Mandatory Portfolio Disclosure, Stock Liquidity, and Mutual Fund Performance

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ABSTRACT

We examine the impact of mandatory portfolio disclosure by mutual funds on stock liquidity and fund performance. We develop a model of informed trading with disclosure and test its predictions using the SEC regulation in May 2004 requiring more frequent disclosure. Stocks with higher fund ownership, especially those held by more informed funds or subject to greater information asymmetry, experience larger increases in liquidity after the regulation change. More informed funds, especially those holding stocks with greater information asymmetry, experience greater performance deterioration after the regulation change. Overall, mandatory disclosure improves stock liquidity but imposes costs on informed investors.

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Mandatory disclosure of portfolio holdings by institutional money managers is a vital component of securities market regulation. Mandated by the Securities Exchange Act of 1934 and the Investment Company Act of 1940, portfolio disclosure provides the public with information about the holdings and investment activities of institutional investors. Among the mandatory disclosure requirements on institutional investors, those on mutual funds provide perhaps the most detailed information about their portfolios (see Section I for more details). Such disclosure requirements have broad implications. On one hand, mandatory portfolio disclosure can help improve the transparency of capital markets. On the other hand, it can potentially reduce fund managers' incentives to collect and process information. To shed light on such costs and benefits of mandatory portfolio disclosure by mutual funds, we examine how disclosure affects (i) the liquidity of disclosed stocks and (ii) fund performance.

One of the challenges we face is the difficulty in identifying the causal effects of portfolio disclosure on stock liquidity and fund performance. We overcome this challenge by using a Securities Exchange Commission (SEC)-mandated regulation change in May 2004 regarding the disclosure requirements for mutual funds. This change forced mutual funds to increase their portfolio disclosure from a *semiannual* to a *quarterly* frequency. We use this regulation change as a quasi-natural experiment to identify the effects of funds' portfolio disclosure on stock liquidity and fund performance.

We motivate our empirical analyses using the theoretical literature on mandatory disclosure and informed trading. Huddart, Hughes, and Levine (2001) extend the Kyle (1985) model and study mandatory disclosure of trades by informed traders. We develop a model that builds on these two models and allows for different mandatory disclosure frequencies.

We analyze the impact of a change in disclosure frequency on stock liquidity and informed trader's profits and produce several testable predictions.

First, our model predicts that more frequent disclosure by informed traders improves market liquidity as measured by market depth, namely the inverse of the Kyle (1985) lambda. The intuition is that, with mandatory disclosure, the market maker can infer information from the disclosed positions of informed traders as well as from the aggregate order flows, which reduces the impact of informed trades on prices. Second, the liquidity improvement should be greater for stocks subject to higher information asymmetry. Third, our model predicts that the informed trader's profits are negatively related to disclosure frequency because the market's learning of disclosed trades limits the trader's ability to reap the full benefits of his information. Finally, the informed trader's profit drop should be positively related to both the level of information asymmetry in the stocks the trader holds and the time it takes the trader to complete his trades.

We begin our empirical analysis by examining the impact of an increase in portfolio disclosure frequency on the liquidity of disclosed stocks. A large body of literature has shown that mutual funds' disclosed portfolios contain valuable information (see Section II for more details). Given this evidence, our model predicts that stocks with higher fund ownership should experience greater increases in liquidity with more frequent disclosure. To test this prediction, we employ a difference-in-differences approach to examine the change in stock liquidity during the two-year period around the SEC rule change in May 2004. In particular, we examine how changes in stock liquidity (first difference) vary with the ownership of actively managed domestic equity mutual funds (second difference). Ge and Zheng (2006) document that some funds voluntarily disclose their portfolios. We carefully identify such funds that disclose to different sources (Morningstar and Thomson Reuters) in addition to the SEC EDGAR (Electronic Data Gathering, Analysis, and Retrieval) database (see Section IV for more details). We exclude these voluntarily disclosing funds to construct a sample of funds that increase their disclosure frequencies due to the 2004 SEC rule change. We then focus on this sample of funds in our analysis, which allows us to isolate the effect of the regulation change from that of the voluntary disclosure behavior of certain funds.

We find that stocks with higher fund ownership experience greater improvements in liquidity after funds are subject to more frequent mandatory disclosure. Moreover, the increase in liquidity is economically large. For instance, a one standard deviation increase in the ownership of funds forced to increase their disclosure frequency due to the regulation change is associated with a 0.13 and 0.22 standard deviation decrease in the Amihud (2002) illiquidity measure and Trade and Quote (TAQ) relative bid-ask spread, respectively.

We corroborate this finding by conducting several sets of placebo tests. First, we use two types of institutional investors, non-mutual-fund 13F institutions and hedge funds, as control groups for our cross-sectional placebo tests. The underlying argument is that the regulation change in 2004 only applies to mutual funds, but not to other institutional investors. In addition, we use domestic equity index funds as a control group. Unlike the treatment group of actively managed funds, index funds are passive and thus their disclosed portfolios should not contain private information. We find that the ownership of actively managed funds has a larger impact on the change in stock liquidity than does the ownership of non-mutual funds, hedge funds, or index funds. Second, we conduct a time-series placebo test using a two-year period around November 2006 as our placebo period. We choose this period to avoid any overlap with major market events (e.g., 2008 financial crisis) that may affect stock liquidity. We do not find similar effects of mutual fund ownership on stock liquidity during the placebo period. Together, cross-sectional and time-series placebo tests suggest that our finding of improvement in stock liquidity is not driven by institutional ownership or by a time trend in liquidity.

As mentioned earlier, some funds voluntarily disclosed on a quarterly basis prior to the regulation change. For these funds, the effect of increase in mandatory disclosure frequency on stock liquidity should be weaker because the frequency at which they disclose remains unchanged.[1] Ge and Zheng (2006) argue that the decision to voluntarily disclose is strategic. Thus, we follow their study and use the propensity score from a logistic model to construct a control sample of voluntarily disclosing funds. We find that, compared to the ownership of voluntarily disclosing funds, the ownership of funds that are forced to increase their disclosure frequency due to the regulation change has a larger effect on stock liquidity.

Our model also predicts that the improvement in stock liquidity is larger for the stocks held by more informed funds and for stocks associated with greater information asymmetry. The underlying intuition for this prediction is that when the trader is more informed or when the fundamental value of the stock is subject to greater information asymmetry, the market can learn more information from portfolio disclosure. To test this prediction of the model, we first compare the impact of the ownership of more- versus less-informed funds on stock

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[1] For example, consider a fund that mandatorily discloses twice to the SEC and voluntarily discloses twice to a data vendor (Morningstar or Thomson Reuters) in the year prior to the rule change. Subsequent to the rule change, this fund will mandatorily disclose four times per year to the SEC.

liquidity. We use four abnormal performance measures to proxy funds' informativeness: four-factor alpha (Carhart (1997)), DGTW characteristics-adjusted returns (Daniel et al. (1997)), and a liquidity-adjusted version of each (i.e., five-factor alpha and liquidity-adjusted DGTW return). Using these proxies, we find that the stocks held by more informed funds (i.e., those in the top quartile of past abnormal performance) experience greater increases in liquidity after the increase in the disclosure frequency. Next, we compare the effect of the regulation change on stocks with higher versus lower levels of information asymmetry using firm size, analyst coverage, and liquidity as proxies. Consistent with our model's prediction, we find that stocks with more information asymmetry (i.e., smaller market capitalization, lower analyst coverage, or lower liquidity) experience larger increases in liquidity than do other stocks.

We next test the prediction of our model regarding the impact of an increase in the frequency of mandatory portfolio disclosure on mutual fund performance. The underlying intuition for this prediction is that, because the market learns more information with more frequent disclosure, the informed trader is less able to fully reap the benefits of his information. We find that informed funds bear costs from the increase in mandatory portfolio disclosure. Specifically, better performing funds, i.e., those in the top quartile of each of the four abnormal performance measures, experience significant declines in their performance subsequent to the 2004 regulation change. Since we use performance measures adjusted for liquidity, the performance change these funds experience cannot be explained solely by a change in the illiquidity premium they earn on their holdings.

To alleviate concerns of mean reversion driving our fund performance results, we conduct several cross-sectional and time-series placebo tests. We offer the following rationale for these tests. If there is mean reversion in the performance of top funds, it should also influence the performance of (i) top funds that voluntarily disclose prior to the regulation change and (ii) top funds in other periods. After adjusting for potential mean reversion through these placebo tests, we continue to observe a significant decline in the performance of top funds forced to increase their disclosure frequency due to the regulation change. The magnitude of this decline ranges from 1.3% to 4.6% on an annualized basis.

Next, we examine how informed funds' portfolio characteristics and trading behavior affect the extent to which more frequent disclosure hurts their performance. Our model predicts that the decline in performance of top funds is greater when they hold stocks that are subject to higher information asymmetry or when they take longer to finish their trades. Consistent with these predictions, we find that top-performing funds whose portfolios consist of stocks with smaller market capitalization, lower analyst coverage, and lower liquidity experience greater performance declines after the regulation change. Also, top funds that take longer to build or unwind their positions experience larger performance deterioration.

Since informed funds experience performance declines due to the regulation change, one would expect that these funds should respond by changing their trading behavior to mitigate this adverse effect. Indeed, we find some evidence that informed funds attempt to reduce the impact of more frequency disclosure by trading stocks with lower information asymmetry and by trading more quickly.

Our paper contributes to the literature that studies issues related to portfolio disclosure of institutional investors (see Section II for details). We complement the work of Ge and

Zheng (2006) on voluntary portfolio disclosure by examining the implications of mandatory portfolio disclosure on both stock liquidity and fund performance. Our study is the first to provide a theoretical model allowing for mandatory disclosure with different frequencies and generate several testable predictions. Then, we use the regulation change in 2004 to test these predictions and establish causal relations between disclosure and (i) the liquidity of disclosed stocks, and (ii) fund performance.

Our empirical evidence shows that there are both costs and benefits of more frequent mandatory portfolio disclosure. Specifically, we find the benefits in the form of an improvement in stock liquidity. This improvement in liquidity can help reduce the cost of capital for issuing firms and trading costs for investors.[2] In contrast, we uncover costs in terms of a decline in the performance of informed funds subject to more frequent portfolio disclosure.[3] To the extent that mandatory portfolio disclosure can reveal information about proprietary investment strategies of money managers, it can affect their incentives to collect and process information and, in turn, affect the informational efficiency of financial markets (Grossman and Stiglitz (1980)). Therefore, for policy decisions related to portfolio disclosure, regulators should weigh the benefits of a more liquid capital market against the costs borne by institutional money managers.

The remainder of the paper is organized as follows. Section I provides the institutional background. Section II discusses the related literature. Section III presents the model and

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[2] This effect is similar to that of an increase in issuer or corporate disclosure, which has been shown to lead to more liquid capital markets (Diamond and Verrecchia (1991), Fishman and Hagerty (1998, 2003), and Admati and Pfleiderer (2000)).

[3] We find that the effects of increase in mandatory disclosure frequency are not transitory. Neither the increase in stock liquidity nor the decline in fund performance revert over a three-year period after the regulation change.

empirical predictions. Section IV describes the data and variable construction. Sections V and VI present the empirical analyses of the impact of mandatory disclosure on stock liquidity and fund performance, respectively. Section VII discusses mutual funds' response to the regulation change. Section VIII concludes.

I. Institutional Background

Mandatory disclosure of institutional investors' portfolio holdings is a key part of securities market regulation. The SEC requires mutual funds to disclose their portfolio holdings through periodical filings. Since May 2004, the Investment Company Act of 1940 mandates that individual mutual funds disclose their portfolio holdings quarterly in Forms N-CSR and N-Q with a delay of no longer than 60 days. The other important disclosure requirement, mandated by Section 13(f) of the 1934 Securities Exchange Act, is the Form 13F that requires mutual fund companies to disclose their aggregate holdings (at the company level) on a quarterly basis, with no more than a 45-day delay.[4]

Although the two ownership disclosure regimes described above apply in parallel, the former requirement typically offers much more detailed information about the investment of mutual funds than that provided by the 13F form for two reasons. First, the 13F data is at the company level only while the N-CSR and N-Q data is at the individual fund level. Since mutual fund companies often operate multiple funds, the aggregated 13F data is less informative. Second, 13F forms are only filed by large investors (those with more than $100

[4] Institutions filing 13F forms can seek confidential treatment on certain portfolio holdings which, if approved by the SEC, allows them to delay the disclosure by up to one year. See Agarwal et al. (2013) and Aragon, Hertzel, and Shi (2013) for details.

million in 13F securities) and include information only on the large (more than 10,000 shares and market value exceeding $200,000) positions in the 13F securities, which consist of equities, convertible bonds, and exchange-listed options.[5] In contrast, N-Q and N-CSR forms are filed by *all* mutual funds for *all* types of securities regardless of the fund's size or the size of the positions held in individual securities. These requirements make the mutual fund disclosure through N-Q and N-CSR forms more informative than the 13F forms filed by mutual fund families.

The 13F forms have always been required on a quarterly basis and there has been no regulatory change in the frequency of mandatory disclosure in these forms. The disclosure requirements for individual mutual funds, however, have changed over time. Prior to May 2004, the SEC only required mutual funds to file their portfolio holdings twice a year using the semi-annual N-30D form.[6] In May 2004, the SEC enacted a new rule that changed the N-30D form to the N-CSR form, and required mutual funds to complete and file the form at the end of the second and fourth fiscal quarters. In addition, the new rule also required mutual funds to file N-Q forms at the end of the first and third fiscal quarters, thus increasing the reporting frequency to four times per year.[7] To balance the benefits of more transparency to investors and the potential costs on mutual funds, e.g. of front-running and copycat behavior, the SEC allowed the funds to file the disclosure forms with a 60-day delay.

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[5] See http://www.sec.gov/divisions/investment/13ffaq.htm for more information on 13F filings.

[6] Note that before 1985, funds were required to report their portfolios to the SEC on a quarterly basis. The SEC changed this requirement to semi-annual disclosure sometime during 1985 (e.g., Ge and Zheng (2006), Wermers, Yao and Zhao (2010), and George and Hwang (2011)). However, neither these studies nor our search of public data sources reveal the precise date of this change. Nevertheless, we repeat our analysis by assuming that the rule became effective at the end of 1985. We find insignificant results for all tests (see Table SA.I of the Supplementary Appendix), which may be due to the small sample of funds in existence during that time period.

[7] See the SEC Final Rule IC-26372 on May 10, 2004 at http://www.sec.gov/rules/final/33-8393.htm.

To illustrate the SEC regulation change in 2004, we present in Table I the total number of mutual fund holdings reports in each year from 1994 to 2011, the period over which data is electronically available from the EDGAR database. We find that the total number of filings almost *doubled* from 6,474 in 2003 to 12,438 in 2005 as shown in the last column. We break down the numbers for each form type and find that this dramatic increase in the total number of filings is completely due to the introduction of the N-Q form in 2004. The N-Q forms account for about half of all filings from 2005 onward.

[Insert Table I Here]

Individual funds can voluntarily report their portfolio information more frequently than is mandated by the SEC. Such voluntary disclosure can be made to multiple sources. First, funds can use Form N-30B2 to voluntarily disclose their holdings to the SEC. Second, funds can choose to provide information on their portfolio holdings to data vendors such as Morningstar and Thomson Reuters (formerly CDA/Spectrum).[8] We identify and separate these funds from our main sample to isolate the effect of the increase in mandatory disclosure frequency.

II. Literature Review

Our paper is motivated by three strands of literature. First, a large number of papers have shown that mutual funds' disclosed portfolios contain valuable information for investors (e.g., Grinblatt and Titman (1989, 1993), Grinblatt, Titman, and Wermers (1995), Daniel et al.

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[8] Certain fund companies sometimes opt to disclose the largest holdings of their funds on their websites. For example, the top ten holdings of the Fidelity OTC Portfolio fund are currently available on a quarterly basis at http://fundresearch.fidelity.com/mutual-funds/composition/316389105. However, such information may not be available for fund's entire portfolio on a historical basis. Thus, it cannot be used for our analysis in this paper.

(1997), Wermers (1999, 2000), Chen, Jegadeesh, and Wermers (2000), Cohen, Coval, and Pástor (2005), Kacperczyk, Sialm, and Zheng (2005, 2008), Alexander, Cici, and Gibson (2007), Jiang, Yao, and Yu (2007), Kacperczyk and Seru (2007), Cremers and Petajisto (2009), Baker et al. (2010), Ciccotello, Greene, and Rakowski (2011), Da, Gao, and Jagannathan (2011), Wermers, Yao, and Zhao (2012), and Huang and Kale (2013)). Therefore, any change in the portfolio disclosure requirement should affect the underlying asset markets and individual mutual funds.

Second, a strand of theoretical literature studies the impact of disclosure on informed trading (e.g., Fishman and Hagerty (1995), John and Narayanan (1997), Huddart, Hughes, and Brunnermeier (1999), Huddart, Hughes, and Levine (2001), and George and Hwang (2011)). Perhaps most relevant to our context is the study by Huddart, Hughes, and Levine (2001), which extends the Kyle (1985) model of an informed trader by introducing mandatory disclosure of trades at the end of each trading period. Huddart, Hughes, and Levine (2001) prove the existence of a mixed strategy equilibrium in which the informed trader adds a random noise to a linear strategy in each period to prevent the market maker from fully inferring his private information. Such a "dissimulation" strategy minimizes the loss in trading profits due to mandatory disclosure. In this study, we develop a model that builds on Huddart, Hughes, and Levine (2001) and allows for different mandatory disclosure frequencies and test its predictions using the SEC regulation in May 2004.

Third, there is a large strand of empirical literature that studies the costs and benefits of both mandatory and voluntary disclosure by institutional investors. A number of studies discuss the potential costs of disclosure borne by informed traders including mutual funds

(Wermers (2001), Frank et al. (2004), and Verbeek and Wang (2010)) and hedge funds (Shi (2012)) due to front-running and copycat trading activities of other market participants. Other studies have examined various responses of institutional investors to mandatory portfolio disclosure. Specifically, institutions can respond by (a) window dressing to mislead investors (e.g. Lakonishok et al. (1991), Musto (1997, 1999), Agarwal, Gay, and Ling (2014)), (b) front running their followers (Brown and Schwarz (2012)), (c) hiding certain positions to maximize the benefits of their private information (Agarwal et al. (2013) and Aragon, Hertzel, and Shi (2013)), and (d) trading strategically within the quarter to minimize the impact of disclosure (Wang (2010) and Puckett and Yan (2011)). In another study, Ge and Zheng (2006) investigate the determinants and consequences of mutual funds' decision to voluntarily disclose their portfolio holdings. Our paper contributes to this literature by documenting that an increase in mandatory portfolio disclosure benefits the capital markets by improving stock liquidity but imposes costs on informed investors that experience performance deterioration.

III. Theoretical Model and Empirical Hypotheses

In this section, we develop a theoretical model to study the effects of changes in mandatory disclosure frequency on stock liquidity and informed trader's profits. Our model builds on the models by Kyle (1985) and Huddart, Hughes, and Levine (2001).

Following Kyle (1985), there exist a risky security and a risk-free security in the market. In each of the N periods, $n = 1, 2, \ldots, N$, traders submit orders, and a market maker sets the price. There are two types of traders, an informed trader and a noise trader. The informed trader learns of the true value v of the risky security at the beginning of period 1 and strategically submits order x_n in period n to maximize his expected profits. The noise traders' trade in any period n is normally distributed, $u_n \sim N(0,\sigma_u^2)$. The market maker knows the prior distribution, $v \sim N(0,\Sigma_0)$. The random variables $v, u_1, u_2, \ldots, u_N$ are mutually independent. All agents are risk-neutral. Finally, the market maker observes the total order flow $y_n = x_n + u_n$ but not its decomposition in period *n*. The market maker sets the price so that he makes zero expected profits.

There is mandatory disclosure once in every *k* periods. In other words, in every period $n = k, 2k, \ldots, N$, the informed trader is required to disclose his trade x_n to the regulator *after* trading occurs. For simplicity, we assume that N is a multiple of *k*, with $\frac{N}{k}$ being the frequency of disclosure. The regulator disseminates such information to all market participants instantly.

Let p_n denote the stock price that the market maker sets based on the total order flow in period *n*, and p_n^* be the stock price that the market maker updates to at the end of the period if the trade by the informed trader (x_n) during the period is disclosed. During the periods when mandatory disclosure is not required, p_n remains unchanged until the end of the period. The conditional variance $\Sigma_n = Var(v \mid p_1^*, \ldots, p_{n-1}^*)$ represents the extent of the remaining private information of the informed trader, after $n-1$ rounds of trades.

Let π_n denote the informed trader's profits on positions in period n, and $\tilde{\pi}_n$ denote his total profits over the periods $n, n+1, \ldots, N$. In other words,

$$\pi_n = (v - p_n)x_n, \quad \tilde{\pi}_n = \sum_{k=n}^{N} \pi_n = \sum_{k=n}^{N} (v - p_k)x_k. \tag{1}$$

In equilibrium, the informed trader chooses a trading strategy to maximize his expected profits $E[\tilde{\pi}_n \mid p_1^*, \ldots, p_{n-1}^*, v]$ at the beginning of every period *n*, and the market maker set the price to be equal to his expectation of the asset's fundamental value.

Using the standard technique from Kyle (1985), we will show that a unique equilibrium exists in which the informed trader's strategy is of the following form:

$$\begin{aligned} x_n &= \beta_n (v - p_{n-1}^*), \text{ if } n \notin \{k, 2k, \ldots, N\} \\ x_n &= \beta_n (v - p_{n-1}^*) + z_n, \text{ if } n \in \{k, 2k, \ldots, N\} \end{aligned} \tag{2}$$

where $z_n \sim N(0, \sigma_{z_n}^2)$ is normally distributed and independent of v and $\{u_t\}_{1 \le t \le N}$. Intuitively, (2) indicates that the informed trader adopts a linear strategy during the non-disclosure periods (as in Kyle (1985)) but adds a normal disturbance, z_n, during the disclosure periods (as in Huddart, Hughes, and Levine (2001)). The linear coefficient β_n measures how aggressively he trades on his private information in each period, and the noise variance $\sigma_{z_n}^2$ represents the level of dissimulation he employs to mask private information in the disclosed trade.

The market maker's optimal response to the informed trader's strategy (2) is to set the trading price, p_n, as a linear function of the total order flow,

$$p_n = p_{n-1}^* + \lambda_n (x_n + u_n). \tag{3}$$

The linear coefficient λ_n represents the impact of order flow on price, or the market depth. If the informed trader's action is disclosed at the end of the period, the market maker updates the price based on the following linear rule

$$p_n^* = p_{n-1}^* + \gamma_n x_n. \tag{4}$$

The linear coefficient γ_n captures how responsive the market price is to the disclosure of trade information.

We next discuss our model's empirical predictions and the underlying intuition. To conserve space, we include the formal statements of propositions and proofs in the Supplementary Appendix. Proposition 1 of the model shows that there is a unique equilibrium in which the strategies are of the linear forms in (1) – (4) and provides closed-form solutions of the equilibrium. Proposition 2 produces several testable predictions about the impact of disclosure frequency on stock liquidity and informed trader's profits.

First, our model shows that an increase in mandatory disclosure frequency ($1/k$) by informed traders improves stock liquidity (the inverse of average illiquidity $\frac{1}{N}\sum_{i=1}^{N}\lambda_i$). The intuition is that, with more frequent mandatory disclosure, the market maker can infer more information from the disclosed positions and order flow of the informed trader. This additional information leads to a reduction in the impact of informed trades on prices. We note that this intuition holds even though the informed trader adds random noise to his trades, because the market maker is still able to infer some information from the noisy signal. In our empirical setting, the increase in mandatory disclosure frequency instituted in 2004 by the SEC affects a majority of mutual funds. Based on our model's prediction, if mutual funds are in general informed, we expect that stocks with a higher mutual fund ownership should experience greater increases in liquidity than other stocks after the regulation change on mandatory disclosure.

Second, our model predicts that the improvement in liquidity depends positively on the extent of asymmetric information in the stock ($\sqrt{\Sigma_0}$). When the insider is more informed or when the fundamental value of the stock is subject to greater information asymmetry, the market can learn more information from portfolio disclosure. Therefore, we hypothesize the liquidity improvement to be greater for stocks with higher ownership by more informed funds as compared to stocks primarily held by funds that are less likely to be informed. We also expect that the liquidity increase depends positively on a stock's information asymmetry.

Third, our model predicts a decrease in the informed trader's profits ($\sum_{i=1}^{N} E[\pi_i]$) after an increase in the frequency of mandatory portfolio disclosure. The underlying intuition is that because the market maker learns more information with more frequent disclosure, the informed trader is less able to fully reap the benefits of his information. Thus, we posit that informed funds are likely to experience a drop in their abnormal performance as a result of more frequent portfolio disclosure after May 2004.

Finally, our model predicts that the magnitude of the informed trader's profit drop depends positively on the extent of information asymmetry in the stocks disclosed. Thus, we expect the performance decline to be larger for informed funds when these funds hold stocks that are subject to greater information asymmetry. Further, our model predicts that informed traders are hurt more when their trades take a greater number of periods (N) to complete. Therefore, we expect that informed funds that take longer to finish their trades should experience a greater decline in their performance.

IV. Data Description and Variable Construction

A. Data description

We start by identifying the mutual funds that increased their portfolio disclosure frequency due to the SEC regulation change in 2004. For this purpose, we first obtain funds' portfolio disclosure dates from three major data sources: the SEC EDGAR, Morningstar, and

Thomson Reuters S12.[9] We manually match the funds across these sources using fund names, tickers, and CUSIPs. Finally, we merge the lists of disclosure dates and remove any duplicates. This gives us a comprehensive list of all unique instances of disclosure for each fund over time.

The above procedure helps us identify the funds affected by the regulation change. Next, we obtain the portfolio holdings data of these funds from the Thomson Reuters S12 database for our empirical analyses. We further merge the resulting data with the CRSP mutual fund data using the Wharton Research Data Services' (WRDS) MFLINKS tables to obtain fund returns and characteristics such as total assets under management, expense ratio, load, and turnover. Since our hypotheses and empirical tests are related to informed investors, we focus on actively managed domestic equity funds after excluding index funds from our sample. This gives us a final sample of 1,459 funds forced to increase their disclosure frequency due to the regulation change.[10]

B. Variable construction

B.1 Stock-Level Variables

We construct our sample of stocks from the CRSP stock database. We consider all common stocks in CRSP over the period May 2003 to April 2005 in our main analyses. We choose this period so that we have one year prior to and one year after the SEC disclosure regulation change in May 2004 to examine the changes in stock liquidity and fund

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[9] There are differences in mutual funds' portfolio disclosure dates to the SEC and to Thomson Reuters (Schwarz and Potter (2014)). Therefore, we take a comprehensive approach and combine the portfolio disclosure dates from the SEC and the two major mutual fund database vendors (Morningstar and Thomson Reuters).

[10] Our sample of 1,459 funds comes from a total of 2,063 actively managed domestic equity funds before the 2004 regulation change. Later in the paper, we will use the remaining 604 funds that were disclosing voluntarily as a control group for our cross-sectional placebo tests in Sections V.C and VI.B.

performance.

We first construct several stock-level institutional ownership variables that we use in our empirical tests. First, for each stock-month observation, we calculate the variable *Mutual Fund Ownership* as the aggregate ownership of our final sample of 1,459 funds, scaled by the total shares outstanding of the stock at the month end. When stock holdings are not reported by a fund at a given month end, we use fund's most recently available stock holdings.

While the 2004 regulation change affects the reporting behavior of mutual funds, it does not affect the disclosure frequency of other institutional investors who disclose their holdings through the Form 13F. We use these non-mutual-fund institutions as a control group to identify the effects of the SEC rule change. For this purpose, we define *Non-MF Ownership* as the quarterly aggregate institutional ownership from Thomson Reuters Institutional Holdings (S34), excluding mutual funds and asset management companies. In addition, we isolate hedge funds from the non-mutual-fund institutions to form another control group because they are arguably the most actively managed institutions. We define *Hedge Fund Ownership* as the quarterly aggregate hedge fund ownership in the Thomson Reuters S34 database. Classification of institutional investors and hedge funds follows that in Agarwal et al. (2013). Lastly, we also use U.S. index equity funds as a control group because index funds are passive investors and by definition their disclosed portfolios should not contain any private information. We construct *Index Fund Ownership* as the ownership of index funds that we identify from the CRSP Mutual Fund Database.

Next, we construct a number of variables to proxy for stock liquidity. The first measure is the *Amihud* illiquidity measure (Amihud (2002)), calculated as the monthly average of daily Amihud measures. Specifically, we construct this measure as follows,

$$Amihud_{i,t} = \sqrt{\left|r_{i,t}\right| / \left(P_{i,t} * Vol_{i,t}\right)} \tag{5}$$

where i indexes stocks and t indexes dates, $r_{i,t}$ is the daily stock return, $P_{i,t}$ is the daily price, and $Vol_{i,t}$ is the daily volume.

Our model suggests that an increase in disclosure frequency should result in lower adverse selection costs for the market maker and thus lower bid-ask spreads. Therefore, we also use the high-frequency Trade and Quote (TAQ) data to compute three bid-ask spread measures widely used in previous studies (e.g., Chordia, Roll, and Subrahmanyam (2000, 2001), Goyenko, Holden, and Trzcinka (2009), Nimalendran and Ray (2014)). The three measures include: (i) *Rspread*, defined as the daily average of the relative spread (quoted bid-ask spread divided by its midpoint), (ii) *Size-Weighted Rspread*, defined as daily average of relative spread weighted by the size of the associated trade, and (iii) *Effective Spread*, calculated as two times the absolute value of the percentage difference between the execution price and the bid-ask midpoint (with the denominator being the bid-ask midpoint), averaged daily. We average all liquidity measures over a month and take the log of all these monthly average measures.[11]

We also construct several stock characteristic variables for our analysis. These include: *Momentum*, i.e., the past 12-month cumulative stock return; *Book-to-Market*, i.e., the ratio of book equity to market equity; *Size*, i.e., the natural logarithm of market equity; and *Analyst Coverage*, i.e., the number of analysts covering the stock from Institutional Brokers' Estimate System (I/B/E/S).

[11] We use natural logarithmic transformations to mitigate the effect of any outliers.

B.2 Fund-Level Variables

We construct both returns-based and holdings-based abnormal performance measures of mutual funds. We first construct *4-factor alpha* based on the Carhart (1997) model using fund returns and *DGTW-adjusted return* (Daniel et al. (1997)) using fund holdings. To control for any liquidity changes affecting fund performance, we also construct the liquidity-adjusted versions of the two performance measures. These include *5-factor alpha* based on the Carhart (1997) model augmented by the Pástor and Stambaugh (2003) liquidity factor and *Liquidity-adjusted DGTW* return by augmenting size, book-to-market, and momentum with stock liquidity in the characteristics used to form the DGTW benchmark portfolios.

For each month, we estimate 4-factor or 5-factor alphas using betas estimated over the 24-month window ending in the prior month, as follows:

$$R_{j,s} = \hat{\alpha}_{j,t-1} + \sum_{k=1}^{4} \hat{\beta}_{j,k,t-1} F_{k,s} + \varepsilon_{j,s}, \quad s = t-24, \ldots, t-1 \tag{6}$$

$$\alpha_{j,t} = R_{j,t} - \sum_{k=1}^{4} \hat{\beta}_{j,k,t-1} F_{k,t} \tag{7}$$

where *s* and *t* indicate months, *j* indicates funds, R is the monthly return of fund *j*, and *F* is the monthly returns of the factors (excess market, size, book-to-market, and momentum) when estimating the *4-factor alpha*. For *5-factor alpha*, we also include the Pástor and Stambaugh (2003) liquidity factor in equation (6) above.

To compute the *DGTW-adjusted return*, we follow Daniel et al. (1997) to sort stocks into 5×5×5 portfolios based on the size, book-to-market, and momentum quintiles. Then, we calculate the benchmark-adjusted returns for each stock position in a fund's portfolio and construct the value-weighted average at the fund level using the portfolio weights. Lastly, we compute the cumulative benchmark-adjusted returns between two successive report dates in the Thomson Reuters S12 database and then divide them by the number of months in the period to obtain a monthly *DGTW-adjusted return*. We compute the *Liquidity-adjusted DGTW* return as a modified version of the *DGTW-adjusted return.* To ensure that we have a sufficient number of stocks in each portfolio, we sort stocks into terciles instead of quintiles. In particular, we construct 3×3×3×3 portfolios based on stock size, book-to-market, momentum, and Amihud illiquidity. Finally, we follow the same procedure as above to compute the monthly *Liquidity-adjusted DGTW* return.

To examine whether the regulation change has a greater effect on funds that take longer to complete their trades, we construct a fund-level variable *Trade Length* from funds' portfolio holdings. We first construct a position-level measure for each stock in a fund's portfolio by counting the number of consecutive quarters over which the fund either builds or unwinds the position in that stock during the one-year period prior to that quarter. Second, we value weight this position-level measure across all stock positions held by each fund to obtain a fund-level *Trade Length* measure. This variable captures how long it takes a fund to complete its acquisition or disposition of stocks.

Lastly, we use several variables as controls. These include: (i) *Size*, defined as the natural logarithm of the total net assets under management, (ii) *Turnover*, is the average annual turnover from Thomson Reuters S12 mutual fund holdings,[12] (iii) *Flow*, defined as the change in total net assets (TNA) after adjusting for fund returns, scaled by lagged TNA,

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[12] Every quarter, we compute portfolio turnover rate as the lesser of purchases and sales divided by the average portfolio size of the last and the current quarter, and then sum it across the four quarters in the year. Purchases (sales) are the sum of the products of positive (negative) changes in the number of shares in the holdings from the previous to the current quarter-end and the average of the stocks prices at the two quarter-ends.

(iv) *Expense Ratio*, defined as the total operating expenses scaled by TNA, and (v) *Load* status, defined as an indicator variable which equals one if the mutual fund has a share class with load, and zero otherwise. We value weight these variables at the share-class level to obtain fund-level variables.

V. Impact of Mandatory Portfolio Disclosure on Stock Liquidity

A. Regulatory Change in Mandatory Disclosure and Stock Liquidity

To evaluate the impact of the 2004 regulation change, we first compute the average of monthly stock-level variables for the 12 months prior to May 2004 and then for the 12 months after May 2004 (inclusive of May 2004). Next, we compute the changes in the annual averages as the difference between the average after May 2004 and the average before May 2004. We denote the resulting change variables by the prefix Δ. All variables are winsorized at the 1% and 99% levels.

We report summary statistics of the level and change in the stock-level variables in Panel A of Table II. We observe that Amihud and the three TAQ bid-ask spread measures all decrease after May 2004, i.e., the average stock liquidity improves from 2003 to 2005. In the year prior to May 2004, mutual funds that increased their portfolio disclosure frequency due to the regulation change own 6.6% of outstanding shares of stocks on average.

[Insert Table II Here]

To empirically test the effects of the change in funds' portfolio disclosure frequency on stock liquidity, we estimate the following cross-sectional regression for each liquidity variable *y*:

$$\Delta y_{i,t} = \alpha + \beta MFOwn_{i,t-1} + \gamma y_{i,t-1} + \Gamma' X_{i,t-1} + \varepsilon_i \quad (8)$$

where *i* indicates the stock, *t* is the year after May 2004, $\Delta y_{i,t}$ is the change in liquidity from the one year before to the one year after May 2004, $MFOwn_{i,t-1}$ is the lagged (i.e., one year before May 2004) *Mutual Fund Ownership*, $y_{i,t-1}$ is the lagged liquidity variable, and $X_{i,t-1}$ are lagged stock characteristics, including *Momentum*, *Size*, and *Book-to-Market* ratio.

The identification of the regression in equation (8) relies on a cross-sectional comparison of stocks with higher mutual fund ownership (the treatment group) to those with lower mutual fund ownership (the control group). Equation (8) essentially uses a difference-in-differences approach to estimate the effect of the 2004 disclosure regulation change on the treatment group.[13] The first difference is the change in stock liquidity over the 12 months before and after May 2004 for the stocks. The second difference is the difference in the liquidity changes of the treatment and control groups.

Panel B of Table II reports the estimation results of equation (8). Our primary independent variable of interest is *Mutual Fund Ownership*. The results show that for all four liquidity measures, the coefficients of *Mutual Fund Ownership* are negative and statistically significant at the 1% level. Since a lower level of each of our measures implies greater liquidity, higher mutual fund ownership is associated with greater improvement in stock liquidity after the 2004 regulation change. These findings are also economically significant. A one standard deviation increase in mutual fund ownership is associated with a 0.13 to 0.23 standard deviation decrease in illiquidity, depending on the liquidity measure chosen. This evidence is consistent with our model's prediction that more frequent portfolio disclosure by

[13] For illustration purposes, we discuss here the case with two groups. We actually use mutual fund ownership as a continuous variable in the regression but the intuition is the same.

informed traders will lead to an increase in the liquidity of the disclosed stocks.[14]

B. Cross-Sectional and Time-Series Placebo Tests

The results in the previous section cannot rule out the possibility that mutual fund ownership proxies for institutional ownership and stocks with higher institutional ownership experience greater improvement in liquidity after May 2004. To distinguish this alternative scenario from the effect of disclosure regulation, we first conduct a series of cross-sectional placebo tests using three different types of institutions as control groups: (i) non-mutual-fund institutions, (ii) hedge funds, and (iii) index funds. The intuition for using non-mutual-fund institutions and hedge funds as control groups is that their holdings disclosure regime (i.e., Form 13F) is not affected by the 2004 regulation. The argument for using index funds as a control group is that they are, by definition, passive investors and therefore their disclosed holdings should not contain private information that in turn affects stock liquidity.[15] Using these control groups can also help capture any potential trends in stock liquidity as there is no reason to believe that liquidity trends are different for different types of institutional investors.

We add the ownership of each of the three control groups to equation (8) and estimate the following cross-sectional regression:

$$\Delta y_{i,t} = \alpha + \beta MFOwn_{i,t-1} + \beta^{'} ControlOwn_{i,t-1} + \gamma y_{i,t-1} + \Gamma^{'} X_{i,t-1} + \eta_i \qquad (9)$$

[14] Mutual fund trading may change around the 2004 regulation. To control for the level of trading by funds, we repeat our analysis after including the change in ownership as an additional control variable in our regression in equation (8). In results reported in Table SA.II of the Supplementary Appendix, we find that the coefficients on the mutual fund ownership continue to be negative and significant and, in some cases, become stronger.

[15] One caveat is in order here. This argument may not apply if index funds track portfolios based on liquidity criteria. However, we use the ownership of index funds prior to the regulation change in our tests. Thus, a potential ownership shift by such index funds should not materially affect our empirical tests.

Intuitively, equation (9) uses a difference-in-difference-in-differences approach to estimate the effect of the 2004 disclosure regulation change on stock liquidity. The coefficients on *MFOwn* (*Mutual Fund Ownership*) and *ControlOwn* (*Non-MF Ownership*, *Hedge Fund Ownership*, or *Index Fund Ownership*) represent the difference-in-differences effect of the ownership variables on changes in liquidity as discussed before in reference to equation (8). The difference of these two coefficients provides an estimate of the effect of the increase in mutual funds' disclosure frequency on stock liquidity after accounting for the ownership of other institutional control groups.

We report the results of these regressions in Table III. Panel A presents the results using non-mutual-fund institutions as the control group, while Panels B and C present the results using hedge funds and index funds, respectively.[16] We find that mutual fund ownership has a statistically greater impact on liquidity than does the ownership of any of the three control groups (see the last two rows of each panel).[17] Our results suggest that it is not institutional ownership *per se*, but rather the increase in mutual fund portfolio disclosure after May 2004 that leads to the improvement in stock liquidity.

[Insert Table III Here]

We next conduct a time-series placebo test using the two-year period around

[16] Because index funds own less than 1% of the average stock, we normalize both index fund and mutual fund ownership by converting them into percentiles for the results in Panel C. The results in Panels A and B are also robust to this normalization.

[17] For robustness, we also use a two-stage procedure to control for the possibility that mutual fund ownership may be related to the stock characteristics. In the first stage, we estimate the abnormal fund ownership as the residual from regressing fund ownership on stock characteristics. We use a similar procedure for the hedge fund ownership and non-mutual-fund ownership. In the second stage, we regress the change in liquidity on the abnormal fund ownership from the first stage and our control variables. Our results are robust using the abnormal ownership (see Tables SA.III and IV in the Supplementary Appendix).

November 2006 as our placebo period. Note that we cannot choose a period prior to the regulation change because of events such as the Russian sovereign bond default and the Long-Term Capital Management debacle in 1998, the burst of the dotcom bubble in 2000, and the decimalization of stock prices quotes in 2001, all of which significantly affected stock liquidity. Furthermore, we choose the placebo period such that it is as far away from the event date in 2004 as possible and not affected by the 2008 recession.

We first estimate the regressions as in equation (8) for the placebo period. We then compare the coefficients for the placebo period with those for the two-year period surrounding the 2004 regulation change as reported in Panel B of Table II. We report the results of this comparison in Panel D of Table III. Our results show that mutual fund ownership has a positive effect on liquidity in 2004, but has either a smaller or an insignificant effect in 2006. The difference in the effects for the two time periods is highly significant, as shown by the *F*-tests in the last row.

We note that the ownership of each of our three control groups in Table III (Panels A to C) is associated with a significant improvement in liquidity. Moreover, the coefficient on mutual fund ownership in 2006 is also negative and significant. These findings suggest that there are other factors besides the regulation change that contribute to the increase in stock liquidity. Thus, merely using the coefficients on the mutual fund ownership in Panel B of Table II to infer the impact of disclosure change may overstate the regulation's impact. Our difference-in-differences tests help to control for these factors or any temporal trend in liquidity and identify the incremental impact of the regulation change (as shown in the last two rows of each panel).

C. Voluntarily Disclosing Funds

As mentioned earlier in Section I, mutual funds can voluntarily disclose their portfolios more frequently than what is required by the SEC. Prior studies document that many funds were already disclosing their portfolios on a quarterly basis to Thomson Reuters prior to the 2004 regulation change (e.g., Ge and Zheng (2006), Wermers, Yao, and Zhao (2010)). We consider a fund's disclosure to be voluntary if it is made to the SEC through Form N-30B2 or to a data vendor (Thomson Reuters or Morningstar), after excluding the mandatory disclosures to the SEC. We find that there are 604 funds that voluntarily disclose to one or more of these three data sources and also do not increase their total number of disclosures around the regulation change.

For the voluntarily disclosing funds, the effect of increase in mandatory disclosure frequency on stock liquidity should be weaker because the frequency at which they disclose remains unchanged. Hence, the amount of information that the market receives from these funds is comparable before and after the regulation change. We therefore use the voluntarily disclosing funds as another control group. As suggested by Ge and Zheng (2006), funds' decision to voluntarily disclose is strategic. The strategic nature of this decision implies that we need to model this decision in order to construct an appropriate control group of voluntarily disclosing funds.

Specifically, we use a logistic model similar to that in Ge and Zheng (2006) to estimate the probability that a fund voluntarily discloses its portfolio. We estimate the following cross-sectional regression in May 2004:

$$\text{Prob}(Voluntary_j) = F(\delta_0 + \delta_1 Z_j + \varepsilon_j), \quad (10)$$

where Z_j refers to a vector of lagged characteristics of fund *j*. These include all independent variables in Ge and Zheng (2006), i.e., *Expense Ratio*, *Turnover*, *Fraud*, *Size*, *Age*, and past 12-month *Return Volatility* (see Table 3 of their paper). *Fraud* is an indicator variable equal to one if the fund's family was investigated by the SEC for potential market timing or late trading (see Table 1 in Houge and Wellman (2005)), and zero otherwise. Other variables are defined earlier in Section IV.B.2. In addition to the variables in Ge and Zheng (2006), we include several others: (i) *Trade Length*, (ii) an indicator variable, *Top Fund*, equal to one if a fund's performance over the past year is in the top quartile and zero otherwise, and (iii) the interaction of *Trade Length* and *Top Fund*. The intuition for including these variables is as follows. Funds with longer trade length are less likely to voluntarily disclose due to greater costs associated with disclosure. Moreover, the interaction term tests whether these costs are higher for more informed funds. We report the results of the logistic regressions in Panel A of Table IV. Note that we use *4-factor Alpha* as the performance measure in Model 1 and use *DGTW* in Model 2. Overall, our findings are consistent with those of Ge and Zheng (2006). Furthermore, we find that funds with longer trade length are less likely to voluntarily disclose their portfolios.

[Insert Table IV Here]

Next, we proceed with constructing a control group of voluntarily disclosing funds using the propensity score from the logistic model. We then compare the effect of the ownership of the funds affected by the regulation change (the treatment group) with that of the ownership of the control group. Specifically, we estimate the following cross-sectional regression:

$$\Delta y_{i,t} = \alpha + \beta MandatoryOwn_{i,t-1} + \beta^{'} VoluntaryOwn_{i,t-1} + \gamma y_{i,t-1} + \Gamma^{'} X_{i,t-1} + \eta_i \qquad (11)$$

where *MandatoryOwn* (*Mandatory Ownership*) is the ownership of funds forced to increase their mandatory disclosure frequency and *VoluntaryOwn* (*Voluntary Ownership*) is the ownership of funds that voluntarily disclose prior to the regulation change.

We report the results of these regressions in Panels B and C of Table IV. The coefficients on both ownership variables are negative and significant for all liquidity measures. More importantly, the coefficient of the ownership of the funds affected by the regulation change is larger than the coefficient of the control group of voluntarily disclosing funds in all specifications. Moreover, the differences in these two coefficients are statistically significant in most cases. These findings help us separate the effect of an increase in mandatory disclosure frequency on stock liquidity from that of the voluntary disclosure behavior of certain funds.

D. Subsample Analyses

Our model predicts that increases in stock liquidity due to more frequent mandatory disclosure should be more pronounced in (i) funds that are more informed and (ii) stocks that have greater information asymmetry. In this section, we use subsamples of both mutual funds and stocks to test these two predictions.

First, we test our model's prediction that the improvement in liquidity should be greater for stocks disclosed by more informed funds compared to other funds. For this purpose, we use four proxies of funds being informed: (i) *4-factor Alpha*, (ii) *5-factor Alpha*, (iii) *DGTW-adjusted Return*, and (iv) *Liquidity-adjusted DGTW* measure. Using each of these four proxies, we divide the mutual funds into two subsamples: more informed, i.e., the top-quartile funds, and less informed, i.e., the non-top-quartile funds. We include the aggregate ownership of the funds in each subsample in the following cross-sectional regression and test the difference in the coefficients of the two ownership variables:[18]

$$\Delta y_{i,t} = \alpha + \beta MFOwn_{i,t-1}^{top} + \beta^{'} MFOwn_{i,t-1}^{non-top} + \gamma y_{i,t-1} + \Gamma^{'} X_{i,t-1} + \varsigma_i \quad (12)$$

Our findings in Table V show that the ownership of the top-quartile funds has a statistically larger impact on liquidity than the ownership of other funds. These results support our model's prediction that the market learns from the holdings of more informed funds, which results in a greater improvement in liquidity of the disclosed stocks.[19]

[Insert Table V Here]

Second, we investigate the type of stocks that experience greater increases in liquidity as a result of the regulatory change increasing the mandatory disclosure frequency. Our model predicts that the improvement in liquidity should be more pronounced in stocks with greater information asymmetry. To test this idea, we divide our sample of stocks into subsamples based on the top quartiles of firm size, analyst coverage, and illiquidity. We then estimate the regressions in equation (8) separately for the two subsamples and compare the coefficients of fund ownership from these regressions.

We report the results in Table VI. As shown in the table, the differences in the coefficients of fund ownership of the two subsamples have the predicted positive sign and are

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[18] Since the average ownership of top-performing funds is relatively low (about 1.5% of shares outstanding), as in the case of index funds, we normalize the ownership variables into percentiles. Note that our tests rely on cross-sectional variation in the ownership of top-performing funds, rather than on the average ownership.

[19] In addition to the four proxies of funds being more informed, we also use another liquidity-parsed DGTW measure of Da, Gao, and Jagannathan (2011). In particular, we use their impatient trading component of the DGTW measure and find similar results (see Table SA.V in the Supplementary Appendix).

significant at the 5% level or better for all measures of information asymmetry. In particular, smaller stocks, stocks with lower analyst coverage, and less liquid stocks benefit more from the increase in mandatory disclosure frequency. This evidence is consistent with our model's prediction that more frequent mandatory disclosure leads to higher liquidity when there is greater information asymmetry in the disclosed stocks.

[Insert Table VI Here]

Taken together, the evidence in this section strongly supports our model's prediction that the stocks disclosed by more informed funds experience greater improvement in liquidity in the year after the 2004 regulation change.

VI. Impact of Mandatory Portfolio Disclosure on Fund Performance

Our results in the previous section suggest that the market learns more when mutual funds are required to disclose more frequently and, as a result, stock liquidity improves. The increase in liquidity reduces trading costs and benefits investors in general. We next examine how more frequent mandatory portfolio disclosure affects fund performance.

A. Mutual Fund Performance and the Regulation Change

Our theoretical model predicts that the informed trader's profits decrease when mandatory disclosure becomes more frequent. The intuition is that the market's learning of disclosed positions decreases the ability of the informed traders to fully reap the benefits of their private information. Consistent with this intuition, fund managers argue that holdings disclosure can lead to front-running and/or free riding on their trades. Both theory and the reaction from practitioners motivate us to examine the impact of mandatory disclosure on fund performance.

As discussed earlier in Section IV.B.2, we consider four measures of funds' abnormal performance: *4-factor alpha, 5-factor alpha, DGTW-adjusted return,* and *Liquidity-adjusted DGTW return*. We use the annualized values of these variables for funds in our sample during the one-year periods prior to and after May 2004, and then calculate the differences to measure the performance changes. Panel A of Table VII reports the summary statistics of fund performance and other fund characteristics around the 2004 regulation change. The average annualized 4-factor (5-factor) alphas of mutual fund increase by 1.3% (0.9%) after May 2004, the annualized DGTW-adjusted returns drop by 1.5%, and the annualized liquidity-adjusted DGTW returns increase by 0.1%. These figures suggest that there is no obvious downward trend in fund performance that would mechanically support our model's predictions.

[Insert Table VII Here]

To test our model's prediction, we examine the effect of the May 2004 regulation change on the performance of the top-performing funds. Specifically, we estimate the following cross-sectional regression at the fund level:

$$\Delta Perf_{j,t} = \lambda_0 + \lambda_1 TopFund_{j,t-1} + \lambda_2 Z_{j,t-1} + \varphi_j \quad (13)$$

where *j* indicates the fund and *t* is the year after the regulation change. $\Delta Perf_{j,t}$ is the change in abnormal performance of fund *j*; $TopFund_{j,t-1}$ is an indicator variable that equals one if fund *j* is in the top quartile based on fund performance in the year prior to the regulation change and zero otherwise; $Z_{j,t-1}$ include a number of lagged fund characteristics.

Panel B of Table VII reports the results of regressions of performance changes in equation (13). In column (1) of Panel B, we observe that funds with 4-factor alphas in the top quartile experience a statistically significant decrease of 10.1% in annualized alphas relative to non-top funds. Similarly, in columns (2) to (4), funds with top 5-factor alphas, top DGTW-adjusted returns, and top liquidity-adjusted DGTW returns experience significant decreases of 8.9%, 14.3%, and 6.8% in the respective performance measures.[20]

B. Cross-sectional and Time-Series Placebo Tests

A potential concern about the above finding is that the drop in performance of top-performing funds may be driven by mean reversion in fund performance. To alleviate this concern, we conduct both cross-sectional and time-series placebo tests.

We start with the cross-sectional test for which we use the propensity score matched sample of funds from Section V.C. Specifically, we compare the drop in performance after 2004 for top funds affected by the regulation change (*Top Mandatory*) with that of the top funds that voluntarily disclose (*Top Voluntary*). Note that our matching procedure controls for mean reversion since we use past performance as one of the variables when estimating the propensity score. In particular, we estimate equation (13) for each group separately and then calculate the difference in the coefficients on *Top Mandatory* and *Top Voluntary*.

We report our findings in Table VIII. Panels A and B present the results for the samples matched using the propensity scores from Models 1 and 2 shown in Panel A of Table IV. We find that, although there is deterioration in the performance after 2004 for top funds that voluntarily disclose, the decline in performance for top mandatory funds is consistently

[20] For robustness, we also estimate the regressions in Table VII by controlling for changes in fund characteristics, rather than using lagged fund characteristics as independent variables. We obtain qualitatively similar results as shown in Table SA.VI in the Supplementary Appendix.

greater regardless of the performance measure used. The differences in the performance declines range from 1.4% to 6.0% and are statistically significant in all but one case (see "Cross-sectional Placebo Test in 2004" in Panels A and B of Table VIII).

[Insert Table VIII Here]

For our time-series placebo test, we estimate the regression in equation (13) using the 2006 placebo period. We then compute the difference in the *Top Mandatory* coefficients from the regressions in 2004 and 2006. From the results under "Time-series Placebo Tests-Mandatory" in Table VIII, we observe that top-performing funds also experience performance deterioration in the year after the 2006 placebo date. However, the declines in fund performance in 2004 are uniformly larger than those in the placebo period. The differences range from 1.7% to 5.6% and are statistically significant in all cases. As expected, we do not find similar evidence of a consistently larger performance decline for top funds that voluntarily disclose (see "Time-series Placebo Tests-Voluntary" in Table VIII).

Further, we combine the cross-sectional and time-series placebo tests as follows. We first compute the difference in the coefficients on *Top Mandatory* and *Top Voluntary* in 2004 and the corresponding difference in the 2006 placebo period. We then compare these two differences and report the results in Table VIII. We find that in contrast to 2004, the differences in 2006 between the top mandatory and top voluntary funds are insignificant, except when using the DGTW-adjusted return as the performance measure (see "Cross-sectional Placebo Test in 2006"). More importantly, the difference-in-differences are consistently negative for all cases and statistically significant in six out of eight cases (see "Combination of Cross-sectional and Time-series Tests"). Moreover, the magnitude of the differences-in-differences range from 1.3% to 4.6%, which represents an economically large effect.

For the time-series placebo tests above, we use November 2006 as the placebo month since it is not affected by extreme market conditions and other major events that can affect stock liquidity (e.g., decimalization in 2001). To further allay any concerns about potential mean reversion in fund performance, we combine our cross-sectional placebo test with a longer time-series placebo period. Specifically, this period extends from 1994, the earliest date for which SEC EDGAR data are available, and ends in 2006 before the onset of the recent financial crisis. Note that we exclude 2004 (our treatment period) from this placebo period.

Since there are multiple placebo months over the alternative placebo period of 1994 to 2006, we compute the difference in the coefficients on *Top Mandatory* and *Top Voluntary* for each placebo month. Then from the corresponding difference for May 2004 (the treatment month), we subtract the difference for each placebo month. Finally, we take the time-series average of these difference-in-differences and assess its statistical significance using *t*-statistics.

We report the results in Table IX, which follows a format similar to that of Table VIII. For each of our four performance measures, we find the difference in the performance drop for top mandatory and top voluntary funds is uniformly greater in May 2004 compared to the 1994 to 2006 placebo period. Moreover, the difference-in-differences is statistically significant in six out of eight cases. Further, we exclude the turbulent and crisis years of 1998, 2000, and 2001 from the 1994 to 2006 placebo period and repeat the above analysis. The results are qualitatively similar to those in Table IX (see Table SA.VII of the Supplementary Appendix).

[Insert Table IX Here]

The evidence in this section strongly supports our model's prediction that informed funds that are forced to disclose more often due to the regulation change experience a decline in their performance. Moreover, the decline in performance of the affected funds is concentrated around the regulation change.

C. Fund Performance and Information Asymmetry

According to our model, the decline in the performance of an informed fund after the regulation change is greater when the stocks in its portfolio are subject to higher information asymmetry. For this purpose, we first calculate the value-weighted average of different proxies of information asymmetry (i.e., market capitalization, analyst coverage, and liquidity) using all positions in a fund's portfolio. We then create an indicator variable that equals one if a fund is in the top quartile for a fund-level measure of information asymmetry, and zero otherwise. We test whether the performance drop is greater for informed funds with higher levels of information asymmetry. In particular, we estimate regressions of changes in fund performance on the interactions of funds' past performance and information asymmetry. Our model predicts the coefficients of these interactions to be negative and significant.

Table X presents our findings. Consistent with our model's prediction, we find that the top-performing funds holding stocks with higher levels of information asymmetry experience greater declines in performance. For example, funds in the top-quartile of 5-factor alpha that hold stocks with high information asymmetry (i.e., stocks with smaller size, lower analyst coverage, and higher illiquidity) suffer incremental performance declines ranging from 2.1% to 4.9% compared to top-performing funds holding stocks with low information asymmetry (see row 1 of Panel B of Table X).

[Insert Table X Here]

D. Fund Performance and Trade Length

Our model predicts that the regulation change would have an even greater adverse effect on funds that take longer to complete their trades. To test this prediction, we estimate regressions of changes in fund performance on the interactions of past fund performance and the *Trade Length* measure. Based on our model's prediction, we expect the coefficients of these interactions to be negative and significant. Panel E of Table X presents the estimation results. Using holdings-based performance measures, we find evidence that the funds in the top quartile of both past performance and *Trade Length* experience greater declines in their performance. For example, funds in the top quartile of past liquidity-adjusted DGTW returns that also take longer to complete their trades experience an additional decline of 2.2% compared to other top-performing funds.

E. Long-term Effects on Stock Liquidity and Fund Performance

In this section, we examine the long-term effects of an increase in mandatory disclosure frequency on stock liquidity and fund performance. Our model predicts that the effects of an increase in disclosure frequency on both stock liquidity and fund performance should be permanent.

To test if the improvement in stock liquidity is permanent, we estimate the regression in equation (9) using the long-term (i.e., three-year) cumulative change in stock liquidity after

May 2004 as the dependent variable. We test the differences between the long-term and short-term changes in liquidity. The results in the last column of Panel A of Table XI show that the differences are not statistically significant for any of the liquidity measures. These findings suggest that the regulation change had a permanent effect on stock liquidity.

We next test the permanence in fund performance by following a procedure similar to that for stock liquidity. Specifically, we estimate the regression in equation (13) using the three-year cumulative change in performance after May 2004 as the dependent variable. Panel B of Table XI presents the short-term and long-term changes in fund performance and the differences between the two. We find no evidence of reversals in the performance of more informed funds, suggesting that the changes in fund performance are also permanent.

[Insert Table XI Here]

Taken together, the evidence in this section strongly supports our model's predictions that: (i) more informed funds experience greater performance deterioration due to an increase in the mandatory disclosure frequency, and (ii) the performance decline is exacerbated for funds that hold stocks with higher level of information asymmetry and for funds that take longer to complete their trades. Further, the effects of the regulation change on stock liquidity and fund performance are permanent.

VII. Mutual Funds' Response to the Regulation Change

Our evidence so far shows that informed funds bear significant costs in the form of a performance decline in the year after the regulation change. In the model, such costs take the form of informed traders adding noise to their private signal and the market maker's response to the disclosure by the informed traders. Moreover, we find that these costs are greater for the funds that hold stocks with higher information asymmetry and for the funds that take longer to complete their trades. Thus, one would expect that these funds should respond by changing their trading behavior to mitigate the adverse effects of more frequent disclosure. Specifically, we expect the informed funds to shift to stocks with lower information asymmetry and to shorten the time they take to finish their trading. Therefore, we examine the changes in (i) the degree of information asymmetry of funds' portfolios and (ii) funds' trade lengths.

We first compute the changes made by funds in the information asymmetry of their portfolios in the year subsequent to the regulation change. In particular, the change in the information asymmetry for fund j, $\Delta\bar{X}_{j,t}$, is calculated as follows,

$$\Delta\bar{X}_{j,t} = \sum_{i=1}^{N}(\hat{w}_{i,j,t} - w_{i,j,t-1})X_{i,t-1},$$
$$w_{i,j,t-1} = \frac{M_{i,j,t-1}P_{i,t-1}}{\sum_{k=1}^{N}M_{k,j,t-1}P_{k,t-1}},\ \hat{w}_{i,j,t} = \frac{M_{i,j,t}P_{i,t-1}}{\sum_{k=1}^{N}M_{k,j,t}P_{k,t-1}}, \quad (14)$$

where $X_{i,t-1}$ is a measure of information asymmetry (i.e., market capitalization, analyst coverage, or stock liquidity) for stock i in the year prior to the regulation change (t–1) and N is the number of stocks held by fund j; $M_{i,j,t}$ and $M_{i,j,t-1}$ are the number of shares of stock i held by fund j in the year after and prior to the regulation change; $P_{i,t-1}$ is the price of stock i at the beginning of year t–1; $w_{i,j,t-1}$ is the weight of stock i in fund j's portfolio in year t–1; $\hat{w}_{i,j,t}$ is the imputed weight of stock i in fund j's portfolio in year t assuming stock prices do not change from year t–1 to year t. Note that we use the imputed weight because information asymmetry of stocks can change over time even when funds do not actively adjust their portfolios. Our measure, $\Delta\bar{X}_{j,t}$, thus captures only the changes in information asymmetry caused by funds actively rebalancing their portfolios. If a fund does not adjust its portfolio holdings after the regulation change, then the measure will be equal to zero. Next we compute the changes in the fund-level *Trade Length* variable in the year after the regulation change.

We then estimate the following cross-sectional regressions,

$$\Delta Y_{j,t} = \mu_0 + \mu_1 TopFund_{j,t-1} + \mu_2 Z_{j,t-1} + \psi_j, \tag{15}$$

where $\Delta Y_{j,t}$ is either $\Delta\bar{X}_{j,t}$ for an information asymmetry variable X or the change in *Trade Length*; $TopFund_{j,t-1}$ and $Z_{j,t-1}$ are as defined earlier in equation (13).

We report the results from these regressions in Table XII. The results in the first six columns suggest that more informed funds shift to larger stocks, stocks with higher analyst coverage, and more liquid stocks. Moreover, the last column of Table XII shows some evidence of a reduction in the trade length of more informed funds. Taken together, these findings suggest that informed funds attempt to mitigate the effects of more frequent disclosure by trading stocks with lower information asymmetry and by trading more quickly.

[Insert Table XII Here]

VIII. Concluding Remarks

We use the regulation change in May 2004 that increased the mandatory disclosure frequency of mutual funds from two to four times a year to examine the impact of disclosure on the liquidity of disclosed stocks and on fund performance. This regulation change provides us with a quasi-natural experiment to identify causal relations between disclosure and stock liquidity, and between disclosure and fund performance.

We develop a model building on Kyle (1985) and Huddart, Hughes, and Levine (2001) to allow for mandatory disclosure by informed traders at different frequencies. Our model yields several testable predictions that we test using a difference-in-differences approach. We find evidence consistent with our model's predictions. First, we observe that the increase in stock liquidity is positively related to the ownership of funds forced to increase their disclosure frequency. Second, the liquidity improvement is more pronounced for stocks held by informed funds and for stocks subject to greater information asymmetry. Third, after controlling for potential mean reversion, we find that performance deteriorates substantially for top-performing funds. Fourth, the performance decline for these funds is greater when they hold stocks with greater information asymmetry or when they take longer to complete their trades. Finally, we find some evidence that informed funds respond to the increase in disclosure frequency by adjusting their trading behavior.

Taken together, our findings suggest that more frequent mandatory portfolio disclosure by informed funds improves the liquidity of the disclosed stocks. However, increasing the disclosure frequency can hurt these funds' ability to capitalize on their information and thus can reduce their incentives to collect and process information. Therefore, policymakers should weigh the benefits of disclosure to capital markets against the costs borne by informed funds.

Appendix: Definition of Variables

Variable	Description
Liquidity Measures	
Amihud	Illiquidity measure of Amihud (2002) calculated as the square root of the absolute value of the daily return over daily dollar volume
Rspread	Average difference between the bid and ask prices divided by their midpoint from the TAQ data, equally weighted across all trades of a trading day
Size-Weighted Rspread	Average difference between the bid and ask prices divided by their midpoint, weighted by their trade size across all trades of a trading day
Effective Spread	Two times the absolute value of the difference between the execution price and the bid-ask midpoint divided by the midpoint of the bid-ask spread, averaged across all trades of a trading day
Ownership Variables	
Mutual Fund Ownership	Thomson Reuters S12 stock ownership of actively managed U.S. equity funds whose number of mandatory portfolio disclosures increased due to the May 2004 regulation change
Non-MF Ownership	Total ownership of Thomson Reuters S34 institutions excluding the ownership of mutual funds and asset management companies
Hedge Fund Ownership	Ownership of hedge fund companies, as identified in Agarwal et al. (2013) and Agarwal, Fos, and Jiang (2013) in the Thomson Reuters S34 database
Index Fund Ownership	Ownership of mutual funds identified as pure index funds in the CRSP Mutual Fund database
Fund-Level Measures	
4-factor alpha	Alpha measure calculated using equations (6) and (7) based on the Carhart (1997) four-factor model
5-factor alpha	Alpha measure calculated using equations (6) and (7) based on the Carhart (1997) model augmented by the Pástor and Stambaugh (2003) liquidity factor
DGTW-adjusted return	Characteristics-adjusted return calculated following Daniel et al. (1997) based on stock size, book-to-market, and momentum
Liquidity-adjusted DGTW	Characteristics-adjusted return calculated by augmenting size, book-to-market, and momentum with stock liquidity in the characteristics used to form the DGTW benchmark portfolios
Trade Length	Average number of consecutive quarters over which the fund either builds or unwinds its positions in all stocks during the one-year period prior to a quarter
Stock Characteristics	
Momentum	Past 12-month cumulative stock return
Book-to-Market	Book assets divided by (book assets − book equity + market equity)
Size	Natural logarithm of market capitalization
Analyst Coverage	Number of analysts covering a stock from I/B/E/S

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Table I
SEC Reporting Frequencies of Mutual Funds' Portfolio Holdings

This table reports the frequencies of different SEC forms used by the mutual funds to report their holdings from 1994 to 2011. N-30D is the form that contains semi-annual portfolio holdings of mutual funds reported to the SEC before the May 2004 regulation. N-CSRS and N-CSR are the SEC forms that contain the portfolio holdings at the end of the second and fourth fiscal quarters after May 2004. N-Q is the SEC form that contains portfolio holdings at the end of the first and third fiscal quarters after May 2004.

Year	N-30D	N-CSR	N-CSRS	N-Q	Total
1994	1,159	0	0	0	1,159
1995	3,565	0	0	0	3,565
1996	5,714	0	0	0	5,714
1997	6,040	0	0	0	6,040
1998	6,217	0	0	0	6,217
1999	6,282	0	0	0	6,282
2000	6,259	0	0	0	6,259
2001	6,305	0	0	0	6,305
2002	6,216	0	0	0	6,216
2003	2,850	2,682	939	3	6,474
2004	450	3,850	2,488	2,195	8,983
2005	330	3,434	2,632	6,042	12,438
2006	423	3,290	2,667	5,871	12,251
2007	455	3,261	2,746	5,889	12,351
2008	456	3,224	2,723	5,843	12,246
2009	379	3,082	2,675	5,613	11,749
2010	347	2,862	2,709	5,463	11,381
2011	349	2,891	2,657	5,374	11,271

Table II
Impact of Mandatory Portfolio Disclosure on Stock Liquidity

Panel A of this table reports the summary statistics of the variables we use in our analysis. We report the liquidity variables, institutional ownership, and other stock characteristics variables for the one-year period prior to the regulation (May 2003 to April 2004). Annual averages are reported for these variables. Liquidity variables *Amihud*, *Rspread, Size-Weighted Rspread,* and *Effective Spread* are defined in the Appendix. We take the natural logarithm of all liquidity measures. The changes in liquidity variables are defined as values in the one-year period after (including) May 2004 minus values in the one-year period before May 2004. All other variables are also defined in the Appendix. All variables are winsorized at the 1% and 99% levels. Panel B reports the regression results of the changes in stock liquidity variables around May 2004 on the mutual fund ownership and other control variables. The independent variables are the averages of the variables in the year prior to May 2004. Standard errors are adjusted for heteroskedasticity and clustered at the stock level and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level, respectively.

Panel A. Summary Statistics

Variable	Mean	Median	Std. Dev.	Min	Max	N
Liquidity Variables						
Amihud	–8.963	–8.979	1.477	–12.158	–5.979	4635
Rspread	–5.063	–4.992	1.374	–7.918	–2.534	4634
Size-Weighted Rspread	–5.207	–5.217	1.216	–7.572	–2.843	4634
Effective Spread	–5.394	–5.314	1.325	–8.047	–2.920	4634
ΔAmihud	–0.129	–0.108	0.395	–1.342	0.835	4635
ΔRspread	–0.264	–0.253	0.390	–2.359	1.485	4634
ΔSize-Weighted Rspread	–0.218	–0.193	0.389	–2.049	1.233	4634
ΔEffective Spread	–0.232	–0.225	0.374	–1.920	1.134	4634
Ownership and Stock Characteristics						
Mutual Fund Ownership	6.60%	4.96%	6.46%	0.00%	25.80%	4635
Non-MF Ownership	22.29%	21.01%	16.70%	0.03%	66.16%	4635
Hedge Fund Ownership	7.90%	5.90%	7.78%	0.00%	35.66%	4635
Index Fund Ownership	0.99%	1.01%	0.79%	0.00%	3.49%	4635
Momentum	0.601	0.358	0.765	–0.529	3.639	4635
Book-to-Market	0.646	0.556	0.518	–0.579	2.871	4635
Size	5.634	5.549	1.937	1.923	10.838	4635
Analyst Coverage	6.43	3	8.6	0	39	4616

Panel B. Impact of the Regulation Change in Portfolio Disclosure on Stock Liquidity

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Mutual Fund Ownership	–0.815***	–1.795***	–2.100***	–1.459***
	(–7.17)	(–11.96)	(–12.94)	(–8.83)
Momentum	–0.082***	–0.119***	–0.137***	–0.131***
	(–8.23)	(–11.93)	(–12.95)	(–9.20)
Book-to-Market	–0.129***	–0.052***	–0.032**	–0.132***
	(–8.90)	(–3.47)	(–2.07)	(–6.30)
Size	–0.155***	–0.125***	–0.144***	–0.052***
	(–13.75)	(–16.84)	(–21.01)	(–5.74)
Lagged Liquidity	–0.223***	–0.223***	–0.271***	–0.100***
	(–13.22)	(–12.74)	(–16.45)	(–7.43)
Constant	–1.064***	–0.342***	–0.432***	–0.326***
	(–11.95)	(–7.89)	(–9.76)	(–7.70)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.083	0.137	0.165	0.059

Table III
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Cross-sectional Placebo Tests

Panel A of this table reports the regression results of the changes in stock liquidity variables (from the one-year period prior to May 2004 to one year afterward) on the mutual fund ownership and non-mutual fund institutional ownership. Panel B reports the regression results of the changes in stock liquidity on the mutual fund ownership and hedge fund ownership. Panel C reports the regression results of the changes in stock liquidity on the mutual fund ownership and index fund ownership. The ownership variables in Panel C are normalized to percentile variables due to the small magnitude of index fund ownership. The last two rows in each panel report the differences between the coefficients of the two ownership variables and the *p*-values from the *F*-tests of the differences. In Panel D, we compare the regression results of the changes in stock liquidity variables over the SEC disclosure regulation in 2004 with the same regressions conducted for a placebo period in 2006. In the placebo regressions, changes in the liquidity variables from one year prior to November 2006 to one year afterward are used as the dependent variable. All regressions contain controls for lagged stock liquidity and other stock characteristics as in Panel B of Table II. Standard errors are adjusted for heteroskedasticity and clustered at the stock level and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

Panel A. Non-MF Ownership

	(1)	(2)	(3)	(4)
Dependent Variable	ΔAmihud	ΔRspread	ΔSize-Weighted Rspread	ΔEff. Spread
Mutual Fund Ownership	–0.636***	–1.302***	–1.562***	–1.056***
	(–5.29)	(–7.61)	(–8.58)	(–5.72)
Non-MF Ownership	–0.228***	–0.447***	–0.494***	–0.399***
	(–3.95)	(–6.60)	(–6.93)	(–4.92)
Diff. of Coeffs. (MF – Non-MF)	–0.408**	–0.855***	–1.068***	–0.657***
Test of Difference (*p*-value)	0.011	<.0001	<.0001	0.005

Panel B. Hedge Fund Ownership

	(1)	(2)	(3)	(4)
Dependent Variable	ΔAmihud	ΔRspread	ΔSize-Weighted Rspread	ΔEff. Spread
Mutual Fund Ownership	–0.720***	–1.437***	–1.691***	–1.205***
	(–6.19)	(–8.98)	(–9.89)	(–6.93)
Hedge Fund Ownership	–0.313***	–0.758***	–0.881***	–0.590***
	(–3.67)	(–7.23)	(–8.07)	(–4.79)
Diff. of Coeffs. (MF – HF)	–0.407**	–0.679***	–0.810***	–0.615***
Test of Difference (*p*-value)	0.010	0.002	0.001	0.009

Panel C. Index Fund Ownership

Dependent Variable	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Mutual Fund Ownership	–0.002***	–0.005***	–0.006***	–0.004***
	(–7.29)	(–15.62)	(–17.31)	(–9.94)
Index Fund Ownership	–0.001***	–0.001	–0.000	–0.001*
	(–3.38)	(–1.48)	(–1.00)	(–1.86)
Diff. of Coeffs. (MF – Index)	–0.001***	–0.004***	–0.006***	–0.003***
Test of Difference (*p*-value)	0.005	<.0001	<.0001	<.0001

Panel D. Time-series Placebo Tests

Dependent Variable	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Regression in 2004				
Mutual Fund Ownership	–0.815***	–1.795***	–2.100***	–1.459***
	(–7.16)	(–11.96)	(–12.94)	(–8.83)
Regression in 2006				
Mutual Fund Ownership	–0.525***	–0.629***	–0.639***	–0.575***
	(–4.99)	(–6.67)	(–6.80)	(–6.44)
Diff. of Coeffs. (2004–2006)	–0.290*	–1.166***	–1.461***	–0.884**
Test of Differences (*p*-value)	0.059	<.0001	<.0001	<.0001

Table IV
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Propensity Score Matching

Panel A of this table reports results from logistic regressions where the dependent variable is an indicator variable equal to one if a fund voluntarily disclosed its portfolio holdings prior to the May 2004 regulation. *Fraud* is an indicator variable equal to one if the fund family was investigated by the SEC for potential market timing or late trading and zero otherwise. The rest of the independent variables are defined in Table VII. We form matched samples of mandatory and voluntary funds based on the propensity scores from the logistic regressions. Panels B and C present the regressions results of the changes in stock liquidity on the matched mutual fund ownership samples. Panel B contains the results when funds are matched using Model 1 and Panel C contains the results using Model 2 in Panel A. The dependent variables are the changes in liquidity variables from the one-year period prior to May 2004 to one year afterward. All regressions contain controls for lagged stock liquidity and other stock characteristics as in Panel B of Table II. The last two rows report the differences between the coefficients of the two ownership variables and the *p*-values from the *F*-tests of the differences. Standard errors are adjusted for heteroskedasticity and clustered at the stock level and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

Panel A. Logistic Regressions

VARIABLES	(1)	(2)
Expense Ratio	–27.065**	–26.279**
	(–2.30)	(–2.23)
Turnover	–0.047	–0.045
	(–1.60)	(–1.54)
Size	0.050	0.049
	(1.56)	(1.51)
Age	–0.128*	–0.116
	(–1.72)	(–1.57)
Fraud	–0.859***	–0.869***
	(–4.36)	(–4.42)
Std. Deviation	14.856***	15.504***
	(3.26)	(3.35)
Trade Length	–0.742***	–0.685***
	(–8.32)	(–8.02)
Trade Length × Top Alpha	–0.025	
	(–0.15)	
Top Alpha	0.258	
	(0.86)	
Trade Length × Top DGTW		–0.224
		(–1.23)
Top DGTW		0.331
		(1.11)
Constant	0.297	0.215
	(0.93)	(0.68)
Observations	1,688	1,688
Pseudo R-Squared	0.068	0.067

Panel B. Mandatory vs. Voluntary Funds Matched by Model 1

Dependent Variable	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Mandatory Ownership	–0.624***	–1.497***	–1.788***	–1.130***
	(–4.46)	(–9.01)	(–10.16)	(–5.56)
Voluntary Ownership	–0.221***	–0.385***	–0.429***	–0.391***
	(–3.46)	(–4.78)	(–5.05)	(–3.95)
Diff. of Coeffs. (Mand – Vol.)	–0.404**	–1.112***	–1.359***	–0.739***
Test of Difference (*p*-value)	0.018	<.0001	<.0001	0.004

Panel C. Mandatory vs. Voluntary Funds Matched by Model 2

Dependent Variable	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Mandatory Ownership	–0.603***	–1.244***	–1.493***	–0.911***
	(–4.30)	(–7.46)	(–8.47)	(–4.45)
Voluntary Ownership	–0.320***	–0.764***	–0.878***	–0.760***
	(–4.40)	(–8.40)	(–9.17)	(–6.77)
Diff. of Coeffs. (Mand – Vol.)	–0.282	–0.480**	–0.615***	–0.151
Test of Difference (*p*-value)	0.110	0.028	0.008	0.573

Table V
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Subsamples of Mutual Funds

This table reports the regression results of the changes in stock liquidity on mutual fund ownership of top- and non-top-performing funds. The dependent variables are the changes in the liquidity variables from the one-year period prior to May 2004 to one year afterward. All regressions contain controls for lagged stock liquidity and other stock characteristics as in Panel B of Table II. The last two rows report the differences between the coefficients of the above and below top quartile ownership and the *p*-values from the *F*-tests of the differences. Performance measures *4-factor alpha*, *5-factor alpha*, *DGTW-adjusted return*, and *Liquidity-adjusted DGTW* are defined in the Appendix. Panels A to D report the results when funds are separated based on whether or not they are in the top quartile of these abnormal performance measures for the prior year. Standard errors are adjusted for heteroskedasticity and clustered at the stock level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

Panel A: 4-Factor Alpha

	(1)	(2)	(3)	(4)
VARIABLES	ΔAmihud	ΔRspread	ΔSize-Weighted Rspread	ΔEff. Spread
Top Fund Ownership	–0.0018***	–0.0049***	–0.0057***	–0.0033***
	(–5.60)	(–12.52)	(–13.79)	(–6.56)
Non-Top Fund Ownership	–0.0008***	–0.0015***	–0.0018***	–0.0018***
	(–3.21)	(–5.20)	(–5.96)	(–4.79)
Difference (Top – Non-top)	–0.001**	–0.0034***	–0.0039***	–0.0015**
p-value (diff.)	0.019	<.0001	<.0001	0.041

Panel B: 5-Factor Alpha

	(1)	(2)	(3)	(4)
VARIABLES	ΔAmihud	ΔRspread	ΔSize-Weighted Rspread	ΔEff. Spread
Top Fund Ownership	–0.0016***	–0.0056***	–0.0066***	–0.0037***
	(–4.91)	(–14.49)	(–16.33)	(–7.52)
Non-Top Fund Ownership	–0.0009***	–0.0007**	–0.0007**	–0.0013***
	(–3.68)	(–2.27)	(–2.36)	(–3.45)
Difference (Top – Non-top)	–0.0007	–0.0049***	–0.0059***	–0.0024***
p-value (diff.)	0.106	<.0001	<.0001	0.001

Panel C: DGTW-adjusted Return

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Top Fund Ownership	–0.0010***	–0.0046***	–0.0052***	–0.0029***
	(–2.82)	(–11.11)	(–12.02)	(–5.53)
Non-Top Fund Ownership	–0.0016***	–0.0019***	–0.0023***	–0.0022***
	(–6.37)	(–6.10)	(–7.09)	(–5.72)
Difference (Top – Non-top)	0.0006	–0.0027***	–0.0029***	–0.0007
p-value (diff.)	0.224	<.0001	<.0001	0.417

Panel D: Liquidity-adjusted DGTW

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-Weighted Rspread	(4) ΔEff. Spread
Top Fund Ownership	–0.0019***	–0.0040***	–0.0046***	–0.0034***
	(–5.97)	(–10.16)	(–10.99)	(–6.71)
Non-Top Fund Ownership	–0.0006**	–0.0022***	–0.0027***	–0.0017***
	(–2.25)	(–6.34)	(–7.37)	(–3.73)
Difference (Top – Non-top)	–0.0013**	–0.0018***	–0.0019***	–0.0017**
p-value (diff.)	0.012	0.007	0.007	0.040

Table VI
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Subsamples of Stocks

This table compares the regression results of the changes in stock liquidity variables in 2004 for subsamples of stocks grouped by market capitalization, analyst coverage, and illiquidity. The stocks are placed into two subsamples based on whether or not they fall into the top quartile of the given variable. Most variables are defined in Table II. Panel A divides the stocks based on market capitalization (size). Panel B divides the stocks based on analyst coverage. Panels C to F divide the stocks based on the illiquidity measures (i.e., Amihud, relative spread, size-weighted relative spread, and effective spread). All regressions contain controls for prior liquidity and stock characteristics. Standard errors are adjusted for heteroskedasticity and clustered at the stock level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

	(1)	(2)	(3)	(4)
VARIABLES	ΔAmihud	ΔRspread	ΔSize-weighted Rspread	ΔEff. Spread
Panel A: Subsamples Based on Size				
<u>Top Size Stocks</u>				
Mutual Fund Ownership	–0.300**	0.020	(–0.065)	(–0.273)
	(–2.31)	(0.09)	(–0.27)	(–1.15)
<u>Non-Top Size Stocks</u>				
Mutual Fund Ownership	–0.937***	–2.143***	–2.539***	–1.665***
	(–5.51)	(–11.11)	(–12.17)	(–7.02)
Diff. of Coeffs. (Top – Non-Top)	0.637***	2.163***	2.475***	1.392***
Test of Differences. (*p*-values)	(0.003)	<.0001	<.0001	<.0001
Panel B: Subsamples Based on Analyst Coverage				
<u>Top Analyst Coverage Stocks</u>				
Mutual Fund Ownership	–0.128	–0.054	–0.259	–0.446*
	(–0.81)	(–0.24)	(–1.04)	(–1.74)
<u>Non-Top Analyst Coverage Stocks</u>				
Mutual Fund Ownership	–1.142***	–1.899***	–2.252***	–1.711***
	(–6.98)	(–9.53)	(–10.25)	(–7.36)
Diff. of Coeffs. (Top – Non-Top)	1.014***	1.845***	1.993***	1.266***
Test of Differences. (*p*-values)	<.0001	<.0001	<.0001	0.0003

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-weighted Rspread	(4) ΔEff. Spread
Panel C: Subsamples Based on Amihud				
<u>Top Amihud Stocks</u>				
Mutual Fund Ownership	–0.139	–0.132	–0.266	–0.259
	(–0.93)	(–0.56)	(–1.07)	(–1.03)
<u>Non-Top Amihud Stocks</u>				
Mutual Fund Ownership	–1.109***	–2.383***	–2.838***	–1.855***
	(–6.25)	(–12.35)	(–13.27)	(–7.45)
Diff. of Coeffs. (Top – Non-Top)	0.970***	2.252***	2.572***	1.596***
Test of Differences. (*p*-values)	<.0001	<.0001	<.0001	<.0001
Panel D: Subsamples Based on Rspread				
<u>Top Rspread Stocks</u>				
Mutual Fund Ownership	–0.338**	–0.605***	–0.667***	–0.608***
	(–2.28)	(–2.72)	(–2.80)	(–2.68)
<u>Non-Top Rspread Stocks</u>				
Mutual Fund Ownership	–0.941***	–1.287***	–1.730***	–1.424***
	(–5.52)	(–6.14)	(–7.57)	(–5.77)
Diff. of Coeffs. (Top – Non-Top)	0.603***	0.682**	1.063***	0.816**
Test of Differences. (*p*-values)	0.008	0.026	0.001	0.015
Panel E: Subsamples Based on Size-Weighted Rspread				
<u>Top Size-Weighted Rspread Stocks</u>				
Mutual Fund Ownership	–0.288*	–0.484**	–0.571**	–0.578**
	(–1.92)	(–2.16)	(–2.35)	(–2.53)
<u>Non-Top Size-Weighted Rspread Stocks</u>				
Mutual Fund Ownership	–0.999***	–1.536***	–1.965***	–1.524***
	(–5.79)	(–7.40)	(–8.68)	(–6.13)
Diff. of Coeffs. (Top – Non-Top)	0.711***	1.052***	1.394***	0.946***
Test of Differences. (*p*-values)	0.002	0.001	<.0001	0.005
Panel F: Subsamples Based on Effective Spread				
<u>Top Effective Spread Stocks</u>				
Mutual Fund Ownership	–0.221	–0.379*	–0.483*	–0.800***
	(–1.57)	(–1.65)	(–1.90)	(–4.18)
<u>Non-Top Effective Spread Stocks</u>				
Mutual Fund Ownership	–0.954***	–1.990***	–2.464***	–1.383***
	(–5.61)	(–9.62)	(–10.97)	(–5.57)
Diff. of Coeffs. (Top – Non-Top)	0.733***	1.611***	1.981***	0.583*
Test of Differences. (*p*-values)	0.0009	<.0001	<.0001	0.0629

Table VII
Impact of Mandatory Portfolio Disclosure on Mutual Fund Performance

Panel A reports the summary statistics of performance and characteristics of funds prior to the 2004 disclosure regulation (values in the one-year period before May 2004) and the changes in fund performance after the regulation (values in the one-year period after (including) May 2004 minus values in the one-year period before May 2004). Performance measures *4-factor alpha*, *5-factor alpha*, *DGTW-adjusted return*, and *Liquidity-adjusted DGTW* and *Trade Length* are defined in the Appendix. All performance measures are annualized. *TNA* is the total net assets under management in millions of dollars. *Turnover* is the average annual turnover computed from holdings data. *Flow* is changes of TNA from last period after adjusting for fund returns, scaled by lagged TNA. *Expense Ratio* is the total operating expenses scaled by TNA. *Load* is an indicator variable that equals one if the mutual fund has a share class with load and zero otherwise. Panel B reports the results of multivariate regressions of changes in fund performance around 2004 on lagged performance and characteristics of funds. Top performance indicators are equal to one if the fund's performance is in the top quartile in the one year before May 2004 and zero otherwise. All regressions contain controls for prior liquidity and stock characteristics. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

Panel A. Summary Statistics

Variable	Mean	Median	Std. Dev.	Min	Max	N
Abnormal Fund Returns						
4-factor Alpha	–0.024	–0.027	0.089	–0.743	0.690	1,122
Δ 4-factor Alpha	0.013	0.013	0.097	–0.658	0.810	1,122
5-factor Alpha	–0.021	–0.021	0.089	–0.723	0.701	1,122
Δ 5-factor Alpha	0.009	0.005	0.098	–0.579	0.858	1,122
DGTW-adjusted Return	0.024	0.012	0.106	–0.408	0.592	1,221
ΔDGTW-adjusted Return	–0.015	–0.006	0.123	–0.676	0.566	1,221
Liquidity-adj. DGTW	0.005	0.002	0.049	–0.343	0.326	1,221
ΔLiquidity-adj. DGTW	0.001	0.002	0.054	–0.381	0.331	1,221
Other Fund Characteristics						
TNA ($million)	929	153	2,576	2	18,309	1,311
Turnover	0.507	0.438	0.351	0	1.650	1,311
Flow	0.021	0.005	0.065	–0.195	0.368	1,311
Expense Ratio	0.014	0.014	0.005	0.001	0.030	1,243
Load	0.720	1	0.445	0	1	1,311
Trade Length	1.770	1.768	0.814	0.043	4.193	1,214

Panel B. Impact of Mandatory Portfolio Disclosure on Fund Performance

VARIABLES	(1) Δ4-factor Alpha	(2) Δ5-factor Alpha	(3) ΔDGTW-adj. Return	(4) ΔLiq.-adj. DGTW
Top 4-factor Alpha	–0.101***			
	(–16.50)			
Top 5-factor Alpha		–0.089***		
		(–14.19)		
Top DGTW			–0.143***	
			(–19.28)	
Top Liquidity-Adj. DGTW				–0.068***
				(–23.11)
Log(TNA)	0.002	0.002	–0.002	–0.000
	(1.05)	(1.41)	(–0.91)	(–0.55)
Turnover	0.002	0.004**	0.001	0.001
	(1.20)	(2.06)	(0.38)	(0.71)
Flow	–0.111**	–0.098*	0.153**	0.089***
	(–2.09)	(–1.78)	(2.50)	(3.50)
Expense Ratio	0.688	2.053***	–0.570	–0.153
	(1.14)	(3.27)	(–0.80)	(–0.52)
Load	–0.008	–0.010	–0.004	–0.004
	(–1.18)	(–1.44)	(–0.49)	(–1.31)
Constant	0.025*	–0.005	0.035**	0.026***
	(1.85)	(–0.39)	(2.22)	(3.93)
Observations	1,113	1,113	1,171	1,171
Adjusted R-squared	0.211	0.169	0.246	0.311

Table VIII: Impact of Portfolio Disclosure on Mutual Fund Performance: Cross-sectional and Time-series Placebo Tests

This table compares the regression results of the changes in fund performance for matched samples of mandatory and voluntary funds (see Table IV) in a two-year period around the SEC disclosure regulation in 2004 with the same regressions conducted for a placebo sample period around 2006. In the time-series placebo regressions we use the changes in the performance variables from one year prior to November 2006 to one year afterward as the dependent variable. The independent variables in the placebo tests are the lagged variables prior to November 2006. All performance variables are annualized. In all regressions, we control for *Log(TNA)*, *Turnover*, *Flow*, *Expense Ratio*, and *Load*. Panels A and B report results for the samples matched using Models 1 and 2 in Table IV, respectively. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level.

Panel A. Mandatory and Voluntary Funds Matched by Model 1

VARIABLES	(1) Y= 4-factor Alpha	(2) Y=5-factor Alpha	(3) Y=DGTW	(4) Y=Liq.-adj. DGTW
Regressions for Mandatory Funds in 2004				
Top Mandatory Y	–0.096***	–0.088***	–0.143***	–0.069***
	(–16.23)	(–13.12)	(–18.55)	(–22.50)
Regressions for Voluntary Funds in 2004				
Top Voluntary Y	–0.075***	–0.073***	–0.083***	–0.022***
	(–15.91)	(–11.75)	(–14.62)	(–8.00)
Cross-sectional Placebo Test in 2004				
Diff. for Mandatory 2004 – Voluntary 2004	–0.021***	–0.014	–0.060***	–0.047***
F-test	(–2.82)	(–1.57)	(–6.22)	(–11.22)
Regressions for Mandatory Funds in 2006				
Top Mandatory Y	–0.051***	–0.068***	–0.087***	–0.033***
	(–9.60)	(–11.81)	(–14.05)	(–13.31)
Regressions for Voluntary Funds in 2006				
Top Voluntary Y	–0.052***	–0.077***	–0.074***	–0.029***
	(–10.77)	(–15.38)	(–13.69)	(–12.36)
Cross-sectional Placebo Test in 2006				
Diff. for Mandatory 2006 – Voluntary 2006	0.001	0.009	–0.013*	–0.004
F-test	(0.15)	(1.24)	(–1.65)	(–1.15)
Time-series Placebo Tests - Mandatory				
Diff. for Mandatory 2004 – Mandatory 2006	–0.046***	–0.020**	–0.056***	–0.036***
F-test	(–5.74)	(–2.21)	(–5.51)	(–8.87)
Time-series Placebo Tests - Voluntary				
Diff. for Voluntary 2004 – Voluntary 2006	–0.023***	0.004	–0.009	0.007**
F-test	(–3.44)	(0.55)	(–1.16)	(1.98)
Combination of Cross-sectional and Time-series Tests				
Diff. in Diff. Mand. – Volun. and 2004 – 2006	–0.023**	–0.024**	–0.046***	–0.043***
F-test	(–2.15)	(–2.00)	(–3.64)	(–7.91)

Panel B. Mandatory and Voluntary Funds Matched by Model 2

VARIABLES	(1) Y= 4-factor Alpha	(2) Y=5-factor Alpha	(3) Y=DGTW	(4) Y=Liq.-adj. DGTW
Regressions for Mandatory Funds in 2004				
Top Mandatory Y	–0.095***	–0.085***	–0.142***	–0.069***
	(–16.07)	(–11.92)	(–18.51)	(–22.52)
Regressions for Voluntary Funds in 2004				
Top Voluntary Y	–0.065***	–0.061***	–0.101***	–0.029***
	(–14.55)	(–9.65)	(–19.88)	(–10.93)
Cross-sectional Placebo Test in 2004				
Diff. for Mandatory 2004 – Voluntary 2004	–0.030***	–0.024**	–0.041***	–0.040***
F-test	(–4.10)	(–2.50)	(–4.49)	(–9.84)
Regressions for Mandatory Funds in 2006				
Top Mandatory Y	–0.051***	–0.068***	–0.087***	–0.034***
	(–9.64)	(–12.19)	(–14.11)	(–13.66)
Regressions for Voluntary Funds in 2006				
Top Voluntary Y	–0.040***	–0.058***	–0.065***	–0.033***
	(–7.50)	(–10.80)	(–11.50)	(–15.56)
Cross-sectional Placebo Test in 2006				
Diff. for Mandatory 2006 – Voluntary 2006	–0.010	–0.010	–0.022***	–0.001
F-test	(–1.35)	(–1.33)	(–2.61)	(–0.24)
Time-series Placebo Tests-Mandatory				
Diff. for Mandatory 2004 – Mandatory 2006	–0.045***	–0.017*	–0.055***	–0.035***
F-test	(–5.63)	(–1.85)	(–5.47)	(–8.72)
Time-series Placebo Tests-Voluntary				
Diff. for Voluntary 2004 – Voluntary 2006	–0.024***	–0.003	–0.036***	0.004
F-test	(–3.51)	(–0.39)	(–4.71)	(1.28)
Combination of Cross-sectional and Time-series Tests				
Diff. in Diff. Mand. – Volun. and 2004 – 2006	–0.020*	–0.013	–0.019	–0.040***
F-test	(–1.91)	(–1.10)	(–1.52)	(–7.45)

Table IX
Impact of Portfolio Disclosure on Mutual Fund Performance: Full Placebo Periods

This table compares the regression results of the changes in fund performance for the matched samples of mandatory and voluntary funds (see Table IV) in a two-year period around the SEC disclosure regulation in 2004 with the same regressions conducted for placebo periods constructed using each placebo month in 1994–2006 (except 2004). The independent variables in the placebo tests are the lagged variables. All performance variables are annualized. In all regressions, we control for *Log(TNA)*, *Turnover*, *Flow*, *Expense Ratio*, and *Load*. Panels A and B report results for the samples matched using Models 1 and 2 in Table IV, respectively. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level.

	(1)	(2)	(3)	(4)
	Δ4-factor Alpha	Δ5-factor Alpha	ΔDGTW	ΔLiq.-adj. DGTW
Panel A. Mandatory and Voluntary Funds Matched by Model 1				
Mandatory – Voluntary (May 2004)	–0.021	–0.014	–0.06	–0.047
Mand. – Vol. (Mean over all placebo periods)	–0.015	–0.012	–0.01	–0.004
Diff. in Diff. (Mand. – Vol. and 2004 – Placebo)	–0.006	–0.002	–0.05***	–0.043***
t-stat	(–1.51)	(–0.47)	(–15.82)	(–7.81)
Panel B. Mandatory and Voluntary Funds Matched by Model 2				
Mandatory – Voluntary (May 2004)	–0.030	–0.024	–0.041	–0.040
Mand. – Vol. (Mean over all placebo periods)	–0.015	–0.012	–0.008	–0.010
Diff. in Diff. (Mand. – Vol. and 2004 – Placebo)	–0.015***	–0.012**	–0.033***	–0.030***
t-stat	(–3.69)	(–2.33)	(–7.76)	(–5.67)

Table X
Impact of Mandatory Portfolio Disclosure on Mutual Fund Performance: Interaction Effects

This table reports multivariate regressions of changes in fund performance around 2004 on lagged fund performance, proxies for information asymmetry, and the interactions of the two. All variables are defined in Tables II and VII. For any performance variable *Y*, *Top Y* is the indicator variable that equals one if *Y* is in the top quartile in the one year before May 2004 and zero otherwise. *X* in the table refers to one of the variables that proxy for information asymmetry at the stock level, which is value-weighted to form the fund-level measures. Panels A to D report the results when the top performance quartile is determined by *4-factor Alpha*, *5-factor Alpha*, *DGTW-adj. Return*, and *Liquidity-adj. DGTW*, respectively. Panel E reports the results for the tests based on *Trade Length*. All regressions include controls for fund characteristics as in Table VII. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	X = Size	X=Analyst Coverage	X=Amihud	X=Rspread	X=Size-Wght. Rspread	X=Eff. Spread
Panel A. Y = 4-factor Alpha						
Top X × Top Y	–0.072***	–0.032**	–0.050***	–0.046***	–0.053***	–0.066***
	(–5.14)	(–2.13)	(–3.81)	(–3.43)	(–4.02)	(–5.03)
Top X	0.029***	0.041***	0.017**	0.025***	0.022***	0.018**
	(4.03)	(5.98)	(2.37)	(3.39)	(2.99)	(2.49)
Top Y	–0.111***	–0.119***	–0.114***	–0.117***	–0.114***	–0.109***
	(–15.99)	(–17.48)	(–15.64)	(–16.15)	(–15.77)	(–14.95)
Panel B: Y = 5-factor Alpha						
Top X × Top Y	–0.049***	–0.027**	–0.022*	–0.021*	–0.027**	–0.034***
	(–3.82)	(–1.98)	(–1.81)	(–1.71)	(–2.19)	(–2.77)
Top X	0.029***	0.017***	0.010	0.016**	0.018**	0.014**
	(4.34)	(2.68)	(1.42)	(2.34)	(2.52)	(2.02)
Top Y	–0.080***	–0.086***	–0.086***	–0.087***	–0.085***	–0.082***
	(–12.56)	(–13.61)	(–12.72)	(–12.96)	(–12.60)	(–12.21)
Panel C: Y = DGTW-adj. Return						
Top X × Top Y	–0.049***	0.005	–0.021	–0.026	–0.028*	–0.031*
	(–2.81)	(0.27)	(–1.26)	(–1.57)	(–1.65)	(–1.84)
Top X	–0.008	–0.001	0.000	0.003	0.004	–0.000
	(–0.86)	(–0.13)	(0.05)	(0.33)	(0.45)	(–0.02)
Top Y	–0.130***	–0.144***	–0.135***	–0.134***	–0.133***	–0.132***
	(–14.76)	(–15.94)	(–14.43)	(–14.30)	(–14.25)	(–14.26)

Panel D: Y = Liquidity-adj. DGTW

Top X × Top Y	–0.005	0.006	–0.012*	–0.009	–0.012*	–0.016**
	(–0.66)	(0.82)	(–1.67)	(–1.35)	(–1.72)	(–2.25)
Top X	–0.008**	–0.009**	–0.000	–0.001	–0.000	–0.001
	(–2.07)	(–2.51)	(–0.06)	(–0.30)	(–0.05)	(–0.27)
Top Y	–0.068***	–0.071***	–0.066***	–0.066***	–0.066***	–0.065***
	(–19.43)	(–20.01)	(–18.36)	(–18.50)	(–18.15)	(–18.11)

Panel E. Trade Length

	Y= 4-factor Alpha	Y=5-factor Alpha	Y=DGTW	Y=Liq.-adj. DGTW
Top X × Top Y	0.001	–0.012	–0.089***	–0.022***
	(0.06)	(–1.01)	(–5.09)	(–3.31)
Top X	0.008	0.012*	0.006	0.013***
	(1.17)	(1.81)	(0.67)	(3.45)
Top Y	–0.130***	–0.090***	–0.120***	–0.063***
	(–17.87)	(–13.39)	(–13.77)	(–17.21)

Table XI
Long-Term Effects of the Regulation Change on Liquidity and Fund Performance

This table reports results related to the long-term effects of the regulation change on stock liquidity and fund performance. Panel A contains regressions of changes in stock liquidity on *Mutual Fund Ownership*, *Non-MF Ownership*, and the stock-level control variables as in Panel A of Table III. Panel B contains regressions of changes in mutual fund performance on a top fund indicator variable and the fund-level controls as in Panel B of Table VII. The first column in each panel presents the results where the dependent variable is the one-year change in liquidity or performance, while the second column presents the results where the dependent variable is the three-year change in liquidity or performance. The third column presents the differences between coefficients in the first and second columns. Standard errors are adjusted for heteroskedasticity and clustered at the stock level in Panel A and the fund level in Panel B and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level, respectively.

Panel A. Stock Liquidity

VARIABLES	Short-Term Change in *Y*	Long-Term Change in *Y*	Long-Term – Short-Term
Y = Amihud			
Diff. (MF – Non-MF)	–0.408**	–0.474	–0.066
	(–2.56)	(–1.53)	(–0.20)
Y = Rspread			
Diff. (MF – Non-MF)	–0.855***	–1.287***	–0.432
	(–4.25)	(–4.04)	(–1.19)
Y = Size-Weighted Rspread			
Diff. (MF – Non-MF)	–1.068***	–1.302***	–0.234
	(–5.04)	(–4.20)	(–0.64)
Y = Effective Spread			
Diff. (MF – Non-MF)	–0.657***	–0.774**	–0.117
	(2.69)	(–2.51)	(–0.30)

Panel B. Fund Performance

VARIABLES	Short-Term Change in *Y*	Long-Term Change in *Y*	Long-Term – Short-Term
Y = 4-factor Alpha			
Top Y	–0.101***	–0.114***	–0.013
	(–16.50)	(–16.06)	(–1.38)
Y = 5-factor Alpha			
Top Y	–0.089***	–0.109***	–0.020**
	(–14.19)	(–15.04)	(–2.05)
Y = DGTW-adj. Return			
Top Y	–0.143***	–0.162***	–0.019
	(–19.28)	(–26.27)	(–1.18)
Y = Liquidity-adjusted DGTW			
Top Y	–0.068***	–0.075***	–0.007
	(–23.11)	(–25.07)	(–1.64)

Table XII
Mutual Funds' Responses to the Regulation Change

This table reports the results of multivariate regressions of changes in the information asymmetry of funds' portfolios and changes in funds' trade length after the regulation change in 2004. All variables are as defined in Tables II and VII. The changes in fund-level information asymmetry variables are constructed following the procedure in Section VII to capture the effects of funds actively rebalancing their portfolios. For any performance variable *Y*, *Top Y* is the indicator variable that equals one if *Y* is in the top quartile in the one year prior to May 2004 and zero otherwise. This table reports the results when the top performance quartile is determined by *4-factor Alpha*, *5-factor Alpha*, *DGTW-adj. Return*, and *Liquidity-adj. DGTW*, respectively. The variables are defined in the Appendix. All regressions include controls for fund characteristics as in Table VII. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	ΔSize	ΔAnalyst Coverage	ΔAmihud	ΔRspread	ΔSize-wght. Rspread	ΔEff. Spread	ΔTrade Length
Y = 4-factor Alpha	0.065*	0.358**	–0.075*	–0.040**	–0.041*	–0.040**	–0.062
Top Y	(1.75)	(2.56)	(–1.72)	(–2.02)	(–1.78)	(–2.03)	(–1.26)
Y = 5-factor Alpha	0.075**	0.301**	–0.093**	–0.047**	–0.049**	–0.047**	–0.066
Top Y	(2.04)	(2.19)	(–2.16)	(–2.38)	(–2.16)	(–2.39)	(–1.34)
Y = DGTW-adj. return	0.107***	0.348***	–0.113***	–0.066***	–0.056***	–0.058***	–0.160***
Top Y	(3.60)	(2.90)	(–3.30)	(–4.09)	(–3.18)	(–3.69)	(–3.55)
Y = Liquidity-adj.DGTW	0.081***	0.462***	–0.065**	–0.050***	–0.034**	–0.042***	–0.072
Top Y	(3.01)	(3.93)	(–2.17)	(–3.38)	(–2.14)	(–2.98)	(–1.56)

Supplementary Appendix for

"Mandatory Portfolio Disclosure, Stock Liquidity, and Mutual Fund Performance"

This Supplementary Appendix consists of two sections. Section I provides the propositions and their proofs about our model of informed trading with different mandatory disclosure frequencies. Section II tabulates additional results for some of the empirical tests that we conduct in the paper.

I. Propositions and Proofs

A. Propositions

The following proposition characterizes the strategies and expected profits of the informed trader, and the pricing rules of the market maker. In the proof of the proposition, we also show that this is the unique equilibrium when strategies are constrained to be of the forms given in (1) – (4).

Proposition 1: If $k > 1$, then the equilibrium strategies can be characterized as follows.

(i) There are constants α_n, δ_n, λ_n, β_n, Σ_n, γ_n, $\sigma^2_{z_n}$, such that the strategies satisfy (1) – (4), and the informed trader's expected profits are given by

$$E[\tilde{\pi}_n \mid p^*_1, \ldots, p^*_{n-1}, v] = \alpha_{n-1}(v - p^*_{n-1})^2 + \delta_{n-1}, \text{ for } 1 \le n \le N. \quad \text{(SA1)}$$

We define constants $\mu_n \equiv \alpha_n \lambda_n$, for $1 \le n \le N-1$ and $\mu_N = 0$, to facilitate the presentation of results below. Given Σ_0 and σ^2_u, the constants α_n, λ_n, β_n, Σ_n, γ_n, and $\sigma^2_{z_n}$ solve the following recursive equation system:

(a) If $n = N$,

$$\alpha_{N-1} = \frac{1}{4\lambda_N}, \beta_N = \frac{1}{2\lambda_N}, \lambda_N = \beta_N \frac{\Sigma_N}{\sigma^2_u}, \Sigma_N = \frac{1}{2}\Sigma_{N-1}. \quad \text{(SA2)}$$

(b) If $n = N-1$, or $n < N$ is not equal to km or $km-1$ for some integer $m > 0$,

$$\lambda_{n+1} = \frac{\lambda_n}{4\mu_n(1-\mu_{n+1})}, \alpha_{n-1} = \frac{1}{4\lambda_n(1-\mu_n)}, \beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)},$$
$$\lambda_n = \frac{\beta_n \Sigma_n}{\sigma_u^2}, \Sigma_n = \frac{1}{2(1-\mu_n)}\Sigma_{n-1}. \tag{SA3}$$

(c) If $n < N-1$ is equal to $km-1$ for some integer $m > 0$,

$$\lambda_{n+1} = \frac{\lambda_n}{4\mu_n}, \alpha_{n-1} = \frac{1}{4\lambda_n(1-\mu_n)}, \beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)}$$
$$\lambda_n = \beta_n \frac{\Sigma_n}{\sigma_u^2}, \Sigma_n = \frac{1}{2(1-\mu_n)}\Sigma_{n-1}. \tag{SA4}$$

(d) If $n < N$ is a multiple of k,

$$\lambda_{n+1} = \frac{\lambda_n}{1-\mu_{n+1}}, \alpha_{n-1} = \frac{1}{4\lambda_{n+1}(1-\mu_{n+1})}, \beta_n = \frac{1-2\mu_{n+1}}{4\lambda_n(1-\mu_{n+1})},$$
$$\lambda_n = \frac{\beta_n \Sigma_{n-1}}{2\sigma_u^2} = \frac{(1-\mu_{n+1})\beta_n \Sigma_n}{\sigma_u^2}, \Sigma_n = \frac{1}{2(1-\mu_{n+1})}\Sigma_{n-1}, \gamma_n = 2\lambda_n, \sigma_{z_n}^2 = \frac{1}{2(1-\mu_{n+1})}\sigma_u^2. \tag{SA5}$$

(e) In the first period, the market depth parameter is given by

$$\lambda_1 = \frac{\sqrt{1-2\mu_1}}{2(1-\mu_1)} \frac{\sqrt{\Sigma_0}}{\sigma_u}. \tag{SA6}$$

(ii) The sequence of constants $\{\mu_n\}_{1 \le n \le N}$ that appear in the recursive formulas (SA2) – (SA6) do not depend on Σ_0 and σ_u, and are uniquely determined by the following equations:

(a) If $n = N$, then $\mu_N = 0$.

(b) If $n = N-1$, or $n < N$ is not equal to km or $km-1$ for some integer $m > 0$, then $0 < \mu_n < 1/2$ and

$$8(\mu_n^3 - \mu_n^2) - \frac{1}{1-2\mu_{n+1}}(2\mu_n - 1) = 0. \tag{SA7}$$

(c) If $n < N-1$ is equal to $km-1$ for some $m > 0$, then $0 < \mu_n < 1/2$ and

$$8(\mu_n^3 - \mu_n^2) - \frac{2(1-\mu_{n+2})}{1-2\mu_{n+2}}(2\mu_n - 1) = 0. \quad \text{(SA8)}$$

(d) If $n < N$ is a multiple of k, then $\mu_n = 1/4$.

(iii) In the case of full disclosure in each period (or the case of k = 1), the equilibrium strategies are characterized below. Denote the constants by $\hat{\alpha}_n$, $\hat{\delta}_n$, $\hat{\lambda}_n$, $\hat{\beta}_n$, $\hat{\Sigma}_n$, $\hat{\gamma}_n$, $\sigma^2_{\hat{z}_n}$.

(a) If $n = N$, then

$$\hat{\alpha}_{N-1} = \frac{1}{4\hat{\lambda}_N}, \hat{\lambda}_N = \frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{N}}, \hat{\beta}_N = \frac{1}{2\hat{\lambda}_N}, \hat{\Sigma}_N = \frac{1}{2}\hat{\Sigma}_{N-1}. \quad \text{(SA9)}$$

(b) If n < N, then

$$\begin{aligned} &\hat{\alpha}_{n-1} = \frac{1}{4\hat{\lambda}_n}, \hat{\lambda}_n = \frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{N}}, \hat{\beta}_n = \frac{1}{2(N-n+1)\hat{\lambda}_n}, \\ &\hat{\Sigma}_n = \frac{N-n}{N-n+1}\hat{\Sigma}_{n-1} = \frac{N-n}{N}\Sigma_0, \hat{\gamma}_n = 2\hat{\lambda}_n, \sigma^2_{\hat{z}_n} = \frac{N-n}{N-n+1}\sigma_u^2. \end{aligned} \quad \text{(SA10)}$$

Part (i) gives the recursive formulae for the strategy parameters. Part (ii) directly computes the series of key constants μ_n (used in the recursive formulae) through backward induction. Part (iii) for the case k = 1 simply replicates the solution given in Proposition 4 in Huddart, Hughes, and Levine (2001). In the special case $k = N$, the equilibrium given in the above proposition reduces to the Kyle (1985) model.

Proposition 2. (i) Assume k = 2, that is, the informed trader is required to disclose once every two periods. Denote the average illiquidity for the case in which the informed trader is required to disclose every two periods by $\Lambda_N = \frac{1}{N}\sum_{i=1}^{N}\lambda_i$ and denote the average illiquidity for the case the informed trader is required to disclose every period by $\hat{\Lambda}_N = \frac{1}{N}\sum_{n=1}^{N}\hat{\lambda}_n$. Then

$$\hat{\Lambda}_N < \Lambda_N. \tag{SA11}$$

That is, more frequent disclosure leads to lower average illiquidity or higher average liquidity. Furthermore, the difference $\Lambda_N - \hat{\Lambda}_N$ increases with the extent of asymmetric information $\sqrt{\Sigma_0}$.

(ii) Denote the expected profits of the informed trader in the case in which the informed trader is required to disclose every two periods by Π_N and every period by $\hat{\Pi}_N$. Then

$$\Pi_N > \hat{\Pi}_N. \tag{SA12}$$

In other words, the informed trader's profits are decreasing in the frequency of disclosure. The difference $\Pi_N - \hat{\Pi}_N$ increases with the extent of asymmetric information $\sqrt{\Sigma_0}$.

(iii) If $N' > N \geq 2$, then

$$\hat{\Pi}_{N'} - \Pi_{N'} < \hat{\Pi}_N - \Pi_N. \tag{SA13}$$

In other words, the informed trader's profit decline from more frequent disclosure is greater when the total number of periods is larger.

This proposition shows that market liquidity increases as a result of more frequent disclosure. Furthermore, the liquidity improvement depends positively on the extent of asymmetric information about the underlying security. The informed trader, however, makes less profits due to the more frequent mandatory disclosure. His profit decline is greater when information asymmetry is higher or when trading takes longer. Note that the cases $k = 2$ and $k = 1$ in the proposition correspond closely to the regulation where the mandatory disclosure frequency is increased from semi-annual to quarterly.

B. Proofs

Proof of Proposition 1.

Part (i): We first prove (a)-(d) by induction.

Case (a): Because $n = N$ is the last period, the disclosure requirement does not change the insider's strategy and thus the solution given in Theorem 2 of Kyle (1985) applies and

(A6) holds. Now assume that (a)-(d) holds for the (n+1)-th period, we will show that it also holds for the n-th period.

Case (b): If $n = N-1$, or $n < N$ is not equal to km or $km-1$ for some integer $m > 0$, then Theorem 2 of Kyle (1985) applies to period n and we have

$$\begin{aligned} &\alpha_{n-1} = \frac{1}{4\lambda_n(1-\mu_n)}, \beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)} \\ &\lambda_n = \beta_n \frac{\Sigma_n}{\sigma_u^2}, \Sigma_n = (1-\lambda_n\beta_n)\Sigma_{n-1} = \frac{1}{2(1-\mu_n)}\Sigma_{n-1}. \end{aligned} \tag{SA14}$$

Furthermore, because n+1 is not a multiple of k, cases (a)-(c) for the (n+1)-th period imply that

$$\begin{aligned} &\alpha_n = \frac{1}{\lambda_{n+1}(1-\mu_{n+1})}, \\ &\lambda_{n+1} = \frac{1}{4\alpha_n(1-\mu_{n+1})} = \frac{\lambda_n}{4(1-\mu_{n+1})\alpha_n\lambda_n} = \frac{\lambda_n}{4\mu_n(1-\mu_{n+1})}. \end{aligned} \tag{SA15}$$

Equations (SA14) and (SA15) complete the proof of (SA3) in case (b).

Case (c): If $n < N-1$ is equal to $km-1$ for some integer $m > 0$, then the insider is not required to disclose and Theorem 2 of Kyle (1985) also applies to period n and we have

$$\begin{aligned} &\alpha_{n-1} = \frac{1}{4\lambda_n(1-\mu_n)}, \beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)} \\ &\lambda_n = \beta_n \frac{\Sigma_n}{\sigma_u^2}, \Sigma_n = (1-\lambda_n\beta_n)\Sigma_{n-1} = \frac{1}{2(1-\mu_n)}\Sigma_{n-1}. \end{aligned} \tag{SA16}$$

Since n+1 is equal to km, case (d) for the (n+1)-th period implies

$$\lambda_{n+2} = \frac{1}{4\alpha_n(1-\mu_{n+2})} = \frac{\lambda_n}{4(1-\mu_{n+2})\alpha_n\lambda_n} = \frac{\lambda_n}{4\mu_n(1-\mu_{n+2})}$$

and

$$\lambda_{n+2} = \frac{\lambda_{n+1}}{1-\mu_{n+2}}.$$

Therefore,

$$\lambda_{n+1} = \lambda_{n+2}(1-\mu_{n+2}) = \frac{\lambda_n}{4\mu_n}. \qquad \text{(SA17)}$$

Equations (SA16) and (SA17) complete the proof of (SA4) in case (c).

Case (d): If $n < N$ is a multiple of *k*, consider the insider's expected profits conditional on his information set in the (*n*-1)-th period,

$$\begin{aligned} &E_{n-1}[\tilde{\pi}_n(p^*_{n-1}, v) \mid v] = E_{n-1}[x_n(v-p_n) + \alpha_n(v-p^*_n)^2 + \delta_n \mid v] \\ &= E_{n-1}[x_n(v-p^*_{n-1} - \lambda_n(x_n+u_n)) + \alpha_n(v-p^*_{n-1} - \gamma_n x_n)^2 + \delta_n \mid v] \\ &= E_{n-1}[(\alpha_n\gamma_n^2 - \lambda_n)x_n^2 + (1-2\gamma_n\alpha_n)x_n(v-p^*_{n-1}) + \alpha_n(v-p^*_{n-1})^2 \mid v] + \delta_n. \end{aligned} \qquad \text{(SA18)}$$

The strategy $x_n = \beta_n(v-p^*_{n-1}) + z_n$ with the noise term $z_n \sim N(0, \sigma^2_{z_n})$ implies that the insider is indifferent among different values of x_n, therefore

$$\begin{aligned} \alpha_n\gamma_n^2 - \lambda_n &= 0, \\ 1-2\gamma_n\alpha_n &= 0. \end{aligned}$$

This implies that

$$\gamma_n = 2\lambda_n, \lambda_n = \frac{1}{4\alpha_n} = \frac{\lambda_{n+1}}{1-\mu_{n+1}}. \qquad \text{(SA19)}$$

where in the last step we use the equation for α_n given by cases (a)-(c) for the period (*n*+1). The breakeven conditions of the market maker are

$$\begin{aligned} p_n &= E_{n-1}[v \mid x_n + u_n] = p^*_{n-1} + \lambda_n(x_n+u_n) \\ p^*_n &= E_{n-1}[v \mid x_n] = p^*_{n-1} + \gamma_n x_n \end{aligned}$$

implying that

$$\begin{aligned} \lambda_n &= \frac{Cov(v, x_n+u_n)}{Var(x_n+u_n)} = \frac{\beta_n\Sigma_{n-1}}{\beta_n^2\Sigma_{n-1} + \sigma^2_{z_n} + \sigma^2_u} \\ \gamma_n &= \frac{Cov(v, x_n)}{Var(x_n)} = \frac{\beta_n\Sigma_{n-1}}{\beta_n^2\Sigma_{n-1} + \sigma^2_{z_n}} \end{aligned} \qquad \text{(SA20)}$$

Equations (SA19) and (SA20) imply that

$$\beta_n^2\Sigma_{n-1} + \sigma_{z_n}^2 = \sigma_u^2 \tag{SA21}$$

and

$$\lambda_n = \frac{\beta_n \Sigma_{n-1}}{2\sigma_u^2} \tag{SA22}$$

We also have

$$\Sigma_n = Var_{n-1}[v \mid x_n] = Var_{n-1}[v] - \frac{Cov_{n-1}(v, x_n)^2}{Var_{n-1}(x_n)} = \Sigma_{n-1} - \gamma_n \beta_n \Sigma_{n-1} \tag{SA23}$$

Equations (SA22) and (SA23) imply that

$$\Sigma_n = \Sigma_{n-1} - 4\lambda_n{}^2 \sigma_u^2 = \Sigma_{n-1} - 4\lambda_{n+1}^2 (1-\mu_{n+1})^2 \sigma_u^2 \tag{SA24}$$

Recall from the (n+1)-period that

$$\begin{aligned} \Sigma_{n+1} &= \frac{1}{2(1-\mu_{n+1})}\Sigma_n, \\ \lambda_{n+1}^2 &= \frac{\lambda_{n+1}\beta_{n+1}\Sigma_{n+1}}{\sigma_u^2} = \frac{1-2\mu_{n+1}}{2(1-\mu_{n+1})}\frac{\Sigma_{n+1}}{\sigma_u^2} = \frac{1-2\mu_{n+1}}{4(1-\mu_{n+1})^2}\frac{\Sigma_n}{\sigma_u^2} \end{aligned} \tag{SA25}$$

Plugging into (SA24), we obtain

$$\Sigma_n = \frac{\Sigma_{n-1}}{2(1-\mu_{n+1})}. \tag{SA26}$$

Equations (SA22), (SA25), and (SA26) imply that

$$\begin{aligned} \beta_n &= \frac{2\lambda_n \sigma_u^2}{\Sigma_{n-1}} = \frac{2\sigma_u^2(1-\mu_{n+1})\lambda_{n+1}}{\Sigma_{n-1}} = \frac{2\sigma_u^2(1-\mu_{n+1})\lambda_{n+1}^2}{\lambda_{n+1}\Sigma_{n-1}} \\ &= \frac{(1-2\mu_{n+1})\Sigma_{n+1}}{\lambda_{n+1}\Sigma_{n-1}} = \frac{(1-2\mu_{n+1})}{4\lambda_{n+1}(1-\mu_{n+1})^2} = \frac{1-2\mu_{n+1}}{4\lambda_n(1-\mu_{n+1})}. \end{aligned} \tag{SA27}$$

Finally, equations (SA18) and (SA19) imply that

$$\alpha_{n-1} = \alpha_n = \frac{1}{4\lambda_{n+1}(1-\mu_{n+1})} = \frac{1}{4\lambda_n}. \tag{SA28}$$

Equations (SA19), (SA22), (SA26), (SA27), and (SA28) complete the proof of (SA5) in case (d).

Case (e): Since $k > 1$, cases (b) and (c) imply that

$$\lambda_1 = \beta_1 \frac{\Sigma_1}{\sigma_u^2} = \frac{\beta_1 \Sigma_0}{2(1-\mu_1)\sigma_u^2} = \frac{1-2\mu_1}{4\lambda_1(1-\mu_1)^2} \frac{\Sigma_0}{\sigma_u^2}.$$

Therefore, $\lambda_1 = \dfrac{\sqrt{1-2\mu_1}}{2(1-\mu_1)} \dfrac{\sqrt{\Sigma_0}}{\sigma_u}$.

Part (ii): The proof of this part will need the following lemma.

Lemma 1. Suppose $K > 0$, then there is a unique solution $\mu \in (0,1)$ to the following equation

$$8\mu^3 - 8\mu^2 - K(2\mu - 1) = 0. \tag{SA29}$$

Furthermore, $0 < \mu < 1/2$.

Proof of the Lemma 1. By taking the derivative, it is easy to show that the function $f(\mu) = \dfrac{8\mu^2(1-\mu)}{1-2\mu}$ is increasing for $\mu \in (0,1/2)$. Because $f(\mu)$ approaches 0 as $\mu \searrow 0^+$, and ∞ as $\mu \nearrow {}^1\!/_2{}^-$, there is a unique $\mu \in (0,1/2)$ such that $f(\mu) = K$, i.e., (SA29) is satisfied. Because $f(\mu) < 0$ for $\mu \in (1/2,1)$, the above solution is also the unique solution in the interval $(0,1)$. Q.E.D.

We proceed to prove cases (a)-(d) sequentially. Case (a) is trivial as we define $\mu_N = 0$. In Case (b), $n = N-1$, or $n < N$ is not equal to km or $km-1$ for some integer $m > 0$. Applying Part (i) Cases (a)-(c) to the periods n and (n+1),

$$\begin{aligned} &\lambda_n = \beta_n \frac{\Sigma_n}{\sigma_u^2}, \beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)}, \\ &\lambda_{n+1} = \beta_{n+1} \frac{\Sigma_{n+1}}{\sigma_u^2}, \Sigma_{n+1} = \frac{1}{2(1-\mu_{n+1})}\Sigma_n, \beta_{n+1} = \frac{1-2\mu_{n+1}}{2\lambda_{n+1}(1-\mu_{n+1})}. \end{aligned} \tag{SA30}$$

From (SA30), we obtain

$$\frac{\lambda_{n+1}}{\lambda_n} = \frac{1}{2(1-\mu_{n+1})}\frac{\beta_{n+1}}{\beta_n}. \tag{SA31}$$

Next, plugging the equality $\beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)}$ and $\beta_{n+1} = \frac{1-2\mu_{n+1}}{2\lambda_{n+1}(1-\mu_{n+1})}$ from (SA30) into (SA31) and reorganizing, we obtain

$$\left(\frac{\lambda_{n+1}}{\lambda_n}\right)^2 = \frac{2(1-\mu_n)}{1-2\mu_n}\frac{1-2\mu_{n+1}}{4(1-\mu_{n+1})^2}. \tag{SA32}$$

Part (i) Case (b) implies that

$$\frac{\lambda_{n+1}}{\lambda_n} = \frac{1}{4\mu_n(1-\mu_{n+1})}. \tag{SA33}$$

Substituting (SA33) into (SA32), we obtain the recursive equation

$$8(\mu_n^3 - \mu_n^2) - \frac{1}{1-2\mu_{n+1}}(2\mu_n - 1) = 0. \tag{SA34}$$

By the second order condition in Kyle (1985), $0 < \mu_n < 1$. It then follows from Lemma 1 that if $0 < \mu_{n+1} < 1/2$, there is a unique root μ_n of (SA34) in (0,1) such that $0 < \mu_n < 1/2$, which proves Case (b).

Case (c): Applying Part (i) Cases (c) and (d) to the periods n and (n+1), respectively,

$$\begin{aligned}&\lambda_n = \beta_n \frac{\Sigma_n}{\sigma_u^2}, \beta_n = \frac{1-2\mu_n}{2\lambda_n(1-\mu_n)},\\ &\lambda_{n+1} = \beta_{n+1}\frac{\Sigma_n}{2\sigma_u^2}, \beta_{n+1} = \frac{1-2\mu_{n+2}}{4\lambda_{n+1}(1-\mu_{n+2})}, \lambda_{n+1} = \frac{\lambda_n}{4\mu_n}.\end{aligned} \tag{SA35}$$

Using (SA35) and similar algebra as in Case (b), we obtain

$$8(\mu_n^3 - \mu_n^2) - \frac{2(1-\mu_{n+2})}{1-2\mu_{n+2}}(2\mu_n - 1) = 0. \tag{SA36}$$

The lemma now together with induction then implies that Case (c) holds.

Case (d): By Part (i) Case (a)-(d), $\alpha_n = \frac{1}{4\lambda_{n+1}(1-\mu_{n+1})} = \frac{1}{4\lambda_n}$, which implies that

$\mu_n = \alpha_n \lambda_n = 1/4.$

Part (iii): This is simply a replication of the solution for the case of disclosure in every period given in Proposition 4 of HHL. We refer the reader to HHL for the proof. Q.E.D.

Proof of Proposition 2.

Since λ_n is proportional to $\frac{\sqrt{\Sigma_0}}{\sigma_u}$, the aggregate illiquidity function $\Lambda_N = \sum_{n=1}^{N} \lambda_n$ is proportional to $\sqrt{\Sigma_0}\sigma_u$, and so is the aggregate illiquidity in the full-disclosure case $\hat{\Lambda}_N$. Therefore, if (A15) is true, the decrease in illiquidity $\Lambda_N - \hat{\Lambda}_N$, or improvement in liquidity is proportional to $\sqrt{\Sigma_0}\sigma_u$, and is thus increasing in Σ_0. We next proceed to prove (SA11).

To facilitate the proof, we explicitly indicate the total number of periods in our notations below, such as using $\mu_{n,N} = \mu_n, \lambda_{n,N} = \lambda_n$. We will also assume that $\frac{\sqrt{\Sigma_0}}{\sigma_u} = 1$, since it is just a normalizing constant in (SA11). We first show the following lemma that is useful for our proof.

Lemma 2. i) $\mu_{2k-1,N}, k = 1, 2, \ldots, \frac{N}{2}$ is decreasing with *k*.

ii) For $N \geq 4$,

$$\lambda_{2m-1,N} + \lambda_{2m,N} > \lambda_{2m+1,N} + \lambda_{2m+2,N}, \text{ if } m \leq \frac{N}{2} - 2. \tag{SA37}$$

iii) For any $0 \leq k \leq N$,

$$\frac{\lambda_{N-2k+2,N+2}}{\lambda_{N-2k,N}} > \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}} \tag{SA38}$$

$$\frac{\lambda_{N-2k+1,N+2}}{\lambda_{N-2k-1,N}} > \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}} \tag{SA39}$$

Proof of Lemma 2.

Part i): Define $v_i = \mu_{N-2i+1}$, the recursive formula (SA8) implies that

$$f(v_{i+1}) = \frac{2(1-v_i)}{1-2v_i} \tag{SA40}$$

where $f(x) = \frac{8x^2(1-x)}{1-2x}$. We also have $v_k \in (0,1/2)$. Therefore

$$f(v_{i+1}) = \frac{8v_{i+1}^2(1-v_{i+1})}{1-2v_{i+1}} = \frac{2(1-v_i)}{1-2v_i} > \frac{8v_i^2(1-v_i)}{1-2v_i} = f(v_i)$$

Since $f(\cdot)$ is increasing for $x \in (0,1/2)$, v_i is increasing in *i* and thus μ_{2k-1} is decreasing in *k*.

Part ii): We have

$$\frac{\lambda_{2m-1}+\lambda_{2m}}{\lambda_{2m+1}+\lambda_{2m+2}} = \frac{1+\frac{1}{4\mu_{2m-1}}}{1+\frac{1}{4\mu_{2m+1}}} 4\mu_{2m-1}(1-\mu_{2m+1}) = \frac{1+4\mu_{2m-1}}{1+4\mu_{2m+1}} 4\mu_{2m+1}(1-\mu_{2m+1}) \tag{SA41}$$

We know that $f(\mu_{2m-1}) = \frac{1-\mu_{2m+1}}{1-2\mu_{2m+1}}$ and the function $y = \frac{1+4x^2}{16x(1-x)}$ satisfies $f(y) < \frac{2(1-x)}{1-2x}$, if 1/2>$x > 0.36$. Therefore, the increasing property of the function *f* implies that

$$\mu_{2m-1} > \frac{1+4\mu_{2m+1}^2}{16\mu_{2m+1}(1-\mu_{2m+1})}, \text{ if } \mu_{2m+1} > 0.36 \tag{SA42}$$

Plugging (SA42) into (SA41), we have

$$\frac{\lambda_{2m-1}+\lambda_{2m}}{\lambda_{2m+1}+\lambda_{2m+2}} > 1, \text{ if } \mu_{2m+1} > 0.36. \tag{SA43}$$

Since $m \le \frac{N}{2} - 2$, Part i) and the fact that $\mu_{N-3} = v_2 = 0.387 > 0.36$ imply that $\mu_{2m+1} > 0.36$ and thus (SA37) holds.

Part iii): First, note that by the recursive formulas in Proposition 1,

$$\lambda_{N-2k,N} = \frac{1}{4\mu_{N-2k-1}}\lambda_{N-2k-1,N} = \frac{1}{4\mu_{N-2k-1}}\frac{1}{4\mu_{N-2k-3}(1-\mu_{N-2k-1})}\lambda_{N-2k-3,N} = \dots$$

$$= \left(\prod_{m=2}^{N/2-k}\frac{1}{4\mu_{2m-1}(1-\mu_{2m-1})}\right)\frac{1}{4\mu_1}\lambda_{1,N} = \frac{\sqrt{1-2\mu_1}}{2}\left(\prod_{m=1}^{N/2-k}\frac{1}{4\mu_{2m-1}(1-\mu_{2m-1})}\right)$$

$$= \frac{\sqrt{1-2v_{N/2}}}{2}\left(\prod_{i=N/2-k}^{N/2}\frac{1}{4v_i(1-v_i)}\right)$$

Therefore,

$$\frac{\lambda_{N-2k+2,N+2}}{\lambda_{N-2k,N}} = \frac{\sqrt{1-2v_{N/2+1}}}{2}\frac{1}{4v_{N/2+1}(1-v_{N/2+1})}\frac{2}{\sqrt{1-2v_{N/2}}}$$

$$= \frac{\sqrt{1-2v_{N/2+1}}}{\sqrt{1-2v_{N/2}}}\frac{1}{4v_{N/2+1}(1-v_{N/2+1})}$$

$$= \sqrt{\frac{4v_{N/2+1}^2(1-v_{N/2+1})}{1-v_{N/2}}}\frac{1}{4v_{N/2+1}(1-v_{N/2+1})}$$

$$= \frac{1}{2\sqrt{(1-v_{N/2})(1-v_{N/2+1})}} > \frac{1}{2\sqrt{(1-\frac{N-1}{2N})(1-\frac{N+1}{2(N+2)})}}$$

$$= \frac{\sqrt{N(N+2)}}{\sqrt{(N+1)(N+3)}} > \sqrt{\frac{N}{N+2}} = \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}}.$$

Where we used the fact that $v_i \geq \frac{i-1}{2i}$, which is easily verified using the recursive formula (SA40) and the increasing property of the function *f*. This proves (SA38). (SA39) now follows from (SA38) and the recursive relations $\lambda_{N-2k-1,N} = 4\mu_{N-2k-1}\lambda_{N-2k,N} = 4v_{k-1}\lambda_{N-2k,N}$ and $\lambda_{N-2k+1,N+2} = 4v_{k-1}\lambda_{N-2k+2,N+2}$. This completes the proof of the lemma. Q.E.D.

Given the lemma, we will prove (SA11) using induction on the number of periods *N*. In the case *N* = 2, using the recursive formulas in Proposition 1, it is easy to obtain that

$$\lambda_{1,2} + \lambda_{2,2} = 0.462 + 0.416 > 2\hat{\lambda}_{2,2} = 0.707$$

We will next show the following equations hold for any $N \geq 4$,

$$\begin{aligned}\lambda_{N-3,N} + \lambda_{N-2,N} &\geq 2\hat{\lambda}_{N,N},\\ \lambda_{N-2,N} + \lambda_{N-1,N} &\geq 2\hat{\lambda}_{N,N}.\end{aligned} \qquad \text{(SA44)}$$

For $N = 4$, we have

$$\lambda_{1,4} + \lambda_{2,4} = 0.388 + 0.251 > 2\hat{\lambda}_{2,2} = 0.5$$
$$\lambda_{3,4} + \lambda_{4,4} = 0.345 + 0.312 > 2\hat{\lambda}_{2,2} = 0.5$$

Now suppose (SA44) hold for N. Equation (SA38) from Lemma 2 then imply that

$$\frac{\lambda_{N-1,N+2} + \lambda_{N,N+2}}{\hat{\lambda}_{N+2,N+2}} \geq \frac{\lambda_{N-3,N} + \lambda_{N-2,N}}{\hat{\lambda}_{N,N}} \geq 2$$
$$\frac{\lambda_{N+1,N+2} + \lambda_{N+2,N+2}}{\hat{\lambda}_{N+2,N+2}} \geq \frac{\lambda_{N-1,N} + \lambda_{N,N}}{\hat{\lambda}_{N,N}} \geq 2$$

Thus (SA44) also hold for $N + 2$. Combing (SA44) and (SA37), we see that

$$\begin{aligned} \Lambda_N &= \sum_{m=1}^{N/2} (\lambda_{2m-1,N} + \lambda_{2m,N}) \geq \frac{N-2}{2}(\lambda_{N-3,N} + \lambda_{N-2,N}) + (\lambda_{N-1,N} + \lambda_{N,N}) \\ &\geq \frac{N}{2} \times 2\hat{\lambda}_{N,N} = \hat{\Lambda}_N \end{aligned} \tag{SA45}$$

This completes the proof of (SA11).

(ii) We shall first show that the expected profits of the informed trader in period n for the cases $k = 1$ and $k = 2$ are given by

$$\begin{aligned} E[\pi_n] &= \lambda_n \sigma_n^2, \quad 1 \leq n \leq N, \\ E[\hat{\pi}_n] &= \hat{\lambda}_n \sigma_n^2, \quad 1 \leq n \leq N. \end{aligned} \tag{SA46}$$

Indeed, in the case where the informed trader is required to disclose every period (k = 1), Proposition 4 of HHL shows that the expected profit is given by $E[\hat{\pi}_n] = \frac{\sigma_u}{2}\sqrt{\hat{\Sigma}_0 / N} = \hat{\lambda}_n \sigma_u^2$.

In the case where the informed trader is only required to disclose every two periods (k = 2), if $n = N$ or n is not a multiple of 2, then by (1), (2), (SA12), and (SA15), the expected profit is

$$\begin{aligned} E[x_n(v - p_n)] &= E[\beta_n(v - p_{n-1}^*)(v - p_{n-1}^* - \lambda_n(\beta_n(v - p_{n-1}^*) + u_n))] \\ &= \beta_n(1 - \lambda_n\beta_n)\Sigma_{n-1} = \beta_n\Sigma_n = \lambda_n\sigma_u^2. \end{aligned}$$

If $n < N$ is a multiple of 2, then by (1), (2), and (SA5),

$$\begin{aligned} E[x_n(v - p_n)] &= E[(\beta_n(v - p_{n-1}^*) + z_n)(v - p_{n-1}^* - \lambda_n(\beta_n(v - p_{n-1}^*) + z_n + u_n))] \\ &= \beta_n(1 - \lambda_n\beta_n)\Sigma_{n-1} - \lambda_n\sigma_{z_n}^2 = \beta_n \frac{3 - 2\mu_{n+1}}{4(1 - \mu_{n+1})}\Sigma_{n-1} - \frac{1}{2(1 - \mu_{n+1})}\lambda_n\sigma_u^2 \\ &= \frac{3 - 2\mu_{n+1}}{2(1 - \mu_{n+1})}\lambda_n\sigma_u^2 - \frac{1}{2(1 - \mu_{n+1})}\lambda_n\sigma_u^2 \\ &= \lambda_n\sigma_u^2. \end{aligned}$$

Therefore, (SA46) always hold. Combining part (i) and (SA46), we obtain the desired result on total expected profits,

$$\Pi_N = \sum_{n=1}^{N} E[\pi_n] = \sum_{n=1}^{N} \lambda_n \sigma_u^2 = \Lambda_N \sigma_u^2 > \hat{\Lambda}_N \sigma_u^2 = \hat{\Pi}_N .$$

As the expected profits are proportional to the aggregate illiquidity, by part (i), the difference $\Pi_N - \hat{\Pi}_N$ decreases with $\sqrt{\Sigma_0}$.

(iii) We shall show for any $N \geq 2$,

$$\hat{\Pi}_{N+2} - \Pi_{N+2} < \hat{\Pi}_N - \Pi_N . \tag{SA47}$$

If this is true, then (A17) follows by induction. Because of (SA46), this is equivalent to

$$\hat{\Lambda}_{N+2} - \Lambda_{N+2} < \hat{\Lambda}_N - \Lambda_N . \tag{SA48}$$

The case $N = 2$ can be directly verified using the expressions of λ 's calculated in (i). Next we show (SA48) holds for any $N \geq 4$. From (SA38) and (SA39) in Lemma 2, we have

$$\lambda_{2i+1,N+2} + \lambda_{2i+2,N+2} > (\lambda_{2i-1,N} + \lambda_{2i,N}) \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}}, \quad 1 \leq i \leq N/2. \tag{SA49}$$

From (SA37) and induction, it is easy to show that

$$\lambda_{1,N+2} + \lambda_{2,N+2} > \lambda_{2i+1,N+2} + \lambda_{2i+2,N+2}, \quad 1 \leq i \leq N/2. \tag{SA50}$$

Using (SA49) and (SA50),

$$\begin{aligned}
&\Lambda_{N+2} - \hat{\Lambda}_{N+2} = \sum_{i=0}^{N/2} (\lambda_{2i+1,N+2} + \lambda_{2i+2,N+2}) - (N+2)\hat{\lambda}_{N+2,N+2} \\
&\geq \frac{N+2}{N} \sum_{i=1}^{N/2} (\lambda_{2i-1,N+2} + \lambda_{2i,N}) \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}} - (N+2)\hat{\lambda}_{N+2,N+2} \\
&= \frac{N+2}{N} \left(\sum_{i=1}^{N/2} (\lambda_{2i-1,N+2} + \lambda_{2i,N}) - N\hat{\lambda}_{N,N} \right) \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}} = \frac{N+2}{N} (\Lambda_N - \hat{\Lambda}_N) \frac{\hat{\lambda}_{N+2,N+2}}{\hat{\lambda}_{N,N}} \\
&= \sqrt{\frac{N+2}{N}} (\Lambda_N - \hat{\Lambda}_N) > \Lambda_N - \hat{\Lambda}_N .
\end{aligned}$$

Q.E.D.

II. Additional Tables for Robustness Checks

In this section, we present results that are omitted from the main text of the paper for the sake of brevity.

SA.I. Analysis of the 1985 Regulation Change

This table presents results for tests on stock liquidity and fund performance conducted using December 1985 as another event month. In the year of 1985, the SEC changed the frequency of disclosure required for mutual funds from a quarterly frequency to a semi-annual frequency. We repeat our analyses in Panel A of Table III and Panel B of Table VII of the paper and present the results in this table.

SA.II. Tests Controlling for the Change in Mutual Fund Ownership

This table presents the results of regressions of the change in stock liquidity on *Mutual Fund Ownership* and the change in mutual fund ownership. It is possible that mutual fund trading changes around the regulation change. Including the change in mutual fund ownership in the regressions helps control for this possibility. We find our results on the impact of the regulation change on stock liquidity are robust to the inclusion of this variable.

SA.III-IV. Tests using Abnormal Ownership

These two tables present results using abnormal mutual fund ownership as the main independent variable in our tests. It is possible that mutual fund ownership of stocks is related to the stock characteristics. To control for this possibility, we use employ a two-stage procedure. In the first stage, we regress mutual fund ownership on both stock characteristics and a lagged liquidity variable. We define the residual from this regression as *Abnormal Mutual Fund Ownership*. In the second stage, we regress the change in stock liquidity on *Abnormal Mutual Fund Ownership* and other control variables. Table SA.III shows that our results in Panel B of Table II and Panel D of Table III in the paper are robust to this specification. Further, the results in Table SA.IV show that our findings on *Non-MF Ownership* and *Hedge Fund Ownership* are also robust to this two-stage procedure.

SA.V. Fund Subsample Tests using Alternative Performance Measures

This table reports results from our fund subsample tests in which we use alternative measures of fund performance. Specifically, we classify informed funds using *Liquidity-adjusted DGTW (Rspread)* and the impatient trading measure of Da, Gao, and Jagannathan (2011). *Liquidity-adjusted DGTW (Rspread)* is analogous to *Liquidity-adjusted DGTW* in the paper (stocks sorted using *Rspread* instead of *Amihud* when forming the DGTW benchmark portfolios). Our results using these alternative measures are qualitatively similar to those presented in Table V in the paper.

SA.VI. Tests using Changes in Mutual Fund Characteristics

In this table, we present results using changes in mutual fund characteristics as the independent variables in regressions estimated using equation (13) of the paper. It is possible that top mutual funds themselves experienced changes around the SEC rule change in 2004; such changes in fund characteristics, rather than the regulation change, may explain the performance deterioration in top funds. Our results on fund performance in this table rules out such a possibility.

SA.VII. Full Period Time-series Placebo Tests excluding Crisis Periods

This table presents results analogous to those presented in Table IX of the paper. We exclude known crisis years (1998, 2000, and 2001) from our placebo period to ensure that our results are not driven by these years. We continue to find the difference in the performance drop for top mandatory and top voluntary funds is statistically larger in May 2004 compared to the 1994–2006 placebo period after excluding the crisis years.

Table SA.I
Impact of the 1985 Regulation Change on Stock Liquidity and Fund Performance

This table presents results related to the 1985 regulation change. Panel A presents regressions of the change in liquidity around December 1985 on *Mutual Fund Ownership*, *Non-MF Ownership*, and the lagged stock characteristic variables we use in Panel B of Table II of the paper. The last two rows report the differences between the coefficients of *Mutual Fund Ownership* and *Non-MF Ownership* and the *p*-values from the *F*-tests of the differences. Panel B presents regressions of the change in mutual fund performance on an indicator variable equal to one if the fund was in the top quartile of a given performance measure and zero otherwise, and the fund characteristics we use in Panel B of Table VII in the paper. Standard errors are adjusted for heteroskedasticity and clustered at the stock level, and *t*-statistics are reported below the coefficients. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

Panel A: 1985 Liquidity Analysis

	(1)	(2)
VARIABLES	ΔAmihud	ΔRspread
MF Ownership	0.453	–1.004
	(0.39)	(–1.14)
Non-MF Ownership	–0.258***	–0.165***
	(–3.61)	(–3.25)
Momentum	–0.484***	–0.392***
	(–18.95)	(–19.80)
Book-to-Market	0.067***	–0.037**
	(3.02)	(–2.10)
Size	–0.193***	–0.112***
	(–11.15)	(–10.40)
Lagged Liquidity	–0.224***	–0.246***
	(–9.76)	(–12.46)
Constant	–0.860***	–0.278***
	(–6.78)	(–6.01)
Observations	1,386	1,386
Adj. R-squared	0.524	0.496
Difference (MF – Non-MF)	0.7112	–0.8388
p-value (Difference)	0.547	0.349

Panel B: 1985 Performance Analysis

VARIABLES	(1) 4-factor Alpha	(2) 5-factor Alpha	(3) DGTW
4-factor Alpha	–0.195		
	(–1.40)		
5-factor Alpha		–0.157	
		(–1.39)	
DGTW			–0.092
			(–0.96)
Log(TNA)	0.156*	0.069	0.066
	(2.11)	(1.26)	(1.69)
Turnover	0.044	0.120	–0.012
	(0.35)	(1.40)	(–0.16)
Expense Ratio	45.559	9.551	20.339
	(1.29)	(0.38)	(1.12)
Constant	–1.283	–0.521	–0.514
	(–1.80)	(–1.02)	(–1.46)
Observations	11	11	12
Adjusted R-squared	0.418	0.367	0.049

Table SA.II
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Regressions Including the Change in Mutual Fund Ownership

This table reports the regression results of the changes in stock liquidity variables around May 2004 on the mutual fund ownership and other control variables as in Panel B of Table II of the paper. We augment these regressions by including *ΔMutual Fund Ownership* as an additional control variable. The independent variables are the averages of the variables in Panel A of Table II in the year prior to May 2004. Standard errors are adjusted for heteroskedasticity and clustered at the stock level and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	ΔAmihud	ΔRspread	ΔSize-weighted Rspread	ΔEff. Spread
Mutual Fund Ownership	–1.194***	–2.088***	–2.416***	–1.966***
	(–10.49)	(–13.64)	(–14.53)	(–11.73)
ΔMutual Fund Ownership	–4.218***	–3.460***	–3.612***	–5.461***
	(–19.79)	(–12.75)	(–12.30)	(–17.59)
Momentum	–0.061***	–0.102***	–0.119***	–0.105***
	(–6.42)	(–10.64)	(–11.74)	(–7.42)
Book-to-Market	–0.123***	–0.049***	–0.029*	–0.136***
	(–9.12)	(–3.34)	(–1.88)	(–6.47)
Size	–0.153***	–0.119***	–0.138***	–0.051***
	(–14.16)	(–16.10)	(–20.41)	(–5.75)
Lagged Liquidity	–0.233***	–0.227***	–0.278***	–0.118***
	(–14.25)	(–12.87)	(–16.79)	(–8.85)
Constant	–1.137***	–0.361***	–0.457***	–0.351***
	(–13.06)	(–8.33)	(–10.35)	(–8.23)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.175	0.173	0.199	0.120

Table SA.III
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Base Regressions Using Abnormal Ownership

This table reports the results of a two-stage regression procedure. In the first stage, we regress the aggregate mutual fund ownership on *Momentum*, *Size*, *Book-to-Market*, and the corresponding lagged liquidity variable. We define *Abnormal MF Ownership* as the residual of this first-stage regression. We then regress the change in stock liquidity around May 2004 on this abnormal ownership variable and other control variables as in Panel B of Table II of the paper. Panels A and C report the results of the first-stage analysis in 2004 and the placebo period in 2006, respectively. Panels B and D report the second-stage regressions in 2004 and 2006, respectively. Panel E reports the differences between the coefficients on abnormal mutual fund ownership in 2004 and 2006 and the *p*-values from *F*-tests. Standard errors are adjusted for heteroskedasticity and clustered at the stock level and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level, respectively.

Panel A. First-Stage Analysis in 2004

	Dependent Variable: MF Ownership			
	(1)	(2)	(3)	(4)
VARIABLES	X = Amihud	X = Rspread	X = Size-weighted Rspread	X = Effective Spread
Momentum	–0.002**	0.004***	0.005***	0.006***
	(–2.53)	(5.28)	(5.47)	(7.29)
Book-to-Market	0.004***	0.002	0.002*	–0.002*
	(3.55)	(1.60)	(1.72)	(–1.81)
Size	–0.020***	0.010***	0.010***	0.011***
	(–15.99)	(13.30)	(14.52)	(16.39)
Liquidity (X)	–0.056***	–0.027***	–0.029***	–0.016***
	(–35.08)	(–16.38)	(–18.80)	(–18.39)
Constant	–0.330***	–0.101***	–0.108***	–0.070***
	(–42.03)	(–29.09)	(–31.29)	(–30.13)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.547	0.449	0.458	0.45

Panel B: Second-Stage Regressions in 2004

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-weighted Rspread	(4) ΔEff. Spread
Abnormal MF Ownership	–0.815***	–1.795***	–2.100***	–1.459***
	(–7.17)	(–11.96)	(–12.94)	(–8.83)
Momentum	–0.081***	–0.127***	–0.146***	–0.140***
	(–8.04)	(–12.80)	(–13.96)	(–9.92)
Book-to-Market	–0.133***	–0.055***	–0.036**	–0.129***
	(–9.13)	(–3.70)	(–2.35)	(–6.14)
Size	–0.139***	–0.143***	–0.165***	–0.068***
	(–13.24)	(–19.24)	(–24.26)	(–7.64)
Lagged Liquidity	–0.177***	–0.174***	–0.211***	–0.077***
	(–12.56)	(–10.46)	(–13.59)	(–5.94)
Constant	–0.795***	–0.160***	–0.206***	–0.224***
	(–10.87)	(–4.02)	(–5.14)	(–5.59)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.0827	0.137	0.165	0.0586

Panel C: First-Stage Analysis in 2006

	Dependent Variable: MF Ownership			
	(1)	(3)	(4)	(5)
VARIABLES	X = Amihud	X = Rspread	X = Size-weighted Rspread	X = Effective Spread
Momentum	–0.004**	0.009***	0.008***	0.009***
	(–2.22)	(4.70)	(4.66)	(4.90)
Book-to-Market	0.001	–0.002	–0.003*	–0.007***
	(0.79)	(–1.59)	(–1.90)	(–4.81)
Size	–0.022***	–0.011***	–0.008***	–0.011***
	(–17.67)	(–10.93)	(–9.31)	(–10.88)
Liquidity (X)	–0.059***	–0.051***	–0.054***	–0.049***
	(–38.26)	(–36.39)	(–39.54)	(–37.10)
Constant	–0.344***	–0.134***	–0.166***	–0.136***
	(–46.43)	(–46.24)	(–50.65)	(–47.16)
Observations	4,467	4,467	4,467	4,467
Adj. R-squared	0.531	0.517	0.536	0.518

Panel D: Second-Stage Regressions in 2006

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-weighted Rspread	(4) ΔEff. Spread
Abnormal MF Ownership	–0.525***	–0.629***	–0.639***	–0.575***
	(–4.99)	(–6.67)	(–6.80)	(–6.44)
Momentum	–0.216***	–0.271***	–0.301***	–0.287***
	(–10.84)	(–15.66)	(–17.48)	(–16.33)
Book-to-Market	–0.036**	–0.038***	–0.021	–0.017
	(–2.42)	(–2.73)	(–1.43)	(–1.19)
Size	–0.072***	–0.114***	–0.129***	–0.090***
	(–7.36)	(–14.28)	(–19.81)	(–11.84)
Lagged Liquidity	–0.085***	–0.127***	–0.156***	–0.182***
	(–6.50)	(–10.79)	(–14.17)	(–15.89)
Constant	–0.439***	–0.395***	–0.481***	–0.802***
	(–6.35)	(–13.37)	(–14.45)	(–25.40)
Observations	4,467	4,466	4,466	4,466
Adj. R-squared	0.0521	0.126	0.172	0.147

Panel E: Differences in the Coefficients on Abnormal Mutual Fund Ownership (Panels B and D)

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-weighted Rspread	(4) ΔEff. Spread
Diff. of Coefficients (2004–2006)	–0.290*	–1.166***	–1.461***	–0.884**
Test of Differences (*p*-value)	0.059	<.0001	<.0001	<.0001

Table SA.IV
Impact of Mandatory Portfolio Disclosure on Stock Liquidity:
Cross-sectional Placebo Regressions Using Abnormal Ownership

This table reports the results of a two-stage regression procedure. In the first stage, we regress the aggregate mutual fund (or non-mutual fund or hedge fund) ownership on *Momentum*, *Size*, *Book-to-Market*, and the corresponding lagged liquidity variable. We define *Abnormal MF Ownership (*or *Abnormal Non-MF Ownership* or *Abnormal Hedge Fund Ownership*) as the residual of the first-stage regression. We then regress the change in stock liquidity around May 2004 on this abnormal ownership variable and other control variables as in Panel B of Table II of the paper. Panels A and C report the results of the first-stage analysis in 2004 for *Non-MF Ownership* and *Hedge Fund Ownership*, respectively. Panels B and D report the second-stage regressions in which we compare *Abnormal MF Ownership* with *Abnormal Non-MF Ownership* and *Abnormal Hedge Fund Ownership*, respectively. The last two rows in Panels B and D compare the coefficients on abnormal mutual fund ownership and the corresponding abnormal institutional ownership variable and the *p*-values from *F*-tests. Standard errors are adjusted for heteroskedasticity and clustered at the stock level and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level, respectively.

Panel A. First-Stage Analysis for Non-MF Institutions

	Dependent Variable: Non-MF Ownership			
	(1)	(2)	(3)	(4)
VARIABLES	X = Amihud	X = Rspread	X = Size-weighted Rspread	X = Effective Spread
Momentum	–0.025***	–0.010***	–0.010***	–0.007***
	(–12.44)	(–5.04)	(–5.03)	(–3.41)
Book-to-Market	0.032***	0.024***	0.025***	0.017***
	(8.45)	(6.19)	(6.36)	(4.37)
Size	–0.029***	0.047***	0.045***	0.035***
	(–8.75)	(23.70)	(24.46)	(21.87)
Liquidity (X)	–0.122***	–0.031***	–0.037***	–0.040***
	(–27.67)	(–7.37)	(–9.29)	(–19.20)
Constant	–0.713***	–0.172***	–0.187***	–0.152***
	(–32.37)	(–18.11)	(–19.61)	(–23.21)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.572	0.483	0.487	0.512

Panel B. Second Stage Regressions for Abnormal Non-MF Ownership

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-weighted Rspread	(4) ΔEff. Spread
Abnormal MF Ownership	–0.636***	–1.302***	–1.562***	–1.057***
	(–5.29)	(–7.66)	(–8.60)	(–5.82)
Abnormal Non-MF Ownership	–0.228***	–0.447***	–0.494***	–0.400***
	(–3.95)	(–6.64)	(–6.93)	(–4.93)
Momentum	–0.081***	–0.127***	–0.146***	–0.140***
	(–8.06)	(–12.84)	(–14.00)	(–9.93)
Book-to-Market	–0.133***	–0.055***	–0.036**	–0.128***
	(–9.16)	(–3.72)	(–2.36)	(–6.16)
Size	–0.139***	–0.143***	–0.165***	–0.068***
	(–13.25)	(–19.42)	(–24.69)	(–7.69)
Lagged Liquidity	–0.177***	–0.173***	–0.211***	–0.077***
	(–12.55)	(–10.49)	(–13.71)	(–5.95)
Constant	–0.795***	–0.160***	–0.206***	–0.224***
	(–10.86)	(–4.01)	(–5.13)	(–5.61)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.0861	0.146	0.174	0.0632
Diff. of Coeffs. (MF – Non-MF)	–0.408***	–0.855***	–1.068***	–0.657***
Test of Difference (*p*-value)	.007	<.0001	<.0001	.004

Panel C. First-Stage Analysis for Hedge Funds

	Dependent Variable: HF Ownership			
	(1)	(2)	(3)	(4)
VARIABLES	X = Amihud	X = Rspread	X = Size-weighted Rspread	X = Effective Spread
Momentum	–0.005***	0.002*	0.002*	0.004***
	(–3.79)	(1.89)	(1.92)	(3.08)
Book-to-Market	0.009***	0.005**	0.005**	0.002
	(3.69)	(2.11)	(2.23)	(0.76)
Size	–0.031***	0.006***	0.005***	0.001
	(–16.41)	(5.25)	(4.78)	(0.95)
Liquidity (X)	–0.059***	–0.015***	–0.018***	–0.018***
	(–23.45)	(–6.20)	(–8.05)	(–13.50)
Constant	–0.279***	–0.017***	–0.025***	–0.007
	(–21.79)	(–2.99)	(–4.31)	(–1.54)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.190	0.0934	0.0985	0.120

Panel D. Second Stage Regressions for Abnormal HF Ownership

VARIABLES	(1) ΔAmihud	(2) ΔRspread	(3) ΔSize-weighted Rspread	(4) ΔEff. Spread
Abnormal MF Ownership	–0.720***	–0.108	–1.691***	–1.205***
	(–6.19)	(–0.99)	(–9.91)	(–7.04)
Abnormal HF Ownership	–0.313***	–0.118	–0.881***	–0.590***
	(–3.67)	(–1.43)	(–8.03)	(–4.79)
Momentum	–0.081***	–0.083***	–0.146***	–0.140***
	(–8.06)	(–9.22)	(–14.19)	(–9.96)
Book-to-Market	–0.133***	–0.115***	–0.036**	–0.128***
	(–9.14)	(–8.35)	(–2.37)	(–6.16)
Size	–0.139***	–0.073***	–0.165***	–0.068***
	(–13.24)	(–10.28)	(–24.77)	(–7.67)
Lagged Liquidity	–0.177***	–0.102***	–0.211***	–0.077***
	(–12.55)	(–9.22)	(–13.73)	(–5.94)
Constant	–0.795***	–0.249***	–0.206***	–0.224***
	(–10.85)	(–7.21)	(–5.14)	(–5.60)
Observations	4,635	4,634	4,634	4,634
Adj. R-squared	0.0855	0.148	0.177	0.0629
Diff. of Coeffs. (MF – HF)	–0.407**	–0.679***	–0.81***	–0.615***
Test of Difference (*p*-value)	0.010	0.002	0.0004	0.009

Table SA.V
Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Subsamples of Mutual Funds

This table reports the regression results of the changes in stock liquidity on mutual fund ownership of top- and non-top-performing funds. The dependent variables are the changes in the liquidity variables after May 2004. All regressions include controls for lagged stock liquidity and other stock characteristics as in Panel B of Table II in the paper. The last two rows report the differences between the coefficients of the ownership of top-quartile and non-top-quartile funds and the *p*-values from the *F*-tests of the differences. *Liquidity-adjusted DGTW (Rspread)* is calculated by augmenting size, book-to-market, and momentum with stock liquidity (using *Rspread*) in the characteristics used to form the DGTW benchmark portfolios. *Da, Gao, and Jagannathan DGTW* is the impatient trading measure of Da, Gao and Jagannathan (2011). Panels A and B report the results when funds are separated based on whether or not they are in the top quartile of these performance measures for the prior year. Standard errors are adjusted for heteroskedasticity and clustered at the stock level, and *t*-statistics are reported below the coefficients in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

Panel A: Liquidity-Adjusted DGTW (Rspread)

	(1)	(2)	(3)	(4)
VARIABLES	ΔAmihud	ΔRspread	ΔSize-Weighted Rspread	ΔEff. Spread
Top Fund Ownership	–0.0019***	–0.0040***	–0.0045***	–0.0033***
	(–5.97)	(–10.11)	(–10.97)	(–6.81)
Non-Top Fund Ownership	–0.0006**	–0.0022***	–0.0027***	–0.0017***
	(–2.25)	(–6.34)	(–7.31)	(–3.87)
Difference (Top – Non-top)	4,635	4,634	4,634	4,634
p-value (diff.)	0.0872	0.163	0.195	0.0696

Panel B: Da, Gao, and Jagannathan (2011)

	(1)	(2)	(3)	(4)
VARIABLES	ΔAmihud	ΔRspread	ΔSize-Weighted Rspread	ΔEff. Spread
Top Fund Ownership	–0.0014***	–0.0039***	–0.0043***	–0.0033***
	(–4.14)	(–9.39)	(–9.74)	(–6.23)
Non-Top Fund Ownership	–0.0011***	–0.0024***	–0.0031***	–0.0019***
	(–4.49)	(–7.97)	(–9.48)	(–4.86)
Difference (Top – Non-top)	4,635	4,634	4,634	4,634
p-value (diff.)	0.0876	0.169	0.202	0.0711

Table SA.VI
Impact of Disclosure Regulation on Mutual Fund Performance: Changes on Changes Regressions

This table reports results of multivariate regressions of changes in fund performance after 2004 on lagged fund performance and changes in fund characteristics. In all regressions, we control for changes in fund characteristics, including *ΔLog(TNA)*, *ΔTurnover*, *ΔFlow*, *ΔExpense Ratio*, and *ΔLoad*. All variables are defined as in Table VII of the paper. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level respectively.

	(1)	(2)	(3)	(4)
VARIABLES	4-factor Alpha	5-factor Alpha	DGTW	Liquidity-adj. DGTW
Top 4-factor Alpha	–0.103***			
	(–16.78)			
Top 5-factor Alpha		–0.087***		
		(–13.53)		
Top DGTW			–0.152***	
			(–22.89)	
Top Liquidity-Adj. DGTW				–0.067***
				(–22.57)
ΔLog(TNA)	0.004	–0.016**	0.028***	0.005
	(0.58)	(–2.10)	(3.69)	(1.56)
ΔTurnover	–0.005	–0.006	0.012**	–0.000
	(–0.88)	(–1.15)	(2.00)	(–0.06)
ΔFlow	0.125**	0.036	0.048	–0.040*
	(2.56)	(0.70)	(0.91)	(–1.70)
ΔExpense Ratio	0.026	–0.866	1.915	1.619
	(0.01)	(–0.38)	(0.80)	(1.53)
ΔLoad	–0.006	–0.007	–0.002	0.007
	(–0.29)	(–0.33)	(–0.07)	(0.74)
Constant	0.040***	0.033***	0.027***	0.019***
	(12.23)	(9.69)	(6.92)	(11.22)
Observations	1,113	1,113	1,171	1,171
Adjusted R-squared	0.211	0.157	0.312	0.305

Table SA.VII
Impact on Mutual Fund Performance: Full Placebo Periods Excluding Crisis Periods

This table compares the regression results of the changes in fund performance for the matched samples of mandatory and voluntary funds (see Table IV of the paper) in a two-year period around the SEC disclosure regulation in 2004 with the same regressions conducted for placebo periods constructed using each placebo month in the period of 1994–2006 (excluding 2004 and the known crisis years of 1998, 2000, and 2001). The independent variables in the placebo tests are the lagged variables. All performance variables are annualized. In all regressions, we control for *Log(TNA)*, *Turnover*, *Flow*, *Expense Ratio*, and *Load*. Panels A and B report results for the samples matched using Models 1 and 2 in Table IV of the paper, respectively. Standard errors are adjusted for heteroskedasticity and clustered at the fund level, and *t*-statistics are reported in parentheses. Coefficients marked with ***, **, and * are significant at the 1%, 5%, and 10% level.

	4-factor Alpha	5-factor Alpha	DGTW	Liq.-adj. DGTW
Panel A. Mandatory and Voluntary Funds Matched by Model 1				
Mand – Vol (May 2004)	–0.021	–0.014	–0.06	–0.047
Mand – Vol (Mean over placebo periods)	–0.016	–0.013	–0.012	–0.001
Quad diff (May 2004 – Placebo period)	–0.005	–0.001	–0.048***	–0.046***
t-statistic	(–0.97)	(–0.24)	(–12.83)	(–6.66)
Panel B. Mandatory and Voluntary Funds Matched by Model 2				
Mand – Vol (May 2004)	–0.030	–0.024	–0.041	–0.040
Mand – Vol (Mean over placebo periods)	–0.013	–0.010	–0.009	–0.007
Quad diff (May 2004 – Placebo period)	–0.017***	–0.014**	–0.032***	–0.033***
t-statistic	(–3.53)	(–2.14)	(–9.94)	(–5.22)