and $A_L = 0$. Therefore, the cash flows of A_H from the risky project could be interpreted as an "earnings surprise". The firm has a total of 1 (normalized) outstanding share. Traders in the stock market trade on the firm's shares at times $t = 1$ and $t = 2$. At $t = 3$, the true state, either S_G or S_B, and the project's cash flows, A_H or A_L, are publicly revealed through financial reports, and trading ends. Therefore, $t = 3$ serves as the date when the financial results are disclosed to the public. Additionally, there are no intertemporal discounts in this framework.

Trading. There are three types of traders: an informed manager, many uninformed traders, and competitive market makers. At each trading round, the informed manager could repurchase $q_t = 0$ (no repurchase), x (repurchase small), or $2x$ (repurchase large) fraction of the total outstanding share. To prevent the manager from repurchasing the whole firm, we add a regulatory assumption that $x \in (0, \frac{1}{4})$[2]. If she repurchases any fractions of the share, she would mark them as "treasury shares" in the quarterly financial reports at $t = 3$. Treasury share is a contra-equity entry, which would be subtracted from the outstanding shares when calculating the "per share" measures like earnings per share or dividend per share[3]. At each round of the trading, uninformed traders face exogenous liquidity needs and collectively submit the order u_t, either in the quantity of $-x$ or 0, with equal probability of 1/2. Therefore, the economic meaning of x is the uninformed trading volume. This assumption is not only common in market microstructure literature (Glosten and Milgrom, 1985; Kyle, 1985), but has more intuitions in corporate finance settings: those sellers are shareholders who are impatient or disagree with the managers, and share repurchase essentially expels such shareholders (Huang and Thakor, 2013). After observing the aggregate order flow, $z_t = q_t + u_t$, the competitive market makers set the price equal to the expected value of the risky project based on previous trading histories. This assumption implies market makers make zero profit, which is standard as per Kyle (1985). Market makers only know the distributions of states and the cash flows from the risky project. We summarize the information structure in Figure 1.

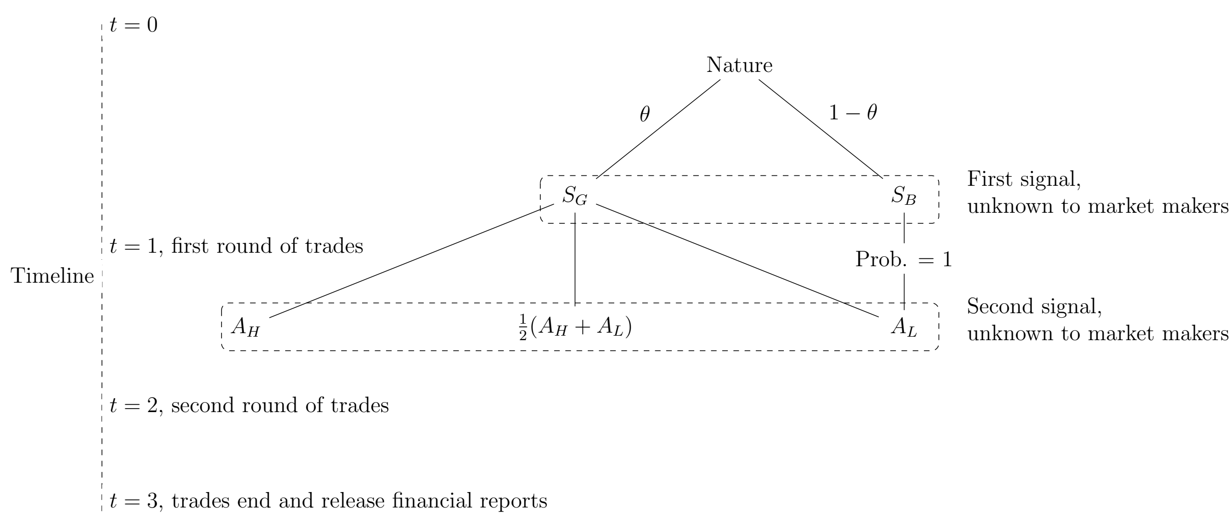

Figure 1: The Information Structure

Disclosure Structures. We consider two disclosure structures: (1) a less frequent disclo-

[2]This is a quite loose constraint because the SEC restricts the maximum amounts that a firm could repurchase from the market: it should no more than 25% of average daily trading volume from the past two weeks. Since the daily trading volume is usually less than 1% of total outstanding shares, the x in practice should be much smaller than 20%. In our sample, the quarterly repurchased shares are around 0.6% of total outstanding shares.

[3]More accounting details can be found in PWC Share repurchase and treasury stock.

sure: the firm only discloses the share repurchase activities at $t = 3$ along with the financial reports, which resembles the SEC's current quarterly share repurchase disclosure in the 10-Q file; (2) a more frequent disclosure: the firm discloses the share repurchase activities at the end of $t = 1$ and at $t = 3$, which captures the idea of a more frequent share repurchase disclosure in the SEC's proposed rule.

Manager's Objective. We assume no agency cost in manager's behaviors. Therefore, the objective of the informed manager is to maximize the firm value for remaining shareholders at time $t = 3$, based on her information set, $\mathbf{I}$. Denoting q_t as the shares repurchased at time t with price p_t, we could express the manager's objective function as follows mathematically:

$$\max_{q_1,q_2\in\{0,x,2x\}} \mathbf{E}\left[V_3\left(q_1,q_2|\mathbf{I}\right)\right] = \frac{\overbrace{\mathbf{E}\left[A\right]}^{\text{Expected Earnings}} - \overbrace{\left(p_1q_1 + p_2q_2\right)}^{\text{Cash Spent on Repurchase}}}{\underbrace{1-\left(q_1+q_2\right)}_{\text{Reduction in Outstanding Shares}}} \tag{2.1}$$

Equation 2.1 highlights the benefits of conducting share repurchases: it is a way to pay out residual cash flowsMiller and Modigliani (1961), but it is more flexible than dividends. Through open market share repurchases, the informed manager could repurchase shares when the stock is undervalued, and increase the residual shareholder's value (Huang and Thakor, 2013). Note that, however, share repurchase along does not increase the total payout because suppose the firm does not make new investment,

$$\begin{aligned}\text{Total Payout} &= \underbrace{\left[1-\left(q_1+q_2\right)\right] \times \frac{\mathbf{E}\left[A\right] - \left(p_1q_1+p_2q_2\right)}{1-\left(q_1+q_2\right)}}_{\text{Dividend Payout}} + \underbrace{\left(p_1q_1+p_2q_2\right)}_{\text{Repurchase Payout}} \\ &= \mathbf{E}\left[A\right]\end{aligned}$$

Market Efficiency. Competitive market makers set the price as the expected values of terminal share price, conditional on the trading histories $\mathcal{Z}_t$ and the disclosure structure $\mathbf{D}$. In the following sections, we consider two information structures: less frequent and more frequent disclosure structures. Specifically,

$$\begin{aligned}&p_1 = E[V_3|z_1] \quad \text{Under a less frequent disclosure}\\&p_2 = E[V_3|z_2,z_1] \quad \text{Under a less frequent disclosure}\\&p_1 = E[V_3|z_1] \quad \text{Under a more frequent disclosure}\\&p_2 = E[V_3|z_2,z_1,q_1] \quad \text{Under a more frequent disclosure}\end{aligned} \tag{2.2}$$

2.2 Equilibrium

Equilibrium of the game specifies the pricing rules by market makers and informed manager's strategy. We consider two equilibria under the less and more frequent disclosures. We then compare the two equilibrium outcomes. The change in the information structure changes the manager's strategies, hence resulting in the change in payout policy.

To avoid full revelation of her private information, the informed manager would not repurchase a large fraction of shares in the first trading round. However, if the firm is in the good state, the informed manager will opt to repurchase a small fraction of shares. The intuition is that, in the good state, the project has the potential to generate positive cash flows, and an early-stage repurchase could deliver higher returns to residual shareholders if the high cash flows materialize. This intuition is formalized in the following lemma.

Lemma 2.1 *When $S = S_G$, the optimal strategy is to repurchase x at time $t = 1$.*

Proof: See Appendix B

2.2.1 Equilibrium under less Frequent Disclosure

In this section, we consider the firm only discloses its share repurchase activities along with the announcement of realized states and cash flows at time $t = 3$. Market makers do not know the informed manager's orders when setting prices. This information structure reflects current share repurchase regulations, where firms report repurchases only in their quarterly 10-Q filings. We first derive the pricing rules of market makers in the following lemma.

Lemma 2.2 (Pricing Rules under less Frequent Disclosure) *If the firm only discloses its repurchase activities at the time $t = 3$, the pricing rules are as follows:*

$$p_1 = E[V_3|z_1] = \begin{cases} 0 & z_1 = -x \\ \dfrac{\theta}{2(1 - x + \theta x)} & z_1 = 0 \\ \dfrac{1}{2} & z_1 = x \\ 1 & z_1 = 2x; \end{cases}$$

$$
p_2 = E[V_3|z_1, z_2] = \begin{array}{c|c|c|c|c}
z_2 \backslash z_1 & -x & 0 & x & 2x \\
\hline
-x & 0 & \dfrac{\theta}{2(1-x+\theta x)} & \dfrac{1}{2} & 1 \\[2ex]
0 & \dfrac{\theta}{2(1-x+\theta x)} & \theta \cdot \dfrac{1-2p_1(0)x}{2(1-2x+\theta x)} & \dfrac{1-2p_1(x)x}{2(1-x)} & 1 \\[2ex]
x & \dfrac{1}{2} & \dfrac{1-2p_1(0)x}{2(1-x)} & \dfrac{1-2p_1(x)x}{2(1-x)} & 1 \\[2ex]
2x & 1 & \dfrac{1-p_1(0)x}{1-x} & \dfrac{1-p_1(x)x}{1-x} & 1
\end{array}
$$

where z_1 and z_2 are the aggregate order flows observed by the market makers at $t = 1, 2$.

Proof: See Appendix B.

Intuitively, when market makers observe an aggregate order flow of zero, they cannot discern whether the informed manager has submitted orders or whether the firm's realized state is good or bad. If the aggregate flow observed is x, market makers can infer that the firm is in the good state, although they still do not know the realized cash flows of the risky project. Finally, if the observed order flow is $2x$, they would set the price as if both the good state ($S = S_G$) and high realized cash flows ($A = A_H$) were realized. This is a "credible threat" to the informed manager in the equilibrium that prevents her repurchasing a large fraction of shares in the first trading round, as suggested by Lemma 2.1.

Market makers then set prices based on the expected repurchase-adjusted value per share, conditional on observed order flows. In the second period, they incorporate both past and current order flows when setting prices. For illustration, Figure 2 shows the pricing rules at $t = 1$ and $t = 2$, assuming $z_1 = 0$. These pricing rules reflect key aspects of Kyle's model: the upward-sloping pricing functions indicate adverse selection risk—higher observed quantities suggest a higher likelihood of informed trading, leading to higher prices. Furthermore, second-period prices are higher than those in the first period, reflecting the gradual incorporation of private information as trading unfolds. Based on these pricing rules, we can characterize the informed manager's strategies in the following proposition.

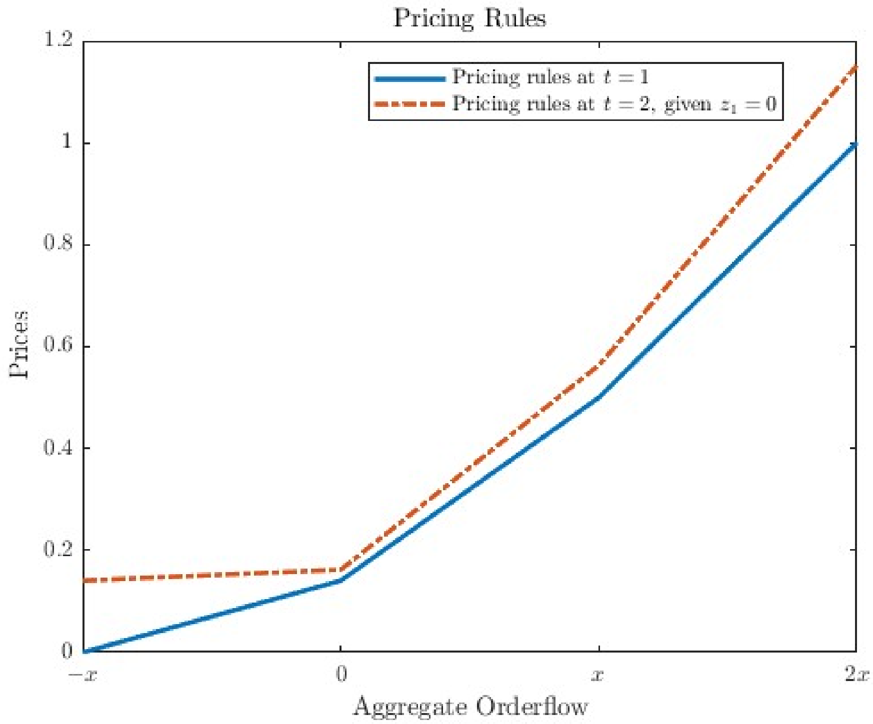

Figure 2: Pricing Rules at $t = 1$ and $t = 2$ given $z_1 = 0$; $\theta = 0.25$, $x = 0.15$.

Proposition 2.1 (Repurchase Strategy under less Frequent Disclosure) *If the firm only discloses its repurchase activities at the end of two trading rounds, there exists $x_Q^* \in (0, \frac{1}{4})$ and the manager's best strategy is as follows:*

1. *After receiving the first informational shock:*
   (a) *If $S = S_G$: repurchase x shares at $t = 1$;*
   (b) *If $S = S_B$: do not repurchase at either period.*
2. *After receiving the second informational shock:*
   (a) *If $A = A_H$:*
      - *For any $0 < x \leq x_Q^*$, it is optimal to repurchase x shares at $t = 2$;*
      - *For any $x_Q^* < x < \frac{1}{4}$, it is optimal to repurchase $2x$ at $t = 2$.*

   (b) *If $A = \frac{1}{2}(A_H + A_L)$: repurchase x at $t = 2$.*
   (c) *If $A = A_L$ or $A = \frac{1}{2}(A_H + A_L)$: Do not repurchase at $t = 2$.*

In Figure 3, we illustratively present the final expected value per share, EV_3, and the x_Q^* under different uninformed trading volumes x given A_H. Intuitively, the optimal strategy depends on both pricing rules and the uninformed trading volumes. If the uninformed trading volume is below the thereshold ($x < x_Q^*$), hiding its identity by repurchasing small in both periods is optimal. If, however, the uninformed trading volume is very large ($x > x_Q^*$), repurchasing small in the first period to hide its identity but repurchasing larger in the second period to exploit uninformed traders becomes optimal. The intuition is that if there is a large number of uninformed sold-offs, the benefits of marginal increase in the remaining shareholder's value prevail over the marginal cost of purchasing additional shares. Therefore, the firm would repurchase a larger amount in the second period. This result is consistent with the empirical findings that share repurchase volume increases with the short-sale activities (Liu and Swanson, 2016).

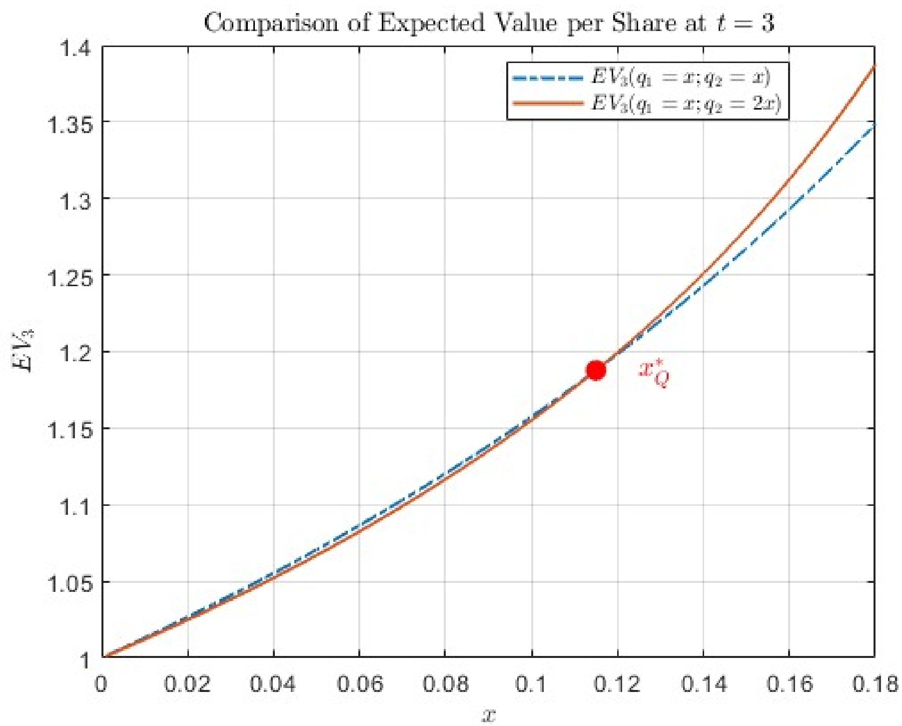

Figure 3: Expected Utilities under Different Repurchase Decisions, $\theta = 0.25$ and $A = A_H$

2.2.2 Equilibrium under more Frequent Disclosure

We now consider the equilibrium under the disclosure structure that the firm discloses its share repurchase quantity (and price) after the first trading round. Therefore, market makers know the firm's repurchase amount in the second round when setting the price. This structure reflects a more frequent disclosure of share repurchase, as in the SEC's proposed rules. In the first period, the pricing rules are the same as in the case of non-disclosure. In the second period, the market makers would update their beliefs about the states based on the disclosed information following the Bayesian updates. Specifically, at time $t = 2$, market makers' belief about the states is updated as follows

$$\text{Prob}\left(S=S_G|q_1\right)=\frac{\text{Prob}\left(q_1|S=S_G\right)\text{Prob}\left(S=S_G\right)}{\text{Prob}\left(q_1|S=S_G\right)\text{Prob}\left(S=S_G\right)+\text{Prob}\left(q_1|S=S_B\right)\text{Prob}\left(S=S_B\right)} \tag{2.3}$$

$$\text{Prob}\left(S=S_B|q_1\right)=\frac{\text{Prob}\left(q_1|S=S_B\right)\text{Prob}\left(S=S_B\right)}{\text{Prob}\left(q_1|S=S_G\right)\text{Prob}\left(S=S_G\right)+\text{Prob}\left(q_1|S=S_B\right)\text{Prob}\left(S=S_B\right)} \tag{2.4}$$

We first summarize the pricing rules under the more frequent disclosure.

Lemma 2.3 (Pricing Rules under more Frequent Disclosure) *If the firm discloses its repurchase activities after each trading round, the pricing rules are as follows:*

$$p_1=E[V_3|z_1]=\begin{cases}0 & z_1=-x\\ \dfrac{\theta}{2(1-x+\theta x)} & z_1=0\\ \dfrac{1}{2} & z_1=x\\ 1 & z_1=2x;\end{cases}$$

$p_2=E[V_3|z_1,z_2,q_1]=$

Disclosure	$\boldsymbol{q_1=0}$		$\boldsymbol{q_1=x}$		$\boldsymbol{q_1=2x}$	
$z_2\backslash z_1$	$-x$	0	0	x	x	$2x$
$-x$	0	$\frac{1}{2}$	$\frac{1-2p_1(0)x}{2(1-x)}$	$\frac{1-2p_1(x)x}{2(1-x)}$	$\frac{1-2p_1(x)x}{1-2x}$	1
0	$\frac{\theta}{2(1-x+\theta x)}$	$\frac{\theta}{2(1-x+\theta x)}$	$\frac{1-2p_1(0)x}{2(1-x)}$	$\frac{1-2p_1(x)x}{2(1-x)}$	$\frac{1-2p_1(x)x}{1-2x}$	1
x	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1-2p_1(0)x}{2(1-x)}$	$\frac{1-2p_1(x)x}{2(1-x)}$	$\frac{1-2p_1(x)x}{1-2x}$	1
$2x$	1	1	$\frac{1-p_1(0)x}{1-x}$	$\frac{1-p_1(x)x}{1-x}$	$\frac{1-2p_1(x)x}{1-2x}$	1

where z_1, and z_2 are the aggregate order flows observed by the market makers at $t=1,2$ and q_1 the disclosed amount of bought-back shares in the first round.

In comparison to lemma 2.2, lemma 2.3 demonstrates that more frequent disclosure of share repurchases reduces information asymmetry regarding the firm's state. For instance, when a manager repurchases a small amount, x, in the first period and discloses it, market makers can infer that the firm is in a good state, $S = S_G$. They can also infer the repurchase price and the expected profit the firm has made. Market makers will therefore set the prices upwards at time $t = 2$. The realization of the cash flows, however, is still private information to the firm. The informed manager would adjust her trading strategy accordingly. Following the new pricing rules, we proceed to characterize the optimal repurchase strategy for the informed manager in the following proposition.

Proposition 2.2 (Repurchase Strategy under more Frequent Disclosure) *If the firm discloses its repurchase quantity (and price) at the end of the first trading round, the optimal repurchase strategy for the informed manager is as follows:*

1. *After receiving the first informational shock,*
   - *If $S = S_G$: repurchase x shares at $t = 1$;*
   - *If $S = S_B$: do not repurchase at either period.*
2. *After receiving the second informational shock:*
   - *If $A = A_H$: repurchase $2x$ at $t = 2$;*
   - *If $A = \frac{1}{2}(A_H + A_L)$: repurchase x at $t = 2$.*
   - *If $A = A_L$: do not repurchase at $t = 2$.*

Under a more frequent disclosure, the best strategy for the manager is always repurchasing large in the second period if received $A = A_H$. In other words, the manager would conduct a higher repurchase volume compared with the less frequent disclosure case. The intuition is that a more frequent disclosure of share repurchases reduces the information asymmetry. Consequently, the prices in the second period jump higher and the marginal price impact of an additional share repurchased decreases. Conditional on the price jump, the optimal strategy of the informed manager changes to repurchase more shares. However, the manager still dislikes a more frequent disclosure because she has to pay a higher repurchase price.

2.3 Empirical Predictions

Now, we compare the equilibrium outcomes specified in propositions 2.1 and 2.2. We crystallize three empirical predictions regarding how the more frequent disclosure affects stock liquidity, repurchase price, and payout policy.

2.3.1 Stock Liquidity and Repurchase Price

The first prediction is about price impact. After making a more frequent disclosure, the price impact of the firm's stock reduces along with the reduction in information asymmetry, and therefore the liquidity increases. We can easily derive this result by comparing lemmas 2.2 and 2.3.

Prediction 2.1 *Disclosing share repurchases more frequently activities decreases the stock's price impact.*

Proof: See Appendix B.

We illustrate Prediction 2.1 in Figure 4. The blue solid line is the pricing rules in the second period under quarterly disclosure, and the dashed red line is the pricing rules with more frequent disclosure. After a more frequent disclosure of share repurchase, the price "jumps" and the slope flattens. Hence, the price impact of repurchasing larger shares $(\frac{1}{2}(p(x) + p(2x)) - \frac{1}{2}(p(0) + p(x)))$ decreases.

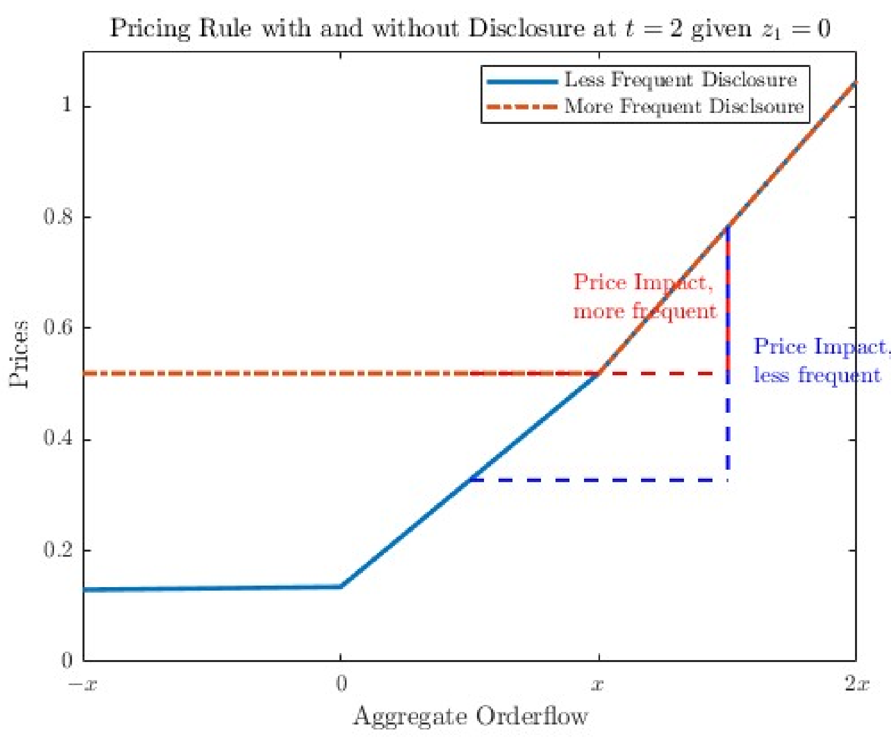

Figure 4: Equilibrium Pricing Rule at $t = 2$ Given $z_1 = 0$ under Quarterly Disclosure and a more Frequent Disclosure, $\theta = 0.25$ and $x = 0.05$.

Another prediction from our model is that under a more frequent disclosure, the firm will pay a higher repurchase price, as also shown in Figure 4 that the price "jumps". We summarize the following prediction.

Prediction 2.2 *Disclosing share repurchase activities more frequently increases the average share repurchase price.*

Proof: See Appendix B.

2.3.2 Payout Policy

Under a more frequent disclosure, the optimal strategy for the informed manager is to repurchase larger shares, $2x$, in the second trading round. This is because the reduction in price impact, as also shown in Figure 4. Conditional on the more frequent disclosure and the price jump, the marginal price change given an additional x repurchased decreases. If the informed manager receives a positive informational shock of $A = A_H$, repurchasing $2x$ at time $t = 2$ yields a higher expected return than repurchasing x. In other words, by repurchasing $2x$ rather than x at time $t = 2$, the marginal increase in the expected per-share value at time $t = 3$ exceeds the additional cash spent on share repurchases at time $t = 2$.

Since both the repurchase price and the repurchase quantity increase, we predict that the repurchase volume, calculated as the product of the repurchase price and quantity, also increases. Finally, since the total payout depends on the residual earnings, we would expect a decrease in the dividend payout, as the repurchase payout substitutes. To see this intuition, suppose the firm liquidates at time $t = 3$, the dividend per share equals the firm's value per share (Miller and Modigliani, 1961).

$$V_3 = \frac{\overbrace{A - (p_1 q_1 + p_2 q_2)}^{\text{Dividend Payout}}}{\underbrace{1 - (q_1 + q_2)}_{\text{Outstanding Shares}}} = \text{Dividend Per Share} \tag{2.5}$$

Therefore, an increase in repurchase payout, $p_1 q_1 + p_2 q_2$, would substitute divides. We summarize the prediction on payout policy in the following proposition.

Prediction 2.3 *Disclosing share repurchase activities more frequently increases the average repurchase payout and reduce the dividend payout.*

Proof: See Appendix B.

We demonstrate Prediction 2.3 in Figure 5. We plot the value per share at time $t = 3$, or equivalently, the dividend per share, when the realized cash flows are high ($A = A_H$). The x-axis is the uniformed trading volume and the y-axis is the expected value per share defined in equation 2.5. There are three lines in the figure. The dashed red line presents the value per share of repurchasing x in both periods under a less frequent disclosure; the dashed blue line is that of repurchasing x in both periods under a more frequent disclosure; and the solid black line is that of repurchasing x in the first period but repurchasing $2x$ in the second period.

We highlight four observations from Figure 5. First, share repurchase increases the firm's value for remaining shareholders. In the world of Miller and Modigliani (1961), the firm's value only depends on the cash flow, $A_H = 1$. However, the information asymmetry between the firm and investors makes share repurchase profitable, resulting a larger firm value for remaining shareholders. Second, under the a less frequent disclosure, it is optimal to repurchase small in both periods when the uninformed trading volume is small ($x < x_Q^*$ or in area I); but it is optimal to repurchase $2x$ in the second period if the uninformed trading volume is large ($x > x_Q^*$ or in area II). This observation is similar to Figure 3. Third, under a more frequent disclosure, it is always optimal to repurchase $2x$ in the second period, as shown that the black solid line is always above the blue dashed line. Finally, if $x < x_Q^*$, a more frequent disclosure decreases the final value of the firm, as the dashed red line is always above the black solid line.

In summary, the informed manager would only repurchase $2x$ in the second period if the uninformed trading volume is large under a less frequent disclosure. However, she would always repurchase large in the second period under a more frequent disclosure. In our model, the uninformed trading volume, x, is exogenous. In the real world, however, one could imagine the uninformed trading volume varying with time and it is very unlikely to be greater than $x_Q^* \approx 10.5\%$. Therefore, we can conclude that the informed manager would repurchase a (at worst, a weakly) larger quantity.

Finally, our model can also explain why are the firms so against the more frequent disclosure. This is simply because disclosing more frequently would make them pay a higher repurchase price (as in Figure 4) and hence lower final value for remaining shareholders (as in Figure 5).

In the next section, we provide empirical tests on predictions 2.1, 2.2 and 2.3. Overall, our predictions imply that requiring a more frequent disclosure of share repurchase reduces information asymmetry in the stock, increases stock liquidity, and results in a "price jump". An informed manager responds to this market reaction by repurchasing more shares but making fewer trading profits. We summarize our model predictions in the following Table 1.

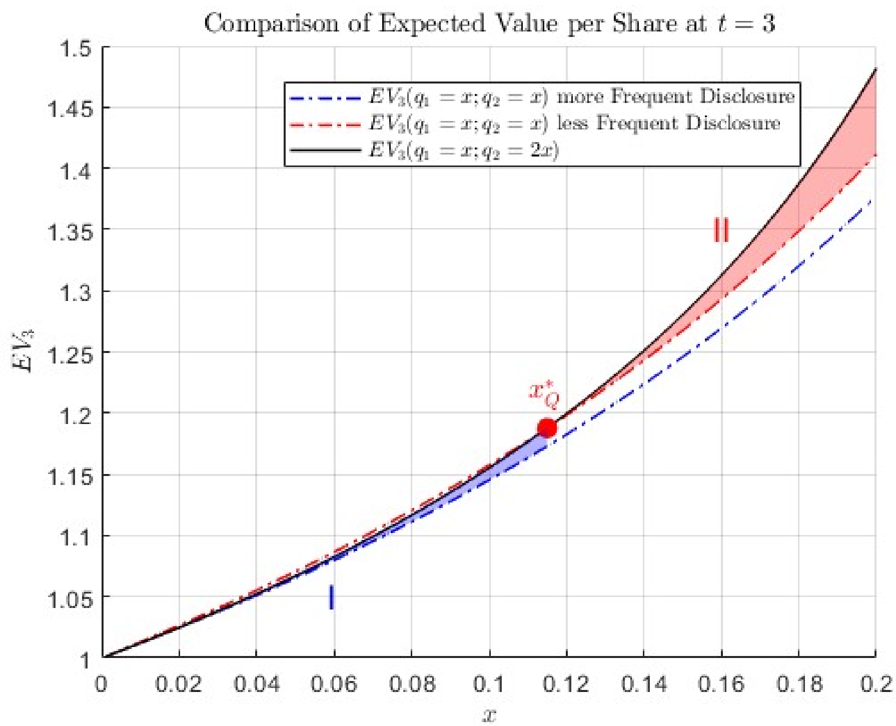

Figure 5: Comparison of Expected Utilities under Quarterly and More Frequent Disclosure, $\theta = 0.25$, $A = A_H$, $S = S_G$.

Table 1: Summary of Model Predictions and Intuitions

Predictions	Measures	Change	Intuitions
1	Price Impact	$\downarrow$	Less information asymmetry
2	Repurchase Payout	$\uparrow$	Marginal benefits (the marginal increase in the value for remaining shareholders) of repurchasing large become larger than the marginal costs (the cash sepent on repurchases) .
3	Dividend Payout	$\downarrow$	Substituted by Repurchase Payout
4	Firms dislike more frequent disclosures		Higher repurchase prices

3 Empirical Strategy

In this section, we test the model's predictions on the effects of more frequent disclosure of share repurchases by exploiting a policy change in the US, which requires US firms to disclose their share repurchase activities more frequently. Prior to March 2004, the SEC Rule 10b-18 mandated that US-listed firms must disclose their share repurchase activities on an annual basis (i.e., in their 10-K filings). The Rule was amended in December 2003, requiring that, effective on March 15, 2004, US-listed firms must disclose their share repurchase activities, including the number of shares repurchased and the average repurchase price, on a quarterly basis (i.e., in the 10-Q filings).

The amendment of Rule 10b-18 is an exogenous shock to the disclosure frequency of US-listed public firms. As a result, US-listed firms must disclose their share repurchase activities more frequently. On the other hand, firms cross-listed in both UK and US have been disclosing their share repurchase activities in both UK and US stock exchanges on a daily basis since 1981 as required by the UK listing rules (Andriosopoulos and Lasfer, 2015; BOE, 1998). Firms cross-listed in Canada and US have been disclosing their share repurchase activities in both Canada and US markets on a monthly basis since 1985 (Ikenberry et al., 2000). The amendment of Rule 10b-18 did not alter these cross-listed firms' disclosure frequency because they had already been disclosing more frequently than required by the amended rule 10b-18.

We thus conduct a difference-in-differences (DiD) analysis, using firms that are listed only in US as treatment firms and US-UK/Canada cross-listed firms as control firms. To enhance the comparability of the treatment and control firms, we match each the treatmeng and control firms based on firm characteristics relevant for share repurchases and stock liquidity.

3.1 Institutional Backgrounds

The Amendment of Rule 10b-18. The SEC Rule 10b-18 was amended on December 17, 2003. The amendment requires that, starting from March 15, 2004, firms must disclose the following information every quarter in their 10-Q filings regarding their share repurchases in each of the three months within the quarter: the number of shares repurchased, the average repurchase price per share, and the remaining shares authorized from the repurchase plan that could be repurchased in the future. The amendment aims to enhance the transparency of firm share repurchase activities with more frequent disclosure.

Before the amendment, the SEC Rule 10b-18 required that public firms must disclosure their share repurchase activities yearly in the 10-K forms. The information to be disclosed was more limited: firms only disclosed the repurchase dollar volume in the cash flow statement in a given fiscal year. The less frequent disclosure of limited information made it difficult for investors and market makers to know precisely the number of shares repurchased in each month/quarter and the repurchase price. Investors and market makers had to rely on indirect information to infer the number of shares repurchased in each quarter or month and the repurchase price. The indirect information includes the number of shares outstanding, the number of treasury stocks in 10-Q filings, and the amount of money spent on share repurchases in 10-Q filings (Guay and Harford, 2000; Fama and French, 2001). However, estimates of the number of shares repurchased and the average repurchase price in each quarter based on the indirect information are often inaccurate. They could be affected by simultaneous stock issuance, exercise of executive stock options, and the firm's accounting method. Some firms simply retire repurchased shares, while others hold them as treasury stocks (Banyi et al., 2008; Bonaimé, 2015).

In sum, investors and market makers know each firm's exact number of shares repurchased and the average repurchase price in each month after March 2004. Before that, they can at best estimate each firm's number of shares repurchased and the average share repurchase in each quarter, and the estimates are inaccurate. As such, we expect the amendment of the SEC Rule 10b-18 to affect firms' repurchase volume, repurchase price, and stock liquidity, as our model predicts.

Disclosure of Share Repurchases in UK and Canada. The Financial Conduct Authority (FCA) requires that firms list in the UK must disclose their share repurchase activities daily since 1981. Required information in the disclosure includes the number of shares repurchased on the day, the average repurchase price per share, and the total amount of money spent on share repurchases on the day. The summary of repurchase activities from the last business day must be disclosed to the public no later than 9:30 am of the following day. Compared to less frequent disclosure, the daily disclosure of share repurchase activities in the UK is expected to enhance information transparency, allowing investors and market makers to assess the information content of share repurchases (BOE, 1998; Andriosopoulos and Lasfer, 2015).

In Canada, the Toronto Stock Exchange (TSE) provides a monthly summary detailing the status of all authorized repurchase programs, including the program size, termination date, the number of shares purchased in the previous month (across all exchanges), and the cumulative shares repurchased to date under each program (Ikenberry et al., 2000).

Firms cross-listed in the UK and US must disclose their share repurchase activities in both markets on a daily basis since 1981 per the UK regulations. Similarly, firms cross-listed in Canada and US must disclose their share repurchase activities in both Canada and US markets every month to be compliant with the regulations of Canada since 1985. Thus, the amendment of the SEC Rule 10b-18 does not affect these cross-listed firms' disclosure frequency. On the other hand, they raises the disclosure frequency of firms listed only in the US.

3.2 Data and Matching Sample

We retrieve annual and quarterly data of firm fundamentals from the Compustat database. We identify firms cross-listed in the US and the UK/Canada using the identifier "fic" in the Compustat database. This item identifies the country in which the company is incorporated or legally registered. We also manually check the Canadian and UK firms listed in the US in the DataStream database to ensure that they are also cross-listed in the UK and Canada. All intraday variables are calculated using the Trade and Quotes (TAQ) databse. Daily closing prices are retrieved from the CRSP database.

Firms that are listed only on US stock exchanges are the treatment firms in our difference-in-differences analysis, while firms cross-listed on both US exchanges and Canadian/British exchanges are the control firms. To alleviate the concern that the treatment and control firms differ on important characteristics, we form a matched sample of treatment/control firms based on their propensity scores. Given the relatively small sample of firms cross-listed in US and British/Canadian stock exchanges, we match each of these cross-listed firm to five firms that are listed in only the US.

We use the following covariates to estimate the propensity score following Fama and French (2001); Li et al. (2024): (1) firm size, measured by the natural logarithm of total asset; (2) Tobin's Q, which is the ratio of the firm's market value of asset to its book value of asset in the last year;[4] (3) ROA, which is the ratio of the firm's income before extraordinary items plus depreciation and amortization to its book value of asset in the last year;[5] and (4) Repurchase Payout, which is the ratio of the firm's dollar amount of share repurchases to its book value of asset in the last year.[6] We estimate each firm's propensity to be cross-listed in a Canadian/British exchange using the logit regression, where the dependent variable is an indicator for the firm being cross-listed in a Canadian/British exchange and the explanatory variables are the aforementioned covariates. For each firm cross-listed in Canada/UK, we identify five firms that are listed in only the US with the closest propensity scores. The matched sample consists of 1,305 firms, of which 260 (19.90%) are control firms and 1,045 (80.10%) are treatment firms.

Table 2 presents summary statistics of the four covariates for the unmatched sample of all treatment/control firms and for the sample of treatment/control firms that are matched based on the propensity score. Among the unmatched sample, treatment firms are larger in size and repurchase less than control firms although the two groups of firms have comparable Tobin's Q and ROA. Among the matched sample, treatment and control firms have comparable size, Tobin's Q, ROA, and share repurchases: the difference in the mean of each variable is statistically insignificant between the treatment and control firms. That is, the matched treatment and control firms have similar firm fundamentals.

[4] Tobin's Q equals $(prcc_f * csho + at - ceq)/at_{t-1}$. All variable are retrieved from the Compustat database.

[5] ROA equals $100 * (ib + dp)/at_{t-1}$. All variables are retrieved from the Compustat database.

[6] Repurchase payout equals $100 * (prstkc_t + pstkrv_t - pstkrv_{t-1})/at_{t-1}$. All variables are retrieved from the Compustat database.

Table 2: Summary Statistics for Treatment and Control Groups before the Reform

This table presents the mean of four variables for treatment firms (listed in U.S. stock exchanges only) and control firms (crossed-listed in U.S. and Canada/UK) in two samples: the unmatched sample of all firms and the sample of treatment/control firms matched based on propensity score. The four variables are firm size, Tobin's Q, ROA, and Repurchase Payouts. We also test whether the mean of each variable is the same for the treatment versus control firms, and report the t-statistics. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

		Mean			% reduct	t-test	
Variable	(Un)Matched	Control	Treatment	%bias	$\|bias\|$	t	$p > \|t\|$
Size	Unmatched	6.401	5.6311	32.0		5.64	0.000***
	Matched	6.3769	6.4426	-2.7	91.5	-0.30	0.762
Tobin's Q	Unmatched	3.34	3.11	5.5		0.85	0.394
	Matched	3.3115	3.6125	-7.2	-30.8	-0.74	0.462
ROA	Unmatched	0.0043	-0.00747	4.3		0.64	0.521
	Matched	0.00379	-0.00604	3.6	16.5	0.42	0.678
Rep. Payout	Unmatched	0.96245	2.045	-30.3		-4.01	0.000***
	Matched	0.96606	1.1905	-6.3	79.3	-0.99	0.322

3.3 Difference-in-Difference Regression

We employ the difference-in-differences (DiD) analysis to estimate the effects of the mandatory quarterly disclosure of share repurchases on stock liquidity, repurchase activity, and repurchase price. The treatment firms are the firms that are listed in only U.S. stock exchanges, while the control firms are those crossed listed in the U.S. and Canada/UK. In particular, we estimate the following DiD regression:

$$Y_{i,t} = \beta_0 + \beta_1 \left(Treat_i \times Post_t\right) + \beta \mathbf{X}_{i,t} + v_i + \eta_t + \varepsilon_{i,t} \tag{3.1}$$

where $Y_{i,t}$ is the outcome variable (number of shares repurchased, repurchase price, or stock liquidity,) for firm i in period t. $Treat_i$ equals 1 for treatment firms and 0 for control firms. $Post_t$ equals 1 if the period is after March 15, 2004 (inclusive), and 0 otherwise. Effective on March 15, 2004, all US-listed firms must disclose their amount of share repurchases and the average repurchase price every quarter rather than every year before that. The coefficient on the interaction term $Treat_i \times Post_t$ captures the average treatment effect of a more frequent disclosure of share repurchase on stock liquidity, repurchase activity, and repurchase price. $\mathbf{X}_{i,t}$ is a vector of control variables. Following Fama and French (2001); Li et al. (2024), we control for firm size, Tobin's Q, ROA, and leverage ratio. We further control for microstructure-level variables, including quarterly average volatility, price level, trading volume, numbers of trades, and order imbalances when the outcome variable is stock liquidity. Lastly, v_i is the firm fixed effects, and η_t is the time fixed effects. We also cluster the standard error at the firm level.

4 Empirical Results

In this section, we present the empirical results concerning the model's predictions for payout policy, price impacts, and repurchase prices.

4.1 Payout Policy

Prediction 2.3 of the model states that the treated firms will repurchase more of their stocks after they must disclose their repurchase activities more frequently. The reason is that repurchases have smaller price impacts under more frequent disclosure because of subdued information asymmetry. We test this prediction using the following dependent variables in model 3.1: repurchase payout, dividend payout, total payout, and payout structure. Repurchase payout is the ratio of the firm's annual repurchase expenditure divided to its total asset at the end of the the last year, while dividend payout is the ratio of the firm's annual cash dividends to its total asset at the end of the the last year. Total payout is the sum of repurchase payout and dividend payout. All the three variables are expressed in percentages. Payout structure equals (repurchase payouts +1) / (dividend payouts +1). It takes the value of one when the firm does not distribute cash to shareholders through dividends or share repurchases. It is greater than one when the firm returns more cash to shareholders through repurchases than dividends, and smaller than one when the opposite is true.

Table 3 summarizes the yearly data used in our analysis. Firm size, proxied by the natural logarithm of total assets, has a mean of 6.627 and a standard deviation of 2.384. It exhibits considerable variation, spanning from the 1st percentile at 1.349 to the 99th percentile at 12.54. ROA has a mean of 2.67% and a standard deviation of 27.9%. The average firm has Tobin's Q of 2.925 and leverage ratio of 26.1%; the standard deviations of the two variables are also large: 5.156 and 29.6%, respectively.

The average firm repurchases their own stocks that are equivalent to 1.839% of their total assets in a year, and distributes cash dividends that are equivalent to 1.087% of their total assets. Consistent with prior studies, share repurchases and cash dividends concentrate among certain firms and are positively skewed. The median firm does not repurchase stocks or pay cash dividends. The 99th percentile of the repurchases-to-asset ratio is 25.47, and the 99th percentile of the dividends-to-asset ratio is 15.66. Total payout, which is the sum of repurchase payout and dividend payout, has a mean of 2.946%. That is, the average firm distributes 2.946% of their assets to shareholders through share repurchases and cash dividends in a year. The *Post* indicator has a mean of 0.497, indicating that about half of the firm-year observations in the sample are after the policy change. The *Treat* dummy has a mean of 0.800 because we identify five treatment firms for each control firm (i.e., each cross-listed firm).

Table 3: Summary Statistics for Yearly Data

This table presents the summary statistics for the yearly variables in regression analysis. Repurchase payout is the ratio of the firm's annual repurchase expenditure divided to its total asset at the end of the the last year, while dividend payout is the ratio of the firm's annual cash dividends to its total asset at the end of the the last year. Total payout is the sum of repurchase payout and dividend payout. All the three variables are expressed in percentages. Payout structure equals (repurchase payouts +1) / (dividend payouts +1). Firm size is measured by the natural logarithm of total asset; Tobin's Q is the ratio of the firm's market value of asset to its book value of asset in the last year; ROA is the ratio of the firm's income before extraordinary items plus depreciation and amortization to its book value of asset in the last year; Leverage Ratio is the ratio of current liabilities plus long-term debt over lagged total asset.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	N	mean	sd	p1	p25	p50	p75	p99
Size	9,530	6.627	2.384	1.349	4.957	6.558	8.165	12.54
ROA	9,314	0.0267	0.279	-1.527	0.0110	0.0738	0.131	0.536
Tobin's Q	8,901	2.925	5.156	0.462	1.118	1.582	2.623	41.09
Leverage Ratio	8,740	0.261	0.296	0.000	0.0217	0.198	0.382	1.505
Repurchase Payout	8,632	1.839	5.087	0.000	0.000	0.000	1.083	25.47
Dividend Payout	9,398	1.087	2.666	0.000	0.000	0.000	1.099	15.66
Total Payout	8,587	2.946	5.950	0.000	0.000	0.502	3.095	29.58
Payout Structure	8,587	2.028	4.160	0.0715	0.839	1.000	1.288	22.16
Treat	9,563	0.800	0.400	0.000	1.000	1.000	1.000	1.000
Post	9,563	0.497	0.500	0.000	0.000	0.000	1.000	1.000

Table 4 presents the regression results for model 3.1, where the dependent variables are the four measures of payout policy. We estimate the regressions using firm-year observations from 2000 to 2008. Note that firms disclose their repurchase activities, including both the number of shares repurchased and the average repurchase price, on an annual basis before 2004. We thus estimate the regressions using firm-year observations. *Post* takes the value of one if it is after 2004 (inclusive) and zero otherwise.

The coefficient on $Treat * Post$ is 1.010 and is statistically significant at the 1% level in column (1), where the dependent variable is repurchase payout. The coefficient on $Treat * Post$ becomes -0.431 and is statistically significant at the 5% level in column (2), where the dependent variable is repurchase payout. That is, compared to the control variables, the treated firms increase their share repurchases by 0.990% and reduces their dividend payout by 0.431% under more frequent disclosure of their share repurchase activities. As for the total payout, the coefficient on $Treat * Post$ is 0.550, but is only statistically significant at 10% level in column (3). It turns out that the treated firms conduct more share repurchase but reduce less cash dividends after more frequent disclosure, probably due to the sticky dividend (Guttman et al., 2010), which increases the total payout. Lastly, the coefficient on $Treat * Post$ is 0.877 and is statistically significant at the 1% level in column (4), where the dependent variable is repurchase structure. This result is consistent with those in the first three columns: the treated firms substitute cash dividends with share repurchases after being required to disclose their repurchase activities more frequently.

Table 4: More Frequent Disclosure of Share Repurchases and Payout Policy

This table reports the results of the DiD regression $\text{Payout}_{i,t} = \beta_0 + \beta_1 (Treat_i \times Post_t) + \beta \mathbf{X}_{i,t} + v_i + \eta_t + \varepsilon_{i,m,t}$. The payout measures are repurchase payout, dividend payout, total payout, and payout structure. *Treat* takes the value of 1 if the firm is listed in U.S. only and 0 if it is cross-listed in the U.S. and Canada/UK. *Post* takes the value of 1 if it is after 2004 (inclusive) and 0 otherwise. The control variables are firm size, ROA, Tobin's Q, and leverage ratio. We estimate the regressions using firm-year observations from 2000 to 2008. All variables are winsorized at the 1% and 99% levels. Firm-clustered standard errors are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

VARIABLES	(1) Repur Payout	(2) Divid Payout	(3) Total Payout	(4) Payout Structure
Treat *Post	**0.990***** **(0.290)**	**-0.431**** **(0.172)**	**0.550*** **(1.401)**	**0.877***** **(0.300)**
Observations	7,560	8,102	8,003	7,524
R-squared	0.360	0.705	0.418	0.336
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

To check whether the parallel-trends assumption is violated, we estimate dynamic treatment effects diff-in-diff regressions in which the interaction variable $Treat * Post$ is replaced with the interactions between $Treat$ and each of the indicators for each year from 2000 to 2008. Figure 6 plots the coefficients on the interaction variables between $Treat$ and the year indicators and the 95% confidence intervals of the coefficients. The dependent variable is repurchase payout. The coefficient on the interaction variable between $Treat$ and the year indicator is economically small and statistically insignificant before the treatment year of 2004, and becomes positive and significant over the years from 2004 to 2008. In short, we observe no evidence that the parallel-trends assumption is violated.

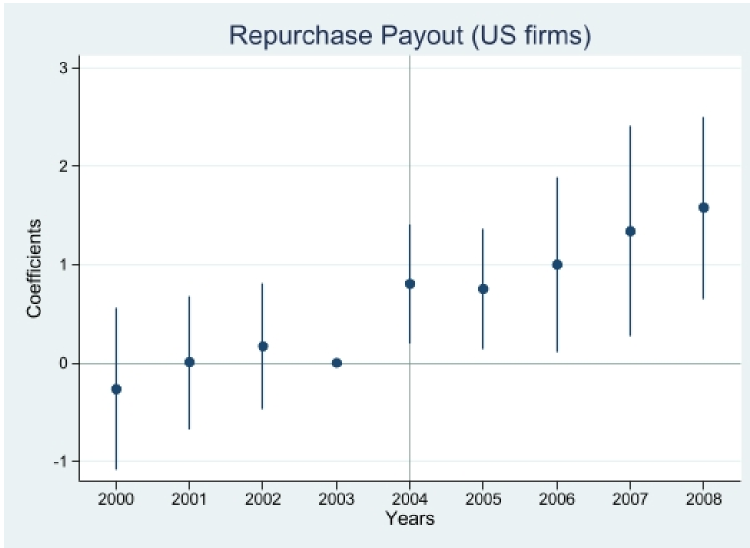

Figure 6: Dynamic Treatment Effects of More Frequent Disclosure of Share Repurchases on Repurchase Payout

We estimate dynamic treatment effects diff-in-diff regressions in which the interaction variable $Treat * Post$ in model 3.1 is replaced with the interactions between $Treat$ and each of the indicators for each year from 2000 to 2008. This figure plots the coefficients on the interaction variables between $Treat$ and the year indicators and the 95% confidence intervals of the coefficients.

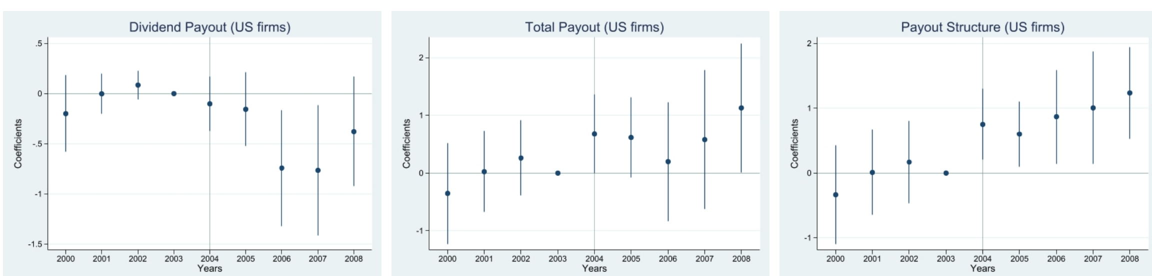

Figure 7: Dynamic Treatment Effects of More Frequent Disclosure of Share Repurchases on Dividend Payout, Total Payout, and Payout Structure

We estimate dynamic treatment effects diff-in-diff regressions in which the interaction variable $Treat * Post$ in model 3.1 is replaced with the interactions between $Treat$ and each of the indicators for each year from 2000 to 2008. This figure plots the coefficients on the interaction variables between $Treat$ and the year indicators and the 95% confidence intervals of the coefficients.

4.2 Price Impact and Repurchase Price

Prediction 2.1 indicates that price impact decreases under more frequent disclosure of share repurchase activities. To test this prediction, we consider three commonly-used price impact measures: Kyle's Lambda, percentage price impact, and turnover ratio (Hasbrouck, 2009;

Goyenko et al., 2009; Karolyi et al., 2012). Kyle's lambda is an estimated coefficient from the intraday regression where the dependent variable is the log-difference between the mid-points in 300 seconds, and the regressor is the (signed) squared volume difference between buy and sell orders. Kyle's lambda captures how much would the price change if there were one dollar net buy/sell volume. A lower Kyle's lambda implies a lower price impact and a higher market resiliency. Percentage price impact is the difference between the mid-point price five minutes later and the current mid-point price, divided by the mid-point price five minutes later. We calculate Kyle's Lambda and price impact using the TAQ data following Holden et al. (2014). Percentage price impact is a proxy for the informed traders' trading profits, and a lower percentage price impact implies a less informatively asymmetry market. Turnover ratio is the number of shares traded in a day divided by the number of shares outstanding. A higher turnover ratio implies a better liquidity in the market. A higher turnover ratio together with lower price impacts suggests that investors can more easily buy or sell the stock without significantly impacting its price.

We calculate each of the price impact measures every day using intraday data and then compute the average measure in each quarter. The quarterly price impact measures are used as dependent variables to estimate regression 3.1. In addition to the control variables specified in equation 3.1, we also control for variables related to price impact, including the quoted-based intraday volatility, the firm's quarter-end stock price, the natural logarithm of trading volume in the quarter, the natural logarithm of the number of trades in the quarter, and the order imbalance, which is the log-difference between buy and sell volume. We estimate regression 3.1 using quarterly data over the period from 2000 to 2008, 16 quarters before March 15, 2004 and 19 quarters thereafter. Recall that US-listed firms must start to disclose their share repurchase activities every quarter since March 2004.

Prediction 2.2 of the model is that share repurchase price is higher under more frequent disclosure of share repurchase activity as a result of subdued information asymmetry. To test this prediction, we construct the measure of relative repurchase price as the ratio of the firm's average repurchase price in a quarter to the average daily closing price in the quarter. Since treated firms do not disclose their average repurchase price on a quarterly basis before 2004, we replace the repurchase price with zero for all firms before 2004.

We first provide summary statistics for the dependent and independent variables used in our regression analysis in Table 5. Firm size, ROA, Tobin's Q, leverage ratio, $Treat$, and $Post$ are comparable to those in Table 3. As for the additional control variables, Volatility is relatively low on average (0.225), though individual values range widely. Trading metrics such as Number of Trades (10.07) and Trading Volume (16.24) indicate active trading behavior, while Order Imbalances (0.0104) and Turnover (0.447) suggest varying degrees of market activity and liquidity. The Price Level, Percentage Price Impact and Kyle's Lambda also display considerable variability, reflecting the variation in the information asymmetry among different stocks. Since we replace the pre-shock repurchase price as zero, we do obtain a relatively skewed distribution, yet still obtaining ideal variation as the standard error of 35.27%, which suggests sharp differences in relative repurchase price between individual stocks.

Table 5: Summary Statistics for Quarterly Data

This table presents the summary statistics for the main variables in our quarterly regression analysis. Size is measured by the natural logarithm of total asset; Tobin's Q is the ratio of the firm's market value of asset to its book value of asset in the last year; ROA is the ratio of the firm's income before extraordinary items plus depreciation and amortization to its book value of asset in the last year; Leverage Ratio is the ratio of current liabilities plus long-term debt over lagged total asset. Kyle's lambda is an estimated coefficient from the intraday regression where the dependent variable is the log-difference between the mid-points in 300 seconds, and the regressor is the (signed) squared volume difference between buy and sell orders. Percentage price impact is the difference between the mid-point price five minutes later and the current mid-point price, divided by the mid-point price five minutes later. Turnover ratio is the number of shares traded in a day divided by the number of shares outstanding. Relative repurchase price is the ratio of the firm's average repurchase price in a quarter to the average daily closing price in that quarter, as expressed in percentage; it is set to 0 before March 2004 because it is unobserved for the treated firms. Order imbalances is the log-difference between the buy and sell dollar volume. Volatility is the Quote-based intraday volatility. For the intraday variables, we average them at the quarter level.

VARIABLES	(1) N	(2) mean	(3) sd	(4) p1	(5) p25	(6) p50	(7) p75	(8) p99
Price Level	30,393	23.70	21.06	0.610	7.240	18.03	34.26	105.4
ROA	27,128	1.181	4.892	-23.68	0.485	1.931	3.309	12.26
Leverage Ratio	27,994	21.29	20.93	0.000	1.504	17.75	33.56	95.32
Size	29,989	6.573	2.211	2.112	4.953	6.416	7.976	12.57
Tobin's Q	29,256	2.224	2.253	0.559	1.137	1.516	2.340	16.45
Volatility	30,414	0.225	0.806	4.96e-5	9.44e-3	0.00543	0.0525	6.026
Numbes of Trades	30,415	10.07	2.170	4.977	8.539	10.24	11.62	14.75
Trading Volume	30,415	16.24	2.077	11.12	14.85	16.43	17.67	20.64
Order Imbalances	30,414	0.0104	0.262	-0.983	-0.0899	0.0274	0.166	0.614
Post	30,415	0.511	0.500	0.000	0.000	1.000	1.000	1.000
Treat	30,415	0.833	0.373	0.000	1.000	1.000	1.000	1.000
Percentage Price Impact	30,415	0.347	0.430	0.0122	0.0824	0.187	0.434	2.419
Kyle's Lambda	29,887	11.94	25.92	-16.37	1.036	3.152	10.21	168.2
Turnover	29,642	0.447	0.491	0.00405	0.125	0.286	0.583	2.720
Relative Repurchase Price (%)	30,393	13.97	35.27	0.000	0.000	0.000	0.000	115.9

Prediction 2.2 of the model is that the repurchase price is higher under more frequent disclosure as a result of subdued information asymmetry. To test this prediction, we construct the measure of relative repurchase price as the ratio of the firm's average repurchase price in a quarter to the average daily closing price in the quarter. Since the 10-Q files did not document the average repurchase price before 2004, we replace the repurchase price with zero for all firms before 2004. The repurchase price of UK and Canadian firms are unaffected by the quarterly disclosure because they had been disclosing more frequently. Any change in the repurchase price in the US domestic firms reflects the policy impact.

Table 6: More Frequent Disclosure of Share Repurchases, Price Impact, and Relative Repurchase Price

This table reports the results of the DiD regression $\text{PriceImpact}_{i,t} = \beta_0 + \beta_1 (Treat_i \times Post_t) + \beta\mathbf{X}_{i,t} + v_i + \eta_t + \varepsilon_{i,m,t}$. Price impact measures include the Kyle's Lambda, percentage price impact, and turnover. Relative repurchase price is the ratio of the firm's average repurchase price in a quarter to the average daily closing price in that quarter. *Treat* takes the value of 1 if the firm is listed in U.S. only and 0 if it is cross-listed in the U.S. and Canada/UK. *Post* takes the value of 1 if it is after 2004 Q1 (inclusive) and 0 otherwise. The control variables are firm size, ROA, Tobin's Q, leverage ratio, quarterly average volatility, quarter-end stock price, the natural logarithm of trading volume in the quarter, the natural logarithm of the number of trades in the quarter, and the order imbalance. We estimate the regression using firm-quarter observations from 2000 to 2008. All variables are winsorized at the 1% and 99% levels. Firm-clustered standard errors are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

VARIABLES	(1) Kyle's Lambda	(2) Price Impact (%)	(3) Turnover	(4) Relative Repurchase Price (%)
Treat*Post	**-0.036****	**-0.045****	**0.160*****	**17.991****
	(0.017)	**(0.021)**	**(0.036)**	**(2.462)**
Observations	26,287	26,732	26,732	25,699
R-squared	0.573	0.745	0.500	0.433
Controls	YES	YES	YES	YES
Quarter-Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

Table 6 reports the regression results. The coefficient on $Treat * Post$ is negative when the dependent variable is Kyle's Lambda and price impact. It becomes positive when the dependent variables are turnover ratio and relative repurchase price. The coefficients are statistically significant throughout the four regressions. Recall that the first two measures are positively correlated with the price impact of a stock, while the turnover ratio is negatively correlated with stock liquidity. Viewed together, the results indicate that, compared to the control firms, the treatment firms' stock price impact decreases after they are required to report their share repurchase activities on a quarterly basis since March 2004. The results are consistent with Prediction 2.1 of the model: stock price impact decreases and information asymmetry is subdued after firms start to disclose their share repurchases more frequently. Investors can trade the stocks in the treatment firms more easily without moving the stock prices too much.

The effects on price impact are economically meaningful. The coefficient on $Treat * Post$ is -0.036 in column (1) where the dependent variable is Kyle's Lambda. It is statistically significant at the 5% level. This result implies that a one dollar increase in the buy volume moves the average treatment firm's mid-point price by 3.6 bps (0.036%) less after March 2004 than before, compared to the average control firm. The coefficient is -0.045 and is statistically significant at the 5% level in column (2), where the dependent variable is price impact. That is, the price impact for the treatment firms drops by 4.5 bps (0.045%) after

March 2004 than before, compared to the control firms. This result indicates that the average price impact of the treatment firms decrease by around 4 bps after March 2004 than before, compared to the control firms. In column (3), where the dependent variable is turnover ratio, the coefficient on $Treat * Post$ is 0.160, which is statistically significant at the 1% level. This result suggest that, compared to the control firms, the treated firms experience an increase of 16.0% in turnover ratio, after they start to disclose their share repurchase activities on a quarterly basis than before.

The last column of Table 6 reports the results on the relative repurchase price. The coefficient on $Treat * Post$ is 17.99 and is statistically significant at the 1% level. That is, compared to the control firms, the treated firms' relative repurchase price increases by 17.99% after they are required to disclose their share repurchase activities every quarter. This result is consistent with model's prediction 2.2.

To check whether the parallel-trends assumption is violated in our diff-in-diff analysis, we estimate dynamic treatment effects diff-in-diff regressions in which the interaction variable $Treat * Post$ is replaced with the interactions between $Treat$ and each of the indicators for each quarter from 2000 Q1 to 2008 Q4. Figure 8 plots the coefficients on the interaction variables between $Treat$ and the quarter indicators and the 95% confidence intervals of the coefficients. The five plots are for the five liquidity measures, respectively.

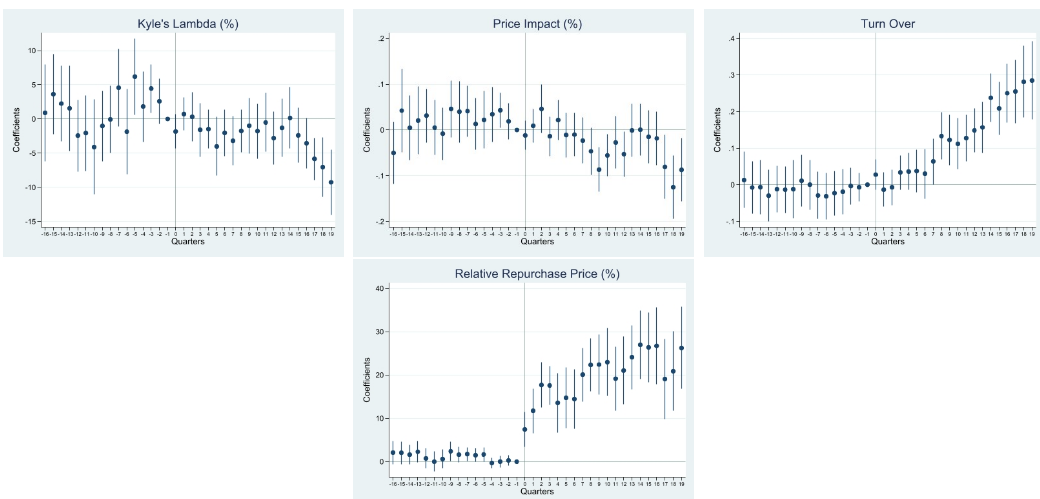

Figure 8: Dynamic Treatment Effects of More Frequent Disclosure of Share Repurchases on Stock Liquidity

We estimate dynamic treatment effects diff-in-diff regressions in which the interaction variable $Treat * Post$ in model 3.1 is replaced with the interactions between $Treat$ and each of the indicators for each quarter from 2000 Q1 to 2008 Q4. This figure plots the coefficients on the interaction variables between $Treat$ and the quarter indicators and the 95% confidence intervals of the coefficients. The five plots are for the five liquidity measures, respectively.

Figure 8 reveals no evidence that the parallel-trends assumption is violated in our diff-in-diff analysis. The coefficients on the interactions variables are almost always statistically insignificant for the quarters before the treatment (i.e., quarter 0 in the plots). They are significant at the 5% significance level for only 2 of the 16 pre-treatment quarters when the dependent variable is the Kyle's Lambda, none of the 16 pre-treatment quarters for both price impact or turnover ratio. When the coefficients are statistically significant, the sign of the coefficient is almost always the opposite of the sign of the treatment effect. Two coefficients on the pre-treatment interaction variables are positive and significant at the 5% level when the dependent variable is the Kyle's Lambda, but the treatment effect is negative for the Kyle's Lambda as shown in Table 6. In addition, eyeball tests reveal no clear pre-treatment diverging trends between the treated and control firms for any of the three price impact measures. On balance, the parallel-trends assumption is not violated in our analysis.

4.3 Placebo Tests

We conduct placebo tests to check whether the documented treatment effects are the result of more frequent disclosure of share repurchase activities. Pretending that the SEC required U.S. firms to disclose their repurchase activities on a quarterly basis starting from the first quarter of 2002 rather than the first quarter of 2004, we re-estimate the regressions in Tables 4 and 6 using data over the 2000-2003 period. The variable *Post* is redefined as being one if it is after 2002 Q1 and zero otherwise.

The placebo test results showcased in Tables 7 and 8 reveal that the coefficients on $Treat * Post$ is statistically insignificant throughout the model specifications. The results validate our diff-in-diff regression model based on the increased disclosure frequency of share repurchase activities starting from 2004. They also suggest that the treatment effects reported in Tables 4 and 6 are the result of this change in disclosure frequency.

Table 7: Placebo Test on Price Impact and Relative Repurchase Price

This table reports the results of the DiD regression $\text{Liquidity}_{i,t} = \beta_0 + \beta_1 (Treat_i \times Post_t) + \beta \mathbf{X}_{i,t} + v_i + \eta_t + \varepsilon_{i,m,t}$. Price Imapct measures include the Kyle's Lambda, percentage price impact, and turnover. *Treat* takes the value of 1 if the firm is listed in U.S. only and 0 if it is cross-listed in the U.S. and Canada/UK. *Post* takes the value of 1 if it is after 2002 Q1 (inclusive) and 0 otherwise. The control variables are firm size, ROA, Tobin's Q, leverage ratio, quarterly average volatility, quarter-end stock price, the natural logarithm of trading volume in the quarter, the natural logarithm of the number of trades in the quarter, and the order imbalance. We estimate the regression using firm-quarter observations from 2000 to 2003. All variables are winsorized at the 1% and 99% levels. Firm-clustered standard errors are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

VARIABLES	(1) Kyle's Lambda	(2) Price Impact (%)	(3) Turnover (%)	(4) Relative Repurchase Price (%)
Treat*Post	**1.804**	**0.008**	**0.022**	**0.029**
	(1.575)	**(0.026)**	**(0.024)**	**(0.030)**
Observations	12,261	12,646	12,646	12,635
R-squared	0.692	0.800	0.745	0.064
Controls	YES	YES	YES	YES
Quarter-Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

Table 8: Placebo Test on Payout Policy

This table reports the results of the DiD regression $\text{Payout}_{i,t} = \beta_0 + \beta_1 (Treat_i \times Post_t) + \beta \mathbf{X}_{i,t} + v_i + \eta_t + \varepsilon_{i,m,t}$. The payout measures are repurchase payout, dividend payout, total payout, and payout structure. *Treat* takes the value of 1 if the firm is listed in U.S. only and 0 if it is cross-listed in the U.S. and Canada/UK. *Post* takes the value of 1 if it is after 2002 (inclusive) and 0 otherwise. The control variables are firm size, ROA, Tobin's Q, and leverage ratio. We estimate the regressions using firm-year observations from 2000 to 2003. All variables are winsorized at the 1% and 99% levels. Firm-clustered standard errors are in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

VARIABLES	(1) Repurchase Payout	(2) Divid Payout	(3) Total Payout	(4) Payout Structure
Treat*Post	**0.234**	**0.132**	**0.300**	**0.211**
	(0.268)	**(0.108)**	**(0.258)**	**(0.245)**
Observations	3,915	4,251	3,897	3,897
R-squared	0.452	0.856	0.619	0.434
Controls	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

5 Conclusions

The substantial volume of share repurchases has raised regulatory concerns, prompting proposals for more frequent disclosure mandates. This paper develops a theoretical framework to analyze the potential impacts of such a proposal. Under a more frequent disclosure regime, stock prices become more reflective of firms' fundamentals, and price impact decreases. However, firms increase their repurchase volumes correspondingly.

Our theory highlights the informational motives for firms to conduct share repurchases: with information asymmetry on the future cash slows, firms can use share repurchase to maximize the remaining shareholders' value at the expense of buying back undervalued shares from uninformed investors.

We verify our model predictions by analyzing the 2004 SEC amendment. Changing disclosure of share repurchases from yearly to quarterly, price impact in the stocks decreases by 4.5 bps, firms pay 18% higher relative repurchase price, and increase share repurchase payout by 1% of total asset value by substituting cash dividends.

Our findings have direct implications for policymakers. Mandating more frequent disclosure of share repurchases can enhance market efficiency by making stock prices more informative. However, it may not be effective in curbing the rising volume of repurchases, as firms are likely to adjust their behavior in response to the new disclosure requirements.

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A Supplementary Empirical Results

Table 9: Probit Regression Results: Propensity Score Matching

Variable	**Coefficient**	**Std. Error**	**z**	$P > \|z\|$	**[95% Conf. Interval]**
Size	0.0831	0.0145	5.73	0.000	[0.0547, 0.1115]
Tobin's Q	0.0171	0.0079	2.18	0.030	[0.0017, 0.0326]
Profitability	-0.0209	0.1339	-0.16	0.876	[-0.2834, 0.2416]
Repurchase Payout	-0.0008	0.0040	-0.21	0.837	[-0.0086, 0.0070]
Constant	-2.0672	0.1005	-20.58	0.000	[-2.2641, -1.8703]
Number of obs	4,142				
LR chi2(4)	35.31				
Prob > chi2	0.0000				
Log likelihood	-972.58				
Pseudo R^2	0.0178				

B Proofs of Propositions and Lemmas

B.1 Proofs of Lemmas 2.1, 2.2, and Proposition 2.1

We begin by assuming lemma 2.1 and proposition 2.1 are true to establish lemma 2.1 under the quarterly disclosure requirements. Then, we verify lemma **??** and proposition 2.1 are optimal under the derived pricing rules. This assume-and-verify technique is similar to Kyle (1985).

Uninformed traders may submit 0 or x and the informed manager may submit $0, x, 2x$ in the first period. So, market makers may face four possible aggregate order flows: $z_1 = -x, 0, x, 2x$ and set the price based on equation 2.2. We discuss the prices case by case. Specifically, market makers' pricing rules can be expressed using the law of total probability:

$$\begin{aligned} p_t &= E[P_3|\mathcal{Z}_t, \mathbf{I}] \\ &= P(S_G|\mathcal{Z}_t, \mathbf{I}) \cdot E[P_3|\mathcal{Z}_t, \mathbf{I}, S_G] + P(S_B|\mathcal{Z}_t, \mathbf{I}) \cdot E[P_3|\mathcal{Z}_t, \mathbf{I}, S_B] \end{aligned} \tag{B.1}$$

Now, applying equation B.1, we can calculate the pricing rules case by case:

1. $z_1 = -x$:
$$p_1(-x) = \theta \cdot 0 + (1-\theta) \cdot 0 = 0$$
2. $z_1 = 0$:
$$\begin{aligned} p_1(0) &= \theta \cdot \left(\frac{\frac{1}{2} - p_1(0)x}{1-x} \right) + (1-\theta) \cdot 0 \\ \implies p_1(0) &= \frac{\theta}{2(1-x+\theta x)} \end{aligned}$$
3. $z_1 = x$:
$$\begin{aligned} p_1(x) &= \frac{\frac{1}{2} - p_1(x)x}{1-x} \\ \implies p_1(x) &= \frac{1}{2} \end{aligned}$$
4. $z_1 = 2x$:
$$\begin{aligned} p_1(2x) &= \frac{1 - p_1(2x)2x}{1-2x} \\ \implies p_1(2x) &= 1 \end{aligned}$$

In the second period, the market makers would set the prices conditional on both the first and the second period's order flows, z_1 and z_2. Therefore, there are 16 cases in total.

- $z_1 = -x$
  1. $z_2 = -x$:
  $$p_2(z_2 - x; z_1 = -x) = \theta \cdot 0 + (1-\theta) \cdot 0 = 0$$
  2. $z_2 = 0$:
  $$p_2(z_2 = 0; z_1 = -x) = \theta \cdot \left(\frac{\frac{1}{2} - p_2(z_2 = 0; z_1 = -x)x}{1-x} \right) + (1-\theta) \cdot 0$$
  $$\implies p_2(z_2 = 0; z_1 = -x) = \frac{\theta}{2(1 - x + \theta x)}$$
  3. $z_2 = x$:
  $$p_2(z_2 = x; z_1 = -x) = \frac{\frac{1}{2} - p_2(z_2 = x; z_1 = -x)x}{1-x}$$
  $$\implies p_2(x) = \frac{1}{2}$$
  4. $z_2 = 2x$:
  $$p_2(x_2 = 2x; z_1 = -x) = \frac{1 - p_2(x_2 = 2x; z_1 = -x)2x}{1-2x}$$
  $$\implies p_2(2x) = 1$$
- $z_1 = 0$:
  1. $z_2 = -x$:
  $$p_2(z_2 = -x; z_1 = 0) = \theta \cdot \left(\frac{\frac{1}{2} - p_2(z_2 = -x; z_1 = 0)x}{1-x} \right) + (1-\theta) \cdot 0$$
  $$\implies p_2(z_2 = -x; z_1 = 0) = \frac{\theta}{2(1 - x + \theta x)}$$
  2. $z_2 = 0$:
  $$p_2(z_2 = 0; z_1 = 0) = \theta \left(\frac{\frac{1}{2} - p_1(0)x - p_2(z_2 = 0; z_1 = 0)x}{1-2x} \right) + (1-\theta) \cdot 0$$
  $$\implies p_2(z_2 = 0; z_1 = 0) = \theta \cdot \frac{1 - 2p_1(0)x}{2(1 - 2x + \theta x)}$$
  3. $z_2 = x$:
  $$\begin{aligned} p_2(z_2 = x; z_1 = 0) =& \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(0)x - p_2(z_2 = x; z_1 = 0)x}{1-2x} \\ &+ \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(0)x - p_2(z_2 = x; z_1 = 0) \cdot 2x}{1-3x} \end{aligned}$$
  $$\implies p_2(z_2 = 0; z_1 = 0) = \frac{1 - 2p_1(0)x}{2(1-x)}$$

4. $z_1 = 2x$:

$$p_2(z_2 = 2x; z_1 = 0) = \frac{1 - p_1(0)x - 2p_2(z_2 = 2x; z_1 = 0)x}{1 - 3x}$$
$$\implies p_2(z_2 = 2x; z_1 = 0) = \frac{1 - p_1(0)x}{1 - x} \tag{B.2}$$

- $z_1 = x$:

1. $z_2 = -x$:

$$p_2(z_2 = -x; z_1 = x) = 1 \cdot p_1(x) = \frac{1}{2}$$

This is because $P(S_G|z_2 = -x; z_1 = x, \mathbf{I}) = 1$.

2. $z_2 = 0$:

$$\begin{aligned} p_2(z_2 = 0; z_1 = x) =& \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(x)x - p_2(z_2 = x; z_1 = 0)x}{1 - 2x} \\ &+ \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(x)x}{1 - x} \\ \implies p_2(z_2 = 0; z_1 = x) =& \frac{1 - 2p_1(x)x}{2(1 - x)} \end{aligned}$$

3. $z_2 = x$:

$$\begin{aligned} p_2(z_2 = x; z_1 = x) =& \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(x)x - p_2(z_2 = x; z_1 = x)x}{1 - 2x} \\ &+ \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(x)x - p_2(z_2 = x; z_1 = x) \cdot 2x}{1 - 3x} \\ \implies p_2(z_2 = x; z_1 = x) =& \frac{1 - 2p_1(x)x}{2(1 - x)} \end{aligned}$$

4. $z_2 = 2x$:

$$p_2(z_2 = 2x; z_1 = x) = \frac{1 - p_1(x)x - 2p_2(z_2 = 2x; z_1 = x)x}{1 - 3x}$$
$$\implies p_2(z_2 = 2x; z_1 = x) = \frac{1 - p_1(x)x}{1 - x}$$

- $z_1 = 2x$: In this case, market makers know that $S = S_G$ and $A = A_H$. Therefore, there is no information asymmetry, so the market maker would set the price equal to $A = A_H = 1$.

Now, we need to show that repurchasing $2x$ in the first period is not a dominant strategy in any case. It is obvious that if $S = S_B$, the best strategy is not to repurchase in either periods. Now, we consider the case when $A = A_H$.

$$U(q_1 = x; q_2 = x|A = A_H) = \frac{1 - \frac{1}{2}\left(p_1(0) + p_1(x)\right)x - \frac{1}{4}\left(p_2(0;0) + p_2(0;x) + p_2(x;0) + p_2(x;x)\right)x}{1-2x} + 1$$

$$U(q_1 = 2x; q_2 = x|A = A_H) = \frac{1 - \frac{1}{2}\left(p_1(x) + p_1(2x)\right)2x - \frac{x}{4}\left(p_2(x;0) + p_2(x;x) + p_2(2x;0) + p_2(2x;x)\right)}{1-3x} + 1$$

$$\begin{aligned}
\implies & U(q_1 = x; q_2 = x|A = A_H) - U(q_1 = 2x; q_2 = x|A = A_H) \\
&= \frac{-0.5p_1(0)x - 0.25\left(p_2(x;0) + p_2(x;x) + p_2(2x;0) + p_2(2x;x)\right)x + 1}{1-2x} - \frac{1 - 2.25x}{1-3x} \\
&= \frac{1-ax}{1-2x} - \frac{1-bx}{1-3x}, \quad a = 0.5p_1(0)x + 0.25\left(p_2(x;0) + p_2(x;x) + p_2(2x;0) + p_2(2x;x)\right), b = 2.25 \\
&= \frac{x(a(3x-1) - 2bx + b - 1)}{6x^2 - 5x + 1} > 0
\end{aligned} \tag{B.3}$$

where the last equation uses the fact that $x \in (0, 0.25)$ and that $\theta \in (0, 1)$.

Similarly, we can verify that

$$U(q_1 = x; q_2 = 2x|A = A_H) = \frac{1 - \frac{1}{2}\left(p_1(0) + p_1(x)\right)x - \frac{1}{4}\left(p_2(0;x) + p_2(0;2x) + p_2(x;x) + p_2(x;2x)\right)2x}{1-3x} + 1$$

$$U(q_1 = 2x; q_2 = 2x|A = A_H) = \frac{1 - \frac{1}{2}\left(p_1(x) + p_1(2x)\right)2x - \frac{2x}{4}\left(p_2(x;x) + p_2(x;2x) + p_2(2x;x) + p_2(2x;2x)\right)}{1-4x} + 1$$

$$\begin{aligned}
\implies & U(q_1 = x; q_2 = 2x|A = A_H) - U(q_1 = 2x; q_2 = 2x|A = A_H) \\
&= \frac{x(a'(4x-1) - 3bx + b' - 1)}{12x^2 - 7x + 1} > 0
\end{aligned} \tag{B.4}$$

Finally, we consider $A = A_L$ and $S = S_G$.

$$U(q_1 = x; q_2 = x|A = A_L, S = S_B) = 1 + \frac{0 - \frac{1}{2}\left(p_1(0) + p_1(x)\right)x + \frac{1}{4}\left(p_2(0;0) + p_2(0;x) + p_2(x;0) + p_2(x;x)\right)x}{1-2x}$$

$$U(q_1 = 2x; q_2 = x|A = A_L, S = S_B) = 1 + \frac{0 - \frac{1}{2}\left(p_1(x) + p_1(2x)\right)2x + \frac{x}{4}\left(p_2(x;0) + p_2(x;x) + p_2(2x;0) + p_2(2x;x)\right)}{1-3x} \tag{B.5}$$

It is obvious that $U(q_1 = x; q_2 = x|A = A_L, S = S_B) > U(q_1 = x; q_2 = 2x|A = A_L, S = S_B)$ because the second term is negative and decreasing with x; and we can similarly show that $U(q_1 = x; q_2 = 2x|A = A_L, S = S_B) > U(q_1 = 2x; q_2 = 2x|A = A_L, S = S_B)$.

One last thing is to determine the informed manager's optimal strategy under $A = A_H$.

If she repurchases x in both periods, her expected utility is:

$$U(q_1 = x; q_2 = x | A = A_H) = \frac{1 - \frac{1}{2}\left(p_1(0) + p_1(x)\right)x - \frac{1}{4}\left(p_2(0;0) + p_2(0;x) + p_2(x;0) + p_2(x;x)\right)x}{1 - 2x} + 1$$

$$= \frac{1 - \frac{1}{2}\left(\frac{\theta}{2(1 - x + \theta x)} + \frac{1}{2}\right)x - \frac{1}{4}\left(\frac{\theta(1-x)+1}{2(1 - 2x + \theta x)(1 - x + \theta x)} + 1\right)x}{1 - 2x} + 1$$

If she repurchases x in the first period, but $2x$ in the second period, her expected utility is:

$$U(q_1 = x; q_2 = 2x | A = A_H) = \frac{1 - \frac{1}{2}\left(p_1(0) + p_1(x)\right)x - \frac{1}{4}\left(p_2(0;x) + p_2(0;2x) + p_2(x;x) + p_2(x;2x)\right)2x}{1 - 2x} + 1$$

$$= \frac{1 - \frac{1}{2}\left(\frac{\theta}{2(1 - x + \theta x)} + \frac{1}{2}\right)x - \frac{1}{4}\left(\frac{1}{2(1 - 2x + \theta x)(1 - x + \theta x)} + \frac{2 - 2x + \theta x}{2(1-x)(1 - x + \theta x)} + \frac{1}{2} + \frac{2 - x}{2(1-x)}\right)2x}{1 - 3x} + 1$$

We can simplify the expressions as follows:

$$\begin{aligned}
&U(q_1 = x; q_2 = x | A = A_H) = \frac{1 - \frac{1}{2}ax - \frac{1}{4}bx}{1 - 2x} + 1 \\
&U(q_1 = x; q_2 = 2x | A = A_H) = \frac{1 - \frac{1}{2}ax - \frac{1}{4}c \cdot 2x}{1 - 3x} + 1 \\
&a = p_1(0) + p_1(x); \\
&b = \frac{x(1-2a)}{1-x} + a; \\
&c = \frac{3 - 2ax}{1 - x}
\end{aligned}$$

The difference between these two utilities can therefore be expressed as:

$$\begin{aligned}
&U(q_1 = x; q_2 = x | A = A_H) - U(q_1 = x; q_2 = 2x | A = A_H) \\
&= \frac{\frac{x}{4}\left((3b + 2a - 4c)x + 2c - b - 4\right)}{6x^2 - 5x + 1}
\end{aligned} \tag{B.6}$$

Since $x > 0$, $U(q_1 = x; q_2 = x | A = A_H) \geq U(q_1 = x; q_2 = 2x | A = A_H)$ if and only if

$$x \geq \frac{4 + b - 2c}{3b + 2a - 4c} = \frac{-2 - 3x + ax + a}{3x - 3ax + 5a - 12} \tag{B.7}$$

Therefore, x_Q^* should satisfy:

$$\begin{aligned}
&x = \frac{-2 - 3x + ax + a}{3x - 3ax + 5a - 12} \\
&\iff (3 - 3a)x^2 + (4a - 9)x + (2 - a) = 0
\end{aligned} \tag{B.8}$$

Note that $a = p_1(0) + p_1(x) = \theta \frac{1}{2(1-x+\theta x)} + \frac{1}{2}$. We can further simplify equation B.8 as:

$$F(x) = \frac{\theta}{1-x+\theta x} - \frac{3x^2-14x+1}{3x^2-4x+1} \tag{B.9}$$

Note that $F(0) = \theta - 1 < 0$, $F(\frac{1}{4}) = \frac{4\theta}{3+\theta} + \frac{37}{3}$, $F'(x) = \frac{\theta}{(\theta x - x + 1)^2} - \frac{10\,(3x^2-1)}{(3x^2-4x+1)^2} > 0$ when $x \in (0, 0.25)$. Therefore, there exists x_Q^* such that as long as $x > x_Q^*$, $U(q_1 = x; q_2 = x|A = A_H) < U(q_1 = x; q_2 = 2x|A = A_H)$ and if $x < x_Q^*$, $U(q_1 = x; q_2 = x|A = A_H) > U(q_1 = x; q_2 = 2x|A = A_H)$.

B.2 Proofs of Lemma 2.3 and Propositions 2.2

Now, let us consider the informed manager's best strategy under a more frequent disclosure. We follow the same procedures that we first assume the informed manager's strategy to derive the pricing rules, and then verify the strategy under such pricing rules. Under a more frequent disclosure, the first-period pricing rules are the same as those for the quarterly one. We only need to consider the second-period pricing rules. Recall that q_1 is the (disclosed) informed trading quantity in the first period, so there are only three possible cases: $q_1 = 0$, $q_1 = x$, and $q_1 = 2x$. After seeing the disclosure, market makers would update their beliefs about the distribution of stages using Bayesian rules. We discuss it case by case.

- $q_1 = 0$. In this case, the informed manager did not trade any quantity in the first period, so market makers would keep the same beliefs about the distribution of the states.

    1. $z_2 = -x$:
    $$p_2(z_2 = -x; q_1 = 0) = \theta \cdot 0 + (1-\theta) \cdot 0 = 0$$

    2. $z_1 = 0$:
    $$p_2(z_2 = 0; q_1 = 0) = \theta \cdot \left(\frac{\frac{1}{2} - p_2(z_2 = 0; q_1 = 0)x}{1-x} \right) + (1-\theta) \cdot 0$$
    $$\Longrightarrow p_2(z_2 = 0; q_1 = 0) = \frac{\theta}{2(1-x+\theta x)}$$

    3. $z_1 = x$:
    $$p_2(z_2 = x; q_1 = 0) = \frac{\frac{1}{2} - p_2(z_2 = x; q_1 = 0)(x)x}{1-x}$$
    $$\Longrightarrow p_2(z_2 = x; q_1 = 0) = \frac{1}{2}$$

4. $z_1 = 2x$:

$$\begin{aligned} p_2(z_2 = 2x; q_1 = 0) &= \frac{1 - p_2(z_2 = 2x; q_1 = 0)2x}{1 - 2x} \\ \implies p_1(2x) &= 1 \end{aligned}$$

- $q_1 = x$ and $z_1 = 0$ or $z_1 = x$. In this case, the market makers update their beliefs of the state as follows:

$$\begin{aligned} P(S_G|q_1 = x) &= \frac{P(S_G)P(q_1 = x|S_G)}{P(S_G)P(q_1 = x|S_G) + P(S_B)P(q_1 = x|S_B)} \\ &= \frac{\theta \cdot 1}{\theta \cdot 1 + (1-\theta) \cdot 0} = 1 \end{aligned} \tag{B.10}$$

Therefore, the second-period pricing rules are as follows:

1. $z_2 = -x$:

$$\begin{aligned} p_2(z_2 = -x; q_1 = 0, z_1) &= 1 \cdot \left(\frac{\frac{1}{2} - p_1(z_1)x}{1 - x} \right) \\ \implies p_2(z_2 = -x; q_1 = 0, z_1) &= \frac{1 - p_1(z_1)x}{2(1-x)} \end{aligned}$$

2. $z_2 = 0$:

$$\begin{aligned} p_2(z_2 = 0; q_1 = 0, z_1) &= 1 \cdot \left(\frac{\frac{1}{2} - p_1(z_1)x - p_2(z_2 = 0; q_1 = 0, z_1)x}{1 - 2x} \right) \\ \implies p_2(z_2 = 0; q_1 = 0, z_1) &= \frac{1 - p_1(z_1)x}{2(1-x)} \end{aligned}$$

3. $z_2 = x$:

$$\begin{aligned} p_2(z_2 = x; q_1 = 0, z_1) =& \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(z_1)x - p_2(z_2 = x; q_1 = 0, z_1)x}{1 - 2x} \\ &+ \frac{1}{2} \cdot \frac{\frac{1}{2} - p_1(z_1)x - p_2(z_2 = x; q_1 = 0, z_1) \cdot 2x}{1 - 3x} \\ \implies p_2(z_2 = x; q_1 = 0, z_1) &= \frac{1 - 2p_1(z_1)x}{2(1-x)} \end{aligned}$$

4. $z_1 = 2x$:

$$\begin{aligned} p_2(z_2 = 2x; q_1 = 0, z_1) &= \frac{1 - p_1(z_1)x - 2p_2(z_2 = 2x; q_1 = 0, z_1)x}{1 - 3x} \\ \implies p_2(z_2 = 2x; q_1 = 0, z_1) &= \frac{1 - p_1(z_1)x}{1 - x} \end{aligned}$$

where $z_1 = 0$ or $z_1 = x$.

- $q_1 = 2x$ and $z_1 = x$ or $z_1 = 2x$. In this case, there is no more information asymmetry in the second period because market makers know both the states and the realized cash flows.

  1. If $z_1 = 2x$, then market makers just set the prices as the A_H. Just note that

$$
\begin{aligned}
p_2(z_2 = 2x; q_1 = 2x, z_1 = 2x) &= \frac{1 - p_1(2x)2x - p_2(z_2; q_1 = 2x, z_1 = 2x)2x}{1 - 4x} \\
p_2(z_2 = x; q_1 = 2x, z_1 = 2x) &= \frac{1 - p_1(2x)2x - p_2(z_2; q_1 = 2x, z_1 = 2x)x}{1 - 3x} \\
p_2(z_2 = 0; q_1 = 2x, z_1 = 2x) &= \frac{1 - p_1(2x)2x - p_2(z_2; q_1 = 2x, z_1 = 2x)x}{1 - 3x} \\
p_2(z_2 = -x; q_1 = 2x, z_1 = 2x) &= \frac{1 - p_1(2x)2x}{1 - 2x} \\
\Longrightarrow p_2(z_2; q_1 = 2x, z_1 = 2x) &= 1 \; z_2 = 0, x, 2x
\end{aligned}
$$

  2. If $z_1 = x$, the market makers set the price as follows:

$$
\begin{aligned}
p_2(z_2 = 2x; q_1 = 2x, z_1 = x) &= \frac{1 - p_1(2x)2x - p_2(z_2 = 2x; q_1 = 2x, z_1 = x)2x}{1 - 4x} \\
p_2(z_2 = x; q_1 = 2x, z_1 = x) &= \frac{1 - p_1(2x)2x - p_2(z_2 = x; q_1 = 2x, z_1 = x)x}{1 - 3x} \\
p_2(z_2 = 0; q_1 = 2x, z_1 = x) &= \frac{1 - p_1(2x)2x - p_2(z_2 = 0; q_1 = 2x, z_1 = x)x}{1 - 3x} \\
p_2(z_2 = -x; q_1 = 2x, z_1 = x) &= \frac{1 - p_1(2x)2x}{1 - 2x} \\
\Longrightarrow p_2(z_2; q_1 = 2x, z_1 = x) &= \frac{1 - 2p_1(x)}{1 - 2x} \; z_2 = 0, x, 2x
\end{aligned}
$$

Now, we show that the informed manager would always repurchase $2x$ in the second period. Note that

$$
\begin{aligned}
&U(q_1 = x; q_2 = x | A = A_H, Disclosure) = \frac{1 - \frac{1}{2}ax - \frac{1}{4}bx}{1 - 2x} + 1 \\
&U(q_1 = x; q_2 = 2x | A = A_H, Disclosure) = \frac{1 - \frac{1}{2}ax - \frac{1}{4}c \cdot 2x}{1 - 3x} + 1 \\
&a = p_1(0) + p_1(x); \\
&b = \frac{2 - 2ax}{1 - x}; \\
&c = \frac{3 - 2ax}{1 - x}
\end{aligned}
$$

The difference between these two utilities can therefore be expressed as:

$$U(q_1 = x; q_2 = x|A = A_H, Disclosure) - U(q_1 = x; q_2 = 2x|A = A_H, Disclosure)$$
$$= \frac{\frac{x}{4}\left((3b + 2a - 4c)\,x + 2c - b - 4\right)}{6x^2 - 5x + 1} \tag{B.11}$$

Since $x > 0$, $U(q_1 = x; q_2 = x|A = A_H) < U(q_1 = x; q_2 = 2x|A = A_H)$ if and only if

$$x < \frac{4 + b - 2c}{3b + 2a - 4c} = \frac{(2-a)x}{3-2a} \tag{B.12}$$

which is obvious because $x \in (0, 0.25)$ as the regulatory conditions and $0 < a < 1$. Therefore, $U(q_1 = x; q_2 = 2x|A = A_H, Disclosure) > U(q_1 = x; q_2 = x|A = A_H, Disclosure)$.

Finally, we need to show that it is never optimal to repurchase $2x$ in the first period. We need to show that $U(q_1 = x; q_2 = 2x|A = A_H, Disclosure) > U(q_1 = 2x; q_2 = 2x|A = A_H, Disclosure)$.

$$U(q_1 = x; q_2 = 2x|A = A_H, Disclosure) = \frac{1 - \frac{1}{2}ax - \frac{1}{4}c \cdot 2x}{1 - 3x} + 1$$
$$U(q_1 = 2x; q_2 = 2x|A = A_H, Disclosure) = \frac{1 - \frac{1}{2}a'2x - \frac{1}{4}c' \cdot 2x}{1 - 4x} + 1$$
$$a = p_1(0) + p_1(x);$$
$$a' = p_1(x) + p_1(2x) = \frac{3}{2}$$
$$c = \frac{3 - 2ax}{1 - x};$$
$$c' = p_2(x; 0; q_1 = 2x) + p_2(x; x; q_1 = 2x) + p_2(2x; x; q_1 = 2x) + p_2(2x; 0; q_1 = 2x) = \frac{4 - 5x}{1 - 2x}$$

We now have:

$$U(q_1 = x; q_2 = 2x|A = A_H, Disclosure) - U(q_1 = 2x; q_2 = 2x|A = A_H, Disclosure)$$
$$= \frac{\frac{x}{2}(-2 + 3a + 3c + 2a' + c' - (6a' + 3c')x)}{(1 - 3x)(1 - 4x)}$$

We only need to show that

$$x < \frac{-2 + 3a + 3c + 2a' + c'}{6a' + 3c'}$$

Note that

$$
\begin{aligned}
&\frac{-2+3a+3c+2a'+c'}{6a'+3c'} > x \\
\iff &\frac{1+3a+3c+c'}{9+3c'} > x \\
\iff &1+\frac{4-5x}{1-2x} > 9x+\frac{17x-15x^2-4}{1-2x}
\end{aligned}
\tag{B.13}
$$

where equation B.13 is obvious because $\frac{4-5x}{1-2x}+1 > 9x$ and $\frac{17x-15x^2-4}{1-2x} < 0$ given that $0 < x < 0.25$. Therefore, $U(q_1 = x; q_2 = 2x|A = A_H, Disclosure) > U(q_1 = 2x; q_2 = 2x|A = A_H, Disclosure)$. So the informed manager would not repurchase $2x$ in the first period under the more frequent disclosure.