Market Structure and Corporate Payout Policy: Evidence from a Natural Experiment*

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Abstract

In 2016, the Securities and Exchange Commission increased tick size (the minimum price variation) for 1,200 randomly selected firms, and imposed restrictions on dark-pool trading on 400 of them. We find that firms reduce share repurchases by 70% and total payout by 52% once they face binding tick-size constraints in both stock exchanges and dark pools. Surprisingly, firms with large increases in depth, especially on the bid side, reduce their payouts the most because regulations on share repurchases discourage the use of market orders, which turns a market with great depth into an illiquid market for repurchasing firms. (JEL: G10, G18, G35)

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Miller and Modigliani (1961) find that the level of payouts does not matter for firms and investors, nor does it matter whether payouts are executed through dividends or share repurchases. One key assumption driving these two irrelevances of payout policy is that firms can repurchase shares without market microstructure frictions. In reality, firms need to pay transaction costs when executing repurchases. In a fragmented market with more than 10 stock exchanges and 40 dark pools, they need to decide where to repurchase shares. Finally, SEC Rule 10b-18 imposes regulatory friction on when and how firms can repurchase shares. In this paper, we find that these three market structure frictions (liquidity, market fragmentation, and regulation) have first-order effects on both the level and structure of a firm's payout.

We start our analysis with a unique natural experiment. In October 2016, the U.S. Securities and Exchange Commission (SEC) randomly selected 1,200 test stocks and increased their tick size (the minimum price increment) from 1 cent to 5 cents. Among these test stocks, the SEC also imposed rules to restrict dark-pool trading in 400 stocks in test group 3. This exogenous shock allows us to evaluate the impacts of market structure by comparing the payout policy changes in the test stocks with 1,199 control stocks, and across distinct groups of test stocks.

We find that the Tick Size Pilot Program dramatically reduces repurchase payouts by 70% for tick-size-constrained firms in test group 3. These firms have below-median quoted spreads before the Pilot. Therefore, an increase in tick size is more likely to widen the bid–ask spread and to reduce liquidity in the stock exchange. We find, however, that liquidity increases in the dark pools for stocks in test groups 1 and 2, and those stocks do not experience a statistically significant reduction in repurchase payouts. For stocks in test group 3, both stock-exchange and dark-pool

liquidity decreases, and firms dramatically reduce their share repurchases. Our results indicate that 1) a reduction in liquidity reduces repurchase payouts, and 2) firms use dark pools for share repurchases.

Regulatory frictions affect share repurchases, because they can change the definition of liquidity for distinct groups of market participants. For example, a market with great depth is generally considered a more liquid market, particularly for larger traders (Goldstein and Kavajecz (2000)). Surprisingly, we find that, within tick-constrained firms, those with significant increases in depth reduce share repurchase to a greater extent following the Pilot. We find evidence that SEC rule 10b-18 reconciles this surprising result. This rule states that an issuer must repurchase shares at a price that does not exceed the highest independent bid or last transaction price. The purpose of the rule is to discourage price manipulation, because one way to inflate prices is to use aggressive market orders to demand liquidity from the offer side. One (unintended) consequence of this rule is that it changes the implications of "a liquid market" for issuers. A market with great depth, especially on the bid side, can be an illiquid market for issuers in modern markets. SEC rule 10b-18 implicitly encourages firms to repurchase shares through buy-limit orders, which wait on the bid side of the market to be executed. When tick size is binding, execution priority is determined by speed competition at the same price (Yao and Ye (2018)). As firms and their brokers may not be as fast as high-frequency traders (HFTs), limit orders to repurchase shares may fail to be executed. We find that depth on the bid side harms issuers more than depth on the ask side, suggesting that a combination of tick-size constraints and SEC rule 10b-18 should be one driver of this counterintuitive result.

We find that the Tick Size Pilot Program does not affect announced share repurchase amounts. Tick-size-constrained firms in test group 3 announce similar amounts of share repurchases relative to control firms. Therefore, the dramatic reduction in share repurchases comes mostly from the actual execution of repurchases, which provides another piece of evidence supporting the market-structure channel. Although market structure does not significantly reduce the incentive to announce repurchases, firms or their brokers reduce the actual amounts of repurchases when they face higher transaction costs.

Next, we examine the impact of the Tick Size Pilot Program on total payout amounts and structure of payouts. Brown, Liang, and Weisbenner (2007) find that firms reduced share repurchases when they increased dividend payouts following the 2003 tax cut. We do not find similar substitution effects in the opposite direction. Firms do not increase dividends when the market structure shock forces them to cut share repurchases. In turn, tick-constrained firms in test group 3 reduce their total payouts by 52% (from 0.80% of total assets to 0.39% of total assets). Also, the structure of the payouts (repurchase vs. dividends) changes. Tick-constrained firms in test group 3 used to have a normal payout structure, that is, a payout structure dominated by repurchases (Farre-Mensa, Michaely, and Schmalz (2014)). After the Tick Size Pilot Program, the proportions of repurchases and dividends become roughly equal. Therefore, repurchase payouts do not necessarily need to dominate dividend payouts. When the cost of repurchases increases, firms scale back share repurchases.

Finally, our robustness checks validate the parallel trend assumption and show there are no results in the placebo tests. The main results are robust when we use the nominal share price as the

alternative measure of tick-size constraints (the tick size constraint has a greater effect on low-priced stocks than on high-priced stocks).

Our natural experiment suggests that several tick-size reductions and improved market liquidity over time may provide one explanation for the secular increase in share repurchases over dividend payouts (Figure 1), which is "the most significant change in stylized facts over the past few decades." (Farre-Mensa, Michaely, and Schmalz (2014) pp. 76). As the Tick Size Pilot Program was in effect for only two years, we supplement our natural experiment with a panel regression with firm fixed effects for the universe of all common stocks. We find that market liquidity can explain a significant portion of within-firm time-series variation in share repurchases, and we find that tick-size-constrained firms with greater depth are less likely to repurchase their shares. This correlation, although it is less likely to be causal than the relationship confirmed by the natural experiment, provides further evidence that improvement in market liquidity over time can serve as an interpretation of the secular increase in share repurchases relative to dividend payouts.

Insert Figure 1 about Here

Existing debate on liquidity and payout policy focuses on whether firms can increase their stock liquidity by repurchasing shares.[1] Our results indicate two possible drivers of this controversy. The first is reverse causality. Using the Tick Size Pilot as a natural experiment, we find that firms repurchase fewer shares when liquidity is low. This reverse causality indicates that a positive

[1] Brockman and Chung (2001) and Ginglinger and Hamon (2007) find, using data from Hong Kong and French, respectively, that repurchases have a negative effect on liquidity. In contrast, Cook, Krigman and Leach (2003) and Hillert, Maug, and Obernberger (2016), using a sample of U.S. firms, show that repurchases increase liquidity.

correlation between share repurchase and liquidity does not imply that share repurchases increase liquidity. The second possibility involves mechanical effects fueled by SEC Rule 10b-18. Because this regulation encourages the use of limit orders, we may see a temporary increase in liquidity around repurchases, but such a mechanical increase does not imply that firms can increase their long run liquidity by reducing the amount of shares outstanding.

To the best of our knowledge, our study is the first to establish the causal impact of market structure on share repurchases. In a survey conducted by Brav et at. (2005), financial executives indicate that stock market liquidity is an important factor when they make repurchasing decisions. Our paper provides the first casual evidence for this claim. More broadly, we contribute to the literature on market structure and corporate finance. Previous studies in this literature focus on liquidity in general.[2] Our paper indicates two important new dimensions: "liquidity-for-whom" and "liqudity-of-where."

Regarding liqudity-for-whom, our results indicate that one size does not fit all, and we may need to define liquidity slightly differently for different agents. For example, greater depth means higher liquidity for traders who use market orders, but it may work against repurchasing traders when regulatory constraints force them to use limit orders. We also find that the effective spread, a traditional liquidity measure for retail traders, may contain little information pertinent to share repurchase decisions.

[2] Bhide (1993) and Bolton and von Thadden (1998) show that liquidity affects corporate governance. Booth and Chua (1996) and Ellul and Pagano (2006) find that liquidity affects initial public offerings, and Levine and Zervos (1998) and Grullon, Michenaud, and Weston (2015) show that liquidity affects investment policy.

Regarding liquidity-of-where, we find that dark-pool liquidity matters for share repurchases, at least after the Tick Size Pilot. As firms can choose where to trade, a reduction in liquidity for one type of platform does not reduce share repurchases. Therefore, the liquidity in all the markets and its distribution across types of platforms can be more important than liquidity in one type of platform.

Our results can provide a unified interpretation of two important puzzles in the corporate payout literature: 1) Why do share repurchases increase relative to dividends? 2) Why do share repurcashes not drive out dividends completely?

Regarding the first puzzle, Farre-Mensa, Michaely, and Schmalz (2014) show that none of the traditional theories, such as signaling (Grullon and Michaely (2004), Bargeron, Kulchania, and Thomas (2011)) and agency conflicts (Jensen (1986), Jagannathan, Stephens, and Weisbach (2000)), can explain the secular change in share repurchases. Relative taxation advantages (Chetty and Saez (2006), Hanlon and Hoopes (2014)) have only a second-order impact on payout policy. Market timing (Bolton, Chen, and Wang (2013), Dittmar and Field (2015)) and catering (Baker and Wurgler (2004a, 2004b)) also fail to explain this secular increase, unless we assume an increase in equity undervaluation or a preference for share repurchases over time. The failure of these traditional channels motivates researchers to find alternative mechanisms, such as growth in stock-option compensation (Fenn and Liang (2001)) and executive stock ownership (Brown, Liang, and Weisbenner (2007)), offsetting EPS dilution caused by the exercise of options (Kahle (2002), Hribar, Jenkins, Johnson (2006)). To the best of our knowledge, exisiting evidence pertaining to these alternative channels focuses on cross-sectional variation, and ours is the first

study to show that these channels also correlate with time-series variation in share repurchases. More importantly, we show that market liquidity has a first-order effect after controlling for these alternative channels.

The second important puzzle is the reverse of the secular change in repurchases: Why have share repurchases not completely replaced dividends? Existing explanations focus on the benefit of dividends beyond that of paying cash, such as their disciplinary role (Easterbrook (1984)), their information content (Benartzi, Michaely, and Thaler (1997)), and institutional investors' preferences for dividends (Allen and Michaely (2003)). Our paper, on the other hand, focuses on the cost of repurchases led by market-structure frictions. In summary, share repurchases have increased over the past three decades due to reduced market-structure frictions. However, share repurchases cannot completely drive out dividend payouts because these frictions still exist.

1. The Natural Experiment

We explore the 2016 SEC Tick Size Pilot Program as a natural experiment to identify how the change in stock market structure affects corporate payout policies. The timeline of the Program is shown in Figure 2. The Program originated from the Jumpstart Our Business Startups Act ("JOBS Act") in 2012, which directed the SEC to study the impact of decimalization and design a pilot study to increase the tick size for emerging growth stocks. In the summer of 2014, the SEC directed the Financial Industry Regulatory Authority (FINRA) and the National Securities Exchanges (NSE) to discuss the Pilot Program. The goal of the Program was to stimulate initial public

offerings (IPOs) and research activity among small capitalization companies in an effort to create jobs.

Insert Figure 2 about Here

On August 25, 2014, the FINRA and the NSE proposed the Tick Size Pilot Program. On May 6, 2015, the SEC issued an order approving the National Market System (NMS) plan to implement this Program beginning on October 3, 2016, for a two-year period.[3]

On September 3, 2016, FINRA announced the final list of 2,399 stocks to be included in the Tick Size Pilot Program, as well as their group assignments. All Pilot stocks were chosen from the universe of Reg NMS securities that satisfy certain criteria during a measurement period (a three-month period before Program implementation): a given stock must have a price of at least $1.50 each day, a volume-weighted average price of at least $2, and an average sales volume of less than one million shares during the measurement period; moreover, the stock must have a market capitalization below $3 billion and a closing price higher than $2 on the last day of the measurement period. This process identified 2,399 stocks, which were then divided into 27 categories based on having (1) a low, medium, or high share price; (2) low, medium, or high market capitalization; and (3) low, medium, or high volume. The stocks were randomly selected into three test groups from each category, so that each test group contains 400 stocks. The remaining stocks were assigned to a control group.

A summary of rules governing the four groups of stocks is shown in figure 3. Stocks in the

[3] U.S. Securities and Exchange Commission, Investor Alert: Tick Size Pilot Program-What Investors Need To Know, October 3, 2016, https://www.sec.gov/oiea/investor-alerts-bulletins/ia_ticksize.html. (accessed October 10, 2016)

control group continued to be quoted and traded at the existing 1 cent tick size; stocks in test group 1 can be quoted only in $0.05 increments but still can be traded at their current 1 cent increment; stocks in test group 2 can be quoted and traded only in $0.05 minimum increments; for the above groups of stocks, there is no restriction on dark-pool trading. Stocks in test group 3 adhered to all the same requirements as test group 2 and in addition were subject to a "trade-at" requirement, which grants execution priority to displayed orders, unless non-displayed orders can provide a meaningful price improvement.[4] The purpose of this rule is to prohibit non-displayed trading ahead of displayed orders priced at the National Best Bid and Offer (NBBO) on protected venues and to test whether dark-pool trading negatively affects equity market quality. A white paper by ITG Algorithm states: "Dark pool trading and order routing both passively and aggressively will be limited. Non-displayed, Iceberg and peg offset orders all lose much of their appeal."[5] From October 3 to October 17, 2016, new rules were activated for stocks in test groups 1 and 2. From October 17 to October 31, 2016, new rules were activated for stocks in test group 3.

Insert Figure 3 about Here

2. Empirical Design

2.1 Methodology

We conduct difference-in-differences (DID) tests for firms in the test (treatment) group and control

[4] U.S. Securities and Exchange Commission, "Plan to Implement a Tick Size Pilot Program," https://www.sec.gov/divisions/marketreg/tick size-pilot-plan-final.pdf. (accessed August 31, 2016)

[5] Philip Pearson, and Fangyi Li, "Tick Size 2016 Make Small Caps Great Again," *ITG Algorithms*, August 2016, https://www.itg.com/assets/ITG_Tick-Pilot_Pearson.pdf. (accessed August 31, 2016)

group. We exclude quarters after the FINRA published a list of pre-pilot data collection stocks (2016 Q1) and before the program was implemented (2016 Q4) from our DID tests to alleviate any potential confounding effect. We define the four quarters in 2015 as the pre-treatment period and the four quarters in 2017 as the post-treatment period. We estimate the following equation:

$$y_{i,t} = \eta_i + \lambda_t + \beta \times Post \times Test\# + \zeta' \times X_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where *i* indexes the firm, *t* indexes time. $y_{i,t}$ is the corporate payout variable, η_i and λ_t are firm fixed effects and year-quarter fixed effects, respectively. Firm fixed effects capture the time-invariant heterogeneity, while year-quarter fixed effects capture time-varying shocks. $Post$ is a dummy variable that equals one if the observation is in the post-treatment period and zero if it is in the pre-treatment period. $Test\#$ is a dummy variable equal to one if a firm is in a test group and zero if it is in the control group. $X_{i,t}$ are control variables,[6] for which we use size, profitability, and growth opportunities (market-to-book) following Fama and French (2001). $\varepsilon_{i,t}$ is an error term. The main coefficient of interest is β, which compares the effect of the Tick Size Pilot Program on y for the test firms relative to the control firms.

2.2 Data

We obtained the lists of test and control group stocks from FINRA's website. We obtained corporate policy data from Compustat's North America Fundamentals Quarterly files. Dark-pool trading volume data come from the FINRA Alternative Trading System (ATS) Transparency website, and exchange trading volume is obtained from CRSP. We calculate spread and depth

[6] The results are robust when we interact the control variables with Post.

measures based on Daily TAQ (DTAQ) data. In Table 1 we indicate our sample selection process. We first keep only the stocks remaining in the Pilot Program in August 2018; we then merge the Pilot stocks with the Compustat Database; Finally, we exclude regulated utility firms (SIC codes 4800–4829 and 4900–4999) and financial firms (SIC codes 6000–6999). There are 780, 248, 243, and 221 firms remaining in the control group and test groups 1, 2, and 3, respectively.

Insert Table 1 about Here

In Table 2 we present the summary statistics for our main variables in the pre-shock (2015) period for all test groups and the control group. The definitions for these variables are listed in Appendix Table A1. Specifically, repurchase payouts equal the total expenditure of common stock repurchases in the current quarter divided by total asset value in the previous quarter multiplied by 100. Quoted spread is the time-weighted difference between the consolidated bid side and the consolidated offer side. The effective spread is twice the signed difference of the trade price minus the midpoint of the consolidated bid side and offer at the time of order receipt, which captures the overall cost of executing a trade from the point of view of a trader submitting a marketable order. The percent spreads are the corresponding spreads divided by the midpoint of the consolidated bid side and offer at the time of order receipt, and the units are percentages. Market depth measures the dollar amount that must be traded before a stock price moves and is calculated as the average of the displayed dollar depth at the national bid side and offer side. The average repurchase payout in our sample is around 0.5%, and the average dividend payout is around 0.25% for all three test groups. In our sample, the average percent quoted spread is around 0.75%, while the average daily total turnover is around 0.9%.

Insert Table 2 about Here

3. Effects of the Tick Size Pilot Program on Corporate Payout Policies

In this section, we report the results of exploring the effects of the market structure change induced by the Tick Size Pilot Program on corporate payout policies using the difference-in-differences (DID) approach.

3.1 Tick Size Pilot Program and corporate repurchase payouts

We start by exploring the effects of the Tick Size Pilot Program on repurchase payouts. Firms with high pre-treatment quoted spreads are less sensitive to an increase in tick size. To account for the sensitivity differences, we split the firms in each group equally to form tick-constrained and unconstrained samples based on their average dollar quoted spreads from 2016 Q1 to 2016 Q3. Tick-constrained firms have an average dollar quoted spread during the three quarters that is lower than the median values of the group. The cutoff median values are 6.36, 6.21, 7.41, and 6.58 cents for the control group and test groups 1, 2, 3, respectively. We define other firms as unconstrained. To minimize the impact of observable pre-shock differences between treatment and control firms, instead of using all firms in the control group as the control sample, we created a matched sample from the control group based on average repurchase payouts, dividends payouts, dollar quoted spreads, and the three control variables in the pre-treatment period. All of our matching variables are measured prior to the treatment to ensure that the matching variables are unaffected by the treatment (Roberts and Whited (2013)). We use the nearest-neighbor matching method employed

in Abadie et al. (2004), which minimizes the distance (i.e., the Mahalanobis distance) between the vector of observed covariates across treated and control firms and find matched controls for which the distance between vectors is smallest.[7] Appendix Table A2 illustrates an example of the results of the matching procedure, in which the differences in payout variables and control variables between the test group 3 tick-constrained sample and the control sample are narrowing. The following results use matched samples as the control group.

3.1.1 Firms split into tick-constrained and unconstrained groups. The results shown in columns (1), (2), (4), and (5) in Table 3 show that there are no significant changes in repurchase payouts for either tick-constrained or unconstrained firms in test groups 1 and 2. The results reported in columns (3) and (6) in Table 3 show that, within test group 3, only tick-constrained firms reduced repurchase payouts. For tick-constrained firms, the coefficient on the interaction term is statistically and economically significant. The -0.37% reduction in repurchase payouts represents a 70% decline compared with the pre-shock level. In comparison, repurchase payouts did not change for unconstrained firms in test group 3.

Insert Table 3 about Here

3.1.2 Tick-constrained firms split based on increase in depth. The DID results we report in Table 8 Panel E indicate that there is a significant increase (238%) in market depth for tick-

[7] For each tick-constrained or unconstrained stock in a test group, we match the control stock with a replacement. Therefore, there are fewer firms in the control matched sample than in the test group 3 constrained sample. This method makes better matches possible and reduces estimation bias, but at the cost of higher variance (Abadie et al. (2004)). We follow the suggestion in Roberts and Whited (2013) that matching with replacement is preferred for proper identification in empirical corporate finance studies.

constrained firms in test group 3. Greater depth usually means higher liquidity and may favor repurchase of shares. We thus split tick-constrained firms in test group 3 equally based on changes in average daily depth from 2016 before Pilot to 2017 and run the DID test for repurchase payouts. Surprisingly, as shown in Table 4, we find that the reduction in repurchase payouts concentrates on firms with large increases in depth. In contrast, there is no significant change in repurchase payouts for firms with small increases in depth. Moreover, the effects are more salient on the bid side. The interaction term is higher for firms with large increases in bid-side depth than for firms with large increases in offer-side depth, in terms of both economic magnitude and statistical significance. For firms with large increases in bid-side depth, the decline in repurchase payouts is 0.58%, representing a -76% decline compared with the pre-shock level. In contrast, for firms with small increases in bid-side depth, there is no significant change in repurchase payouts.

Insert Table 4 about Here

3.1.3 Tick Size Pilot Program and corporate repurchase announcement. The above analysis of repurchase payouts applies to actual repurchases made by firms. One important feature of share repurchases is execution flexibility: Firms typically announce their intended repurchasing amounts without committing firmly to those amounts. In this section we test whether firms reduce their announcement amounts of share repurchases following the Tick Size Pilot Program. We collect data on repurchase announcement value from SDC Mergers and Acquisitions. "Repurchase announced" is defined as the announcement value of share repurchases divided by total asset value prior to the announcement multiplied by 100. We aggregate the value to the annual term. We define the year 2015 as the pre-treatment period and the year 2017 as the post-treatment period and run

the DID test on repurchase announced values. In Table 5, we find there is no significant reduction in announcement repurchase values, which means that the incentive to announce repurchases was not greatly affected, so the dramatic reduction in share repurchases comes mostly from the actual implementation of repurchases.

Insert Table 5 about Here

3.2 Tick Size Pilot Program and corporate dividend payouts

Next, we analyze the impact of the change in market structure on dividend payouts. We report the DID results on dividend payouts in Panel A of Table 6. We find that the coefficients on the interaction term are all insignificant for both the tick-constrained and the unconstrained sample, which suggests that the market structure change hardly affects corporate dividend payouts. When there is a shock in market structure, firms reduce repurchase payouts but do not substitute toward dividend payouts. The results are consistent with the dividend-smoothing motive (Leary and Michaely (2011), Michaely and Roberts (2012)): as the Pilot Program is in effect for only two years, when the Pilot ends firms can resume normal repurchasing. If they increase dividends during the Pilot, they need to reduce them when the Pilot ends, an action that firms typically avoid because of the negative market reaction to dividend cuts.

Insert Table 6 about Here

3.3 Tick Size Pilot Program and total payouts and payout structure

We report the DID results on total payouts in Panel B of Table 6. For tick-constrained firms in test group 3, the reduction in repurchase payouts and unchanged dividend payouts caused a decline in total payouts. There is a 0.42% reduction in total payouts compared with the pre-treatment average

payouts of 0.80%, representing a -52% decline. For tick-constrained firms in test groups 1 and 2 and unconstrained firms in all groups, there is no significant change in total payouts.

The DID results for the payout structure are reported in Panel C of Table 6. We define the payout structure ratio as (repurchase payouts +1) / (dividend payouts +1). Since dividend payouts could be 0, we normalize the repurchase payouts over the dividend payouts ratio by adding 1 to both payouts. The payout structure variable is easy to interpret. If repurchase payouts are higher than dividend payouts, this ratio is higher than 1. If these two payouts are equal, this ratio is equal to 1. If repurchase payouts are lower than dividend payouts, the ratio is lower than 1. For the tick-constrained firms in group 3, the average payout structure ratio in the pre-treatment period is 1.40; thus, repurchases dominate dividend payouts as the main vehicle for payouts. Following the Pilot, the reduction in the payout structure ratio is about 0.37. Thus, the composition of the payout became roughly equal between repurchases and dividend payouts following the Pilot Program. For tick-constrained firms in test groups 1 and 2 and unconstrained firms in all groups, there is no significant change in payout structure.

3.4 Robustness checks

3.4.1 Placebo tests. One concern with inferences from studies using natural experiments involves whether the assignment of treatment and control group outcome variables follows parallel trends prior to the treatment. We address this concern by examining data associated with repurchase payouts going farther back in time in non-shock periods.

In Panel A of Table 7 we report the quarter-by-quarter DID results for repurchase payouts, comparing tick-constrained firms in test group 3 and the control group from 2013 Q1 to 2015 Q4.

We compare the quarterly change in repurchase payouts for firms in the two groups and we find that the coefficients on the interaction terms are all statistically insignificant. It is apparent that repurchase payouts change similarly (follow a parallel trend) in the pre-treatment period.

Insert Table 7 about Here

We also conduct another set of placebo test using a two-year interval between the pre- and post-treatment period as in our main tests, and also a one-year interval. In Panel B of Table 7 we show that the estimated difference in repurchase payout changes are indistinguishable across tick-constrained firms in test group 3 and the control group. Therefore, our test-control contrast does not appear in the non-Pilot period, when there was no market-structure shock.

3.4.2 Alternative measure of tick constraints. As stocks with a low nominal share price are constrained to a greater extent by the tick size, another way to sort stocks into tick-constrained and unconstrained samples is based on the nominal share price. We run this exercise as a robustness check. We split stocks equally into high-price and low-price sub-groups based on share prices in 2016 Q3. The stocks in the low-price group are defined as the constrained sample and other stocks are defined as the unconstrained sample. Next, we carry out the same matching procedure (except for that we replace dollar quoted spread with share price as the matching variable) to find the matched control sample and rerun the DID tests. The results are shown in Table A3 of the Appendix. The main results are the same as when we use the dollar quoted spread as the measure of tick constraints.

4. Underlying Channels

To ensure that the reduction in market liquidity is the only channel that affects corporate repurchase payouts differentially for firms in the test and control groups following the Pilot Program, we first examine the reduction in market liquidity for firms in the test groups. We then examine whether our results may be driven by alternative explanations, such as market timing, managers' personal options and stock holdings, and offsetting EPS dilution.

4.1 The exogenous shock on market liquidity

We test the differential effects of the Tick Size Pilot Program on market liquidity for firms in test groups and the control group. We use percent spreads, turnovers, and market depth as liquidity measures. In Table 8 we report the DID results. In Panels A and C we show that percent quoted spreads and market depth increased for tick-constrained firms in test groups 1 and 2. Interestingly, for these firms, dark turnover increased, while total turnover changed very little. These results show that some exchange traders switch to dark pools after the tick size increase. Thus, the findings suggest that there was a reduction in exchange liquidity, but dark liquidity increased for these firms, and the aggregate liquidity change is unclear. As seen in Panel E, we find that there was a decline in both exchange liquidity and dark liquidity for tick-constrained firms in test group 3: the percent quoted spreads and market depth increased significantly, and dark (lit) turnover decreased 0.08% (0.32%), which represents a decline of 44% (32%) compared with the pre-treatment level. The effective spread shows little change for all groups. In fact, the effective spread captures the

trading cost to retail traders and is less relevant to the cost of repurchases.[8] As seen nin Panels B, D, and F, we find that there is less change in market liquidity for unconstrained firms in the Tick Size Pilot Program compared with the constrained firms.

Insert Table 8 about Here

4.2 Alternative explanations

4.2.1 Market timing. Firms may time the market and repurchase more shares when their stocks are undervalued. For example, firms may repurchase less shares when the share price is high. Albuquerque, Song, and Yao (2018) show that the Tick Size Pilot Program has a negative effect to share price for firms in test groups, implying that they will repurchase more shares following the Pilot Program. Therefore, the price change can not explain the reduction in share repurchases. We also run a DID test on repurchase payouts while adding share price as an independent variable, to show that the reduction in repurchase payouts cannot be explained by the differential change in stock prices. As reported in Panel A of Table 9 Column (1), even after we control for share price, the interaction term is still negative and significant, ruling out the market-timing explanation. The economic magnitude and statistical significance are even stronger as the estimation becomes more precise. Moreover, the results reported in column (2) of Table 9 show that there is a significant decline in the share of repurchases, confirming that our results cannot be explained by changes in repurchase prices.

[8] The results for the effective spread are consistent with the joint assessment of the impact of the Tick Size Pilot. See: U.S. Securities and Exchange Commission, "Assessment of the Plan to Implement a Tick Size Pilot Program," July 3, 2018, https://www.sec.gov/files/TICK%20PILOT%20ASSESSMENT%20FINAL%20Aug%202.pdf (accessed July 31, 2018)

Insert Table 9 about Here

4.2.2 Management stock and option holdings. It might be possible that managers hold fewer shares or options after the Tick Size Pilot Program, which causes the reduction in repurchases. If managers own more stocks, they may favor repurchase payouts over dividend payouts because of the relative tax advantage of share repurchases; managerial holdings of options also create incentives not to pay dividends but to repurchase shares, as dividend payouts reduce per-share value. Using annual holding data from Execucomp for managers, we conduct DID tests for manager stock and option holdings using annual data with 2017 as the post-treatment period and 2015 as the pre-treatment period. The results are reported in Columns (1) and (2) of Table 9 Panel B. We find no significant change in managers' stock holdings in test group firms relative to holdings of managers in control firms following the Tick Size Pilot Program; although the interaction term in reflected in column (2) is statistically significant at the 10% level, manager option holdings for test group 3 tick-constrained firms increased relative to those of the control group, which contradicts the prediction that manager option holdings can explain the results for repurchase payouts. These results rule out the manager bonus explanation.

4.2.3 Offsetting EPS dilution. Firms may engage in share repurchases to manage EPS, thereby mitigating the dilutive effects of stock option exercises (Kahle (2002), Hribar, Jenkins, Johnson (2006)). Almeida, Fos, and Kronlund (2016) identify the real effects of EPS-motivated repurchases: managers are willing to trade off investments and employment for stock repurchases that allow them to meet analyst EPS forecasts. Another potential explanation for our results is that there could be fewer exercised or exercisable options following the Tick Size Pilot Program, then managers

would have a weaker incentive to repurchase shares to offset EPS dilution. As the options data from Compustat are also annual, we run DID tests for exercisable options and exercised options using annual data. As seen in Columns (3) and (4) of Table 9 Panel B, we find no significant change in exercisable options or exercised options in Pilot firms relative to holdings of managers in control firms following the Tick Size Pilot Program, ruling out the EPS management explanation. The figures reported in these columns show that our results for repurchase payouts hold when we control for manager stock holding, manager option holding, exercised options, and exercisable options simultaneously.

Overall, our findings are internally consistent and support our assertion that the reduction in market liquidity caused the change in corporate repurchase payouts in the aftermath of the Tick Size Pilot Program.

5. Market Liquidity and the Secular Change in Payout Policies

In this section, we test the firm-level time-series correlation of market liquidity and repurchase payouts. This result, when combined with the causal impact of market liquidity on repurchases which is established in the natural experiment, can provide stronger evidence that the improvement in market liquidity over time can help explain the secular change in payout policies.

We run a panel regression with firm fixed effects while using repurchase payouts as the dependent variable and liquidity measures and other explanatory variables as independent variables. In this case, the coefficients are identified using only *within-firm* time-series variations. We regress repurchase payouts on a measure of stock-market liquidity and other explanatory

variables. The specification is as follows:

$$Repur_{i,t} = \eta_i + \beta_1 Liq_{i,t} + \beta_2 Optex_{i,t} + \beta_3 Optexd_{i,t} + \beta_4 ManSto_{i,t} + \beta_5 ManOpt_{i,t}$$
$$+\beta_6 GDPgrowth_t + \beta_7 Size_{i,t} + \beta_8 Profit_{i,t} + \beta_9 Growth_{i,t} + \varepsilon_{i,t}. \quad (2)$$

The liquidity measures include lit turnover, dark turnover, total turnover, implementation shortfall (IS), percent quoted spread, percent effective spread, and market depth. Our turnover measures are average daily volume measures divided by total shares outstanding. Percent spreads and market depth are calculated using data from the DTAQ database. The effective spread measures mainly the trading cost to retail traders, which may not capture the cost to institutions, which consists mainly in the difference between the intended execution price and the actual execution price. Since large orders may move the market price in a disadvantageous direction, the trading cost could be higher than the effective spread. We therefore include IS as the main measure of the execution cost of institutional traders (Anand et al. (2012, 2013)), which is defined as the value-weighted signed difference in the execution price of a ticket minus the price of the ticket when a broker receives the ticket, divided by the price of the ticket when a broker receives the ticket. Except for these liquidity measures, we include EPS management variables: exercised options and exercisable options (Kahle (2002), Hribar, Jenkins, Johnson (2006)); managers' stock (Brown, Liang, and Weisbenner (2007)) and option holdings (Fenn and Liang (2001)); GDP growth: demeaned growth in gross domestic product (Dittmar and Dittmar (2008)); and firm characteristics including size, profitability, and growth opportunity (market-to-book ratio), following Fama and French (2001).

We obtain these variables from the Compustat Fundamentals Annual database. Among these variables, exercised and exercisable options data cover the period running from 2004 through 2017.

We do not include relative taxation of dividends over capital gains as it has not changed since 2004. Lit turnover is taken from the CRSP database, the sample period runs from 1993 through 2017, and the regression period runs from 2004 through 2017. Because FINRA ATS Transparency Data are reported from May 2014, the sample period and the regression period for dark turnover and total turnover runs from 2014 through 2017. We obtain IS data from Ancerno Ltd. for the period running from 2000 through 2010, while the regression period runs from 2004 through 2010; percent spreads and market depth are calculated based on data taken from the DTAQ Database, and the sample period and regression periods run from 2004 through 2017. To make sure there is sufficient time-series variation, we keep firms in the sample if they have at least ten observations for regressions on lit turnover, percent spreads, and market depth (we require at least three observations for regressions on dark turnover and total turnover, and we require at least five observations for regression on IS).

In Table A4 of the Appendix, we present the summary statistics for the main variables. Table 10 reports the panel regression results. The coefficient in the first line is defined as the estimated coefficient multiplied by the within-firm standard deviation of the explanatory variable, which is the average change in repurchase payouts associated with a one-standard-deviation change in the within-firm explanatory variable. The coefficients in the angle bracket are the fraction of the change in repurchase payouts compared with the mean of the repurchase payouts with an associated one-standard-deviation change in the within-firm explanatory variable. We report the corresponding *t*-values in parentheses.

In the regressions for the results reported in Columns (1)-(3) in Table 10, we use turnover as our

liquidity measure. We find positive and significant coefficients on all turnover measures. Firms repurchase more shares when turnover is high; a one-standard-deviation within-firm increase in total turnover leads to an average 0.26% increase in repurchase payouts, representing 6.83% of its mean value. Increasing dark turnover by one within-firm standard deviation leads to an average 0.28% increase in repurchases, which represents 7.48% of their mean value. This is also suggestive evidence that dark pools are a venue in which firms repurchase shares.

Insert Table 10 about Here

In Column (4) of Table 10, we report the results of using IS as our liquidity measure. We find that the coefficient is statistically and economically significant. Firms repurchase more shares when IS is low. Increasing IS by one within-firm standard deviation leads to an average 0.20% decrease in repurchase payouts, which represents 5.65% of their mean value.

As seen in Column (5) of Table 10, we find that the interaction term is also negative and significant. Firms repurchase more shares when the percent quoted spread is low. Increasing the percent quoted spread by one within-firm standard deviation leads to a 0.17% reduction in repurchase payouts, representing a 4.70% decline compared with its mean value. In contrast, as seen in Column (6) of Table 10, the coefficients for the percent effective spread is insignificant. The effective spread captures the trading costs to small traders, and thus has little explanatory power for repurchases. As shown in Columns (7) and (8) of Table 10, for the full sample of firms the coefficient for market depth is negative and insignificant. For tick-constrained firms (e.g. firms with an average dollar-quoted spread lower than 3 cents in our sample period), however, the coefficient is negative and significant. Increasing market depth by one within-firm standard

deviation leads to a 0.27% reduction in repurchase payouts, representing a 6.56% decline. The traditional interpretation is that greater depth represents higher market liquidity, but when the tick size is binding, execution priority is determined by speed competition at the same price, and greater depths make execution of limit orders more difficult, especially for repurchasing firms that use buy limit orders extensively. Lastly, we find that options exercised, GDP growth, profitability, and growth opportunity are statistically significant throughout all the regressions. Therefore, firms repurchase more shares when market liquidity is high (the cost of repurchase is low); when there are more exercised options; when GDP growth is high; when firms are more profitable; and when firms have lower growth opportunities.

Overall, these results show that within-firm variation in market liquidity is correlated with within-firm changes in corporate repurchase payouts, even after controlling for other explanatory variables. The results provide additional evidence that market liquidity can help explain the secular change in corporate repurchase payouts.

6. Conclusion

Using the 2016 SEC Tick Size Pilot Program as a source of exogenous shocks, we show that market structure has a first-order effect on corporate payout policy. Liquidity certainly plays an important role, because we find that the reduction in share repurchases exists only for firms whose bid-ask spreads are constrained by the tick size. For these firms, an increase in the tick size from 1 cent to 5 cents is more likely to mechanically increase the bid-ask spread and reduce liquidity.

In addition, our paper offers other insights that are new to the literature: liquidity-of-where and liquidity-for-whom.

Regarding liquidity-of-where, we show that a reduction in liquidity on stock exchanges does not reduce firms' payouts as long as they face the same condition when they trade in dark pools. On the other hand, firms that face constraints in both stock exchanges and dark pools reduce their repurchase payouts by 70%. Insofar as they do not increase their dividend payouts, their total payouts decline by 52%. Before the Pilot, these firms make payouts mainly through share repurchases. After the Pilot, the proportions of repurchase payouts and dividend payouts become roughly equal. Our results indicate that the reduction in tick size over several years, the general increase in market liquidity, and the proliferation of trading venues may serve as one interpretation of one of the most important puzzles in the corporate payout literature: the secular increase in share repurchases over dividends.

Regarding liquidity-for-whom, we find that regulations can change the definition for different groups of agents. SEC rule 10b-18, which aims to prevent price manipulation using aggressive market orders, encourages repurchasing firms to use limit orders on the bid side. As firms and their brokers may not be as fast as HFTs, great depth under a constrained tick size may harm firms, because their limit orders may fail to execute. As a consequence, although a market with great depth is generally considered a liquid market, a market with great depth, particularly on the bid side, may be illiquid for repurchasing firms.

Our results can reconcile two seemingly contradictory puzzles in the corporate payout literature. First, a reduction in market structure frictions over time, such as improved liquidity, reduced tick

size, and a proliferation of trading venues, may explain the secular upward trend toward paying out through share repurchases over dividends. Second, these frictions always have existed and continue to exist, which can explain why share repurchases cannot completely drive out dividend payouts.

Finally, our paper contributes to two recent policy debates. First, our results show that an increase in the tick size harms firms, and Yao and Ye (2018) show that an increase in the tick size benefits HFTs. Taken together, these results show that regulators should revoke the initiative to increase the tick size from 1 cent to 5 cents, because the intent of this policy initiative was to help long-term investors and firms while and curbing HFTs. Second, our results suggest that regulators should amend SEC rule 10b-18 to reflect the market structure 36 years after the implementation of the rule. In summary, the updated market structure may defeat the purpose of many well-intended but outdated regulations. It would be fruitful for researchers and regulators to consider a new generation of regulations when accounting for the evolving market structure.

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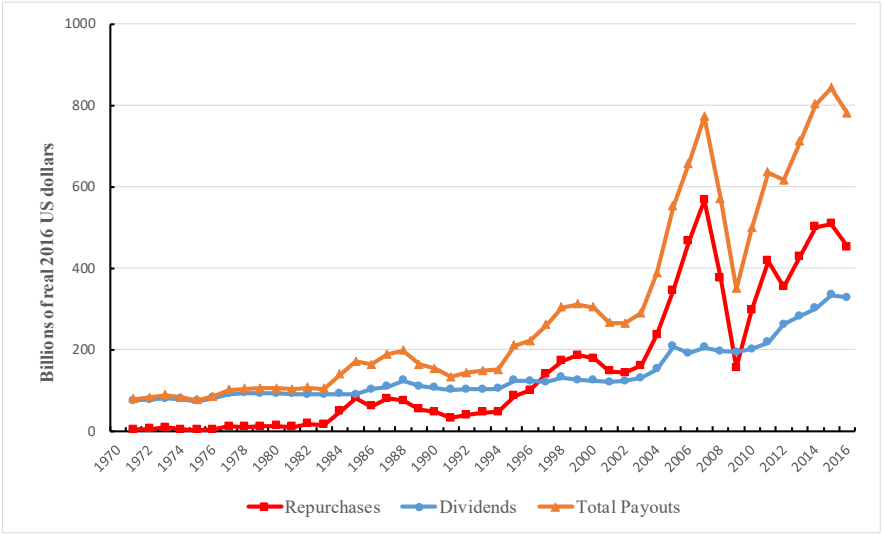
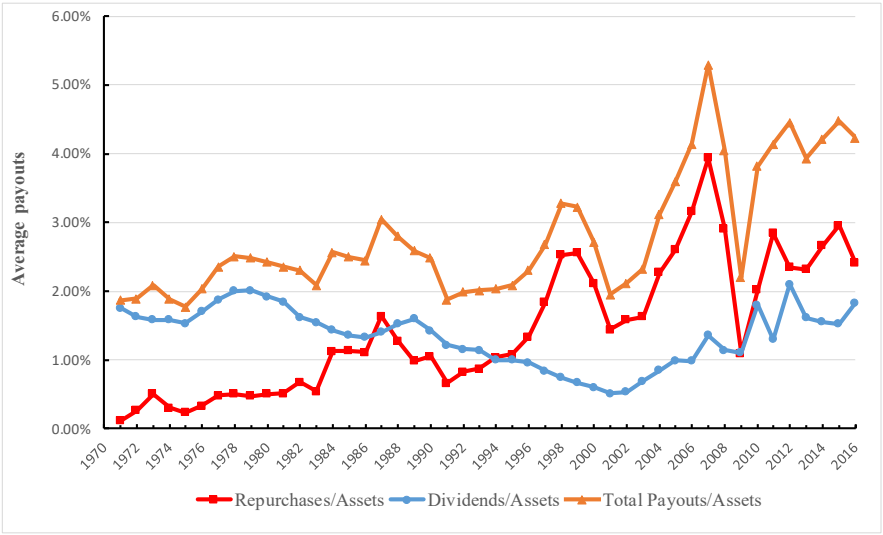


Panel A: Repurchases, dividends, and total payouts level



Panel B: Repurchases/assets, dividends/assets, and total payouts/assets

Figure 1
Time Series Evolution of Corporate Payouts
Panel A is a plot of the equal-weighted average of repurchases, dividends, and total payouts amount by publicly listed U.S. companies from 1971 to 2016. The methodology is the same as in Farre-Mensa, Michaely, and Schmalz (2014). The magnitudes are in billions of real 2016 U.S. dollars of purchasing power. Panel B plots the time-series of repurchase payouts, dividend payouts, and total payouts for our sample of publicly listed U.S. firms. Repurchases are calculated as the total expenditures on the purchase of common and preferred stocks (PRSTKC) minus any reduction in the value of net number of preferred stocks outstanding (PSTKRV). Dividends are calculated as the total amount of dividends declared on the common/ordinary capital of the company. Total payouts are calculated as the sum of repurchases and dividends. Assets are defined the total asset in the previous year. To be included in our sample, a firm has to be in both Compustat and the Center for Research in Security Prices (CRSP); be incorporated and located in the U.S.; be listed on the NYSE, AMEX, or NASDAQ; have valid stock prices in CRSP; have a CRSP share code of 10 or 11; and be neither a regulated utility firms (SIC codes 4800–4829 and 4900–4999) and financials (SIC 6000–6999).

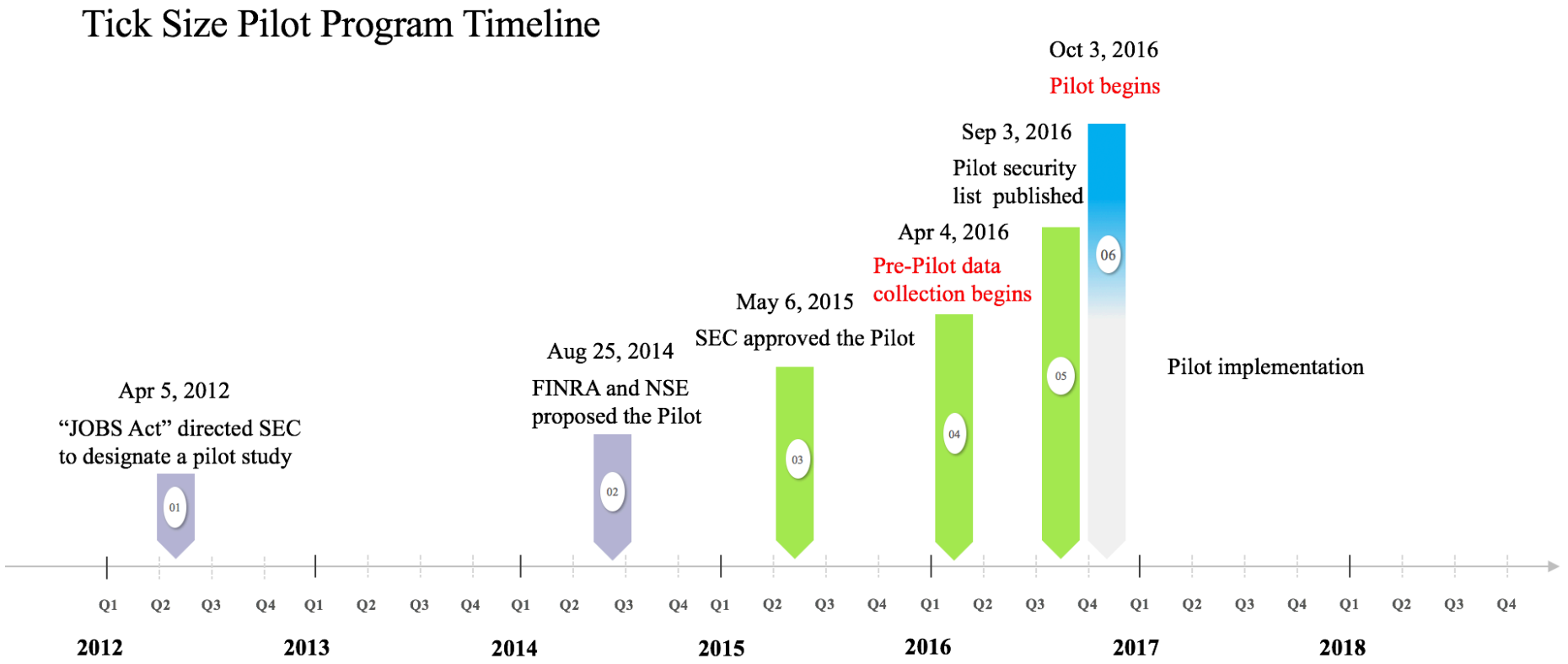


Figure 2
SEC Tick Size Pilot Program Timeline
This figure shows the major events and dates of the 2016 SEC Tick Size Pilot Program.

	Number of Stocks	Quote Rule	Trade Rule	Trade-at Rule
Control Group	1199	0.01	0.01	NO
Test Group 1	400	0.05	0.01	NO
Test Group 2	400	0.05	0.05	NO
Test Group 3	400	0.05	0.05	YES

Figure 3
Summary of rules for test groups and control group
This figure shows a summary of rules that governs the four groups of stocks. Stocks in the control group continued to be quoted and trade at the existing tick size of 1 cent; stocks in test group 1 can only be quoted in $0.05 increments but still can be traded at their current 1 cent increment; stocks in test group 2 can only be quoted and traded in $0.05 minimum increments; stocks in test group 3 adhered to all the requirements of the test group 2 and in addition were subject to a "trade-at" requirement, which grants execution priority to displayed orders, unless non-displayed orders can provide a meaningful price improvement.

Table 1
Sample Selection Process

	Stocks in the beginning of Pilot	Stocks remaining in Pilot in August 2018	Merge with Compustat	Exclude utility and financial firms
Control Group	1200	1080	1061	780
Test Group 1	400	344	337	248
Test Group 2	400	334	328	232
Test Group 3	400	329	323	221

This table reports the change in the number of stocks during our sample selection process, based on the following steps: Firstly, we keep stocks that remain in the Pilot Program in August 2018. FINRA's website provides complete reasons for a firm being removed from the Tick Size Pilot Program: http://www.finra.org/industry/oats/tick size-pilot-data-collection-securities-files, the main reasons include delisting, mergers and acquisitions, price declines below $1; Secondly, we match the Pilot stocks with Compustat fundamentals quarterly data (twelve stocks with no corporate information which are provided by the stock exchanges to facilitate testing such as ATEST A, NTEST B, ZVZZT are removed, Compustat has no record for other missing stocks); Finally, We exclude regulated utility (SIC codes 4800–4829 and 4900–4999) and financial (SIC codes 6000–6999) firms.

Table 2
Summary Statistics

	Test Group 1			Test Group 2			Test Group 3			Control Group		
	N	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.
Repurchase Payouts	604	0.497	1.219	572	0.480	1.237	484	0.513	1.130	1920	0.380	1.082
Dividend Payouts	604	0.222	0.483	572	0.248	0.594	484	0.271	0.677	1920	0.217	0.546
Total Payouts	604	0.719	1.339	572	0.728	1.370	484	0.784	1.301	1920	0.597	1.242
Payout Structure	604	1.306	1.102	572	1.303	1.156	484	1.343	1.101	1920	1.221	0.961
Lit Turnover	604	0.784	0.630	572	0.712	0.656	484	0.749	0.592	1920	0.729	0.631
Dark Turnover	604	0.146	0.119	572	0.131	0.126	484	0.139	0.114	1920	0.132	0.115
Total Turnover	604	0.930	0.741	572	0.843	0.771	484	0.888	0.697	1920	0.860	0.737
Dollar Quoted Spread	604	0.129	0.201	572	0.138	0.186	484	0.140	0.218	1920	0.133	0.205
Percent Quoted Spread	604	0.731	0.992	572	0.790	0.980	484	0.690	0.861	1920	0.815	1.047
Percent Effective Spread	604	0.730	1.320	572	0.663	0.860	484	0.817	1.651	1920	0.821	1.484
Market Depth	604	0.323	0.607	572	0.295	0.514	484	0.269	0.417	1920	0.289	0.494
Bid-Side Depth	604	0.325	0.611	572	0.291	0.518	484	0.271	0.456	1920	0.288	0.492
Offer-Side Depth	604	0.310	0.609	572	0.295	0.537	484	0.264	0.423	1920	0.284	0.508
Size	604	6.033	1.465	572	5.730	1.378	484	5.760	1.324	1920	5.649	1.390
Profitability	604	0.404	5.278	572	0.268	5.930	484	0.246	6.056	1920	-0.542	6.556
Growth	604	2.029	1.776	572	2.352	1.972	484	2.211	1.530	1920	2.389	2.032

This table shows the summary statistics of the key variables for test groups 1-3 and control group. See Appendix Table A1 for variable definitions. In each group, we report the observation number, mean and standard deviation of the key variables. The sample period is 2015 Q1 - 2015 Q4. Data are collected from the Compustat fundamentals quarterly database and DTAQ database. In order to form balanced datasets, firms with missing variables or missing observations in Compustat for the main test period (year 2015 and 2017) have been removed; all variables are winsorized at 1% and 99% levels.

Table 3
Difference-in-Difference Results: Repurchase Payouts

	Tick-Constrained Sample			Unconstrained Sample		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
	(1)	(2)	(3)	(4)	(5)	(6)
Test #×Post	0.0166	-0.0181	-0.365**	-0.160	-0.0256	-0.119
	(0.12)	(-0.13)	(-2.47)	(-1.25)	(-0.16)	(-0.74)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1096	1088	888	1136	1040	920
R^2	0.354	0.384	0.560	0.427	0.572	0.372

This table shows the difference-in-difference results on repurchase payouts. If a stock is in a test group # (# indicates the number of 1, 2, 3, respectively), Test # is equal to 1; if a stock is in control group, Test # is equal to 0. If fiscal year-quarter is in 2017 Q1-Q4, post is equal to 1; if fiscal year-quarter is in 2015 Q1-Q4, post is equal to 0. Besides full sample, we also split each test group into tick-constrained sample and unconstrained sample. The tick-constrained sample includes firms if their average dollar quoted spread during the four quarters before test implementation is below their cutoff median value for each test group. Other firms are defined as unconstrained. Columns (1) (2) (3) present the results for the constrained sample (corresponding to test group 1, 2, 3), and Columns (4) (5) (6) present the results for the unconstrained sample (corresponding to test group 1, 2, 3). Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroscedasticity and clustered at the firm level are in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4
Difference-in-Difference Results: Split Tick-constrained Firms Based on Increase in Depth

	Increase in Market Depth		Increase in Bid-Side Depth		Increase in Offer-Side Depth	
	Small	Large	Small	Large	Small	Large
	(1)	(2)	(3)	(4)	(5)	(6)
Test #×Post	-0.172	-0.556**	-0.170	-0.575**	-0.251	-0.473**
	(-0.91)	(-2.47)	(-0.87)	(-2.52)	(-1.19)	(-2.21)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	448	440	448	440	448	440
R^2	0.618	0.524	0.616	0.526	0.641	0.495

This table shows the difference-in-difference results on repurchase payouts when we equally split the tick-constrained sample in test group 3 into two groups based on the increase in depth from 2016 (before Pilot) to 2017. The small depth sample includes firms if their the increase in depth from 2016 (before Pilot) to 2017 is below their cutoff median value. Other firms are defined as large depth sample. If a stock is in test group 3, Test 3 is equal to 1; if a stock is in control group, Test 3 is equal to 0. If fiscal year-quarter is in 2017 Q1-Q4, post is equal to 1; if fiscal year-quarter is in 2015 Q1-Q4, post is equal to 0. Columns (1) (2) present the results for the small and large sample of the increase in market depth, Columns (3) (4) present the results for the small and large sample of the increase in bid-side depth, and Columns (5) (6) present the results of the small and large sample of the increase in offer-side depth. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroscedasticity and clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5
Difference-in-Difference Results: Repurchase Announced

	Tick-Constrained Sample	Unconstrained Sample
	(1)	(2)
Test 3×Post	-0.136	0.503
	(-0.16)	(0.61)
Firm FE	Yes	Yes
Year-Quarter FE	Yes	Yes
Cluster by Firm	Yes	Yes
N	222	230
R^2	0.493	0.614

This table shows the difference-in-difference results on announced repurchase payouts in test group 3 using annual data. Repurchase announced is defined as announcement value of share repurchases divided by the total asset value prior to the announcement, multiplied by 100. If a stock is in a test group 3, Test 3 is equal to 1; if a stock is in control group, Test 3 is equal to 0. If fiscal year is in 2017, post is equal to 1; if fiscal year is in 2015, post is equal to 0. We split each test group into tick-constrained sample and unconstrained sample. The tick-constrained sample includes firms if their average dollar quoted spread during the four quarters before test implementation is below their cutoff median value for each test group. Other firms are defined as unconstrained. The samples of firms in the test group 3 are consistent with the samples in the main tests. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroscedasticity and clustered at the firm level are in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6
Difference-in-Difference Results: Dividend Payouts, Total Payouts, and Payout Structure

Panel A: Difference-in-difference results of dividend payouts

	Tick-Constrained Sample			Unconstrained Sample		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
	(1)	(2)	(3)	(4)	(5)	(6)
Test #×Post	0.0138	0.0306	-0.0521	-0.0263	-0.0419	-0.0517
	(0.31)	(0.61)	(-0.60)	(-0.97)	(-0.65)	(-1.10)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1096	1088	888	1136	1040	920
R^2	0.780	0.861	0.816	0.643	0.601	0.840

Panel B: Difference-in-difference results of total payouts

	Tick-Constrained Sample			Unconstrained Sample		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
	(1)	(2)	(3)	(4)	(5)	(6)
Test #×Post	0.0303	0.0125	-0.417**	-0.186	-0.0675	-0.171
	(0.20)	(0.08)	(-2.52)	(-1.41)	(-0.41)	(-0.97)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1096	1088	888	1136	1040	920
R^2	0.449	0.537	0.605	0.466	0.600	0.536

Panel C: Difference-in-difference results of payout structure

	Tick-Constrained Sample			Unconstrained Sample		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3

	(1)	(2)	(3)	(4)	(5)	(6)
Test #×Post	0.0367	-0.0323	-0.365**	-0.145	-0.0336	-0.0290
	(0.27)	(-0.26)	(-2.50)	(-1.42)	(-0.23)	(-0.19)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1096	1088	888	1136	1040	920
R^2	0.391	0.378	0.606	0.463	0.602	0.369

This table shows the difference-in-difference results on dividend payouts, total payouts, and payout structure. If a stock is in a test group # (# indicates the number of 1, 2, 3, respectively), Test # is equal to 1; if a stock is in control group, Test # is equal to 0. If fiscal year-quarter is in 2017 Q1-Q4, post is equal to 1; if fiscal year-quarter is in 2015 Q1-Q4, post is equal to 0. Panel A shows the results of dividend payouts, Panel B shows the results of total payouts, and Panel C shows the results of payout structure. We split each test group into tick-constrained sample and unconstrained sample. The tick-constrained sample includes firms if their average dollar quoted spread during the four quarters before test implementation is below their cutoff median value for each test group. In each panel, Columns (1) (2) (3) present the results for the tick-constrained sample (corresponding to test group 1, 2, 3), and Columns (4) (5) (6) present the results for the unconstrained sample (corresponding to test group 1, 2, 3). Other firms are defined as unconstrained. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroscedasticity and clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7
Placebo Tests

Panel A: Quarter-by-Quarter Placebo Test (Parallel trend)

	Pre:2013 Q1 Post:2013 Q2	Pre:2013 Q2 Post:2013 Q3	Pre:2013 Q3 Post:2013 Q4	Pre:2013 Q4 Post:2014 Q1	Pre:2014 Q1 Post:2014 Q2	Pre:2014 Q2 Post:2014 Q3	Pre:2014 Q3 Post:2014 Q4	Pre:2014 Q4 Post:2015 Q1	Pre:2015 Q1 Post:2015 Q2	Pre:2015 Q2 Post:2015 Q3	Pre:2015 Q3 Post:2015 Q4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Test 3×Post	-0.0959	0.188	0.0361	-0.0932	0.00775	0.127	-0.0867	-0.171	0.0819	-0.114	0.235
	(-0.42)	(0.70)	(0.15)	(-0.55)	(0.03)	(0.56)	(-0.37)	(-1.07)	(0.38)	(-0.56)	(1.27)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	180	180	184	190	194	204	210	220	222	222	222
R^2	0.706	0.622	0.607	0.888	0.730	0.749	0.759	0.876	0.792	0.827	0.863

Panel B: Year-by-Year Placebo Test

	Pre:2013 Q1-Q4 Post:2015 Q1-Q4	Pre:2014 Q1-Q4 Post:2015 Q1-Q4	Pre:2013 Q1-Q4 Post:2014 Q1-Q4
	(1)	(2)	(3)
Test 3×Post	0.010	-0.158	0.108
	(0.05)	(-1.24)	(0.70)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes
N	704	776	688
R^2	0.412	0.544	0.411

This table shows the placebo test results of repurchase payouts for test group 3 tick-constrained sample. The tick-constrained sample includes firms if their average dollar quoted spread during the four quarters before test implementation is below their cutoff median value for each test group. If a stock is in test group 3, Test 3

is equal to 1; if a stock is in control group, Test 3 is equal to 0. Panel A shows the period-by-period difference-in-differences results on repurchase payouts comparing tick-constrained firms in test group 3 and control matched group from 2015 Q4 going back up to 2013 Q1 (See Columns (1)-(11)).Panel B shows the results of placebo test with two-years interval between the pre- and post-treatment period as in our main tests (See Column (1)), and also one-year interval (See Columns (2) and (3)). Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. The sample of firms in the test is consistent with the sample in the main tests. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroskedasticity and clustered at the firm level are reported in parentheses below the coefficient estimates. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table 8
Difference-in-Difference Results: Market Liquidity Measures

Panel A: Difference-in-difference results of liquidity measures for test group 1 tick-constrained sample						
	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Total Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Test 1×Post	0.323***	0.343***	-0.127	0.0343**	-0.162*	-0.177
	(3.98)	(4.36)	(-1.22)	(2.01)	(-1.81)	(-0.60)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1096	1096	1096	1096	1096	1096
R^2	0.780	0.674	0.691	0.695	0.696	0.526
Panel B: Difference-in-difference results of liquidity measures for test group 1 unconstrained sample						
	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Total Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Test 1×Post	-0.113	0.130*	-0.0662	-0.00120	-0.0670	-0.111
	(-1.34)	(1.81)	(-0.84)	(-0.09)	(-0.74)	(-1.17)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1136	1136	1136	1136	1136	1136
R^2	0.888	0.858	0.651	0.699	0.662	0.818
Panel C: Difference-in-difference results of liquidity measures for test group 2 tick-constrained sample						
	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Total Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Test 2×Post	0.329***	0.365***	-0.0410	0.0322*	-0.0717	0.171

	(3.77)	(4.50)	(-0.32)	(1.70)	(-0.66)	(0.95)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1088	1088	1088	1088	1088	1088
R^2	0.789	0.632	0.637	0.692	0.651	0.830
Panel D: Difference-in-difference results of liquidity measures for test group 2 unconstrained sample						
	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Total Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Test 2×Post	0.0369	0.194***	-0.140	-0.00936	-0.149	0.156
	(0.34)	(2.70)	(-1.63)	(-0.61)	(-1.50)	(1.04)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1040	1040	1040	1040	1040	1040
R^2	0.853	0.757	0.686	0.724	0.699	0.738
Panel E: Difference-in-difference results of liquidity measures for test group 3 tick-constrained sample						
	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Total Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Test 3×Post	0.346***	0.379***	-0.323***	-0.0779***	-0.399***	-0.251
	(3.61)	(4.07)	(-3.03)	(-4.69)	(-3.29)	(-0.74)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	888	888	888	888	888	888
R^2	0.812	0.604	0.649	0.678	0.654	0.688
Panel F: Difference-in-difference results of liquidity measures for test group 3 unconstrained sample						

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Total Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Test 3×Post	-0.00305	0.215**	-0.0647	-0.0460***	-0.106	0.135
	(-0.03)	(2.53)	(-0.85)	(-3.65)	(-1.22)	(0.66)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	920	920	920	920	920	920
R^2	0.853	0.783	0.725	0.773	0.734	0.744

This table shows the difference-in-difference results on market liquidity measures in constrained and unconstrained sample of test groups. The tick-constrained sample includes firms if their average dollar quoted spread during the four quarters before test implementation is below their cutoff median value for each test group. Other firms are defined as unconstrained. If a stock is in test group # (# indicates the number of 1, 2, and 3, respectively), Test # is equal to 1; if a stock is in control group, Test # is equal to 0. If fiscal year-quarter is in 2017 Q1-Q4, post is equal to 1; if fiscal year-quarter is in 2015 Q1-Q4, post is equal to 0. In each panel, Column (1) uses percent quoted spread as the measure of market liquidity, Column (2) uses market depth as the measure of market liquidity, Column (3) uses lit turnover as the measure of market liquidity, Column (4) uses dark turnover as the measure of market liquidity, Column (5) uses total turnover as the measure of market liquidity, Column (6) uses percent effective spread as the measure of market liquidity. We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. See Appendix Table A1 for variable definitions. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroscedasticity and clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 9
Alternative Explanations

Panel A: Difference-in-difference results of controlling share price

	Repurchases Payouts	Share of Repurchases
	(1)	(2)
Test 3×Post	-0.375**	-0.281**
	(-2.53)	(-2.38)
Share price	Yes	Yes
Controls	Yes	Yes
Firm FE	Yes	Yes
Year-Quarter FE	Yes	Yes
Cluster by Firm	Yes	Yes
N	888	888
R^2	0.562	0.464

Panel B: Difference-in-difference results for manager stock and option holding, EPS management variables

	Manager Stock Holding	Manager Option Holding	Option Exercisable	Option Exercised
	(1)	(2)	(3)	(4)
Test 3×Post	0.000226	0.536*	-0.253	0.656
	(0.01)	(1.90)	(-0.94)	(1.15)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes
N	112	112	112	112
R^2	0.977	0.822	0.799	0.927

This table shows the difference-in-difference results on alternative explanations for test group 3 tick-constrained sample. Panel A shows the results on repurchase payouts and share of repurchases for test group 3 tick-constrained sample, controlling for share price. Column (1) presents the result of repurchase payouts, and Column (2) presents the result of share of repurchase. Repurchase payouts is defined as the value of common stock repurchases divided by the lagged assets in previous quarter, multiplied by 100. Share of repurchases is defined as total shares of common stock repurchased divided by common shares outstanding in previous quarter, multiplied by 100. Panel B shows the difference-in-difference results on management stock and option holding, exercisable options and exercised options for test group 3 tick-constrained sample using annual data (Responding to Columns (1), (2), (3), and (4), respectively.). Manager

stock holding is calculated as number of shares owned by managers divided by the total number of common shares outstanding, multiplied by 100. Manager option holding is calculated as number of unexercised exercisable options owned by managers divided by the total number of common shares outstanding, multiplied by 100. Data is collected from Compustat execucomp database. Option exercisable is calculated as options exercisable divided by the total number of common shares outstanding multiplied by 100, option exercised is calculated as stock options that were exercised for common stocks divided by the total number of common shares outstanding, multiplied by 100. Data is collected from Compustat fundamentals annual database. If a stock is in test group 3, Test 3 is equal to 1; if a stock is in control matched group, Test 3 is equal to 0. If fiscal year is in 2017, Post is equal to 1; if fiscal year is in 2015, Post is equal to 0. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). The sample of firms in the test is consistent with the sample in the main tests. We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. All variables are winsorized at 1% and 99% levels. *t*-statistics based on standard errors that are robust to heteroskedasticity and clustered at the firm level are reported in parentheses below the coefficient estimates. *, **, and *** represent statistical significance at the 10%, 5%, and 1 % level, respectively.

Table 10
Panel Regression

Liquidity measure	Lit Turnover	Dark Turnover	Total Turnover	IS	Percent Quoted Spread	Percent Effective Spread	Market Depth	Market Depth (Constrained Sample)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity	0.285***	0.281***	0.256***	-0.204**	-0.169**	0.080	-0.125	-0.274**
	<7.94%>	<7.48%>	<6.83%>	<-5.65%>	<-4.70%>	<2.22%>	<-3.47%>	<-6.56%>
	(2.92)	(4.01)	(3.35)	(-2.46)	(-2.12)	(0.65)	(-1.63)	(-2.33)
Option	-0.038	-0.101	-0.100	0.078	-0.017	-0.003	0.017	0.210
Exercisable	<-1.05%>	<-2.68%>	<-2.65%>	<2.17%>	<-0.48%>	<-0.09%>	<0.47%>	<5.04%>
	(-0.28)	(-0.95)	(-0.94)	(0.61)	(-0.13)	(-0.02)	(0.13)	(0.95)
Option	0.376***	0.185**	0.188**	0.490***	0.384***	0.405***	0.398***	0.632***
Exercised	<10.46%>	<4.92%>	<5.01%>	<13.60%>	<10.68%>	<11.27%>	<11.08%>	<15.15%>
	(4.35)	(2.37)	(2.40)	(4.19)	(4.35)	(4.65)	(4.54)	(4.51)
Managers	-0.042	0.069	0.067	-0.033	-0.034	-0.047	-0.034	-0.028
Stocks	<-1.16%>	<1.83%>	<1.78%>	<-0.92%>	<-0.94%>	<-1.31%>	<-0.95%>	<-0.68%>
	(-0.47)	(0.95)	(0.92)	(-0.33)	(-0.38)	(-0.52)	(-0.37)	(-0.22)
Managers	0.274**	0.185**	0.187**	0.075	0.256**	0.251**	0.244**	0.055
Options	<7.62%>	<4.93%>	<4.99%>	<2.09%>	<7.13%>	<6.99%>	<6.78%>	<1.32%>
	(2.55)	(2.06)	(2.08)	(0.56)	(2.38)	(2.35)	(2.28)	(0.30)
GDP Growth	0.437***	0.293***	0.306***	0.489***	0.355***	0.366***	0.372***	0.540***
	<12.16%>	<7.81%>	<8.14%>	<13.59%>	<9.88%>	<10.18%>	<10.36%>	<12.94%>
	(7.08)	(4.61)	(4.80)	(5.03)	(6.31)	(6.50)	(6.60)	(5.30)
Size	0.308***	-0.061	-0.058	0.443***	0.287**	0.342***	0.293**	0.185
	<8.58%>	<-1.63%>	<-1.53%>	<12.29%>	<7.98%>	<9.52%>	<8.15%>	<4.43%>
	(2.66)	(-0.77)	(-0.72)	(3.96)	(2.36)	(2.89)	(2.37)	(1.24)
Profitability	0.661***	0.387***	0.382***	0.496***	0.641***	0.679***	0.656***	0.760***
	<18.39%>	<10.30%>	<10.16%>	<13.76%>	<17.83%>	<18.90%>	<18.26%>	<18.22%>
	(7.05)	(4.82)	(4.76)	(4.24)	(6.77)	(7.07)	(6.94)	(4.31)

Growth	-0.328**	-0.464***	-0.472***	-0.398**	-0.328**	-0.304**	-0.324**	-0.429*
	<-9.14%>	<-12.36%>	<-12.58%>	<-11.06%>	<-9.14%>	<-8.46%>	<-9.03%>	<-10.28%>
	(-2.48)	(-4.13)	(-4.20)	(-2.33)	(-2.48)	(-2.30)	(-2.44)	(-1.84)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7022	3400	3400	2943	7022	7022	7022	2239
R^2	0.474	0.725	0.725	0.526	0.473	0.472	0.473	0.466

This table shows the horserace results for repurchase payouts using panel regression, where we use repurchase payouts as the dependent variable and liquidity measures and other explanatory variables as independent variables. The liquidity measures include lit turnover, dark turnover, total turnover, implementation shortfall (IS), percent quoted spread, percent effective spread, and market depth (Responding to Columns (1)-(7)). The constrained sample in column (8) include stocks of which average dollar quoted spread in the sample period is below 3 cents. Other explanatory variables include: options exercised and options exercisable; managers stock and option holdings; GDP Growth is defined as the de-meaned growth in gross domestic product (in percentage); and firm characteristics include: size, profitability, and growth opportunity (market-to-book ratio), following Fama and French (2001). The regression period is 2004 - 2017 for regressions on lit turnover, percent spreads, and market depth; 2014 – 2017 for regressions on dark turnover and total turnover; 2004 – 2010 for regression on IS. We keep firms that have at least ten years of observations in their corresponding period for regression on lit turnover, percent spreads, and market depth; at least three observations for dark turnover and total turnover; at least five observations for IS, respectively. We use firm fixed effects to capture the time-invariant heterogeneity. All variables are winsorized at 1% and 99% levels. The coefficients reported in the first line for each variable is a measure of economic significance, which is the average change in repurchase payouts associated with a one standard deviation change in the explanatory variable. Economic significance scaled by the mean of repurchase payouts are reported in angle brackets. t-statistics based on standard errors that are robust to heteroskedasticity and clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Appendix

Table A1
Variables Description

Variable	Description
Panel A: Corporate payout variables	
Repurchase Payouts	Common stock repurchases in current quarter divided by the lagged assets in previous quarter, multiplied by 100. [Compustat data item: *100×(cshopq×prcraq)/L.atq, cshopq* is the total shares of common stock repurchases, *prcraq* is the average repurchase price per share, *L.atq* is the total assets in the previous quarter.]
Repurchase Announced	Announcement value of share repurchases divided by the total asset value prior to the announcement, multiplied by 100. Data are from SDC Mergers and Acquisitions.
Dividend Payouts	Common stock dividends in current quarter divided by the lagged assets in previous quarter, multiplied by 100. [Compustat data item: *100×(dvyq-dvpq)/L.atq. dvyq is* derived from *dvy,* which are total dividends in the current quarter; *dvpq* are the preferred stock dividends.]
Total Payouts	The sum of repurchase payouts and dividend payouts. [*Repurchase Payouts* + *Dividend Payouts*.]
Payout Structure	The ratio of repurchase payouts over dividend payouts. We normalize the ratio by adding 1 to the numerator and denominator. [(*Repurchase Payouts* + 1) / (*Dividend Payouts* + 1).]
Share of Repurchases	Total shares of common stock repurchased in current quarter, divided by number of common shares outstanding in previous quarter, multiplied by 100. [Compustat data item: *100×cshopq/L.cshoq. cshoq* is the total shares of common stock.]
Share Price	The stock closing price in the current quarter. [Compustat data item: *prccq.*]
Panel B: Market liquidity variables	
Percent Quoted Spread	Value-weighted daily average of percent quoted spread in the quarter. Percent quoted spread is time-weighted difference of the consolidated bid-side and consolidated offer-side, divided by the midpoint of the consolidated bid-side and offer at the time of order receipt. The unit is in percentage. Data are calculated from DTAQ.
Dollar Quoted Spread	Value-weighted daily average of dollar quoted spread in the quarter. Dollar quoted spread is time-weighted difference of the consolidated bid-side and consolidated offer-side. The unit is dollar. Data are calculated from DTAQ.
Market Depth	Value-weighted average of market depth in the quarter. Market depth measures the dollar amount that must be traded before the stock price moves and is calculated as the average of displayed dollar-depth at the national bid-side and offer-side. The unit is ten thousandth. Data are calculated from DTAQ.
Bid-Side Depth	Value-weighted average of bid-side depth divided by market value of the stock in the quarter. Bid-side depth is calculated as the average of displayed dollar-depth at the national bid-side. The unit is ten thousandth. Data are calculated from DTAQ.
Offer-Side Depth	Value-weighted average of offer-side depth divided by market value of the stock in the quarter. Offer-side depth is calculated as the average of displayed dollar-depth at the national offer-side. The unit is ten thousandth. Data are calculated from DTAQ.

Lit Turnover	Average daily exchange share volume divided by shares outstanding of the stock in the quarter. The unit is percentage. Data are calculated from DTAQ.
Dark Turnover	Average daily dark pool share volume divided by shares outstanding of the stock in the quarter. The unit is percentage. Data are from FINRA ATS Transparency website.
Total Turnover	The sum of lit turnover and dark turnover.
Percent Effective Spread	Value-weighted average of percent effective spread in the quarter. Percent effective spread is given by twice the signed difference of the trade price minus the midpoint of the consolidated bid-side and offer-side at the time of order receipt, divided by the midpoint of the consolidated bid-side and offer-side at the time of order receipt. The unit is percentage. Data are calculated from DTAQ.
Implementation Shortfall	Value-weighted signed difference of execution price of a ticket minus the price of the ticket when a broker receives the ticket, divided by the price of the ticket when a broker receives the ticket. Data are from Ancerno Ltd.
Panel C: Control Variables	
Size	Total value of book assets in previous quarter. We normalize it by taking the logarithm. [Compustat data item: *log (L.atq)*.]
Profitability	Income before extraordinary items plus depreciation and amortization in current quarter, divided by the lagged assets in previous quarter, multiplied by 100. [Compustat data item: *100×(ibq+dpq)/L.atq. ibq* is income before extraordinary items, *dpq* is depreciation and amortization]
Growth	Market value of assets in current quarter, divided by the lagged assets in previous quarter. [Compustat data item: *(prccq×cshoq+atq-ceqq-txdbq)/L.atq. prccq* is stock closing price, *cshoq* is common shares outstanding, *atq* is the total assets, *ceqq* is book equity, *txdbq* is deferred taxes and investment tax credits.]

Table A2
Test Group 3 Tick-constrained Sample Matching Results

	Test Group 3 Constrained Sample			Control Constrained Sample			Control Matched Sample		
	N	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.
Repurchase Payouts	240	0.520	1.249	960	0.317	0.993	204	0.431	1.144
Repurchase Announced	60	1.243	3.513	240	0.994	3.643	51	0.997	3.591
Dividend Payouts	240	0.284	0.764	960	0.173	0.488	204	0.254	0.697
Total Payouts	240	0.804	1.387	960	0.489	1.089	204	0.685	1.276
Payout Structure	240	1.397	1.280	960	1.215	0.978	204	1.319	1.177
Lit Turnover	240	0.971	0.687	960	0.888	0.688	204	0.743	0.535
Dark Turnover	240	0.176	0.127	960	0.160	0.122	204	0.140	0.106
Total Turnover	240	1.147	0.802	960	1.049	0.798	204	0.884	0.636
Dollar Quoted Spread	240	0.039	0.021	960	0.048	0.033	204	0.068	0.065
Percent Quoted Spread	240	0.392	0.433	960	0.429	0.449	204	0.556	0.845
Percent Effective Spread	240	0.683	1.708	960	0.545	1.237	204	0.627	1.491
Market Depth	240	0.162	0.221	960	0.152	0.193	204	0.145	0.159
Bid-Side Depth	240	0.170	0.306	960	0.159	0.229	204	0.143	0.168
Offer-Side Depth	240	0.153	0.157	960	0.144	0.181	204	0.147	0.170
Size	240	5.919	1.278	960	5.900	1.302	204	5.920	1.261
Profitability	240	-0.520	6.823	960	-1.204	6.716	204	-0.755	6.497
Growth	240	2.123	1.357	960	2.413	2.087	204	2.154	1.424

This table shows the summary statistics of the key variables for test groups 3 tick-constrained sample, control group tick-constrained sample, and control group matched sample. The tick-constrained sample includes firms if their average dollar quoted spread during the four quarters before test implementation is below their cutoff median value for each test group. We created a matched sample from control group based on the average repurchase payouts, dividends payouts, dollar quoted spread, and the three control variables in the pre-treatment period. In each sample, we report the observation number, mean and standard deviation of the key variables. See Appendix Table A1 for variable definitions. The sample period is 2015 Q1-2015 Q4. Data are collected from Compustat fundamentals quarterly, DTAQ, and SDC mergers and acquisition database. All variables are winsorized at 1% and 99% levels.

Table A3
Difference-in-Difference Results: Split Sample based on Share Price

Panel A: Results for Repurchase Payouts, Share of Repurchases, Dividend Payouts, Total Payouts, and Payout Structure

	Tick-Constrained Sample			Unconstrained Sample		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
	(1)	(2)	(3)	(4)	(5)	(6)
Repurchase Payouts	-0.0556	-0.0103	-0.235**	-0.227	0.0408	-0.197
	(-0.47)	(-0.07)	(-2.20)	(-1.65)	(0.26)	(-1.09)
Share of Repurchases	-0.0543	-0.0307	-0.227**	-0.101	-0.0365	-0.166
	(-0.51)	(-0.28)	(-2.42)	(-0.95)	(-0.30)	(-1.23)
Dividend Payouts	-0.0131	0.0324	-0.0684	-0.0295	-0.0834	-0.0583
	(-0.36)	(0.64)	(-1.19)	(-0.94)	(-0.22)	(-0.75)
Total Payouts	-0.0687	0.0221	-0.304**	-0.256*	0.0250	-0.256
	(-0.56)	(0.14)	(-2.50)	(-1.76)	(0.15)	(-1.33)
Payout Structure	-0.0590	-0.0340	-0.216**	-0.133	0.00894	-0.152
	(-0.51)	(-0.24)	(-2.15)	(-1.12)	(0.06)	(-0.85)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	1096	1048	912	1144	1048	912

Panel B: Results for Split Tick-constrained Firms Based on Increase in Depth

	Increase in Market Depth		Increase in Bid-Side Depth		Increase in Offer-Side Depth	
	Small	Large	Small	Large	Small	Large
	(1)	(2)	(3)	(4)	(5)	(6)
Test 3×Post	-0.104	-0.380**	-0.0788	-0.392***	-0.217	-0.288**
	(-0.68)	(-2.63)	(-0.51)	(-2.73)	(-1.24)	(-2.17)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes

Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	456	456	456	456	456	456
R^2	0.672	0.500	0.671	0.503	0.619	0.573

Panel C: Results for Repurchase Announced

	Tick-Constrained Sample	Unconstrained Sample
	(1)	(2)
Test 3×Post	0.0372	0.790
	(0.05)	(0.85)
Firm FE	Yes	Yes
Year-Quarter FE	Yes	Yes
Cluster by Firm	Yes	Yes
N	228	228
R^2	0.507	0.609

This table shows the robust difference-in-difference results with splitting sample based on share price. In panel A, we report difference-in-difference results for repurchase payouts, share of repurchases, dividend payouts, total payouts, and payout structure, respectively. The tick-constrained sample includes firms if their average share price in the third quarter of 2016 is below their cutoff median value for each test group. Other firms are defined as unconstrained. Columns (1) (2) (3) present the results for the tick-constrained sample (corresponding to test group 1, 2, 3), and Columns (4) (5) (6) present the results for the unconstrained sample (corresponding to test group 1, 2, 3). In panel B, we report the difference-in-difference results on repurchase payouts when we equally split the tick-constrained sample in test group 3 into two groups based on the increase in depth from 2016 to 2017. The small depth sample includes firms if their the increase in depth from 2016 to 2017 is below their cutoff median value. Other firms are defined as large depth sample. If a stock is in test group 3, Test 3 is equal to 1; if a stock is in control group, Test 3 is equal to 0. If fiscal year-quarter is in 2017 Q1-Q4, post is equal to 1; if fiscal year-quarter is in 2015 Q1-Q4, post is equal to 0. Columns (1) (2) present the results for the small and large sample of the increase in market depth, Columns (3) (4) present the results for the small and large sample of the increase in bid-side depth, and Columns (5) (6) present the results of the small and large sample of the increase in offer-side depth. In panel C, we report the difference-in-difference results on announced repurchase payouts in test group 3 using annual data. If a stock is in a test group 3, Test 3 is equal to 1; if a stock is in control group, Test 3 is equal to 0. If fiscal year is in 2017, post is equal to 1; if fiscal year is in 2015, post is equal to 0. The tick-constrained sample includes firms if their average share price in the third quarter of 2016 is below their cutoff median value for each test group. Other firms are defined as unconstrained. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). We use firm fixed effects to capture the time-invariant heterogeneity, and year-quarter fixed effects to capture time-varying shocks. All variables are winsorized at 1% and 99% levels. t-statistics based on standard errors that are robust to heteroscedasticity and clustered at the firm level are in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A4
Summary Statistics of Panel Regression

	N	Mean	Within-Firm Std. Dev.	Sample Period
Repurchase Payouts	7022	3.593	4.583	2004-2017
Percent Quoted Spread	7022	0.196	0.118	2004-2017
Percent Effective Spread	7022	0.245	0.358	2004-2017
Market Depth	7022	0.123	0.089	2004-2017
Option Exercisable	7022	4.013	2.395	2004-2017
Option Exercised	7022	1.083	0.962	2004-2017
Managers Stocks	7022	0.013	0.015	2004-2017
Managers Options	7022	1.389	1.028	2004-2017
GDP Growth	7022	-0.150	1.577	2004-2017
Size	7022	7.117	0.426	2004-2017
Profitability	7022	10.13	7.373	2004-2017
Growth	7022	2.237	1.522	2004-2017
Lit Turnover	7022	1.041	0.423	2004-2017
Dark Turnover	3400	0.176	0.048	2014-2017
Total Turnover	3400	1.170	0.306	2014-2017
Implementation Shortfall	2943	0.236	0.219	2004-2010

This table contains summary statistics of the variables used in the panel regression. Manager stock holding is calculated as number of shares owned by managers divided by the total number of common shares outstanding, multiplied by 100. Manager option holding is calculated as number of unexercised exercisable options owned by managers divided by the total number of common shares outstanding, multiplied by 100. Data is collected from Compustat execucomp database. Option exercisable is calculated as options exercisable divided by the total number of common shares outstanding multiplied by 100, option exercised is calculated as stock options that were exercised for common stocks divided by the total number of common shares outstanding, multiplied by 100. Data is collected from Compustat fundamentals annual database. GDP Growth is defined as the de-meaned growth in gross domestic product (in percentage).