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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 May 2004 SEC regulation 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.

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,

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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 result in perhaps the most detailed information about portfolio holdings (see Section I for more details). Such disclosure requirements have broad implications. On the one hand, mandatory portfolio disclosure can help improve the transparency of capital markets. On the other hand, it can reduce fund managers' incentives to collect and process information. To shed light on the 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.

Identifying the causal effects of portfolio disclosure on stock liquidity and fund performance presents a challenge. We overcome this challenge by using a May 2004 Securities and Exchange Commission (SEC) regulation change that required mutual funds to increase their disclosure frequency from a *semiannual* basis to a *quarterly* basis. We use this regulation change as a quasi-natural experiment to identify the effects of funds' portfolio disclosure on stock liquidity and fund performance.

Our empirical analyses build on the theoretical literature on mandatory disclosure and informed trading. Huddart, Hughes, and Levine (2001) extend the Kyle (1985) model to study mandatory disclosure of trades by informed traders. Here, we further extend this framework to allow for different mandatory disclosure frequencies.

Our model yields several testable predictions. First, our model predicts that more frequent disclosure by informed traders improves market liquidity as measured by market depth, that is, 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 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, informed traders' profits are negatively related to disclosure frequency because the disclosure of trades limits a trader's ability to reap all of the benefits of his information. Finally, an informed trader's profit decrease 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 analysis by examining the impact of an increase in portfolio disclosure frequency on the liquidity of disclosed stocks. A large body of literature shows that mutual funds' portfolio disclosures contain valuable information (see Section II for more details). Accordingly, 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 funds that disclose to sources such as 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 frequency due to the 2004 SEC rule change. Focusing on this sample of funds allows us to isolate the effect of the regulation change from 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 0.29 standard deviation decrease in the Amihud (2002) illiquidity measure and Trade and Quote (TAQ) relative bid-ask spread, respectively.

To corroborate this finding, we conduct several sets of placebo tests. First, we use two types of institutional investors, nonmutual-fund 13F institutions and hedge funds, as control groups for our cross-sectional placebo tests. The underlying argument is that the 2004 regulation change 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 nonmutual 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 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 the increase in mandatory disclosure frequency on stock liquidity should be weaker because the frequency with which they disclose remains unchanged.[1] Ge and Zheng (2006) argue that the decision to voluntarily disclose is strategic. Thus, following their study we 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 increase their disclosure frequency due to the regulation change has a larger effect on stock liquidity.

[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.

Our model also predicts that the improvement in stock liquidity is larger for 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 informed or 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, we first compare the impact of the ownership of more versus less informed funds on stock liquidity. We use four abnormal performance measures to proxy for fund informativeness: the four-factor alpha of Carhart (1997), the characteristics-adjusted returns of Daniel et al. (1997) (DGTW return), 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 as proxied by firm size, analyst coverage, and liquidity. 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 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 obtains more information from more frequent disclosure, an informed trader is less able to reap all of the benefits of his information. We find that informed funds bear costs from the increase in mandatory disclosure frequency. Specifically, better performing funds, that is, those in the top quartile of each of the four abnormal performance measures, experience significant declines in performance subsequent to the 2004 regulation change. Since we use performance measures adjusted for liquidity, the performance change that 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. The rationale for these tests is as follows. 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 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 these funds to change their trading behavior to mitigate this adverse effect. Consistent with this conjecture, we find some evidence that informed funds attempt to reduce the impact of increased disclosure frequency by trading stocks with lower information asymmetry and by trading more quickly.

Our paper contributes to the literature that studies the 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. We use the regulation change in 2004 to test the model's 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. On the benefits side, we find that increased disclosure frequency results in improved stock liquidity, which can reduce both the cost of capital for issuing firms and trading costs for investors.[2] On the costs side, we uncover a decline in the performance of informed funds subject to more frequent portfolio disclosure.[3] To the extent that mandatory portfolio disclosure reveals information about money managers' proprietary investment strategies, it can affect their incentives to collect and process information and in turn 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 institutional background. Section II discusses related literature. Section III presents the model and empirical predictions. Section IV describes the data and variable construction. Sections V and VI present empirical analyses on 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.

[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 the 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.

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, Section 13(f) of the 1934 Securities Exchange Act, requires mutual fund companies to disclose their aggregate holdings (at the company level) on a quarterly basis in Form 13F, with no more than a 45-day delay.[4]

Although the two ownership disclosure regimes described above both apply, the former requirement typically offers much more detailed information about the investment of mutual funds than that provided by the Form 13F. First, 13F data are at the company level only, while the N-CSR and N-Q data are at the individual fund level. Since mutual fund companies often operate multiple funds, the aggregated 13F data are less informative. Second, Form 13F is only filed by large investors (those with more than $100 million in 13F securities) and includes information only on large positions (more than 10,000 shares and market value exceeding $200,000) in the 13F securities, which consist of equities, convertible bonds, and exchange-listed options.[5] In contrast, Forms N-Q and N-CSR 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 disclosure through Forms N-Q and N-CSR more informative than that through the Form 13F filed by mutual fund families.

The Form 13F has always been required on a quarterly basis and there has been no regulatory change in the frequency of mandatory disclosure in these filings. 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.[6] In May 2004, the SEC enacted a new rule that replaced Form N-30D with Form N-CSR, 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 Form N-Q at the end of the first and third fiscal quarters,

[4] Institutions filing Form 13F 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.

[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 in 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 the Internet Appendix, available in the online version of the article on the *Journal of Finance* website), which may be due to the small sample of funds in existence during that time period.

Table I

SEC Reporting Frequencies of Mutual Funds' Portfolio Holdings

This table reports the frequencies of different SEC filings used by mutual funds to report their holdings over the period 1994 to 2011. Form N-30D contains semiannual portfolio holdings of mutual funds reported to the SEC before the May 2004 regulation change. Forms N-CSRS and N-CSR contain the portfolio holdings at the end of the second and fourth fiscal quarters after May 2004. Form N-Q 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

thus increasing the reporting frequency to four times per year.[7] To balance the benefits of increased transparency to investors and the potential costs to mutual funds, for example, front-running and copycat behavior, the SEC allowed funds to file disclosure forms with a 60-day delay.

To illustrate the effect of the SEC regulation change in 2004, in Table I we present the total number of mutual fund holdings disclosures in each year from 1994 to 2011, the period over which data are 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. When we break down the numbers by form type, we find that this dramatic increase in the total number of filings is due to the introduction of Form N-Q in 2004: the N-Q disclosures account for approximately half of all filings from 2005 onward.

Individual funds can voluntarily report their portfolio information more frequently than 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 provide information on their portfolio holdings to data vendors such as Morningstar and Thomson Reuters (formerly

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

CDA/Spectrum).[8] We identify and remove 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 show 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. (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 both 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), who extend 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 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) by allowing for different mandatory disclosure frequencies and test the model's predictions using the May 2004 SEC regulation change.

Third, a large strand of empirical literature 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 examine 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

[8] Certain fund companies sometimes choose to disclose the largest holdings of their funds on their websites. For example, the top 10 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 a fund's entire portfolio on a historical basis. Thus, it cannot be used for our analysis in this paper.

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 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 traders' profits. Our model builds on the models by Kyle (1985) and Huddart, Hughes, and Levine (2001).

Following Kyle (1985), the market contains a risky security and a risk-free security. In each period $n = 1, 2, \ldots, N$, 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 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 trader's 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. 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.

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^* denote the market maker's updated stock price at the end of the period if the trade by the informed trader (x_n) during the period is disclosed. During periods when mandatory disclosure is not required, p_n remains unchanged until the end of the period. The conditional variance $\Sigma_n = \mathrm{Var}(v|p_1^*, \ldots, p_{n-1}^*)$ 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 $E[\tilde{\pi}_n|p_1^*, \ldots, p_{n-1}^*, v]$ at the beginning of every period n, and

the market maker sets the price such that it is equal to his expectation of the asset's fundamental value.

Using the standard approach from Kyle (1985), we will show that a unique equilibrium exists in which the informed trader's strategy is of the 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 $z_n \sim N(0, \sigma^2_{z_n})$ 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 nondisclosure 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 the informed trader trades on his private information in each period, and the noise variance $\sigma^2_{z_n}$ 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 linear rule

$$p^*_n = p^*_{n-1} + \gamma_n x_n. \tag{4}$$

The linear coefficient γ_n captures how sensitive 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 provide the formal statements of propositions and proofs in the Internet Appendix. Proposition 1 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 provides several testable predictions on the impact of disclosure frequency on stock liquidity and the 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 reduces 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 2004 increase in mandatory disclosure frequency

instituted 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 higher mutual fund ownership should experience greater increases in liquidity after the mandatory disclosure regulation change.

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 obtain more information from portfolio disclosure. Therefore, we hypothesize the liquidity improvement to be greater for stocks with higher ownership by more informed funds compared to stocks primarily held by less informed funds. 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 obtains more information with more frequent disclosure, the informed trader is less able to reap the full benefits of his information. Thus, we posit that informed funds are likely to experience a decrease in 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 decline 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 subject to greater information asymmetry. Further, our model predicts that informed traders are hurt more when their trades take more periods (N) to complete. Therefore, we expect informed funds that take longer to finish their trades experience a more pronounced decline in 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. To do so, we first obtain funds' portfolio disclosure dates from three major data sources: SEC EDGAR, Morningstar, and Thomson Reuters S12.[9] We then 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 procedure yields a comprehensive list of all unique instances of disclosure for each fund over time.

[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).

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. We 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 that 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. This period runs from one year before to one year after the May 2004 SEC disclosure rule change, which allows us to examine the changes in stock liquidity and fund performance around the regulation change.

We construct several stock-level institutional ownership variables that we use in our empirical tests. First, for each stock-month, we calculate *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 the 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 Form 13F. We use these nonmutual-fund institutions as a control group to identify the effects of the SEC rule change. For this purpose, we define *NonMF Ownership* as the quarterly aggregate institutional ownership from Thomson Reuters Institutional Holdings (S34), excluding mutual funds and asset management companies. In addition, we separate hedge funds from the nonmutual-fund institutions to form another control group, because hedge funds 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 Agarwal et al. (2013). Finally, we use U.S. index equity funds as another 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.

[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 use the remaining 604 funds that were disclosing voluntarily as a control group in our cross-sectional placebo tests in Sections V.C and VI.B.

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

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

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 use the high-frequency 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 are (i) *Rspread*, the daily average of the relative spread (quoted bid-ask spread divided by its midpoint), (ii) *Size-Weighted Rspread*, the daily average of the relative spread weighted by the size of the associated trade, and (iii) *Effective Spread*, 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 calendar month and take the log of all these monthly average measures.[11]

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

B.2. Fund-Level Variables

We construct both returns-based and holdings-based abnormal performance measures of mutual funds. In particular, we construct *Four-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 liquidity-adjusted versions of these two performance measures: *Five-Factor Alpha* is based on the Carhart (1997) model augmented by the Pástor and Stambaugh (2003) liquidity factor, and *Liquidity-Adjusted DGTW* augments size, book-to-market, and momentum with stock liquidity in the characteristics used to form the DGTW benchmark portfolios.

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

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

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

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

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 *Four-Factor Alpha*. For *Five-Factor Alpha*, we also include the Pástor and Stambaugh (2003) liquidity factor in equations (6) and (7) above.

To compute *DGTW-Adjusted Return*, we follow Daniel et al. (1997) to sort stocks into $5 \times 5 \times 5$ portfolios based on size, book-to-market, and momentum quintiles. We then 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. Last, we compute the cumulative benchmark-adjusted returns between two successive report dates in the Thomson Reuters S12 database and divide them by the number of months in the period to obtain a monthly *DGTW-Adjusted Return*. We compute *Liquidity-Adjusted DGTW* as a modified version of *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 $3 \times 3 \times 3 \times 3$ 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*.

To examine whether the regulation change has a greater effect on funds that take longer to complete their trades, we construct the fund-level variable *Trade Length* from funds' portfolio holdings. We first construct the 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. Next, we value weight this position-level measure across all stock positions held by each fund to obtain the fund-level measure *Trade Length*. This variable captures how long it takes a fund to complete its acquisition or disposition of stocks.

We use several variables as controls. These include: (i) *Size*, the natural logarithm of the total net assets under management, (ii) *Turnover*, the average annual turnover from Thomson Reuters S12 mutual fund holdings,[12] (iii) *Flow*, the change in total net assets (TNA) after adjusting for fund returns, scaled by lagged TNA, (iv) *Expense Ratio*, total operating expenses scaled by TNA, and (v) *Load* status, an indicator variable that 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.

[12] Every quarter, we compute the portfolio turnover rate as the lesser of purchases and sales divided by the average portfolio size of the prior and current quarters, and then sum the rates 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 portfolio holdings from the previous to the current quarter-end and the average of the stock prices at the two quarter-ends.

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 the monthly stock-level variables over the 12 months prior to May 2004 and the 12 months after May 2004 (inclusive of May 2004). Next, we compute the changes in the annual averages as the difference between the post-May 2004 average and the pre-May 2004 average. 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, that is, 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 the outstanding shares of their portfolio stocks on average.

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

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

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 $X_{i,t-1}$is a vector of lagged stock characteristics, including *Momentum*, *Size*, and *Book-to-Market*.

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 between the 12 months before and the 12 months after May 2004. The second difference is the difference in liquidity changes between 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 on *Mutual Fund Ownership* are negative and statistically significant at the 1% level. Since for each of our measures a lower level implies greater liquidity, higher mutual fund ownership is associated with a greater improvement in stock liquidity after the 2004 regulation change. These findings are economically significant. A one standard deviation increase in mutual fund ownership is associated with a 0.13 to 0.35 standard deviation decrease in illiquidity, depending on the liquidity

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

Table II

Impact of Mandatory Portfolio Disclosure on Stock Liquidity

Panel A reports summary statistics for the variables we use in our analysis. We report the liquidity variables, institutional ownership, and other stock characteristic 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. Changes in the liquidity variables are defined as values in the one-year period after (and 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 regression results of changes in the 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

	Mean	Median	Std. Dev.	Min	Max	N
Liquidity variables						
Amihud	−8.963	−8.979	1.477	−12.158	−5.979	4,635
Rspread	−5.063	−4.992	1.374	−7.918	−2.534	4,634
Size-Weighted Rspread	−5.207	−5.217	1.216	−7.572	−2.843	4,634
Effective Spread	−5.394	−5.314	1.325	−8.047	−2.920	4,634
Δ*Amihud*	−0.129	−0.108	0.395	−1.342	0.835	4,635
Δ*Rspread*	−0.264	−0.253	0.390	−2.359	1.485	4,634
Δ*Size-Weighted Rspread*	−0.218	−0.193	0.389	−2.049	1.233	4,634
Δ*Effective Spread*	−0.232	−0.225	0.374	−1.920	1.134	4,634
Ownership and stock characteristics						
Mutual Fund Ownership	6.60%	4.96%	6.46%	0.00%	25.80%	4,635
NonMF Ownership	22.29%	21.01%	16.70%	0.03%	66.16%	4,635
Hedge Fund Ownership	7.90%	5.90%	7.78%	0.00%	35.66%	4,635
Index Fund Ownership	0.99%	1.01%	0.79%	0.00%	3.49%	4,635
Momentum	0.601	0.358	0.765	−0.529	3.639	4,635
Book-to-Market	0.646	0.556	0.518	−0.579	2.871	4,635
Size	5.634	5.549	1.937	1.923	10.838	4,635
Analyst Coverage	6.43	3	8.6	0	39	4,616

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

	(1) Δ*Amihud*	(2) Δ*Rspread*	(3) Δ*Size-Weighted Rspread*	(4) Δ*Effective 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***

(*Continued*)

Table II—*Continued*

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

	(1) $\Delta Amihud$	(2) $\Delta Rspread$	(3) Δ*Size-Weighted Rspread*	(4) Δ*Effective Spread*
	(−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
Adjusted R^2	0.083	0.137	0.165	0.059

measure chosen. This evidence is consistent with our model's prediction that more frequent portfolio disclosure by 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 types of institutions as control groups: (i) nonmutual-fund institutions, (ii) hedge funds, and (iii) index funds. The intuition for using nonmutual-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 rationale for using index funds as a control group is that, by definition, they are 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:

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

[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 the Internet Appendix, we find that the coefficients on 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* (*NonMF 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 between 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 nonmutual-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.

We next conduct a time-series placebo test using the two-year period around November 2006 as our placebo period. Note that we cannot use 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 price 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 but 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 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

[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 hedge fund ownership and nonmutual-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 the Internet Appendix).

Table III

Impact of Mandatory Portfolio Disclosure on Stock Liquidity: Cross-Sectional Placebo Tests

Panel A reports regression results of the changes in stock liquidity variables (from the one-year period prior to May 2004 to one year afterward) on mutual fund ownership and nonmutual fund institutional ownership. Panel B reports regression results of the changes in stock liquidity on mutual fund ownership and hedge fund ownership. Panel C reports regression results of changes in stock liquidity on 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 differences between the coefficients on the two ownership variables and p-values from F-tests of the differences. In Panel D, we compare the regression results of changes in the 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.

	(1)	(2)	(3)	(4)
	Δ*Amihud*	Δ*Rspread*	Δ*Size-Weighted Rspread*	Δ*Effective Spread*
Panel A: *NonMF Ownership*				
Mutual Fund Ownership	−0.636***	−1.302***	−1.562***	−1.056***
	(−5.29)	(−7.61)	(−8.58)	(−5.72)
NonMF Ownership	−0.228***	−0.447***	−0.494***	−0.399***
	(−3.95)	(−6.60)	(−6.93)	(−4.92)
Difference of coeffs. (*MF* − *NonMF*)	−0.408**	−0.855***	−1.068***	−0.657***
Test of difference (p-value)	0.011	<.0001	<.0001	0.005
Panel B: *Hedge Fund Ownership*				
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)
Difference 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*				
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)
Difference 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*				
Regression in 2004				
Mutual Fund Ownership	−0.815***	−1.795***	−2.100***	−1.459***
	(−7.16)	(−11.96)	(−12.94)	(−8.83)

(Continued)

Table III—*Continued*

Panel D: *Time-Series Placebo Tests*

	(1)	(2)	(3)	(4)
	Δ*Amihud*	Δ*Rspread*	Δ*Size-Weighted Rspread*	Δ*Effective Spread*
Regression in 2006				
Mutual Fund Ownership	−0.525***	−0.629***	−0.639***	−0.575***
	(−4.99)	(−6.67)	(−6.80)	(−6.44)
Difference of coeffs. (2004–2006)	−0.290*	−1.166***	−1.461***	−0.884**
Test of difference (p-value)	0.059	<.0001	<.0001	<.0001

significant. These findings suggest that factors besides the regulation change also contribute to the increase in stock liquidity. Thus, merely using the coefficients on 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 hence identify the incremental impact of the regulation change (as shown in the last two rows of each panel).

C. Voluntarily Disclosing Funds

As mentioned in Section I, mutual funds can voluntarily disclose their portfolios more frequently than 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 604 funds voluntarily disclose to one or more of these three data sources and do not increase their total number of disclosures around the regulation change.

For these voluntarily disclosing funds, the effect of the increase in mandatory disclosure frequency on stock liquidity should be weaker because the frequency with which they disclose remains unchanged. The amount of information that the market receives from these funds is therefore comparable before and after the regulation change. Accordingly, we use 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.

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

$$\text{Prob}(\textit{Voluntary}_j) = F(\delta_0 + \delta_1 Z_j + \varepsilon_j), \tag{10}$$

where Z_j is a vector of lagged characteristics of fund j. These characteristics include all independent variables in Ge and Zheng (2006), that is, *Expense Ratio*, *Turnover*, *Fraud*, *Size*, *Age*, and past 12-month *Return Volatility* (see Table III of their paper), where *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 I in Houge and Wellman (2005)), and zero otherwise; the other variables are defined above in Section IV.B.2. In addition to the variables in Ge and Zheng (2006), we include several others: (i) *Trade Length*, (ii) *Top Fund*, an indicator variable equal to one if a fund's performance over the past year is in the top quartile and zero otherwise, and (iii) the interaction between *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. 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 *Four-Factor Alpha* as the performance measure in Model 1 and use *DGTW-Adjusted Return* 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.

Next, we construct 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 the effect of the ownership of the control group. Specifically, we estimate the following cross-sectional regression:

$$\begin{aligned}\Delta y_{i,t} = \alpha + \beta MandatoryOwn_{i,t-1} + \beta' VoluntaryOwn_{i,t-1} \\ + \gamma y_{i,t-1} + \Gamma' X_{i,t-1} + \eta_i,\end{aligned} \tag{11}$$

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 on the ownership of the funds affected by the regulation change is larger than the coefficient for 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 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

Table IV

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

Panel A 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 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 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 differences between the coefficients on the two ownership variables and *p*-values from *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

	(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^2	0.068	0.067

(*Continued*)

Table IV—*Continued*

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

	(1)	(2)	(3)	(4)
	Δ*Amihud*	Δ*Rspread*	Δ*Size-Weighted Rspread*	Δ*Effective 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)
Difference of coeffs. (*Mandatory* − *Voluntary*)	−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

	(1)	(2)	(3)	(4)
	Δ*Amihud*	Δ*Rspread*	Δ*Size-Weighted Rspread*	Δ*Effective 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)
Difference of coeffs. (*Mandatory* − *Voluntary*)	−0.282	−0.480**	−0.615***	−0.151
Test of difference (p-value)	0.110	0.028	0.008	0.573

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 the prediction that the improvement in liquidity should be greater for stocks disclosed by more informed funds compared to other funds. To do so, we use four proxies for informed funds: (i) *Four-Factor Alpha*, (ii) *Five-Factor Alpha*, (iii) *DGTW-Adjusted Return*, and (iv) *Liquidity-Adjusted DGTW*. Using each of these proxies, we divide the sample mutual funds into more informed funds, that is, top-quartile funds, and less informed funds, that is, nontop-quartile funds. We include the aggregate ownership of the funds in each subsample in the following cross-sectional regression and examine the difference in coefficients of the two ownership variables:[18]

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

Our findings, reported in Table V, show that the ownership of the top-quartile funds has a statistically larger impact on liquidity than the ownership of other

[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.

Table V

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

This table reports regression results of changes in stock liquidity on the mutual fund ownership of top- and nontop-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 differences between the coefficients on the top and nontop quartile ownership and *p*-values from *F*-tests of the differences. Performance measures *Four-Factor Alpha*, *Five-Factor Alpha, DGTW-Adjusted Return*, and *Liquidity-Adjusted DGTW* are defined in the Appendix. Panels A to D report results when funds are separated based on whether they are in the top quartile of these abnormal performance measures in 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.

	(1)	(2)	(3)	(4)
	Δ*Amihud*	Δ*Rspread*	Δ*Size-Weighted Rspread*	Δ*Effective Spread*
Panel A: Four-Factor Alpha				
Top Fund Ownership	−0.0018***	−0.0049***	−0.0057***	−0.0033***
	(−5.60)	(−12.52)	(−13.79)	(−6.56)
NonTop Fund Ownership	−0.0008***	−0.0015***	−0.0018***	−0.0018***
	(−3.21)	(−5.20)	(−5.96)	(−4.79)
Difference (*Top* − *NonTop*)	−0.001**	−0.0034***	−0.0039***	−0.0015**
p-value (difference)	0.019	<.0001	<.0001	0.041
Panel B: *Five-Factor Alpha*				
Top Fund Ownership	−0.0016***	−0.0056***	−0.0066***	−0.0037***
	(−4.91)	(−14.49)	(−16.33)	(−7.52)
NonTop Fund Ownership	−0.0009***	−0.0007**	−0.0007**	−0.0013***
	(−3.68)	(−2.27)	(−2.36)	(−3.45)
Difference (*Top* − *NonTop*)	−0.0007	−0.0049***	−0.0059***	−0.0024***
p-value (difference)	0.106	<.0001	<.0001	0.001
Panel C: *DGTW-Adjusted Return*				
Top Fund Ownership	−0.0010***	−0.0046***	−0.0052***	−0.0029***
	(−2.82)	(−11.11)	(−12.02)	(−5.53)
NonTop Fund Ownership	−0.0016***	−0.0019***	−0.0023***	−0.0022***
	(−6.37)	(−6.10)	(−7.09)	(−5.72)
Difference (*Top* − *NonTop*)	0.0006	−0.0027***	−0.0029***	−0.0007
p-value (difference)	0.224	<.0001	<.0001	0.417
Panel D: *Liquidity-Adjusted DGTW*				
Top Fund Ownership	−0.0019***	−0.0040***	−0.0046***	−0.0034***
	(−5.97)	(−10.16)	(−10.99)	(−6.71)
NonTop Fund Ownership	−0.0006**	−0.0022***	−0.0027***	−0.0017***
	(−2.25)	(−6.34)	(−7.37)	(−3.73)
Difference (*Top* − *NonTop*)	−0.0013**	−0.0018***	−0.0019***	−0.0017**
p-value (difference)	0.012	0.007	0.007	0.040

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]

Next, we investigate the type of stocks that experience greater increases in liquidity as a result of the increase in 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 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 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 on fund ownership across subsamples have the predicted positive sign and are 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 for disclosed stocks with greater information asymmetry.

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 obtains more information 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 an informed trader's profits decrease when mandatory disclosure frequency increases. The intuition is that disclosing their positions decreases the ability of informed traders to reap all of 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 practitioner reactions motivate us to examine the impact of mandatory disclosure on fund performance.

As discussed in Section IV.B.2, we consider four measures of funds' abnormal performance: *Four-Factor Alpha*, *Five-Factor Alpha*, *DGTW-Adjusted Return*,

[19] In addition to the four proxies for informed funds, we use the 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 the Internet Appendix).

Table VI

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

This table compares regression results of changes in the stock liquidity variables in 2004 for subsamples of stocks grouped by market capitalization, analyst coverage, and illiquidity. The stocks are placed into subsamples based on whether 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 illiquidity (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) $\Delta Amihud$	(2) $\Delta Rspread$	(3) Δ*Size-Weighted Rspread*	(4) Δ*Effective Spread*
Panel A: Subsamples based on size				
Top size stocks				
Mutual Fund Ownership	−0.300**	0.020	(−0.065)	(−0.273)
	(−2.31)	(0.09)	(−0.27)	(−1.15)
Nontop size stocks				
Mutual Fund Ownership	−0.937***	−2.143***	−2.539***	−1.665***
	(−5.51)	(−11.11)	(−12.17)	(−7.02)
Difference of coeffs. (*Top* − *NonTop*)	0.637***	2.163***	2.475***	1.392***
Test of difference (p-values)	(0.003)	<.0001	<.0001	<.0001
Panel B: Subsamples based on analyst coverage				
Top analyst coverage stocks				
Mutual Fund Ownership	−0.128	−0.054	−0.259	−0.446*
	(−0.81)	(−0.24)	(−1.04)	(−1.74)
NonTop analyst coverage stocks				
Mutual Fund Ownership	−1.142***	−1.899***	−2.252***	−1.711***
	(−6.98)	(−9.53)	(−10.25)	(−7.36)
Difference of coeffs. (*Top* − *NonTop*)	1.014***	1.845***	1.993***	1.266***
Test of difference (p-values)	<.0001	<.0001	<.0001	0.0003
Panel C: Subsamples based on *Amihud*				
Top liquidity stocks (by *Amihud*)				
Mutual Fund Ownership	−0.139	−0.132	−0.266	−0.259
	(−0.93)	(−0.56)	(−1.07)	(−1.03)
Nontop liquidity stocks (by *Amihud*)				
Mutual Fund Ownership	−1.109***	−2.383***	−2.838***	−1.855***
	(−6.25)	(−12.35)	(−13.27)	(−7.45)
Difference of coeffs. (*Top* − *NonTop*)	0.970***	2.252***	2.572***	1.596***
Test of difference (p-values)	<.0001	<.0001	<.0001	<.0001

(*Continued*)

Table VI—*Continued*

Panel D: Subsamples based on *Rspread*				
Top liquidity stocks (by *Rspread*)				
Mutual Fund Ownership	−0.338**	−0.605***	−0.667***	−0.608***
	(−2.28)	(−2.72)	(−2.80)	(−2.68)
Nontop liquidity stocks (by *Rspread*)				
Mutual Fund Ownership	−0.941***	−1.287***	−1.730***	−1.424***
	(−5.52)	(−6.14)	(−7.57)	(−5.77)
Difference of coeffs. (*Top* − *NonTop*)	0.603***	0.682**	1.063***	0.816**
Test of difference (*p*-values)	0.008	0.026	0.001	0.015
Panel E: Subsamples based on *Size-Weighted Rspread*				
Top liquidity stocks (by *Size-Weighted Rspread*)				
Mutual Fund Ownership	−0.288*	−0.484**	−0.571**	−0.578**
	(−1.92)	(−2.16)	(−2.35)	(−2.53)
Nontop liquidity stocks (by Size-Weighted Rspread)				
Mutual Fund Ownership	−0.999***	−1.536***	−1.965***	−1.524***
	(−5.79)	(−7.40)	(−8.68)	(−6.13)
Difference of coeffs. (*Top* − *NonTop*)	0.711***	1.052***	1.394***	0.946***
Test of difference (*p*-values)	0.002	0.001	<.0001	0.005
Panel F: Subsamples based on *Effective Spread*				
Top liquidity stocks (by *Effective Spread*)				
Mutual Fund Ownership	−0.221	−0.379*	−0.483*	−0.800***
	(−1.57)	(−1.65)	(−1.90)	(−4.18)
Nontop liquidity stocks (by *Effective Spread*)				
Mutual Fund Ownership	−0.954***	−1.990***	−2.464***	−1.383***
	(−5.61)	(−9.62)	(−10.97)	(−5.57)
Difference of coeffs. (*Top* − *NonTop*)	0.733***	1.611***	1.981***	0.583*
Test of difference (*p*-values)	0.0009	<.0001	<.0001	0.0629

and *Liquidity-Adjusted DGTW*. We use the annualized values of these variables for sample funds during the one-year periods before and after May 2004, and then calculate the differences to measure the performance changes. Panel A of Table VII reports summary statistics of fund performance and other fund characteristics around the 2004 regulation change. The average annualized four-factor (five-factor) alphas of mutual funds increase by 1.3% (0.9%) after May 2004, the annualized DGTW-adjusted returns decrease 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.

Table VII

Impact of Mandatory Portfolio Disclosure on Mutual Fund Performance

Panel A reports summary statistics for fund performance and characteristics prior to the 2004 disclosure change (values in the one-year period before May 2004) and for the change in fund performance after the disclosure change (values in the one-year period after (including) May 2004 minus values in the one-year period before May 2004). The measures *Four-Factor Alpha*, *Five-Factor Alpha, DGTW-Adjusted Return*, *Liquidity-Adjusted DGTW*, and *Trade Length* are defined in the Appendix. All performance measures are annualized. *TNA* is total net assets under management in millions of dollars. *Turnover* is the average annual turnover computed from holdings data. *Flow* is the change in TNA from the last period after adjusting for fund returns, scaled by lagged TNA. *Expense Ratio* is 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 results of multivariate regressions of changes in fund performance around 2004 on lagged fund performance and characteristics. 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

	Mean	Median	Std. Dev.	Min	Max	N
Abnormal fund returns						
Four-Factor Alpha	−0.024	−0.027	0.089	−0.743	0.690	1,122
Δ*Four-Factor Alpha*	0.013	0.013	0.097	−0.658	0.810	1,122
Five-Factor Alpha	−0.021	−0.021	0.089	−0.723	0.701	1,122
Δ*Five-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
Δ*DGTW-Adjusted Return*	−0.015	−0.006	0.123	−0.676	0.566	1,221
Liquidity-Adjusted DGTW	0.005	0.002	0.049	−0.343	0.326	1,221
Δ*Liquidity-Adjusted 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

	(1) Δ*Four-Factor Alpha*	(2) Δ*Five-Factor Alpha*	(3) Δ*DGTW-Adjusted Return*	(4) Δ*Liquidity-Adjusted DGTW*
Top Four-Factor Alpha	−0.101***			
	(−16.50)			
Top Five-Factor Alpha		−0.089***		
		(−14.19)		
Top DGTW			−0.143***	
			(−19.28)	

(*Continued*)

Table VII—*Continued*

Panel B: Impact of Mandatory Portfolio Disclosure on Fund Performance

	(1) ΔFour-Factor Alpha	(2) ΔFive-Factor Alpha	(3) ΔDGTW-Adjusted Return	(4) ΔLiquidity-Adjusted DGTW
Top Liquidity-Adjusted 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^2	0.211	0.169	0.246	0.311

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:

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

where j indicates the fund, t denotes 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, and $Z_{j,t-1}$ is a vector of lagged fund characteristics.

Panel B of Table VII reports the regression results for equation (13). In column (1) of Panel B, we observe that funds with four-factor alphas in the top quartile experience a statistically significant decrease of 10.1% in annualized alphas relative to nontop funds. Similarly, in columns (2) to (4), funds with top five-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]

[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 the Internet Appendix.

B. Cross-Sectional and Time-Series Placebo Tests

A potential concern about the above finding is that the performance decline 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 performance decrease after 2004 for top funds affected by the regulation change (*Top Mandatory*) with that of 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 coefficients on *Top Mandatory* and *Top Voluntary*.

We report our findings in Table VIII. Panels A and B present results for the samples matched using the propensity scores from Models 1 and 2 in Panel A of Table IV. We find that, although there is deterioration in performance after 2004 for top funds that voluntarily disclose, the performance decrease for top funds that disclose due to the mandate is consistently greater regardless of the performance measure used. The differences in performance decline 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).

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 coefficients on *Top Mandatory* 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).

Next, we combine the cross-sectional and time-series placebo tests as follows. We first compute the difference in 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 of eight cases (see "Combination of cross-sectional and time-series tests"). The magnitude of the differences-in-differences ranges 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

Table VIII

Impact of Portfolio Disclosure on Mutual Fund Performance: Cross-Sectional and Time-Series Placebo Tests

This table compares regression results of changes in fund performance for matched samples of mandatory and voluntary funds (see Table IV) in the two-year period around the SEC disclosure change in 2004 with the same regressions conducted for a placebo sample period around 2006. In the time-series placebo regressions, we use 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. For each performace variable y, Top Mandatary y (Top Voluntory y) is an indicator variable that equals one if a fund with y in the top quartile in the one year before May 2004 is affected by the regulation change (voluntarily discloser its partfolio) and zero otherwise. In all regressions, we control for Log(*TNA*), *Turnover*, *Flow*, *Expense Ratio*, and *Load*. Panels A and B report results for 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, respectively.

Panel A: Mandatory and Voluntary Funds Matched by Model 1

	(1) $Y =$ *Four-Factor Alpha*	(2) $Y =$ *Five-Factor Alpha*	(3) $Y =$ *DGTW Adjusted Return*	(4) $Y =$ *Liquidity-Adjusted 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				
Difference 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				
Difference for *Mandatory 2006 − Voluntary 2006*	0.001	0.009	−0.013*	−0.004
F-test	(0.15)	(1.24)	(−1.65)	(−1.15)

(*Continued*)

Table VIII—*Continued*

	(1)	(2)	(3)	(4)
Panel A: Mandatory and Voluntary Funds Matched by Model 1				
	Y = Four-Factor Alpha	Y = *Five-Factor Alpha*	*Y =DGTW-*Adjusted Return	*Y = Liquidity-Adjusted DGTW*
Time-series placebo tests: mandatory				
Difference 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				
Difference 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				
Difference in Difference *Mandatory − Voluntary* 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				
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				
Difference 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				
Difference 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				
Difference 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				
Difference 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				
Difference in Difference *Mandatory − Voluntary* and *2004 − 2006*	−0.020*	−0.013	−0.019	−0.040***
F-test	(−1.91)	(−1.10)	(−1.52)	(−7.45)

events that can affect stock liquidity (e.g., decimalization in 2001). To further allay 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 starts in 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 coefficients on *Top Mandatory* and *Top Voluntary* for each placebo month. We then subtract the difference for each placebo month from the corresponding difference for May 2004 (the treatment 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 that the difference in performance decline 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 of eight cases. Further, we exclude the turbulent 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 the Internet Appendix).

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 decrease in performance. Moreover, the negative performance effect of the affected funds is concentrated around the regulation change.

C. Fund Performance and Information Asymmetry

According to our model, an informed fund's performance decrease after the regulation change is greater when the stocks in the fund's portfolio are subject to higher information asymmetry. To test this conjecture, we first calculate the value-weighted average of different proxies for 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 decrease is greater for informed funds with higher levels of information asymmetry. In particular, we estimate regressions of changes in fund performance on the interactions between past fund performance and information asymmetry. Our model predicts the coefficients on these interactions to be negative and significant.

Table X presents the results. 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 five-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%

Table IX

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

This table compares regression results of changes in fund performance for matched samples of mandatory and voluntary funds (see Table IV) in a two-year period around the SEC disclosure change in 2004 with the same regressions conducted for placebo periods constructed using each placebo month in 1994 to 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 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, respectively.

	(1) Δ*Four-Factor Alpha*	(2) Δ*Five-Factor Alpha*	(3) Δ*DGTW-Adjusted Return*	(4) Δ*Liquidity-Adjusted DGTW*
Panel A: Mandatory and voluntary funds matched by Model 1				
Mandatory − *Voluntary* (May 2004)	−0.021	−0.014	−0.060	−0.047
Mandatory − *Voluntary* (mean over all placebo periods)	−0.015	−0.012	−0.010	−0.004
Difference in Difference (*Mandatory* − *Voluntary* and 2004 − Placebo)	−0.006	−0.002	−0.050***	−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
Mandatory − *Voluntary* (mean over all placebo periods)	−0.015	−0.012	−0.008	−0.010
Difference in Difference (*Mandatory* − *Voluntary* and 2004 − Placebo)	−0.015***	−0.012**	−0.033***	−0.030***
t-stat	(−3.69)	(−2.33)	(−7.76)	(−5.67)

compared to top-performing funds holding stocks with low information asymmetry (see the first row of Table X, Panel B).

D. Fund Performance and Trade Length

Our model predicts that the regulation change should have a more 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 interaction between past fund performance and *Trade Length*. Based on our model's

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 interaction between the two. All variables are defined in Tables II and VII. For any performance variable *Y*, *Top Y* is an indicator variable that equals one if *Y* is in the top quartile in the one year before May 2004 and zero otherwise. *X* 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. For size and analyst coverage as measures of information asymmetry, we reverse the sorting order (denoted by "Inverse Size" and "Inverse Analyst Coverage" in the table below) because stocks with smaller size and lower analyst coverage exhibit greater information asymmetry. Panels A to D report results when the top performance quartile is determined by *Four-Factor Alpha*, *Five-Factor Alpha*, *DGTW-Adjusted Return*, and *Liquidity-Adjusted DGTW*, respectively. Panel E reports 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) *X* = *Inverse Size*	(2) *X* = *Inverse Analyst Coverage*	(3) *X* = *Amihud*	(4) *X* = *Rspread*	(5) *X* = *Size-Weighted Rspread*	(6) *X* = *Effective Spread*
Panel A: *Y* = *Four-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* = *Five-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-Adjusted 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)

(*Continued*)

Table X—*Continued*

Panel D: *Y = Liquidity-Adjusted 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 = Four-Factor Alpha	*Y = Five-Factor Alpha*	*Y = DGTW-Adjusted Return*	*Y = Liquidity-Adjusted DGTW*
Top Trade Length × Top Y	0.001	−0.012	−0.089***	−0.022***
	(0.06)	(−1.01)	(−5.09)	(−3.31)
Top Trade Length	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)

prediction, we expect the coefficients on 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 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 then examine the differences between the long-term and short-term changes in liquidity. The results in the last column of Table XI, Panel A 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, where 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.

Table XI

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

This table reports results related to 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*, *NonMF Ownership*, and the stock-level control variables 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 in Panel B of Table VII. The first column in each panel presents results where the dependent variable is the one-year change in liquidity or performance, while the second column presents results where the dependent variable is the three-year change in liquidity or performance. The third column presents differences between the 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.

	Short-term change in Y	Long-term change in Y	Long-term − Short-term
Panel A. Stock Liquidity			
$Y = Amihud$			
Difference (*MF* − *NonMF*)	−0.408**	−0.474	−0.066
	(−2.56)	(−1.53)	(−0.20)
$Y = Rspread$			
Difference (*MF* − *NonMF*)	−0.855***	−1.287***	−0.432
	(−4.25)	(−4.04)	(−1.19)
$Y = Size\text{-}Weighted\ Rspread$			
Difference (*MF* − *NonMF*)	−1.068***	−1.302***	−0.234
	(−5.04)	(−4.20)	(−0.64)
$Y = Effective\ Spread$			
Difference (*MF* − *NonMF*)	−0.657***	−0.774**	−0.117
	(2.69)	(−2.51)	(−0.30)
Panel B: Fund Performance			
$Y = Four\text{-}Factor\ Alpha$			
Top Y	−0.101***	−0.114***	−0.013
	(−16.50)	(−16.06)	(−1.38)
$Y = Five\text{-}Factor\ Alpha$			
Top Y	−0.089***	−0.109***	−0.020**
	(−14.19)	(−15.04)	(−2.05)
$Y = DGTW\text{-}Adjusted\ Return$			
Top Y	−0.143***	−0.162***	−0.019
	(−19.28)	(−26.27)	(−1.18)
$Y = Liquidity\text{-}Adjusted\ DGTW$			
Top Y	−0.068***	−0.075***	−0.007
	(−23.11)	(−25.07)	(−1.64)

We find no evidence of reversals in the performance of more informed funds, suggesting that the changes in fund performance are also permanent.

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 mandatory disclosure frequency, and (ii) the

performance decline is more pronounced for funds that hold stocks with a 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 responding to the disclosure by informed traders. We find that these costs are greater for funds that hold stocks with higher information asymmetry and for funds that take longer to complete their trades. Thus, one would expect these funds to change their trading behavior to mitigate the adverse effects of more frequent disclosure. Specifically, we expect informed funds to shift to stocks with lower information asymmetry and to shorten the time they take to finish their trading. We therefore examine the changes in (i) the degree of information asymmetry in funds' portfolios and (ii) funds' trade lengths.

We first compute changes in the information asymmetry of funds' portfolios in the year after the regulation change. In particular, the change in information asymmetry for fund j,$\Delta\bar{X}_{j,t}$, is calculated according to

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

$$w_{i,j,t-1} = \frac{M_{i,j,t-1}P_{i,t-1}}{\sum_{k=1}^{N} M_{k,j,t-1}P_{k,t-1}}, \tag{15}$$

$$\hat{w}_{i,j,t} = \frac{M_{i,j,t}P_{i,t-1}}{\sum_{k=1}^{N} M_{k,j,t}P_{k,t-1}}, \tag{16}$$

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 $(t-1)$, 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 $t-1$, and $\hat{w}_{i,j,t}$ 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 stocks' information asymmetry can change over time even when funds do not actively adjust their portfolios. The 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* in the year after the regulation change.

Table XII

Mutual Funds' Responses to the Regulation Change

This table reports 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 change 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 an 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 results when the top performance quartile is determined by *Four-Factor Alpha*, *Five-Factor Alpha*, *DGTW-Adjusted Return*, and *Liquidity-Adjusted DGTW*. 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)
	ΔSize	*ΔAnalyst Coverage*	*ΔAmihud*	*ΔRspread*	*ΔSize-Weighted Rspread*	*ΔEffective Spread*	*ΔTrade Length*
Y = Four-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 = Five-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-Adjusted 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-Adjusted 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)

With the above variables in hand, we estimate the following cross-sectional regressions:

$$\Delta Y_{j,t} = \mu_0 + \mu_1 itTopFund_{j,t-1} + \mu_2 Z_{j,t-1} + \psi_j, \tag{17}$$

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 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.

VIII. Concluding Remarks

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

Building on Kyle (1985) and Huddart, Hughes, and Levine (2001), we develop a model that allows for mandatory disclosure by informed traders at different frequencies. Our model yields several testable predictions that we examine 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 more pronounced 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, but can hurt these funds' ability to capitalize on their information and thus reduce their incentives to collect and process information. Policymakers should therefore weigh the benefits of disclosure to capital markets against the costs borne by informed funds.

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Appendix

Variable Definitions

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 TAQ midpoint, 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.
NonMF 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	
Four-Factor Alpha	Alpha measure calculated using equations (6) and (7) based on the Carhart (1997) four-factor model.
Five-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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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.