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The effects of stock liquidity on firm value and corporate governance: Endogeneity and the REIT experiment

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ABSTRACT

This study examines the effects of stock liquidity on firm value and corporate governance using the Real Estate Investment Trust (REIT) setting. The unique features of the REIT industry, including homogeneity of the investment structures, the high payout requirement, and the importance of institutional investors, highlight the positive effect of stock liquidity on firm value through corporate governance. To address the endogeneity problem, we perform a difference-in-differences test based on the propensity score matching estimator. The result shows that REIT stock liquidity has a causal and positive effect on firm value, as measured by Tobin's Q. Importantly, REIT stock liquidity is conducive to better corporate governance through the channel of institutional ownership. REIT stock liquidity leads to higher institutional ownership, particularly for institutional investor types that are active monitors and institutional investors with multi-firm ownership in their REIT portfolios.

1. Introduction

Stock liquidity is not only a subject of market microstructure but can also be studied from the perspective of corporate finance. A general view is that stock liquidity has a feedback effect on firm value by lowering the cost of capital and affecting corporate investments (Foucault et al., 2013).[1] Another argument is that stock liquidity can enhance the informativeness of stock prices and consequently, managers learn from informative stock prices and make value-enhancing corporate decisions. In the presence of agency problems, stock liquidity has an economic effect on firm value through corporate governance. This study provides a unique industry experiment to demonstrate that stock liquidity has a positive effect on firm value and is conducive to better corporate governance via the channel of institutional ownership.

Existing theories provide different perspectives on how stock liquidity enhances corporate governance. Diamond and Verrecchia (1982) and Holmström and Tirole (1993) show that information embedded in stock prices is useful for managerial incentive contracts

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[1] Fang et al. (2009) conclude that the effect of stock liquidity that is related to the cost of capital is minor, and such effect is more likely related to managerial decisions, as discussed below.

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and performance monitoring. Faure-Grimaud and Gromb (2004) suggest that a liquid stock market can generate information about the monitor's activity and incentivize large shareholders (such as institutional investors) to monitor. Nevertheless, there are competing views on whether a more liquid stock should deter or enhance corporate governance. On the one hand, Coffee (1991) and Bhide (1993) argue that a liquid stock market lowers the costs of exit and thus reduces the appeal of voice for potential monitors. On the other hand, Kyle and Vila (1991) and Maug (1998) argue that a liquid stock market lowers the cost of acquiring shares and helps investors to accumulate the blocks that generate sufficient incentives to voice or intervene. Edmans (2009) shows that stock liquidity provides a governance mechanism through investors' trading of a firm's shares, including the actual exit by selling shares ex post and the threat of exit by incentivizing the manager ex ante.

Empirical evidence on the effects of stock liquidity on firm value and corporate governance, particularly the underlying mechanisms, remains an understudied area. Fang et al. (2009) find a positive effect of stock liquidity on firm value, which is due to more informative stock prices and better managerial incentives. However, they do not find evidence that stock liquidity affects firm value through the channels of external governance and monitoring. Edmans et al. (2013) use the setting of activist hedge funds to demonstrate that stock liquidity enhances blockholder governance through the mechanisms of exit as well as voice. In contrast, Back et al. (2015) find that stock liquidity deters blockholder activism. The following issues may explain the lack of consensus on the effects of stock liquidity on firm value in the empirical corporate finance literature: (i) an endogeneity problem, particularly unobservable firm characteristics that affect stock liquidity and firm value; (ii) heterogeneity in the relation between stock liquidity and firm value across different corporate or industry settings; and (iii) identification of the specific mechanism underlying the effect of stock liquidity on firm value.

This study attempts to tackle these empirical corporate finance issues by using the Real Estate Investment Trust (REIT) industry as a natural experiment to examine the effects of stock liquidity on firm value. Stock liquidity is a central feature of REITs because the public trading of REITs provides investors with not only liquidity and exposure to real estate assets but also the possibility of implications on firm value. Compared with other industrial firms, REITs, on average, have higher stock liquidity (see Table 1 and Section 4). Unlike other studies that examine the value effects of stock liquidity across different industries, the REIT setting can control for industry- and firm-level heterogeneity such as growth opportunities and business risks (Hartzell et al., 2014).[2] Most importantly, the REIT setting contains the following unique features that provide interesting and different perspectives on the proposition of stock liquidity affecting firm value, particularly the importance of corporate governance and the channel of institutional ownership.

1.1. Homogeneous investment structures

Stock liquidity can affect firm value through the channels of investment and corporate governance (Foucault et al., 2013). While the importance of investment vis-à-vis governance effects may vary with firms or industries, REITs provide a unique setting that can accentuate the potential effect of stock liquidity on corporate governance. REITs have homogeneous asset and investment structures,[3] suggesting that stock liquidity is less likely to have a direct impact on the investment activities of these firms. Although REITs have similar asset and investment structures, they are diversely managed and are subject to agency problems.[4] REITs do not have an active takeover market to support corporate governance due to excess shareholder provisions (Chan et al., 2003).[5] In addition, a large number of REITs are Umbrella Partnership REITs (UPREITs), which allow managers to simultaneously manage several small REITs but creates agency problems (Chung et al., 2012). Furthermore, REITs engage in significant real activities manipulation for earnings management, suggesting that corporate governance is essential for constraining such activities (Anglin et al., 2013). Hartzell et al. (2008) and Bauer et al. (2010) find significant differences in corporate governance in a cross-section of REIT firms.

1.2. High payout requirement

An increase in stock liquidity is not necessarily conducive to improvement in firm value, depending on whether stock liquidity is associated with value-enhancing activities. The REIT setting is particularly useful for examining whether stock liquidity can support value-enhancing activities such as corporate governance. REITs have a high payout requirement (i.e., distribution of at least 90% of their taxable income to investors). According to Easterbrook (1984), dividends can increase a firm's external financing needs and hence increase the opportunity of market monitoring. In the case of REITs, the high payout requirement not only forces REITs to maintain equity dependence (Boudry et al., 2010; Hartzell et al., 2014), but also increases the opportunity of market monitoring by outside investors (Hartzell et al., 2008). Further, the required payout rate in REITs can provide outside investors observable shares of profits, which may lower outside investors' monitoring costs. As such, stock liquidity may become more important in enhancing market monitoring for REITs than for other typical firms.

1.3. Outside ownership structures and institutional investors

The REIT setting highlights the importance of stock liquidity in enhancing specific corporate governance mechanisms, such as monitoring activities by institutional investors. REITs have unique outside ownership structures that require these firms to have at

[2] The existing literature, e.g., Fang et al. (2009), examines the firm value effect of stock liquidity based on a sample of industrial firms, which largely excludes REITs.

[3] REITs must have a least 75% of their total assets invested in real estate assets and cash, derive at least 75% of their gross income from real estate-related sources, and have no more than 25% of their assets consisting of non-qualifying securities or stock in taxable REIT subsidiaries.

[4] See Ghosh and Sirmans (2003), Han (2006), Hartzell et al. (2006), and Bianco et al. (2007).

[5] A majority of REITs are incorporated in Maryland, which provides a specific statute for REIT trusts and strong takeover defenses.

least 100 shareholders, and no more than 50% of a REIT's shares can be owned by five or fewer shareholders (the "five or fewer" rule). Institutional investors, whose ownership is not subject to the "five or fewer" rule, play a significant role in improving the corporate governance and monitoring activities of REITs (Hartzell et al., 2006; Feng et al., 2010; Chung et al. 2012; Hartzell et al., 2014).[6] Fig. 1 shows that REITs have higher average institutional ownership than do other industrial firms, and REIT institutional ownership has grown rapidly over time. These interesting features of REIT institutional ownership suggest that stock liquidity can be particularly important for REIT institutional investors by lowering the costs of trading and monitoring.

Unlike the existing literature (e.g., Fang et al. (2009)) that examines the effect of stock liquidity across different industries, the unique features of REITs (including homogeneity of the investment structures, the high payout requirement, and the importance of institutional investors) can reduce confounding effects in testing the value proposition of stock liquidity and focus on specific mechanism such as corporate governance. To address the endogeneity problem,[7] we perform the difference-in-differences test (see Roberts and Whited (2012)) to identify the causal effect of stock liquidity on firm value and corporate governance for the REIT industry. We use the decimalization of the U.S. stock markets in 2001 as an exogenous shock to liquidity to identify causal effects (Fang et al., 2009; Edmans et al., 2013).[8] The improvement of stock liquidity after the decimalization is especially important for frequently traded firms (Bessembinder, 2003; Furfine, 2003), such as REITs, which are more liquid than other industrial firms (see Table 1 and Section 4).

To perform the difference-in-differences test, we employ propensity score matching estimators used in previous studies (see Rubin (1973a,b), Rosenbaum (1989, 1995), Dehejia and Wahba (1999), Edmans et al. (2013), and Fang et al. (2014)). A limitation of the difference-in-differences estimation (e.g., Edmans et al. (2013)) is that it does not eliminate the possibility of unobserved heterogeneity affecting the treated and control groups differently. The single-industry setting of REITs can reduce the confounding effects (Hartzell et al., 2008), providing a better control for unobserved heterogeneity when conducting matching and difference-in-differences tests.

Using data from 164 U.S. equity REITs from 1994 to 2006, our empirical analysis yields the following sets of results. First, we use Amihud illiquidity to measure the illiquidity of a firm's stock because it captures price impact and trading and monitoring costs. Our regression results show that the negative effect of stock illiquidity on firm value (measured by Tobin's Q) is both statistically and economically significant.

Second, we address the endogeneity concern and identify the causal effect of stock liquidity on firm value. The results of a difference-in-differences test with the propensity score matching show that firms with large liquidity increases during the decimalization experience significantly larger improvements in Tobin's Q than do control firms with closer pre-decimalization characteristics. In the context of economic significance, the average treatment effect (based on the propensity score matching without replacement) implies that the *change* in Tobin's Q is *+9.9% larger* for treatment firms with a large liquidity increase than for control firms.

Third, we find that higher stock liquidity is associated with increases in equity ownership by institutional investors, which are effective monitors in REITs (see, e.g., Chung et al. (2012) and Hartzell et al. (2014)). The results of the difference-in-differences test show that increases in stock liquidity during decimalization led to higher institutional ownership, with the *change* in total institutional ownership being *+9.0% larger* for treatment firms with a large liquidity increase than for control firms.

Fourth, our results demonstrate the importance of investor heterogeneity (Edmans, 2014) and show that stock liquidity is more important for particular institutional investor types, which are more likely to perform monitoring activities. The results of the difference-in-differences test show that increases in stock liquidity during decimalization led to higher ownership of active monitors (such as independent advisors and investment companies) rather than of passive monitors.

Fifth, we uncover interesting findings on REIT institutional investors' portfolio decisions and their reactions to changes in stock liquidity. In theory, blockholders with multi-firm ownership can punish poorly managed firms by selling their shares and retaining rival firms' shares (Edmans et al., 2015). As such, corporate governance through exit can be more effective under multi-firm ownership than under a single-firm benchmark (Edmans, 2014). In the REIT setting, institutional investors with portfolios of REIT stocks are more likely to develop expertise and exert effort on monitoring REIT stocks, and their governance through exit can be stronger under multi-firm ownership. We utilize the REIT setting to examine whether stock liquidity has any causal effect on institutional investors with diversified portfolios of REIT stocks. We provide new evidence that increases in stock liquidity led to higher ownership by institutional investors with diversified investments into multiple REIT stocks. Our finding suggests that stock liquidity can enhance governance through the threat of exit, which is particularly important in the setting of multi-firm ownership.

We perform several robustness tests and further analyses. We find that the effects of stock liquidity on firm value vary with the unique firm characteristics of REITs. For example, the effect of stock liquidity on firm value is larger for diversified REITs that are prone to agency problems (Capozza and Seguin, 1999). Moreover, the effect of stock liquidity on institutional investors' participation and monitoring incentives are related to the lease terms of REIT property types. We find that the effect of stock liquidity on institutional ownership is greater for REITs with short lease terms, which are likely to have lower uncertainty and monitoring costs. Lastly, we perform a controlled experiment to further support the importance of REIT setting in testing the value proposition of stock liquidity. We estimate the causal effect of stock liquidity on firm value for a matched sample of non-REIT firms that are not subject to a high payout requirement and regulatory restriction on investments and outside ownership structures. We find that stock liquidity does not have any significant effect on firm value for the non-REIT sample.

[6] Due to the "five or fewer" rule (as part of the Omnibus Reconciliation Act of 1993), institutional investors are not considered a single stockholder (their ownership is passed through to their beneficiaries). The "five or fewer" rule highlights the importance of institutional investors for REITs (see Crain et al. (2000) and Glascock et al. (2000)). However, no existing literature examines the effect of stock liquidity on institutional ownership for REITs.

[7] If stock liquidity is endogenously determined by certain firm characteristics (e.g., firms with high stock liquidity are different from those with low stock liquidity), then it is important to examine whether the observed change in firm value persists after controlling for differences in these firm characteristics.

[8] See Section 3.3 and footnote 23 for detailed discussion of the decimalization.

Our main contributions include the following. Using a unique industry experiment that controls for firm heterogeneity and specific corporate governance mechanisms, we provide new evidence supporting the general corporate finance insight on stock liquidity. Our empirical findings are consistent with the theories by Holmström and Tirole (1993), Maug (1998), and Faure-Grimaud and Gromb (2004); in contrast, our findings do not suggest that stock liquidity deters monitoring incentives (Coffee, 1991; Bhide, 1993). Whereas Fang et al. (2009) find that stock liquidity increases firm value through the information effect of stock prices and the channel of performance-sensitive managerial compensation, our findings also support the positive causal effect of stock liquidity on firm value but the underlying mechanism is related to corporate governance, especially the monitoring and governance of institutional investors.

Our study provides new insight on how stock liquidity can enhance monitoring and governance activities by different types of investors. Compared with Edmans et al. (2013), who focus on the effect of stock liquidity on hedge fund activism, our study uses a unique industry setting to highlight the importance of stock liquidity in attracting certain types of institutional investors with different objectives, e.g., those that are seeking firms with high payout rates and external monitoring opportunities. Our findings demonstrate that the governance effects of stock liquidity are applicable to not only activist hedge funds (Edmans et al., 2013) but also a broader set of institutional investors, such as independent advisors, investment companies, and institutional investors with multi-firm ownership. Our study also contributes to Fang et al. (2014), which find that non-dedicated institutional investors' short-term focus and lack of monitoring may be a mechanism through which stock liquidity impedes firm innovation. In contrast to Fang et al. (2014), our findings demonstrate that the participation of institutional investors, which are active monitors and have multi-firm ownership, can be a mechanism through which stock liquidity enhances firm value. Most importantly, our study contributes to the recent literature on multi-firm blockholders (Edmans et al., 2015). While Edmans et al. (2015) is mainly theoretical, we are among the first to provide empirical evidence on the role of stock liquidity in enhancing participation by institutional investors with multi-firm ownership.[9]

Furthermore, our study is among the first to document the *causal* effect of stock liquidity on firm value and corporate governance for the REIT industry. Our study tackles both endogeneity issues and corporate governance implications of stock liquidity, which are insufficiently addressed by the existing real estate literature.[10] Lastly, our findings contribute to the cross-area literature that emphasizes the important link between corporate finance and financial markets (O' Hara, 1999; Easley and O'Hara, 2004).

The rest of the paper is organized as follows. Section 2 discusses the hypotheses. Section 3 presents the methodologies. Section 4 discusses the data and summary statistics. Section 5 presents the empirical results. Section 6 concludes.

2. Hypotheses

With its regulatory features (i.e., homogeneous investment structures that accentuate the governance effect, the high payout requirement that increases market monitoring opportunities, and the unique outside ownership structures that favor institutional participation), the REIT industry provides a unique setting to examine the proposition of stock liquidity affecting firm value, particularly the importance of corporate governance and the channel of institutional ownership. In this section, we discuss the main hypotheses and empirical methodologies.

2.1. Effect of stock liquidity on firm performance

Our first empirical hypothesis is to test whether stock liquidity can improve the firm performance of REITs. Given their high payout requirement and equity dependence, REITs may improve stock liquidity to attract funding for investments. Nonetheless, an increase in stock liquidity is not necessarily conducive to improving in firm value. On the one hand, an increase in stock liquidity may help managers to attract new funding for investment projects that do not necessarily create value (e.g., in the presence of agency problems). On the other hand, an increase in stock liquidity may support value-enhancing activities such as corporate governance and market monitoring. In the REIT case, a high payout can increase the opportunity of market monitoring by outside investors (Easterbrook, 1984), and higher stock liquidity can enhance monitoring incentives (Maug, 1998). If stock liquidity is conducive to improvement in firm value through a value-enhancing mechanism such as corporate governance, we would expect a positive effect of stock liquidity on firm value (i.e., a negative effect of the measure of stock illiquidity on firm value). As such, we propose the following hypothesis:

Hypothesis 1. Stock liquidity improves future firm value.

To further support Hypothesis 1, i.e., that stock liquidity has a positive value implication, we construct the following hypotheses to test whether stock liquidity affects firm value through value-enhancing activities such as corporate governance.

2.2. Effect of stock liquidity on corporate governance

Given that REITs may be influenced by external monitoring more than typical firms are (Hartzell et al., 2014), we test the theoretical prediction of Maug (1998) that a liquid stock market can lower trading cost and enhance investors' incentives to monitor. In the REIT case, institutional investors are especially effective in monitoring and enhancing corporate governance (Chung et al., 2012;

[9] Our analysis is also related to other corporate finance literature such as Mori and Ikeda (2015), which examines the relation between a blockholder's monitoring incentive and a firm's dividend policy. While Mori and Ikeda (2015) do not consider the role of stock liquidity, our analysis using the REIT setting demonstrates that firms with high payout requirements can be conducive to institutional monitoring through the channel of stock liquidity.

[10] Prior studies, such as Benveniste et al. (2001) and Brounen et al. (2009), do not address the endogeneity issue, which may affect the inference of the empirical relation between the REIT stock liquidity and firm value.

Hartzell et al., 2014) for REITs.[11] Based on the evidence on institutional monitoring in REITs, we test whether a firm's stock liquidity can improve corporate governance through the channel of institutional ownership. As such, we propose the following hypothesis:

Hypothesis 2. Stock liquidity leads to higher institutional ownership.

A result supporting Hypothesis 2 would be consistent with the governance theory by Maug (1998) that stock liquidity should enhance monitoring incentives of outside investors; in the REIT case, stock liquidity should increase institutional participation. The opposite result (i.e., stock liquidity leads to lower institutional participation) would support the competing theories by Coffee (1991) and Bhide (1993), which argue that stock liquidity deters monitoring incentives.

Institutional investors can be heterogeneous agents in performing corporate governance and affecting firm value. Certain types of institutional investors are more effective in providing monitoring and corporate governance due to their differences in, for example, objectives, information, and skills. In the REIT setting, we identify specific types of institutional investors that are attracted to the unique features of REITs (i.e., high payout and market monitoring opportunity). We examine whether stock liquidity leads to higher ownership of the following types of institutional investors, which may be more effective in providing corporate governance.

We study whether stock liquidity is more important for institutional investors that are more likely to be active monitors. Independent institutional investors, such as independent advisors and investment companies, may provide better monitoring than other institutional investor types. Existing studies, including Almazan et al. (2005), Chen et al. (2007), and Ferreira and Matos (2008), support that independent institutional investors are better monitors. In the REIT setting, Chung et al. (2012) and Hartzell et al. (2014) provide the similar finding that independent institutional investors are active monitors, with a comparative advantage in monitoring managers. If stock liquidity can lower cost of trades (to acquire or exit) and enhance monitoring incentives, stock liquidity should increase the ownership stakes by institutional investors that are active monitors. As such, we propose the following hypothesis:

Hypothesis 2A. Stock liquidity leads to higher participation of institutional investors that are active monitors.

To test Hypothesis 2A, we examine whether stock liquidity leads to higher ownership by institutional investor types that are active monitors such as independent advisors and investment companies. Nevertheless, stock liquidity can enhance corporate governance through not only voice but also exit (Edmans, 2009). We utilize the REIT setting and perform an in-depth analysis to examine whether stock liquidity can also support governance through institutional investors' trading of REIT stocks.

To do so, we stratify institutional investor types based on their investment portfolios and monitoring incentives. Utilizing the REIT setting, we identify institutional investors that manage portfolio of REITs stocks and expect that their monitoring incentives are affected by liquidity of the underlying REIT stocks. As a first step, we identify institutional investors that have REIT stock investments in their overall portfolios. We argue that institutional investors that have investments and portfolios of REIT stocks will likely develop expertise on and make efforts to monitor REIT stocks. As a second step, we examine whether stock liquidity is more important for REIT institutional investors with concentrated investments in REIT stocks or REIT institutional investors with a diversified REIT stock portfolio. On the one hand, investors with higher concentrations of ownership may have stronger incentives to monitor. On the other hand, Edmans et al. (2015) show that in the presence of agency problems, the existence of multiple firms allows the blockholder to punish poorly managed firms by selling their shares (governance through exit) and retaining the rival firms' shares. As such, governance is more effective under multi-firm ownership than under a single-firm benchmark (Edmans, 2014). Utilizing the REIT setting, we test whether stock liquidity should increase the ownership of investors with multiple firms in the same (REIT) industry. We propose the following hypothesis to examine whether stock liquidity is more important for REIT institutional investors with multi-firm ownership in the REIT industry:

Hypothesis 2B. Stock liquidity leads to higher participation of institutional investors with multi-firm ownership.

To test Hypothesis 2B, we examine whether stock liquidity leads to higher ownership by institutional investors that have multi-firm ownership in REIT stocks. This hypothesis is specifically useful for supporting the liquidity-governance theory through exit (or threat of exit) and multi-firm ownership.[12]

3. Methodologies

3.1. Variable definitions

3.1.1. Measures of stock liquidity

To investigate the effect of liquidity on institutional monitoring, we employ Amihud (2002) illiquidity (also known as the Amihud price impact) to measure the stock liquidity depth. As Maug (1998) argues, part of the incentive to monitor comes from the ability to purchase

[11] In the REIT setting, institutional investors provide the monitoring and governance role through different channels such as an investment's response to market valuation (Hartzell et al., 2006), reduction in firm inefficiency (Chung et al., 2012), and managerial pay-for-performance sensitivity (Feng et al., 2010). Hartzell et al. (2014) find that institutional investors, particularly those that are more likely to be active monitors, significantly reduce the diversification discount of REITs. In general industry setting, Hartzell and Starks (2003) and Chen et al. (2007) find evidence that institutional investors provide monitoring and corporate governance.

[12] Both Hypotheses 2A and 2B support the presence of the governance effect of liquidity. Hypothesis 2A is consistent with either the voice or exit effect of governance. Institutional investors can provide governance through voice and active monitoring by increasing their shares with higher liquidity. However, active monitors can also provide governance through their trading of a firm's shares with higher liquidity, including the actual exit by selling shares ex post and the threat of exit by incentivizing the manager ex ante (Edmans, 2009). Hypothesis 2B is interesting in its own right because it focuses on multi-firm ownership governance using the REIT setting. In the multi-firm ownership case, governance is likely exerted through actual exit (or the threat of exit) because investors can sell their shares of poor-performing firms (governance through exit) and retain those of rival firms (Edmans, 2014).

shares at a price that does not reflect the large shareholder improvement. As such, the Amihud price impact, reflecting the ability of investors to purchase additional shares with little impact on prices, is particularly relevant when examining the effect of liquidity on institutional monitoring. Moreover, Goyenko et al. (2009) demonstrate that Amihud's illiquidity measure is the most reliable measure of price impact using daily data. We use the Amihud price impact, which is defined as the logarithm of one plus the average ratio of the daily absolute return to the dollar trading volume on day d for stock i over year t (with D_{it} as the number of trading days for stock i in year t), [13]

$$Amihud_{it} = \log\left(1 + \frac{1}{D_{it}} \sum_{d=1}^{D_{it}} \frac{|R_{idt}|}{DVol_{idt}}\right) \tag{1}$$

where R_{idt} is the daily return on stock i in year t and $DVol_{idt}$ is the daily dollar volume in millions for stock i in year t. The ratio measures the absolute percentage price change per dollar of daily trading volume, representing the daily price impact of the order flow à la Kyle (1985).

3.1.2. Measures of firm performance

To test Hypothesis 1, we measure firm value using Tobin's Q ratio, which is defined as the 1-year ahead market value of assets (the market value of equity + book value of assets – book value of equity – balance sheet deferred taxes), divided by the book value of assets.

3.1.3. Measures of institutional ownership

To test Hypothesis 2, we measure institutional ownership as total equity ownership by institutional investors (Hartzell et al., 2014).[14] Institutional ownership is commonly assumed to be positively related to corporate governance. Data on institutional ownership are obtained from the Thomson Reuters Institutional (13 F) Holdings database. To test Hypothesis 2A, we examine different types of institutional investors using the Thomson Reuters Institutional (13 F) Holdings database and Brian Bushee's classifications of institutional investors: Independent Advisor, Investment Company, Bank Trust, Insurance Company, Corporate Pension Fund, Public Pension Fund, Endowment, and Miscellaneous. As discussed in Section 2.2, we follow the literature (e.g., Chung et al. (2012) and Hartzell et al. (2014)) and identify active monitors as Independent Advisor and Investment Company.

To test Hypothesis 2B, we construct our own measure of institutional investors with multi-firm ownership by examining each institutional investor's stock portfolio and identifying specific types of REIT institutional monitors. Utilizing the REIT setting, we measure the percentage of REIT stocks in each of the individual investors' investment portfolios at the fund-level and identify institutional investors that have investments in REIT stocks. We identify REIT institutional investors with multi-firm ownership based on the following steps: For the last quarter in fiscal year t, we calculate RR, the ratio of REITs in a portfolio of an institution, similar to a Herfindahl index:

$$\frac{1}{J} \le RR_{it} = \sum_{j=1}^{J} \left(\frac{REIT_{ijt}}{\sum_{j=1}^{J} REIT_{ijt}}\right)^2 \le 1 \tag{2}$$

where $REIT_{ijt}$ is the dollars invested in the j-th REIT by institution i in year t, and J is the total number of REITs invested in by institution i in year t. The ratio RR equals 1 if institution i only invests in one REIT. Institutions with zero dollars invested in REITs are excluded. For each fiscal year t, we classify institution i as (i) a high-concentration REIT portfolio institution if $RR_{it} \ge RR_{p50,t}$, where $RR_{p50,t}$ equals the median value of RR_{it} across all i; or (ii) a low-concentration REIT portfolio institution if $RR_{it} < RR_{p50,t}$, where $RR_{p50,t}$ equals the median value of RR_{it} across all i.[15] After we identify REIT institutional investors with multi-firm ownership as those with low-concentration REIT portfolios, we compute the total percentage of equity ownership by the REIT institutional investors with multi-firm ownership for each REIT (firm j).

3.2. Regression analysis

In this section, we present regression models to test the hypotheses discussed above. To test Hypothesis 1, we estimate the following regression:

$$Q_{i,t+1} = a_0 + a_1 Illiquidity_{i,t} + a_2 Control_{i,t} + \epsilon_{i,t+1} \tag{3}$$

where Q_{it+1} is measured by Tobin's Q for firm i in fiscal year $t+1$ The key explanatory variable is stock illiquidity, and we use the Amihud price impact to measure $Illiquidity_{i,t}$. We select the control variables based on the insights from Gompers et al. (2003) and Fang et al. (2009). We also include additional control variables for the REIT setting. The control variables ($Control_{i,t}$) include firm age, firm size, long-term debt, short-term debt, momentum, and Maryland dummy, which are defined below. Age (log_age) is the logarithm of the firm's age. Firm size (log_at) is the

[13] We take the logarithm for our measure of stock illiquidity so that its distribution is closer to normal distribution.

[14] Hartzell et al. (2014) argue that fractional institutional ownership, rather than the number of investors, can be used to measure monitoring in REITs.

[15] Further examination (not reported here) reveals that total number of REIT stocks invested by a low-concentration REIT portfolio institution (with $RR_{it} < RR_{p50,t}$) has a mean (median) of 21 (11). In contrast, the total number of REIT stocks invested by a high-concentration REIT portfolio institution (with $RR_{it} \ge RR_{p50,t}$) has a mean (and median) of 2. As a robustness check, we classify institution i to be (i) a high-concentration REIT portfolio institution if $RR_{it} \ge RR_{p75,t}$, where $RR_{p75,t}$ equals the value of the upper quartile of RR_{it} across all i in year t; (ii) a low-concentration REIT portfolio institution if $RR_{it} \le RR_{p25,t}$, where $RR_{p25,t}$ equals the value of the lower quartile of RR_{it} across all i in year t. We find the same conclusion from our results using this alternative classification.

logarithm of the firm's total assets.[16] Momentum (mom) is the 6-month market excess returns starting in January of the year.[17] Long-term debt is long-term debt divided by total assets. Short-term debt is the sum of debts with maturity less than or equals to 3 years, divided by total assets.[18] Because a majority of REITs incorporate in Maryland, we include a dummy variable of Maryland, which equals unity if the firm is incorporated in Maryland.[19] Hypothesis 1 predicts that $a_1$should be negative.

To test Hypotheses 2, 2A, and 2B, we estimate the following:

$$IO_{i,t+1} = \beta_0 + \beta_1 Illiquidity_{i,t} + \beta_2 Control_{i,t} + \varepsilon_{i,t+1}. \quad (4)$$

We estimate Eq. (4) using the TOBIT model with a dependent variable ($IO_{i,t+1}$) that includes different measures of institutional ownership.[20] As discussed above, the control variables include firm size, Maryland dummy, momentum, firm age, long-term debt, and short-term debt.[21] Hypotheses 2, 2A, and 2B predict that β_1 should be negative for different types of institutional ownership because stock illiquidity should *reduce* governance incentives and hence lower participation by institutional investors.

3.3. Endogeneity and difference-in-differences estimation of treatment effect

Endogeneity remains one of the most pervasive issues in addressing the causal relations between stock liquidity and firm performance.[22] To alleviate endogeneity concerns, we follow the recommendation by Roberts and Whited (2012) and examine the relation between stock liquidity and firm performance using instrumental variables, difference-in-differences estimators, and matching methods. To examine the causal effect of stock liquidity on firm performance, we examine whether the observed firm performance persists after controlling for firm differences other than liquidity. To do so, we conduct a difference-in-differences estimation of an average treatment effect with an exogenous shock to liquidity. The difference-in-differences approach has three advantages over previous approaches. First, the difference-in-differences approach only requires the parallel trends (Roberts and Whited, 2012) assumption, namely, that any trends in outcomes for the treatment and control groups prior to treatment are the same. Second, the difference-in-differences approach avoids the problem of omitted trends in both treated and control groups that are correlated to liquidity and firm performance over time (see, e.g., Roberts and Whited (2012)). Third, the difference-in-differences approach avoids the problem of unobserved differences between the two groups (see Roberts and Whited (2012)). Our estimation was performed according to the following steps.

3.3.1. Step 1. Defining the treatment effect: Decimalization

Similar to Fang et al. (2009) and Edmans et al. (2013), we use the decimalization of the U.S. stock markets in 2001 as an exogenous shock to stock liquidity.[23] Specifically, we define a firm-year after (before) decimalization because fiscal year t ends after (before) January 29, 2001, for firms listed on NYSE/AMEX and April 9, 2001, for firms listed on NASDAQ. We then compute the change in stock liquidity before and after the decimalization for each firm and compare the changes in firm performance surrounding the decimalization for firms with large and small liquidity increases.

The use of decimalization as an exogenous shock to improve stock liquidity is applicable to the REIT setting. First, Bessembinder (2003) and Furfine (2003) find stronger evidence of decimalization in the U.S. stock market in 2001 improving stock liquidity for more frequently-traded firms. Although REITs may have relatively smaller firm size, we find that REITs are more liquid than are average industrial firms (see Section 4 and Panel C of Table 1). Second, a major limitation of difference-in-differences estimation using decimalization (e.g., Edmans et al. (2013)) is that it does not eliminate the possibility that an unobserved variable (which is correlated with the outcome variable) affects the treated and control groups differently. Our single-industry setting of REITs can reduce confounding effects due to cross-sectional differences in risk, transparency, and growth potential (Hartzell et al., 2008; Hartzell et al., 2014), providing a better control for unobserved heterogeneity when conducting matching and difference-in-differences tests. Third, the test design of the difference-in-differences approach with exogenous treatment implies that any causal effect on firm value should originate *only* from change in liquidity due to an exogenous shock such as the

[16] Firm value may increase with firm age and firm size due to economies of scale or less information asymmetry with established firms; in contrast, firm age and firm size may reduce firm value due to firm maturity and diseconomies of scale. The effects of these variables on firm value are subject to empirical investigation.

[17] Institutional investors may have a preference for momentum stocks (Gompers et al. (2003)) and these stocks likely experience a rise in firm value. We predict a positive relation between momentum and Tobin's Q.

[18] Financial leverage can increase or decrease firm value, depending on whether the benefits (e.g., interest tax shield and agency cost reduction) outweigh the costs of leverage (e.g., distress risk). For REITs, financial leverage often includes both long-term and short-term debt, and these may have different value implications. For example, short-term debt increases the likelihood of debt renegotiation and subsequent asset redistribution.

[19] Because Maryland incorporation is associated with strong takeover defenses, we are also interested in examining whether Maryland incorporation has any significant effect on firm value after controlling for other variables.

[20] We obtain similar results and the same conclusion with LOGIT regression and OLS regression using $\log(1 + IO_{i,t+1})$ as the dependent variable.

[21] Institutional equity ownership may increase with firm age and firm size due to less information asymmetry with established firms. Institutional equity ownership may be positively (negatively) related to momentum if these investors are pursuing a momentum (contrarian) strategy. If institutional investors do not invest in stocks with distress risk, then institutional ownership should be negatively related to long-term and short-term debt. Because Maryland incorporation is associated with strong takeover defense for REITs, a positive relation between institutional ownership may suggest that institutional participation provide important source of governance for REITs due to the lack of a takeover market.

[22] While a negative relation between stock illiquidity and Tobin's Q ratio suggests that an improved liquidity helps to enhance firm performance, an alternative interpretation of this relation is that a high Tobin's Q ratio firm attracts liquidity traders (Chung et al., 2010).

[23] For U.S. stock exchanges, the decimalization in 2001 changed the minimum tick size in the bid-ask spreads from the old system of fractional pricing (1/16 of a dollar or US$ 0.0625) to the new system of decimal pricing (US$ 0.01 per share) (source: "Decimal Implementation Plan", U.S. Securities and Exchange Commission). The change in liquidity around the decimalization could be an instrument for liquidity because the decimalization is unlikely to be driven by the future performance of individual firms.

decimalization. Although there could be other events in the REIT industry (such as the effect of the REIT Modernization Act (RMA)) that occurred around the decimalization, such an event cannot be considered an instrument to define the treatment effect of stock liquidity change unless the event can represent an exogenous shock to stock liquidity.[24] Furthermore, the possibility of a delayed effect from the RMA should not weaken our results if the RMA also represents an exogenous shock that also affects stock liquidity.[25]

3.3.2. Step 2. Estimating the treatment effect: Difference-in-differences estimation

We follow the econometric technique to obtain a consistent estimate of the treatment effect (Colak and Whited, 2007; Roberts and Whited, 2012), which has been used in economics to study the effects of regulations and policies. We define L as a binary treatment variable that is equal to 1 if the firm has a (positive) change in liquidity surrounding decimalization in the highest tertile (see, e.g., Fang et al. (2014) for the same definition) and 0 otherwise. We follow the methodology provided by Colak and Whited (2007) and define the treatment effect as follows. We define $Q_i(L)$ as a measure of firm performance (i.e., Tobin's Q), which is a function of L for observation i. $\mathrm{E}[Q_i(1)|L=1]$ is the expected value of the treatment effect on the firm performance of the treated group given the presence of the treatment effect of decimalization. In contrast, $\mathrm{E}[Q_i(0)|L=1]$ is the (hypothetical and unobservable) expected value of no treatment effect on firm performance given that treatment effect actually occurs.

To perform a difference-in-differences estimation of an average treatment effect, we compute the change in $Q_i(L)$ relative to its value before treatment, which is defined as $\Delta Q_i(L)$. We estimate the average effect of the liquidity increase (after decimalization) on firm performance for firms that experience large liquidity increases, known as the average treatment effect on the treated (ATT):

$$\rho = \mathrm{E}[\Delta Q_i(1) - \Delta Q_i(0)|L=1] \tag{5}$$

$\mathrm{E}[\Delta Q_i(0)|L=1]$ is unobservable because we cannot observe the counterfactual effect of no treatment effect on a firm that has actually experienced the effect of treatment (i.e., $\rho|_{L=1}$ is unobservable, as its component $\mathrm{E}[\Delta Q_i(0)|L=1]$ is unobservable). Similar to Colak and Whited (2007), we estimate $\mathrm{E}[\Delta Q_i(0)|L=1]$ by averaging $\Delta Q_i(0)$ over the untreated/control observations. An estimate of the average treatment effect on the treated, $\widehat{\rho|_{L=1}}$, is obtained by subtracting the estimate of $\mathrm{E}[\Delta Q_i(0)|L=1]$ over the untreated/control observations (i.e., $\overline{\Delta Q_i(0)|_{control}}$) from the average of $\Delta Q_i(1)$ over the treated observations (i.e., $\overline{\Delta Q_i(1)|_{treated}}$):

$$\widehat{\rho|_{L=1}} = \overline{\Delta Q_i(1)|_{treated}} - \overline{\Delta Q_i(0)|_{control}} \tag{6}$$

3.3.3. Step 3. Matching estimators: Propensity score matching estimator

Matching estimation theory suggests that if assignment to the treatment is exogenous conditional on a set of observable control variables, then the effect of treatment can be estimated by constructing a matched sample of control firms (see Colak and Whited (2007)). In our case, the treatment effect will be estimated by averaging within-subpopulation differences in firm performance that occur between the treatment and control groups. We employ the propensity score matching based on the existing literature and applications such as Rubin (1973a, b), Rosenbaum (1989, 1995), Dehejia and Wahba (1999), Edmans et al. (2013), and Fang et al. (2014).

3.4. Propensity score matching estimator

The propensity score models the probability of receiving treatment conditional on observable covariates $\boldsymbol{Z}$,

$$pscore(\boldsymbol{Z}) = \Pr(L=1|\boldsymbol{Z}). \tag{7}$$

Following Fang et al. (2014), we estimate the propensity score for observation i by running the following PROBIT regression of an indicator (L) of large liquidity increase around the 2001 decimalization on $\boldsymbol{Zi}$ for both the treated and control groups:

$$\begin{aligned} pscore(\boldsymbol{Z}_i) = \Pr(L=1|\boldsymbol{Z}_i) = \phi\,(&\hat{\beta}_0 + \hat{\beta}_1 age_{i,t-1} + \hat{\beta}_2 size_{i,t-1} + \hat{\beta}_3 Amihud_{i,t-1} \\ &+ \hat{\beta}_5 ltdebt_{i,t-1} + \hat{\beta}_6 momentum_{i,t-1} + \hat{\beta}_7 stdebt_{i,t-1} + \hat{\beta}_8 Maryland_{i,t-1}) \end{aligned} \tag{8}$$

where $\phi(.)$ is the cumulative distribution function of the standard normal distribution; the control variables include the lagged values of firm age (*age*), firm size (*size*), Amihud illiquidity (*Amihud*), long-term debt (*ltdebt*), momentum (*momentum*), short-term debt (*stdebt*), and Maryland (*Maryland*), which are defined above. We perform the propensity score matching with and without replacement. Furthermore, we perform the difference-in-differences estimation of the decimalization effect on institutional ownership $IO_i(L)$, which becomes a function of L for observation i, where L is the binary treatment variable equal to 1 if the firm has a (positive) change in liquidity surrounding the decimalization in the highest tertile and 0 otherwise. We perform the same steps and procedure as described above to examine the causal effect of stock liquidity on different types of institutional ownership (Hypotheses 2, 2A, and 2B).

[24] Although the RMA act was signed in 1999 and effective in 2001, Howe and Jain (2004) find that the effect of the RMA on the stock market is observed in 1999 when the act was signed, suggesting that any delayed effect on the stock market was unlikely to have carried over to 2001.

[25] For example, a possibly delayed effect from RMA might capture the effect of an (REIT) industry-specific shock that affects REIT stock liquidity. However, the introduction and delayed effects of the RMA will not be considered as an exogenous instrument unless the RMA causally affects firm performance *solely* through changes in stock liquidity.

4. Data and summary statistics

Our REIT sample consists of 1229 firm-year observations for 164 equity REITs from the NYSE, AMEX, and NASDAQ from 1994 to 2006. The daily returns data are gathered from the CRSP/Ziman Real Estate database. Annual financial data are obtained from the

Table 1
Summary statistics
This table reports the summary statistics of the key variables for our full sample of REITs, for high- vis-à-vis low-liquidity sub-samples, and for REIT vis-à-vis non-REIT samples. Our REIT sample consists of 1229 firm-year observations from 1994–2006 and 164 REITs. The high- (low-) liquidity sub-sample consists of firm-year observations with Amihud illiquidity lower (higher) than the median for each year. Tobin's Q (Q) ratio is defined as the market value of assets (the market value of equity + book value of assets – book value of equity – balance sheet deferred taxes) divided by the book value of assets. The institutional equity ownership includes the total institutional ownership (Total io), equity ownership by independent advisor (Advisor io), equity ownership by Investment Company (Invest. Co. io), and equity ownership by institutional investors with diversified portfolios of REIT stocks (Diversified io). Tobin's Q and institutional ownership variables are measured as 1-year-ahead values. Amihud is the logarithm of the Amihud illiquidity measure of the firm. Firm age is the logarithm of the number of years since listing on the stock exchange. Firm size is the logarithm of the firm's total assets. Long-term debt is the ratio of long-term debt to total assets. Short-term debt is ratio of the debt with maturity less than or equal to 3 years to total assets. Momentum is the 6-month market excess returns starting January of the year. Maryland equals unity if the firm is incorporated in Maryland and zero otherwise. Panel A reports the summary statistics of the main variables used in our multivariate analysis for full sample of firms. Panel B reports the mean, standard deviation, and t-statistics of firm characteristics for mean differences between subsamples of high- and low-liquidity firms. High (low) liquidity firms have Amihud illiquidity lower (higher) than the median of a given year in the sample. Panel C compares the summary statistics of Amihud illiquidity, Tobin's Q and total institutional ownership between REITs and non-REITs from 1994 to 2006. Non-REITs include: firms from all industries excluding REITs, financials, and utilities (column (2)); a matched sample of non-REIT firms based on total assets (column (3)); and a matched sample of non-REIT firms based on market capitalization (column (4)). Panel C reports the mean, standard deviation (in parenthesis), and median [in square bracket] for the REIT sample (column (1)) and the non-REIT samples (columns (2) to (4)). See footnote 27 for construction of the non-REIT samples.

Panel A: Summary statistics for full sample

Variable	Min	25%	Median	Mean	75%	Max	SD	N
Q	0.708	1.065	1.208	1.268	1.414	2.242	0.301	1229
Total io	0.000	0.168	0.511	0.484	0.786	1.000	0.339	1229
Advisor io	0.000	0.032	0.224	0.245	0.407	0.718	0.203	1229
Invest. Co. io	0.000	0.005	0.053	0.065	0.105	0.281	0.063	1229
Diversified io	0.000	0.143	0.476	0.457	0.753	1.000	0.333	1229
Amihud	0.000	0.003	0.009	0.162	0.042	2.832	0.451	1229
Firm age	1.386	2.079	2.485	2.496	2.890	3.664	0.555	1229
Firm size	2.703	6.118	6.891	6.833	7.796	9.620	1.346	1229
Long-term debt	0.043	0.448	0.542	0.552	0.653	1.003	0.174	1229
Short-term debt	0.000	0.008	0.186	0.212	0.330	0.879	0.199	1229
Momentum	−0.346	−0.094	0.019	0.040	0.154	0.608	0.186	1229
Maryland	0.000	0.000	1.000	0.648	1.000	1.000	0.478	1229

Panel B: Univariate test of firm characteristics for mean differences between subsample of high and low liquidity firms

Variable	High liquidity		Low liquidity		Difference
	Mean	SD	Mean	SD	(high–low liquidity)
Q	1.331	0.273	1.203	0.313	0.128***
Total io	0.625	0.301	0.342	0.315	0.283***
Advisor io	0.303	0.198	0.187	0.191	0.116***
Invest. Co. io	0.087	0.065	0.043	0.052	0.044***
Diversified io	0.598	0.300	0.315	0.304	0.283***
Amihud	0.006	0.009	0.318	0.599	−0.312***
Firm age	2.455	0.529	2.536	0.577	−0.081**
Firm size	7.686	0.916	5.979	1.156	1.707***
Long-term debt	0.537	0.152	0.567	0.194	−0.030***
Short-term debt	0.200	0.176	0.224	0.220	−0.023**
Momentum	0.036	0.170	0.044	0.200	−0.008
Maryland	0.672	0.470	0.622	0.485	0.051*

Panel C: Summary statistics of REITs vs non-REITs from 1994 to 2006

	(1) REITs	(2) Non-REITs	(1) – (2)	(3) Total assets matched sample	(1) – (3)	(4) Market cap matched sample	(1) – (4)
Amihud	0.174	0.562	−0.388***	0.301	−0.127***	0.418	−0.244***
	(0.490)	(0.962)		(0.668)		(0.835)	
	[0.010]	[0.078]		[0.020]		[0.036]	
Q	1.261	2.159	−0.898***	2.032	−0.771***	2.407	−1.146***
	(0.307)	(2.145)		(1.525)		(2.732)	
	[1.207]	[1.517]		[1.530]		[1.698]	
Total io	0.440	0.363	0.077***	0.416	0.024***	0.402	0.038***
	(0.282)	(0.236)		(0.236)		(0.243)	
	[0.446]	[0.366]		[0.443]		[0.422]	

*** Indicate 1% significance level, for statistical significance of the correlation coefficient based on two-tailed t-tests.
** Indicate 5% significance level, for statistical significance of the correlation coefficient based on two-tailed t-tests.
* Indicate 10% significance level, for statistical significance of the correlation coefficient based on two-tailed t-tests.

CRSP and COMPUSTAT databases. The data on institutional equity ownership are obtained from the Thomson Reuters Institutional (13F) Holdings database. Table 1 reports the summary statistics of our illiquidity variables and firm characteristics of REITs.[26] Our interest lies in whether stock liquidity plays a role in firm performance and governance. Panel B of Table 1 reports the univariate differences in firm characteristics between high- and low-liquidity firms. The result in Panel B shows that REITs with more liquid stock (lower Amihud illiquidity) have significantly higher Tobin's Q, higher total institutional ownership, and higher ownership by active monitors, and institutional investors that have multi-firm ownership in REIT stocks. Furthermore, REITs with more liquid stock are larger in size, younger in age, and have less debt (long- or short-term).

Importantly, Table 1 reports several stylized facts of the unique features of the REIT setting. First, Panel C of Table 1 shows that REIT firms are on average more liquid than all other industrial firms (i.e., firms from all industries except REITs, financials, and utilities) and the samples of non-REIT firms matched by comparable firm size (measured by market capitalization or total assets).[27] This finding suggests that REITs are liquid compared with firms from other industries. Second, Panel C of Table 1 shows that REITs have a higher overall average of institutional ownership than all other industrial firms and the samples of non-REIT firms matched by comparable firm size. In addition, Fig. 1 shows that the average institutional ownership of REITs is substantially higher than that of all other industrial firms in all years from 1994 to 2006. Interestingly, REITs experienced a significant increase in institutional ownership after the decimalization. When comparing REITs with non-REIT firms matched by firm size, REITs have higher average institutional ownership than do the non-REIT firms matched by firm size after the decimalization. Although decimalization applies to all publicly traded firms, there are more institutional investors participating in the REIT market compared with other industrial firms. These findings are consistent with the possibility that increase in stock liquidity attracts institutional investors' participation (e.g., due to value-enhancing opportunities). Furthermore, Panel A of Table 1 reveals that a large fraction of the equity stakes of REIT stocks are owned by REIT institutional investors with multi-firm ownership and independent advisors that are more likely to provide governance. Overall, the significance of institutional investors in REITs suggests that the governance implications of stock liquidity (e.g., institutional investors' governance through voice or exit) could be particularly important for REITs.

5. Empirical results

5.1. Does stock liquidity improve the firm value of REITs?

In this section, we examine the effects of stock illiquidity on REIT performance. Table 2 reports the regression results of Tobin's Q in Eq. (3). The results in Table 2 suggest that stock illiquidity has a significantly negative effect on the firm value of REITs. These findings are remarkably robust to alternative model specifications. In Model (1) of Table 2, we examine the effects of stock illiquidity on the firm value of REITs measured by one-year-ahead Tobin's Q. The regressions are estimated using the Petersen (2009) method of clustered standard errors, adjusted for intra-firm correlations. The result shows that the effect of stock illiquidity on firm performance is both statistically and economically significant. We estimate that a one-standard-deviation decrease in the log of Amihud illiquidity measure implies an increase in the Tobin's Q ratio of 8.4% from its unconditional mean.[28]

To account for the time variation in the estimated effect of market liquidity on Tobin's Q, Model (2) of Table 2 presents the result using the Fama–MacBeth (1973) regression, in which the estimated standard errors are corrected for cross-sectional correlation. Consistent with the result in Model (1), the result in Model (2) shows that market illiquidity has a significantly negative effect on 1-year-ahead Tobin's Q.

Model (3) of Table 2 presents the two-stage least squares (2SLS) estimates of the effect of stock illiquidity on firm value. In the first-stage regression, Amihud illiquidity (log_*amihud*) is estimated using instrumental variables linked to market liquidity; however, these variables do not exhibit the predicted effect on firm performance. The instrumental variables are as follows. First, we use the property-type Amihud ratio, which is defined as the market-value-weighted average Amihud illiquidity of REIT *i*'s property type (*ptype_amihud*). Market liquidity can be affected by the property type of an REIT because REITs with certain property types have specific information issues that affect trading activities.[29] Second, we use the indicator variable of the NYSE listing because listing on stock exchanges, such as the NYSE, may affect firm performance through the channel of market liquidity. In contrast, the direct effect of the NYSE on firm-level performance is unclear. In the second-stage regression, we use the predicted value of Amihud illiquidity from the first stage and firm fundamental characteristics (used in Eq. (3)) to estimate the dependent variable, 1-year-ahead Tobin's Q ($Q_{i,t+1}$). Model (3) of Table 2 reports the estimates of the second-stage regression, in which we estimate the effect of the predicted value of Amihud illiquidity on the 1-year-ahead Tobin's Q. The result in Model (3) shows that the coefficient of the predicted Amihud illiquidity has a significantly negative effect on the future firm performance variable in the second-stage regression.[30]

[26] To control for outliers, we winsorize our variables at the top and bottom 1%. To ensure that our estimate of stock illiquidity is comparable to existing studies, such as Cannon and Cole (2011), we re-compute the statistics of our illiquidity measure from 1988–2007 (the sampling period used by Cannon and Cole (2011)). This robustness check (results not reported here) show that the statistics of our stock illiquidity measure are in fact very close to those reported by Cannon and Cole (2011).

[27] To create the matched sample of non-REIT firms, we perform a one-to-one matching between REIT firms and non-REIT firms in each fiscal year from 1994 to 2006. The size differences between the two samples are no more than 1% of either the value of total assets or market capitalization.

[28] Table 1 Panel A indicates that the unconditional mean of Tobin's Q is 1.268 and that the standard deviation of the log of Amihud illiquidity is 0.451. Model (1) of Table 2 indicates that the regression coefficient of the log of Amihud illiquidity on Tobin's Q is −0.235. Thus, a one-standard-deviation *decrease* in the log of Amihud illiquidity measure implies an *increase* in Tobin's Q of 8.36% from the unconditional mean of Tobin's Q, which is computed as $(0.235 * 0.451)/1.268$.

[29] Cannon and Cole (2011) use value-weighted average log_*amihud* for REIT *i*'s property type (*ptype_amihud*) as a determinant of market illiquidity measures. Similarly, Fang et al. (2009) use the industry average of illiquidity as an instrument of a firm's liquidity.

[30] For the control variables, the overall results from Models (1) to (3) suggest that firm age and long-term debt have a significantly positive relationship with firm value, whereas short-term debt has a negative relationship with firm value.

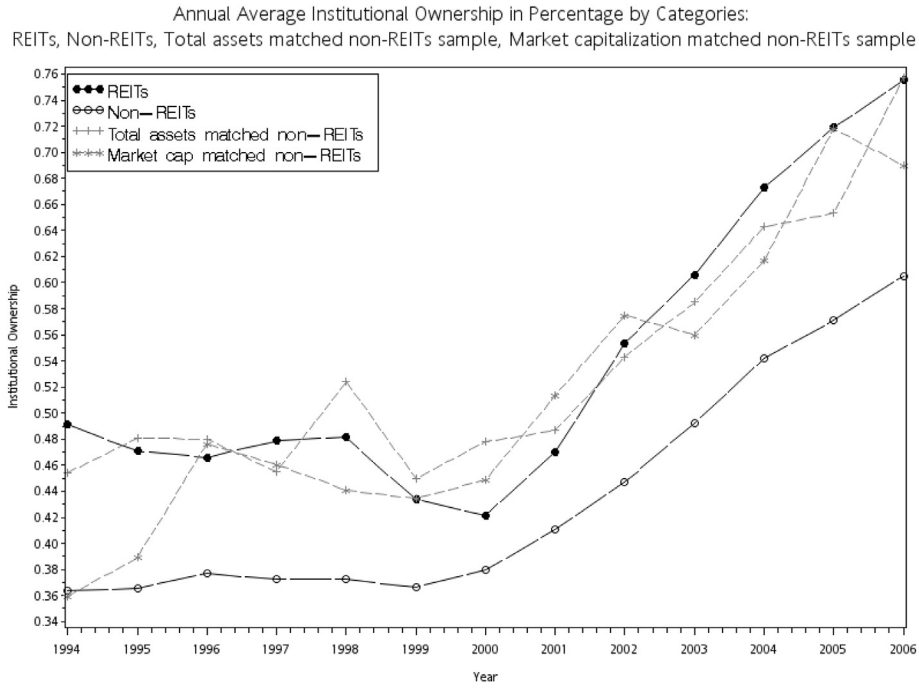

Fig. 1. Average institutional ownership of REIT vs. non-REIT. This figure reports the comparison of the average institution ownership between REIT and three non-REIT samples from 1994 to 2006. The three non-REIT samples are: (1) firms from all industries except REITs, financials, and utilities; (2) total asset matched sample, which is the matched sample of non-REITs firm based on total assets; and (3) market cap matched sample, which is the matched sample of non-REITs firms based on market capitalization. Institutional ownership is total amount of shares invested in the firm by all institutional investors divided by the total number of shares outstanding. Annual average institutional ownership is computed in each year and is shown in the decimal form.

5.2. Difference-in-differences test: Causal effect of liquidity on firm performance

Based on the methodology and notations described in Section 3, we perform endogeneity tests on the relation between stock liquidity and firm performance using a difference-in-differences test. To disentangle the possible two-way relations between stock liquidity and firm performance, we examine whether the observed change in firm performance ($\Delta Q_i(L)$) persists after controlling for firm differences ($\boldsymbol{Z}$) other than liquidity. As such, we estimate an average treatment effect with an exogenous shock to liquidity ($\widehat{\rho|_{L=1}}$).

As discussed in Section 3, we define the treatment group as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile (see, e.g., Fang et al. (2014) for the same definition); the remaining firms of the sub-sample are considered non-treatment firms. The sample of the REIT industry during the decimalization has a total of 106 firms, with 35 firms in the treatment group and 71 firms in the non-treatment group. By applying the propensity score matching estimator, we compare changes in firm performance over decimalization of the treated firms ($\Delta Q_i(1)|_{treated}$) to those of the control firms ($\Delta Q_i(0)|_{control}$).[31] To avoid the effect of outliers on the smaller subsample used for difference-in-differences estimation, we winsorize $\Delta Q_i(L)$ at the top and bottom 5%. We report the difference-in-differences estimates of change in Tobin's Q surrounding the decimalization ($\widehat{\rho|_{L=1}}$) caused by the decimalization policy.

To satisfy the Rosenbaum and Rubin (1983) unconfoundedness condition, differences in the pre-treatment firms' characteristics should be insignificant, meaning that the treated and control groups should be similar along observables that are relevant for the treatment, e.g., firm characteristics that determine propensity scores. We compute the mean differences between the treated and

[31] We perform propensity score matching and ensure quality of matching by selecting the caliper size of a quarter of a standard deviation of the sample estimated propensity scores (Rosenbaum and Rubin, 1985). To estimate the average treatment effect on the treated based on propensity score matching with (without) replacement, we have 23 (17) matched treated firms compared with 71 matched untreated firms. Although the small sample size of available firms may reduce statistical power, our REIT experiment demonstrates a useful application of the difference-in-differences test. First, in term of representativeness of the whole industry, our analysis includes 94 (88) firms in total, based on propensity score matching with (without) replacement, which represents most of the firms in the REIT industry (105 firms in total). Second, the single industry setting of REITs can reduce confounding effects (Hartzell et al., 2008), providing a better control for unobservables or selection bias when conducting matching and difference-in-differences tests. Third, Pirracchio et al. (2012) conduct Monte Carlo simulations to show that even in the case of small study samples (e.g., decreasing the sample size from 1000 to 40), propensity score methods can yield correct estimations of treatment effect unless the true confounders and the variables related only to the outcome are not included in the propensity score model. To further address the effect of the small sample size of REITs and improve the precision of asymptotic approximations, we provide a robustness test of the difference-in-differences test using bootstrapping of the standard error of the estimate (see Section 5.6).

Table 2
Regression results of performance on stock illiquidity measure
This table reports the regression results of firm performance on stock illiquidity measure for the REIT sample from 1994–2006. Panel A reports the regression results of Tobin's Q ratios. Tobin's Q (Q) ratio is defined as the one year-ahead market value of assets (the market value of equity + book value of assets – book value of equity – balance sheet deferred taxes) divided by the book value of assets. The Amihud is the logarithm of the Amihud illiquidity measure of the firm. Maryland equals unity if the firm is incorporated in Maryland and zero otherwise. Firm age is the logarithm of the number of years since listing on the stock exchange. Firm size is the logarithm of the firm's total asset. Momentum is the 6-month market excess returns starting January of the year. Long-term debt is the ratio of long-term debt to total assets. Short-term debt is the ratio of debt with maturity less than or equal to 3 years to total assets. Model (1) reports the results from the OLS regression with the Petersen (2009) method using robust clustered standard errors adjusted for intragroup correlation. Model (2) reports the results from the Fama–MacBeth regression from 1994–2006. Model (3) reports the second-stage regression of the two-stage least squares (2LS) regressions. In the first-stage regression, the Amihud illiquidity is estimated using instrumental variables, which include the market-value-weighted average Amihud illiquidity of REIT *i*'s property type, an indicator variable of NYSE listing, and the return standard deviation. In the second-stage regression, we use the predicted value of the Amihud illiquidity from the first stage and firm fundamental characteristics (used in Eq. (3)) to estimate the dependent variable, one-year-ahead Tobin's Q). Standard errors are reported in parentheses.

	OLS	Fama–MacBeth	2SLS
	Model (1)	Model (2)	Model (3)
Amihud	−0.235***	−0.236***	
	(0.05)	(0.077)	
Predicted Amihud			−0.407***
			(0.04)
Firm age	0.124***	0.128***	0.145***
	(0.04)	(0.031)	(0.02)
Firm size	0.000	0.008	−0.032***
	(0.02)	(0.029)	(0.01)
Long-term debt	0.264*	0.247***	0.315***
	(0.16)	(0.214)	(0.05)
Short-term debt	−0.102	−0.070	−0.073*
	(0.07)	(0.165)	(0.04)
Momentum	0.098	0.149*	−0.007
	(0.06)	(0.254)	(0.06)
Maryland	0.036	0.041***	0.014
	(0.04)	(0.047)	(0.02)
Intercept	0.892***	0.797***	1.078***
	(0.15)	(0.169)	(0.09)
Year dummies	Yes		Yes
R-squared	0.32		
N	1229	1229	1191

*** Indicate 1% significance level for the statistical significance of coefficients.
** Indicate 5% significance level for the statistical significance of coefficients.
* Indicate 10% significance level for the statistical significance of coefficients.

control firms' characteristics and propensity scores and their corresponding *t*-statistics for the year immediately preceding the decimalization.

Table 3 reports the estimated propensity score and pre-treatment observables based on the propensity score matching without replacement. Panel A of Table 3 shows that the difference between the estimated propensity scores for the treated and control groups is insignificant. Additionally, Panel B of Table 3 shows that none of the observed differences between the treatment and control firms' characteristics are statistically significant. These results show that the assignment of treatment is unconfounded, conditional on the set of observable pre-treatment firm characteristics. Importantly, these results validate the use of the propensity score matching estimator for our setting and satisfy the Rosenbaum and Rubin (1983) unconfoundedness condition.

Table 4 reports our difference-in-differences test results from the propensity scores matching estimator. Our findings provide the important result that stock liquidity has a *causal* effect on firm performance. Table 4 shows that when we match the treatment and control firms with the propensity score matching without replacement, the average treatment effect of Amihud illiquidity on Tobin's Q ($\widehat{\rho|_{L=1}}$ in Eq. (6)) is 0.126, equivalent to 9.9% of the unconditional mean of Tobin's Q (which is equal to 1.268, as reported in Table 1). To restate, the *change* in Tobin's Q for treatment firms with a large liquidity increase after the decimalization (the average treatment effect on the treated) is *+9.9% higher* than the *change* in Tobin's Q for control firms without a large liquidity increase after the decimalization.[32] To test alternative matching methods, Table 4 also presents the results on the propensity score matching with replacement.[33] The average treatment effect of Amihud illiquidity on Tobin's Q is 0.122, equivalent to 9.6% of the unconditional mean of Tobin's Q. The treatment effects are positive and significant at the 5% (1%) level based on the propensity score estimator with (without) replacement.

For robustness checks, we perform internal validity tests for the main assumption behind the difference-in-differences estimator, i.e., the parallel trend assumption. This assumption states that in the absence of treatment, the average change in the outcome variable (in our case, firm value) would have been the same for both the treatment and control groups (see Roberts and Whited (2012)). In our

[32] Table 4 shows that treatment firms with a large liquidity increase experience a 0.133 increase in Tobin's Q, which is equivalent to 10.5% of the unconditional mean of Tobin's Q reported in Table 1. In contrast, the Tobin's Q of control firms increases by 0.007, which is equivalent to 0.6% of the unconditional mean of Tobin's Q.

[33] See Dehejia and Wahba (2002). The matching with replacement (reported in Panel B of Table 4) is beneficial in terms of bias reduction; however, this may also introduce larger variance. In contrast, the matching without replacement (reported in Panel A of Table 4) improves the precision of the estimates but may also increase potential bias. See footnote 35 for further discussions of the quality of the matching method.

Table 3
Propensity score and pre-treatment observables
This table reports the estimated propensity score and pre-treatment observables for the treated and control groups. Panel A reports the mean of the propensity score, which is estimated using the PROBIT regression of an indicator (L) of large liquidity increase around the 2001 decimalization on $\boldsymbol{Z}$ for both the treated and control groups. The control variables of the PROBIT regression include the lagged values of firm age, firm size, Amihud illiquidity, long-term debt, momentum, short-term debt, and Maryland. Panel B reports the mean of pre-treatment observables for both treated and control groups. Amihud is the Amihud illiquidity. Firm age is the logarithm of the number of years since listing on the stock exchange. Firm size is the logarithm of the firm's total assets. Long-term debt is the ratio of long-term debt to total assets. Short-term debt is the ratio of debt with maturity less than or equal to 3 years to total assets. Momentum is the 6-month market excess returns starting January of the year. Maryland equals unity if the firm is incorporated in Maryland and zero otherwise. The differences between the treated and control groups and their t-statistics are reported in both panels.

	Treated	Control	Difference	t-statistics for difference
Panel A: Propensity score				
Propensity score	0.346	0.349	−0.003	−0.05
Panel B: Pre-treatment observables				
Amihud	0.168	0.242	−0.074	−0.35
Firm age	2.480	2.594	−0.114	−0.56
Firm size	6.794	6.678	0.116	0.51
Momentum	0.096	0.045	0.051	0.76
Maryland	0.529	0.647	−0.118	−0.68
Long-term debt	0.585	0.569	0.016	0.28
Short-term debt	0.207	0.218	−0.011	−0.15

*** Indicate 1% significance level for statistical significance.
** Indicate 5% significance level for statistical significance.
* Indicate 10% significance level for statistical significance.

analysis, this assumption means that changes in Tobin's Q for our treated and control groups must be the same in the absence of decimalization. We examine whether changes in Tobin's Q for our treated and control groups are the same in the pre-treatment period, i.e., from four years to one year before decimalization in 2001, in which there are no sharp liquidity changes.[34] Based on the propensity score matching without replacement, Table 5 shows that the difference in changes in Tobin's Q of treated firms and control firms in the pre-treatment period is insignificant at the 10% level. Further examination (unreported here) shows the same conclusion for propensity score matching with replacement. Our validation test shows no evidence of significant differential firm performance for our treatment and control firms in the pre-treatment period, supporting the parallel trend assumption. Together with the univariate comparisons of pre-treatment observables (reported in Panel B of Table 3), our results suggest that the parallel trend assumption is satisfied.[35] Overall, the results in Tables 4 and 5 support the proposition of stock liquidity enhancing firm value after proper treatment of causality between liquidity and firm performance. The findings support Hypothesis 1.

5.3. Effects of stock liquidity on institutional ownership

We examine the relation between stock liquidity and institutional ownership to verify the corporate governance effect of stock liquidity. First, we examine the implications of stock liquidity on different types of institutional ownership. Table 6 reports the summary results of the coefficients of Amihud illiquidity for different types of institutional ownership (as the dependent variable). Panel A of Table 6 reports the results of the TOBIT model of different types of institutional ownership on stock illiquidity (see Section 3.2 and Eq. (4)). Model (1) in Panel A of Table 6 shows that Amihud illiquidity does not have any significant effect on total institutional ownership. Models (2) to (3) in Panel A show that Amihud illiquidity has a significant and negative effect on equity ownership by institutional investors that are active monitors. In contrast, Model (4) shows that Amihud illiquidity does not have any significant effect on equity ownership by institutional investors with diversified portfolios of REIT stocks (stronger multi-firm ownership).[36]

Panel B Table 6 presents the result using the Fama-MacBeth regression, in which the estimated standard errors are corrected for cross-sectional correlation. In this case, Amihud illiquidity has a significant and negative impact on 1-year-ahead total institutional ownership (Model (1)), equity ownership by institutional investors that are active monitors (Models (2) to (3)), and equity ownership by institutional investors with multi-firm ownership in REIT stocks (Model (4)). Panel C of Table 6 presents the 2SLS estimates of the effect of stock illiquidity on institutional ownership.[37] It reports the estimates of the second-stage regression, in which we estimate the effect of the predicted value of Amihud illiquidity on various measures of institutional ownership. The result

[34] This test is similar to internal validity tests performed in Fang et al. (2014) and suggested by Roberts and Whited (2012). That is, we try to eliminate the effect of "market liquidity shock" on firm performance for our treated and control groups but allow for effects other than liquidity that could potentially drive our results.
[35] To check the quality of matching and the unconfoundedness condition, Panel B of Table 3 shows that the differences of the pre-decimalization firm characteristics between groups are all statistically insignificant at the 10% level based on the propensity score matching without replacement. To show that our results are not driven by an unknown parallel trend, Table 5 shows that the changes in Tobin's Q exhibit no significant difference between groups before decimalization based on the propensity score matching without replacement.
[36] The results on the control variables (not reported here) are consistent with the predictions discussed in Section 3.2. For example, firm size and Maryland dummy have a significantly positive effect on different types of institutional ownership.
[37] As discussed in Section 5.1, Amihud illiquidity is estimated using instrumental variables that are linked to market liquidity; however, these variables do not exhibit a predicted effect on institutional ownership. The instrumental variables include market value-weighted average illiquidity of REIT property type and the NYSE dummy.

Table 4
Difference-in-differences test: Liquidity impact on firm performance.
This table reports the impact of change in liquidity surrounding the decimalization in 2001 on Tobin's Q (ΔQ_i) using the difference-in-differences approach with matching estimators. Firms are classified into tertiles based on the change in the Amihud measure of liquidity surrounding the decimalization in year 2001. The treatment group is defined as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile; the remaining firms of the sub-sample are considered non-treatment firms. The treatment and control firms are matched using (1) propensity score matching without replacement, and (2) propensity score matching with replacement.

	Treatment group ($\Delta Q_i(1)\|_{treated}$)	Control group ($\Delta Q_i(0)\|_{control}$)	Difference-in- Differences estimator ($\rho\|_{L=1}$)	Standard error	t-statistics for DiD estimator
Change in Tobin's Q (Propensity score matching without replacement)	0.133	0.007	0.126***	0.043	2.92
Change in Tobin's Q (Propensity score matching with replacement)	0.123	0.001	0.122**	0.048	2.55

*** Indicate 1% significance level for statistical significance.
** Indicate 5% significance level for statistical significance.
* Indicate 10% significance level for statistical significance.

Table 5
Tests of parallel trend assumption: Difference in trends of pre-treatment performance
This table reports in the pre-treatment period (1997–2000) the mean change in Tobin's Q for the treatment and the control groups. Firms are classified into tertiles based on the change in the Amihud measure of liquidity surrounding the decimalization in year 2001. The treatment group is defined as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile; the remaining firms of the sub-sample are considered non-treatment firms. The treatment and control firms are matched using (1) propensity score matching without replacement, and (2) propensity score matching with replacement.

	Treatment	Control	Difference	t-statistics for difference
4-year change in Tobin's Q in the pre-treatment period (propensity score matching without replacement)	−0.310	−0.285	−0.025	−0.28
4-year change in Tobin's Q in the pre-treatment period (propensity score matching with replacement)	−0.265	−0.195	−0.070	−1.01

in Panel C of Table 6 shows that the coefficient of the predicted Amihud illiquidity has a significant and negative effect on different types of institutional ownership in Models (1) to (4).

5.4. Difference-in-differences test: Causal effect of liquidity on institutional ownership

To address endogeneity in the relation between stock liquidity and institutional ownership, we perform the difference-in-differences test and estimate the average treatment effect with an exogenous shock to liquidity based on the decimalization in 2001 (see Section 3). In Table 7, we report the difference-in-differences estimates of the change in institutional ownership. The overall results in Table 7 demonstrate that market liquidity has a causal effect on institutional ownership. Panel A of Table 7 shows that for the change in total institutional ownership surrounding the decimalization, the average treatment effect is statistically significant at the 1% (5%) level for the propensity score matching with (without) replacement. In terms of economic significance, the average treatment effect based on the propensity score matching with (without) replacement implies that treatment firms with a large liquidity increase experience a significant change in total institutional ownership, which is *+9.2%* (*+9.0%*) larger than that of the control firms.[38] The findings in Panel A suggest that institutional investors do not take the opportunity to sell shares (exit) with REIT stocks that are more liquid. Instead they increase their investments in REITs that are more liquid. These results from the difference-in-differences test are consistent with Hypothesis 2, i.e., that stock liquidity leads to higher participation of institutional investors.

Panels B to D of Table 7 demonstrate the importance of investor heterogeneity in examining corporate governance (Edmans, 2014), and show that stock liquidity is more important for certain types of institutional investors, particularly those that are more likely to provide corporate governance. In Panels B and C, the overall results from the difference-in-differences test demonstrate that increases in stock liquidity during decimalization led to significant increases (in terms of both statistical and economic significance) in the ownership of active monitors, such as independent advisors and investment companies. For independent advisors (Panel B), the average treatment effect is positive and significant at the 10% (5%) level based on the propensity score matching with (without) replacement. In the context of economic significance, the average treatment effect based on the propensity score matching with (without) replacement implies that the *change* in the equity holdings of investment companies is *+5.0%* (*+5.9%*)

[38] Panel A of Table 7 also reveals that the treatment firms experience a much larger *increase* (+11.9%) in total institutional ownership due to a large liquidity increase after the decimalization; in contrast, the control firms experience a small *increase* (+3.0%) in total institutional ownership without a large liquidity increase.

Table 6
Regression results of institutional ownership on stock illiquidity
This table reports the TOBIT regression results (Panel A), the Fama–MacBeth regression results (Panel B), and the second stage 2SLS regression results (Panel C) of the 1-year-ahead institutional ownership on stock illiquidity. The dependent variable includes different types of institutional ownership: the total institutional ownership (Total io), equity ownership by independent advisor (Advisor io), equity ownership by Investment Company (Invest. Co. io), and equity ownership by institutional investors with diversified portfolios of REIT stocks (Diversified io). The coefficient of Amihud illiquidity is reported for the results based on: TOBIT regression model with the Petersen (2009) method of robust clustered standard errors (Panel A); the Fama–MacBeth regression model (Panel B); and 2SLS regression model (Panel C). The control variables include the following (their results are not reported here). The Maryland dummy equals unity if the firm is incorporated in Maryland and 0 otherwise. Momentum is the 6-month market excess returns starting in January of the year. Long-term debt is the ratio of long-term debt to total assets, and short-term debt is the ratio of the debt with maturity less than or equal to 3 years to total assets. Firm's age is the logarithm of the number of years since listing on the stock exchange. For 2SLS in Panel C, in the first-stage regression, Amihud illiquidity is estimated using instrumental variables, which include the market-value-weighted average Amihud illiquidity of REIT *i*'s property type, an indicator variable of NYSE listing, and the return standard deviation. In the second-stage regression, we use the predicted value of Amihud illiquidity from the first stage and firm fundamental characteristics (used in Eq. (4)) to estimate the dependent variable, log(1 + institutional equity ownership). Standard errors are reported in parentheses.

Dependent variable	Total io	Advisor io	Invest. Co. io	Diversified io
	Model (1)	Model (2)	Model (3)	Model (4)
Panel A: TOBIT regression results				
Amihud	−0.046	−0.065**	−0.038*	−0.040
	(0.03)	(0.03)	(0.02)	(0.03)
Control variables	Yes	Yes	Yes	Yes
N	1229	1229	1229	1229
Panel B: Fama–MacBeth regression results				
Amihud	−0.068**	−0.082***	−0.422*	−0.061*
	(0.112)	(0.094)	(0.838)	(0.107)
Control variables	Yes	Yes	Yes	Yes
N	1229	1229	1229	1229
Panel C: Second stage 2SLS regression results				
Predicted Amihud	−0.173***	−0.100***	−0.025***	−0.171***
	(0.03)	(0.02)	(0.01)	(0.03)
Control variables	Yes	Yes	Yes	Yes
N	1191	1191	1191	1191

*** Indicate statistical significance at 1% level.
** Indicate statistical significance at 5% level.
* Indicate statistical significance at 10% level.

larger for treatment firms than for control firms. For investment companies (Panel C), the average treatment effect is positive and significant at the 5% (1%) level based on the propensity score matching with (without) replacement. The average treatment effect based on the propensity score matching with (without) replacement implies that the *change* in the equity holdings of investment companies is *+2.4%* (*+3.1%*) *larger* for treatment firms than for control firms. Overall, these findings from the difference-in-differences test support Hypothesis 2A, i.e., that stock liquidity leads to higher participation of institutional investors that are active monitors.

Importantly, governance can be more effective under multi-firm ownership than under a single-firm benchmark (Edmans, 2014), and stock liquidity may help REIT investors to diversify and reallocate REIT stocks in their investment portfolio by disgorging poor-performing REITs and acquiring better-performing REITs. To support Hypothesis 2B, Panel D of Table 7 shows that increases in stock liquidity during decimalization led to higher firm-level ownership of institutional investors with multiple stocks (lower concentration) in their REIT investments. Interestingly, we observe a much more significant increase in participation by institutional investors with multi-firm ownership. For institutional investors with diversified portfolios of REIT stocks, the average treatment effect is positive and significant at the 1% (5%) level based on the propensity score matching with (without) replacement. The average treatment effect based on the propensity score matching with or without replacement implies that the *change* in the equity ownership of institutional investors with diversified portfolios of REIT stocks is *+9.0% larger* for treatment firms than for control firms.[39] Our results support Hypothesis 2B.

As a further analysis (results not reported here), we perform the difference-in-differences test for other types of institutional investors. To further support Hypothesis 2A and our findings that stock liquidity leads to higher ownership by active monitors, we find that an increase in stock liquidity during decimalization does not lead to a significant increase in ownership by an Insurance Company, Corporate Pension Fund, Public Pension Fund, Endowment, or Miscellaneous. The average treatment effects are insignificant for all of these institutional investor types. We find that the average treatment effect is significant for Bank Trust (with 10% significance); however, at 1.8%, the economic magnitude of the effect is small. To further support Hypothesis 2B, i.e., that stock liquidity leads to higher ownership by institutional investors that have multi-firm ownership with diversified portfolios of REIT stocks, we find that

[39] As a further analysis (results not reported here), we use an alternative classification of a low-concentration REIT portfolio institution with $RR_{it} \le RR_{p25,t}$, where $RR_{p25,t}$ equals the value of lower quartile of RR_{it} across all *i* in year *t* (see also footnote 15). Using this alternative definition, the average treatment effect based on the propensity score matching with (without) replacement shows that the change in equity ownership of institutional investors with multi-firm ownership is +9.0% (+9.1%) larger for treatment firms than for control firms. We obtain the same conclusion from our results using this alternative classification.

Table 7
Difference-in-differences test: Liquidity impact on institutional ownership
This table reports the mean change in institutional ownership (ΔIO), where institutional ownership includes total institutional ownership (Panel A), equity ownership by independent advisor (Panel B), equity ownership by Investment Company (Panel C), and equity ownership by institutional investors with diversified portfolios of REIT stocks (Panel D). The mean change in institutional ownership is computed from year 2000 to year 2002 (surrounding the decimalization in 2001) using the difference-in-differences approach with (1) propensity score matching without replacement, (2) propensity score matching with replacement. The treatment group is defined as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile; the remaining firms of the sub-sample are considered non-treatment firms.

	Treatment group ($\Delta IO_i(1)\|_{treated}$)	Control group ($\Delta IO_i(0)\|_{control}$)	Difference-in-differences estimator ($\rho\|_{L=1}$)	Standard error	t-statistics for DiD estimator
Panel A: Change in total institutional ownership					
Change in total institutional ownership (Propensity score matching without replacement)	0.119	0.030	0.090**	0.034	2.66
Change in total institutional ownership (Propensity score matching with replacement)	0.107	0.015	0.092***	0.029	3.12
Panel B: Change in equity ownership by independent advisors					
Change in ownership by independent advisors (Propensity score matching without replacement)	0.093	0.034	0.059**	0.028	2.09
Change in ownership by independent advisors (propensity score matching with replacement)	0.072	0.022	0.050*	0.026	1.90
Panel C: Change in equity ownership by investment companies					
Change in institutional ownership by investment companies (propensity score matching without replacement)	0.021	−0.010	0.031***	0.009	3.30
Change in ownership by investment companies (propensity score matching with replacement)	0.020	−0.004	0.024**	0.011	2.30
Panel D: Change in equity ownership by institutional investors with diversified portfolio of REITs					
Change in ownership by institutional investors with diversified portfolios of REIT stocks (propensity score matching without replacement)	0.130	0.040	0.090**	0.033	2.69
Change in ownership by institutional investors with diversified portfolios of REIT stocks (propensity score matching with replacement)	0.112	0.022	0.090***	0.031	2.94

*** Indicate 1% significance level for statistical significance.
** Indicate 5% significance level for statistical significance.
* Indicate 10% significance level for statistical significance.

stock liquidity does not have any significant effect on ownership by institutional investors with highly concentrated REITs portfolios (as defined in Section 3.1).

5.5. Robustness tests

Similar to Section 5.2, we perform internal validity tests for the main assumption behind the difference-in-differences estimator, i.e., the parallel trend assumption. In this section, this assumption means that changes in institutional ownership for our treated and control groups must be the same in the absence of decimalization. While this assumption cannot be tested directly, as it is not observable, we perform a test of the difference in the changes of institutional ownership before the decimalization in 2001 between the treated and control groups.

We examine whether changes in institutional ownership for our treated and control groups are the same in the pre-treatment period, i.e., from four years to one year before decimalization in 2001, when there are no sharp liquidity changes. Panel A of Table 8 shows that the difference in the changes in total institutional ownership of the treated firms and control firms in the pre-treatment period (from four years to one year before decimalization in 2001) is insignificant at the 10% level. In Table 8, the results are similar for other measures of institutional ownership types. Our validation test shows no evidence of significant differential institutional participation for our treatment and control firms in the pre-treatment period, supporting the parallel trend assumption.

5.6. Further analyses

We perform additional analyses to support our findings and conclusions. To address the inference of the small sample size of REITs and improve the precision of the standard error, we conduct a robustness test of the difference-in-differences test using bootstrapping of the standard error of the estimate. Table A1 in the Appendix A reports the bootstrapping results based on 100,000 replications. For change in Tobin's Q, the results in Panel A of Table A1 are similar to those reported in Table 4. For institutional ownership, the results in

Table 8
Test of parallel trend assumption: differences in trends of pre-treatment institutional holdings characteristics.
This table reports in the pre-treatment period (1997–2000) the mean change in institutional ownership, where institutional ownership includes total institutional ownership (Panel A), equity ownership by independent advisor (Panel B), equity ownership by Investment Company (Panel C), and equity ownership by investors with diversified portfolios of REIT stocks (Panel D). The mean change in institutional ownership is computed based on year 1997 and year 2000 for the treatment and the control groups. Firms are classified as tertiles based on the change in the Amihud measure of liquidity surrounding the decimalization in year 2001. The treatment group is defined as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile; the remaining firms of the sub-sample are considered non-treatment firms. The treatment and control firms are matched using (1) propensity score matching without replacement, and (2) propensity score matching with replacement.

	Treatment	Control	Difference	t-statistics for difference
Panel A: Change in total institutional ownership				
4-year change in total institutional ownership in the pre-treatment period (propensity score matching without replacement)	0.044	−0.056	0.100	1.64
4-year change in total institutional ownership in the pre-treatment period (propensity score matching with replacement)	0.065	0.006	0.059	1.20
Panel B: Change in equity ownership by independent advisors				
4-year change in ownership by independent advisors in the pre-treatment period (propensity score matching without replacement)	−0.014	−0.064	0.050	1.59
4-year change in ownership by independent advisors in the pre-treatment period (propensity score matching with replacement)	0.000	−0.030	0.030	1.20
Panel C: Change in equity ownership by investment companies				
4-year change in ownership by investment companies in the pre-treatment period (propensity score matching without replacement)	−0.011	−0.017	0.006	0.32
4-year change in ownership by investment companies in the pre-treatment period (propensity score matching with replacement)	−0.012	−0.001	−0.011	−1.00
Panel D: Change in equity ownership by institutional investors with diversified portfolio of REITs				
4-year change in ownership by institutional investors with diversified portfolios of REIT stocks in the pre-treatment period (propensity score matching without replacement)	0.020	−0.055	0.075	1.49
4-year change in ownership by institutional investors with diversified portfolios of REIT stocks in the pre-treatment period (propensity score matching with replacement)	0.042	0.003	0.039	0.96

Panels B, D, and E of Table A1 are similar to those reported in Table 7. The exception is Panel C of Table A1, which shows that the average treatment effect becomes insignificant for independent advisors.

To address firm heterogeneity of REITs, we examine how the effects of stock liquidity on firm value vary with unique firm-level characteristics of REITs such as property types. We test the effect of stock liquidity for Diversified REITs, which are found to have lower firm value due to poorer liquidity associated with agency problems (Capozza and Seguin, 1999). Panel A of Table 9 shows that the interaction effect between Amihud illiquidity and the dummy variable of Diversified REIT on firm value is negative and significant, suggesting that the effect of stock liquidity on firm value is larger for Diversified REITs that are prone to agency problem.

Moreover, the monitoring incentives and governance effect of stock liquidity are related to the lease terms of REIT property types. For example, Chung et al. (2012) argue that REIT property types with longer lease terms face higher uncertainty and monitoring cost. We explore whether the governance effect of stock liquidity varies with REIT property types stratified by short lease terms (including resort, residential, and storage REITs).[40] In Panel B of Table 9, the interaction effect between Amihud illiquidity and the dummy variable of REITs with short lease terms is significant for different types of institutional ownership, implying that the effect of stock liquidity on institutional ownership is larger for REITs with short lease terms. This result suggests that stock liquidity has a larger effect on institutional investors' monitoring (or threat of exit) for REITs that are likely to have lower uncertainty and monitoring cost.[41]

Lastly, we perform a controlled experiment to further support the importance of REIT setting in examining the value proposition of stock liquidity and examine whether stock liquidity affects firm value differently in other settings. To conduct the experiment, we construct a control sample of non-REIT firms that includes firms from other industries (excluding finance and utilities industries) that are matched by firm sizes (market capitalization or total assets) similar to the firms in our REIT sample.[42] Unlike REITs, the non-REIT firms are not subject to a high payout requirement and regulatory restriction on investments and outside ownership structures. We then perform the difference-in-differences test as described in Section 3.3 to examine the causal effect of stock liquidity on firm value

[40] The stratification of REIT property types by lease terms is based on Chung et al. (2012), who argue that short lease terms can be one day (one year) for hotels (apartments), whereas long lease terms can be 7 to 10 (8 to 15) years for offices (retails).

[41] The effect of stock liquidity on governance (through monitoring or exit) can be stronger for REITs with short lease terms because they are more subject to short-term performance; as such, institutional participation (particularly those that provide governance through exit) could be more immediately responsive to change in liquidity for these firms.

[42] To create the control sample of non-REIT firms, we select non-REIT firms from all industries excluding utilities and financials. We perform a one-to-one matching between REIT firms and non-REIT firms in year 2001 (decimalization). The size differences between the two samples are no more than 1% of either the value of total assets or market capitalization. In addition, the non-REIT firms have non-missing observations of Tobin's Q and Amihud illiquidity from fiscal years 1996 to 2003, allowing us to perform a difference-in-differences test with examination of pre-treatment observables and tests of parallel trend assumption. Within this control sample of non-REIT firms, we follow the methodology described in Section 3.3 to perform a difference-in-differences test with the propensity score matching.

Table 9
Regression results of performance and institutional equity ownership on stock illiquidity (diversified REITs and REITs with short-term lease contracts)
This table reports the regression results on stock illiquidity measure for the REIT sample from 1994–2006,
$Y_{i,t+1} = a_0 + a_1 Illiquidity_{i,t} + \alpha_2 PType_{i,t} + \alpha_3 Illiquidity_{i,t} \times PType_{i,t} + a_4 Control_{i,t} + \epsilon_{i,t+1}$.
Where the dependent variable (Y) includes Tobin's Q, total institutional ownership (Total io), equity ownership by independent advisor (Advisor io), equity ownership by investment company (Invest. Co. io), and equity ownership by investors with diversified portfolios of REIT stocks (Diversified io). Tobin's Q (Q) ratio is defined as the one year-ahead market value of assets (the market value of equity + book value of assets – book value of equity – balance sheet deferred taxes) divided by the book value of assets. *PType* is used as the dummy variable of Diversified REIT or the dummy variable of REITs with short-term leases. The dummy variable of Diversified REIT equals unity if the REIT is a Diversified REIT and zero otherwise. The dummy variable of Short-term leases equals unity if the REIT is a resort, residential, or storage REIT and zero otherwise. *Illiquidity* is the logarithm of one plus the Amihud illiquidity measure of the firm. The control variables include the following (their results are not reported here). Maryland equals unity if the firm is incorporated in Maryland and zero otherwise. Firm age is the logarithm of the number of years since listing on the stock exchange. Firm size is the logarithm of the firm's total asset. Momentum is the 6-month market excess returns starting January of the year. Long-term debt is the ratio of long-term debt to total assets. Short-term debt is the ratio of debt with maturity less than or equal to 3 years to total assets. In Panel A, Model (1) reports the effects of Amihud illiquidity, Diversified REIT dummy, and the interaction of Amihud illiquidity and Diversified REIT dummy on Tobin's Q based on the OLS regression. Models (2) to (5) in Panel A report the effects of Amihud illiquidity, Diversified REIT, and the interaction of Amihud illiquidity and Diversified REIT on different types of institutional ownership based on the TOBIT regression. In Panel B, Model (1) reports the effects of Amihud illiquidity, Short-term leases, and the interaction of Amihud illiquidity and Short-term leases on Tobin's Q based on the OLS regression. Models (2) to (5) in Panel B report the effects of Amihud illiquidity, Short-term leases, and the interaction of Amihud illiquidity and Short-term leases on different types of institutional ownership based on the TOBIT regression. All regressions are estimated with the Petersen (2009) method using robust clustered standard errors. Standard errors are reported in parentheses.

Dependent variable	Q	Total io	Advisor io	Invest. Co. io	Diversified io
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Panel A. Diversified REITs					
Amihud	−0.215***	−0.04	−0.057**	−0.032**	−0.035
	(0.05)	(0.03)	(0.03)	(0.02)	(0.03)
Diversified REIT	−0.054	−0.059	−0.080*	−0.025	−0.055
	(0.08)	(0.05)	(0.05)	(0.02)	(0.05)
Amihud*diversified REIT	−0.184*	−0.053	−0.081	−0.021	−0.041
	(0.10)	(0.07)	(0.09)	(0.04)	(0.08)
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
N	1229	1229	1229	1229	1229
Panel B. REITs with short-term lease contracts					
Amihud	−0.234***	−0.041	−0.057**	−0.033*	−0.034
	(0.05)	(0.03)	(0.03)	(0.02)	(0.03)
Short-term leases	−0.020	0.027	0.053	0.009	0.027
	(0.04)	(0.04)	(0.03)	(0.01)	(0.04)
Amihud*short-term leases	−0.063	−0.323**	−0.435**	−0.148**	−0.326**
	(0.12)	(0.14)	(0.20)	(0.06)	(0.14)
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
N	1229	1229	1229	1229	1229

*** Indicate 1% significance level for the statistical significance of coefficients.
** Indicate 5% significance level for the statistical significance of coefficients.
* Indicate 10% significance level for the statistical significance of coefficients.

for the non-REIT sample. Table A2 in the Appendix A shows that stock liquidity does not have any significant effect on Tobin's Q for the non-REIT sample. These findings suggest that the positive causal effect of stock liquidity on firm value is not necessarily observed in other settings (e.g., firms that are not subject to value-enhancing mechanism such as institutional monitoring).[43] Overall, these findings support the importance of the REIT setting in testing the value proposition of stock liquidity as discussed in Sections 1 and 2. The REIT setting also demonstrates that the value-enhancing mechanism of stock liquidity can be identified with proper experimental design and control for unobserved characteristics and endogeneity.

5.7. Overall interpretations

The REIT experiment and findings help solve the puzzle of whether stock liquidity should enhance or deter firm value and corporate governance. Our overall findings highlight the unique setting of REITs (i.e., the combination of high payout, market

[43] Fang et al. (2009) document a positive value-liquidity relation based on a sample of industrial firms. They use decimalization to address endogeneity concern (i.e., reverse causality) but do not perform difference-in-differences test to control unobserved variables that can affect both liquidity and firm value. Our results from difference-in-differences test demonstrate that, once endogeneity is properly accounted for, the positive causal effect of liquidity can be insignificant. Our results imply that one may also need to control for factors affecting value-enhancing mechanisms (such as equity dependence, investment structures, and institutional ownership in the REIT setting) in order to discover the positive liquidity-value relation.

monitoring, and institutional investors) in supporting the proposition of stock liquidity improving firm value. Together, our findings on the positive effect of liquidity on firm value (Hypothesis 1) and our findings on the positive effect of liquidity on institutional ownership (Hypothesis 2) jointly provide new insight on the corporate governance effect of stock liquidity in which the value-adding effects of stock liquidity actually occur and institutional participation is effective. In contrast, the positive liquidity-value relation is not necessarily significant for other firms or industries without the presence of value-adding mechanisms such as corporate governance. (see Section 5.6).

Specifically, the REIT experiment provides new insight on the effect of stock liquidity on corporate governance, which differentiates our findings from existing studies. In contrast to Edmans et al. (2013), who examine the effect of stock liquidity on governance from the perspective of hedge fund activism, our study uses the REIT setting to demonstrate that stock liquidity can improve firm value and participation by institutional investors that may have different objectives, e.g., investors that are attracted to high payout and external monitoring opportunities. Our findings also reveal that REIT stock liquidity is particularly important for institutional investors that are active monitors (Hypothesis 2A) and have multi-firm ownership (Hypothesis 2B). Our findings further suggest that stock liquidity can strengthen corporate governance (e.g., through the threat of exit) in the multi-firm ownership case (Edmans et al., 2015).

6. Conclusion

This study examines the value and corporate governance implications of stock liquidity by addressing two interrelated themes. Our first theme is to use the unique setting of the REIT industry to demonstrate that stock liquidity has a positive effect on firm value and is conducive to better corporate governance. Our second theme is to address the endogeneity problem in the empirical relation between stock liquidity and firm value. Our findings highlight the essentiality of a liquid stock market in strengthening firm performance for the REIT industry. Importantly, our findings uncover the corporate governance effect of stock liquidity, specifically through the channel of enhancing participation and monitoring incentives of institutional investors, particularly those that are active monitors and have multi-firm ownership.

The implications of our findings include the following. First, our findings suggest that both managers and investors should recognize the potential role of stock liquidity in affecting firm value and understand the liquidity-value relation that can vary with different industry and institutional settings. Once the value-adding activities of stock liquidity are identified, firms should search for opportunities and policies that can increase stock liquidity (Heflin et al., 2005; Foucault et al., 2013; Danielsen et al., 2014). Second, our findings contribute to the policy debate on whether a liquid stock market should support or deter corporate governance. As Edmans (2014) argues, advocates for the Japanese model of illiquid stakes or the European Union financial transaction tax may argue for illiquid stakes to lock in shareholders for the long term and induce them to govern through voice. Given that the relation between stock liquidity and corporate governance is central to this policy debate, our findings from the REIT setting support the view that a liquid stock market should support rather than deter corporate governance. Third, our findings suggest that a firm's payout policy and outside investors' monitoring can interact and complement one another in the presence of a liquid stock market. This insight is applicable to other corporate settings. For example, firms or industries with high payout or equity dependence should recognize the value-adding opportunity of stock liquidity, particularly the case wherein stock liquidity can support participation by certain types of institutional investors that can provide corporate governance. Lastly, our analysis provides springboard for future research that can highlight the important links between corporate finance and market microstructure (O'Hara, 1999; Easley and O'Hara, 2004). Future research may search for unique industry or institutional features that can highlight different value implications of stock liquidity. Future research may also explore different corporate finance implications of stock liquidity and other market microstructure effects.

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Appendix A

Table A1
Difference-in-differences estimator with bootstrapping
This table reports the difference-in-differences estimator with bootstrapping of the standard error of the estimate. The bootstrapping results are based on 100,000 replications. Each panel reports the difference-in-differences estimator and bootstrap standard error with different matching methods including (1) propensity score matching without replacement, and (2) propensity score matching with replacement. Panel A reports the change in Tobin's Q, Panel B reports the change in total institutional ownership, Panel C reports the change in equity ownership by independent advisor, Panel D reports the change in equity ownership by Investment Company, and Panel E reports the change in equity ownership by institutional investors with diversified portfolios of REIT stocks. The mean change in Tobin's Q (or different types of institutional ownership) is computed from year 2000 to year 2002 (surrounding the decimalization in 2001) using the difference-in-differences approach with (1) propensity score matching without replacement, (2) propensity score matching with replacement. The treatment group is defined as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile; the remaining firms of the sub-sample are considered non-treatment firms.

	Difference-in-differences estimator ($\rho\|_{L=1}$)	Bootstrap standard error	z-statistics for DiD estimator
Panel A: Change in Tobin's Q			
Change in Tobin's Q (propensity score matching without replacement)	0.126***	0.038	3.29
Change in Tobin's Q (propensity score matching with replacement)	0.122***	0.038	3.22
Panel B: Change in total institutional equity ownership			
Change in institutional ownership (propensity score matching without replacement)	0.090**	0.040	2.22
Change in institutional ownership (propensity score matching with replacement)	0.092**	0.037	2.47
Panel C: Change in equity ownership by independent advisors			
Change in institutional ownership (propensity score matching without replacement)	0.060	0.036	1.63
Change in institutional ownership (propensity score matching with replacement)	0.050	0.032	1.56
Panel D: Change in equity ownership by investment companies			
Change in institutional ownership (propensity score matching without replacement)	0.031***	0.012	2.65
Change in institutional ownership (propensity score matching with replacement)	0.024*	0.013	1.91
Panel E: Change in equity ownership by institutional investors with diversified portfolios of REITs			
Change in institutional ownership (propensity score matching without replacement)	0.090**	0.040	2.24
Change in institutional ownership (propensity score matching with replacement)	0.090**	0.037	2.48

*** Indicate 1% significance level, for statistical significance.
** Indicate 5% significance level, for statistical significance.
* Indicate 10% significance level, for statistical significance.

Table A2
Difference-in-differences test: Liquidity impact on firm performance for non-REIT samples
This table reports the impact of change in liquidity surrounding the decimalization in 2001 on Tobin's Q (ΔQ_i) using the difference-in-differences approach with matching estimators. The sample includes a control sample of non-REIT firms matched by market cap (Panel A) and total assets (Panel B). See footnote 42 for construction of the non-REIT samples. Firms are classified into tertiles based on the change in the Amihud measure of liquidity surrounding the decimalization in year 2001. The treatment group is defined as firms with a (positive) change in liquidity surrounding the decimalization in the highest tertile; the remaining firms of the sub-sample are considered non-treatment firms. The treatment and control firms are matched using (1) propensity score matching without replacement, and (2) propensity score matching with replacement.

	Treatment group ($\Delta Q_i(1)\|_{treated}$)	Control group ($\Delta Q_i(0)\|_{control}$)	Difference-in- differences estimator ($\rho\|_{L=1}$)	Standard error	t-statistics for DiD estimator
Panel A. Change in Tobin's Q of non-REIT sample matched by market cap					
Change in Tobin's Q (propensity score matching without replacement)	−0.138	−0.156	0.018	0.217	0.08
Change in Tobin's Q (propensity score matching with replacement)	−0.042	−0.022	−0.021	0.224	−0.09
Panel B. Change in Tobin's Q of non-REIT sample matched by total assets					
Change in Tobin's Q (propensity score matching without replacement)	0.031	−0.011	0.042	0.190	0.22
Change in Tobin's Q (propensity score matching with replacement)	0.072	−0.078	0.150	0.202	0.74

*** Indicate 1% significance level, for statistical significance.
** Indicate 5% significance level, for statistical significance.
* Indicate 10% significance level, for statistical significance.

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