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

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In 2016, the Securities and Exchange Commission increased tick size 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 67% and reduce total payouts by 50% when they face constraints in both stock exchanges and dark pools. Surprisingly, firms with larger increases in depth reduce their payouts more because rule 10b-18 discourages issuers from using market orders, turning a market with great depth into an illiquid market for them. The conflicts between rule 10b-18 and the newly imposed trade-at rule also contribute to reductions in payouts. (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 facing market microstructure frictions. In reality, firms 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 microstructure frictions (liquidity, market fragmentation, and regulations) have first-order effects on both the level and structure of corporate payouts.

In October 2016, the U.S. Securities and Exchange Commission (SEC) included 2,399 stocks in a tick size pilot study. The SEC randomly selected 1,200 of these stocks as test stocks and increased their tick size (the minimum price increment) from 1 cent to 5 cents, whereas the tick sizes of the remaining 1,199 control stocks remained at 1 cent. The SEC also randomly assigned 1, 200 test stocks to three test groups, and 400 stocks in test group 3 faced restrictions on dark pool trading.

We find that tick-constrained firms in test group 3 reduced repurchase payouts by 67% compared with similar stocks in the control group following the implementation of tick size pilot. Tick-constrained firms have below-median quoted spreads before the Pilot was implemented, and an increase in the tick size is more likely to widen the bid-ask spread and to reduce liquidity in the stock exchange for these stocks than to unconstrained stocks. We find, however, that liquidity increases in dark pools for stocks in test groups 1 and 2, and those stocks do not experience statistically significant reductions 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 to repurchase shares.

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 large traders (Goldstein and Kavajecz (2000)). Surprisingly, we find that, within tick-constrained firms, those with significant increases in depth reduced share repurchases to a greater extent following the implementation of the Pilot. SEC rule 10b-18 can explain 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 firms may inflate their prices by aggressively consuming liquidity at the offer side. SEC rule 10b-18 encourages firms to repurchase shares through buy-limit orders, which wait on the bid side of the market to be executed. 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. When the tick size is binding, execution priority in stock exchanges 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),[1] 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 offer side, suggesting that a combination of tick-size constraints and SEC rule 10b-18 should be one driver of this counterintuitive result.

Alternative trading systems such as dark pools also help share repurchases, because one way to avoid the long queue in stock exchanges is to send orders that match the national best bid and offers (NBBOs) to dark pools (SEC (2018)). Combining the trade-at rule imposed on test group 3 with SEC rule 10b-18 essentially destroys this price-matching strategy. The trade-at rule prevents the execution of orders in dark pools unless those orders substantially improve the NBBO. Therefore, buy orders from issuers need to be executed at a price higher than national best bids (NBBs) in dark pools. However, SEC rule 10b-18 discourages firms from buying shares above the highest independent bid. The internal conflicts between these two regulations impose constraints

[1] The SEC (2018, p. 18) reports: "sophisticated proprietary trading firms, who invest substantial sums in technology, often are likelier to be first or among the first posting the best prices, resulting in their passive orders being filled more often than those of 'natural' investors. Brokers representing institutional and individual investors, in such instances, often wind up consuming liquidity provided by these prop-trading firms."

on tick-constrained firms in test group 3. Indeed, we find that share repurchases in test groups 1 and 2, where firms face no restrictions on price-matching in dark pools, do not change, even for firms with larger increases in depth.

We find that tick-constrained firms in test group 3 announce share repurchases of similar magnitude relative to repurchases made by control firms following the implementation of the tick size pilot. 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 increased market microstructure frictions. We also find that firms do not switch to alternative repurchase methods such as self-tender offers or accelerated share repurchases (ASRs). The results are consistent with the notion that self-tender offers and ASRs are not popular because of their high cost and less flexibility.

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 substitution effects in the opposite direction: firms do not increase dividends when market structure shocks force them to cut share repurchases. This result is consistent with the dividend-smoothing motive (Leary and Michaely (2011), Michaely and Roberts (2012)). In turn, tick-constrained firms in test group 3 reduce their total payouts by 50% (from 0.82% of total assets to 0.41% of total assets).

As a consequence, 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 was implemented, the proportions of repurchases and dividends became roughly equal. Therefore, repurchase payouts do not necessarily need to dominate dividend payouts. When the cost of repurchases increases, firms scale back share repurchases.

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 al. (2005), financial executives

indicate that stock market liquidity is an important factor when they make repurchasing decisions (e.g. they would begin repurchasing when their stock's liquidity increases). 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 new important research dimensions of liquidity: "liquidity-for-whom" and "liquidity-of-where."

Regarding liquidity-for-whom, our results indicate that one form of liquidity does not fit all, and we need to define liquidity differently for different agents. For example, greater depth means higher liquidity for traders who use market orders, but it may work against issuers when regulatory constraints force them to use limit orders.

Regarding liquidity-of-where, we find that dark pools matter for share repurchases. As firms can choose where to trade, a reduction in liquidity on one type of platform does not necessarily reduce share repurchases. Therefore, liquidity across all markets, and its distribution across types of platforms, are more important than liquidity on one type of platform.

Existing debate on liquidity and payout policy focuses on whether firms can increase their stock liquidity by repurchasing shares.[3] Our results indicate two possible drivers of this controversy. The first is reverse causality. Using the Tick Size Pilot as a controlled experiment, we find that firms repurchase fewer shares when liquidity is low. This reverse causality indicates that a positive 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 repurchasing which reduces the number of shares outstanding in their firms.

[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, while Levine and Zervos (1998) and Grullon, Michenaud, and Weston (2015) show that liquidity affects investment policy.

[3] 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.

Our results can inform a unified interpretation of two important puzzles in the corporate payout literature (Farre-Mensa, Michaely, and Schmalz (2014)): 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 (Dittmar and Field (2015), Bond and Zhong (2016)) 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 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 earnings-per-share (EPS) dilution caused by the exercise of options (Kahle (2002), Hribar, Jenkins, Johnson (2006)). The results of our controlled experiment suggest that several tick-size reductions and improved market liquidity over time (Angel, Harris and Spatt (2011, 2015)) may provide one explanation for the secular increase in share repurchases relative to dividend payouts.

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 benefits of dividends beyond those of paying cash, such as their disciplinary role (Easterbrook (1984)), their information content (Bhattacharya (1979)), 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. Share repurchases cannot completely drive out dividend payouts, however, because these frictions still exist.

I. The Controlled Experiment: Tick Size Pilot Program

The 2016 SEC Tick Size Pilot Program provides an ideal controlled experiment to identify how stock market structure affects corporate payout policies. Figure 1 displays the timeline of the Program. In 2012, The Jumpstart Our Business Startups Act ("JOBS Act") directed the SEC to study whether the reductions in US stock tick sizes in the late 1990s could be driving the decline in the number of initial public offerings (IPOs). 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 more jobs (Weild, Kim, and Newport (2012)).

Insert Figure 1 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 (SEC (2016)).

All stocks included in the Pilot were chosen from the universe of Reg NMS securities that satisfy the following criteria during the 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 market capitalization below $3 billion and a closing price above $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 then drawn randomly into three test groups from each category, so that each test group contains 400 stocks. The remaining stocks were assigned to a control group. On September 3, 2016, FINRA announced the final list of the 2,399 stocks which were included in the pilot and also the group assignments.

We summarize the rules governing the four groups in Table I. Stocks in the control group

continued to be quoted and traded at the existing 1 cent tick size; stocks in test group 1 could be quoted only in $0.05 increments but could still be traded at 1 cent increment; stocks in test group 2 could be quoted and traded only in $0.05 minimum increments; there were no restrictions on dark-pool trading for test groups 1 and 2. Stocks in test group 3 adhered to all the same requirements as those in test group 2 and in addition were subject to a "trade-at" requirement, which granted execution priority to displayed orders, unless non-displayed orders could provide meaningful price improvement, with certain exceptions (SEC (2015)). The trade-at rule prevents dark pools from executing orders by matching the NBBO. As a white paper by ITG Algorithm states: Dark-pool non-displayed, Iceberg, and peg offset orders all lost much of their appeal (Pearson and Li (2016)). 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 Table I about Here

II. Empirical Design

In this section, we describe our empirical design. Subsection II.A explains the specification for the difference-in-differences (DID) test; Subsection II.B presents the data and descriptive statistics.

A. Methodology

To measure the effects of the Tick Size Pilot Program on corporate payout policy, we conduct difference-in-differences (DID) tests for firms in the test group and control group before and after the Pilot implementation. We define the four fiscal quarters in 2015 as the pre-treatment period and the four fiscal quarters in 2017 as the post-treatment period.[4] We estimate the following equation:

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

[4] We define fiscal year 2016 as the transition year and exclude the corresponding quarters in our DID tests to alleviate any potential confounding effects.

where *i* indexes the firm, *t* indexes time. $y_{i,t}$ is the corporate payout variable. η_i is firm fixed effects, which capture time-invariant heterogeneity across firms. λ_t is year-quarter fixed effects, which 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,[5] 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 effects of the Tick Size Pilot Program on y for the test firms relative to the control firms.

B. Data

We obtained the list 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 came from the FINRA Alternative Trading System (ATS) Transparency website. We calculate spread and depth measures based on Daily TAQ (DTAQ) data.

In Table II we characterize our sample selection process. First, we keep only the stocks that remained in the Pilot Program as of August 2018. We then merge these 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). These filters result in 780, 248, 243, and 221 firms in the control group and test groups 1, 2, and 3, respectively.

Insert Table II about Here

In Table III we report the summary statistics for our main variables in the pre-shock period for all test groups and the control group. We list the definitions for these variables in Appendix Table A.I. Specifically, repurchase payouts equal total expenditures in common stock repurchases in the current quarter divided by total asset value in the previous quarter (in percentages). The quoted spread is the time-weighted difference between the consolidated offer price and the consolidated bid price. The effective spread equals twice the signed difference between the trade

[5] The results are robust when we interact the control variables with the *Post* variable.

price and the midpoint of the consolidated bid and offer at the time of order receipt, which captures the cost for a marketable order. The percent spreads are the corresponding spreads divided by the midpoint of the consolidated bid and offer at the time of order receipt, and the units are percentages. The average repurchase payout in our sample is around 0.43%, and the average dividend payout is around 0.23%. In our sample, the average percent quoted spread is around 0.74%, while the average daily lit turnover is around 0.79% and the average daily dark turnover is around 0.13%.

Insert Table III about Here

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

In this section, we report the effects of the Tick Size Pilot Program on corporate payout policies. In Subsection III.A we show the causal effects of the market structure change on corporate repurchase payouts; in Subsection III.B we show that the Tick Size Pilot Program has almost no effects on corporate dividend payouts; in Subsection III.C we show that firms do not switch to alternative repurchasing methods such as self-tender offers or ASRs; in Subsection III.D we show the impacts of the Tick Size Pilot Program on corporate total payouts and payout structure.

A. Tick Size Pilot Program and corporate repurchase payouts

We begin by exploring the effects of the Tick Size Pilot Program on corporate repurchase payouts. Firms with high pre-treatment quoted spreads are less sensitive to an increase in the tick size than firms with low quoted spreads. 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 through 2016 Q3. Tick-constrained firms have an average dollar-quoted spread during the three quarters that is lower than the median values for the group. The cutoff median values are 6.09, 7.33, 6.79, and 6.36 cents for the control group and test groups 1, 2, and 3, respectively. We define other firms as unconstrained. To minimize the impacts of observable pre-shock differences between treatment and control firms, we created a matched

sample from the control group based on average repurchase payouts, dividend payouts, dollar-quoted spreads, and the three control variables (size, profitability, and growth opportunities) 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 introduced in Abadie et al. (2004), which minimizes the Mahalanobis distance between treated and control firms in the vector of observed covariates.[6] In Appendix Table A.II we provide an example to illustrate the matching results for tick-constrained firms in test group 3. The following results use matched samples as the control group.

The results reported in columns (1), (2), (4), and (5) in Table IV reveal no significant changes in repurchase payouts for tick-constrained or unconstrained firms in test groups 1 and 2. The results reported in columns (3) and (6) in Table IV show that, within test group 3, unconstrained firms do not significantly change their repurchase payouts, but tick-constrained firms show statistically significant reduction in their repurchase payouts by 0.36%, which represents a 67% decline compared with the pre-shock level (0.54%, Table A.II).

Tick-constrained firms in test group 3 face both an increase in the tick size and a trade-at restriction on dark-pools, and their stocks' market liquidities are affected most heavily. The results indicate market liquidity as the underlying channel, which we explore in Section IV.

Insert Table IV about Here

B. Tick Size Pilot Program and corporate dividend payouts

In Panel A of Table V we report the DID results on dividend payouts. The coefficients on the interaction term are all insignificant for both tick-constrained and unconstrained samples in all test groups. Therefore, the market structure change hardly affects corporate dividend payouts. Following the implementation of the Tick Size Pilot Program, tick-constrained firms in test group

[6] 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 Roberts and Whited (2013) as matching with replacement is preferred for proper identification in empirical corporate finance studies.

3 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)): firms are more likely to adjust their dividend policies in response to permanent shocks than to temporary shocks. If firms increase dividends during the Pilot, they may want to resume repurchasing and would need to cut dividends when the Pilot ends, an action they typically avoid because of the negative market reaction to dividend cuts.

Insert Table V about Here

C. Do firms switch to alternative methods to repurchase?

In addition to repurchasing shares through the open market, firms can also repurchase through self-tender offers or ASRs, both of which are affected less severely by stock market liquidity. With a self-tender offer, a firm commits to offering its existing shareholders the opportunity to sell their shares directly back to the firm within a short period of time after the offer date. In an ASR, a company hires an investment bank to borrow shares from existing investors and has shares immediately eliminated; the bank then covers its short position by purchasing shares in the open market over several months. We find that alternative share-repurchase methods cannot make up for the decrease in open market share repurchases among tick-constrained firms in test group 3. The data on self-tender offers from SDC Mergers and Acquisitions show that only four firms in test group 2 repurchased through self-tender offers in 2015 and there are no cases in 2017 among all test stocks, while no firms in test group 3 conducted self-tender offers in 2015 or 2017. We then search the SEC Edgar database for any filings that mention an ASR and find only one case of an ASR for tick-constrained firms in test group 3—and that case occurred in 2015. The results show that firms do not switch to alternative repurchase methods and are consistent with the findings reported in the previous literature that self-tender offers and ASRs are less popular repurchase vehicles than open-market repurchases. These results highlight the flexibility inherent in open-market share repurchase programs compared with alternative repurchase methods, as these alternatives are firm commitments to repurchase shares.

D. Tick Size Pilot Program, total payouts, and payout structure

In this subsection, we examine the impact of the Pilot on total payouts and the structure of payouts. We report the DID results pertaining to total payouts in Panel B of Table V. For tick-constrained firms in test group 3, the reduction in repurchase payouts and unchanged dividend payouts lead to a 0.41% reduction in total payouts, representing a -50% decline from the pre-treatment average payouts of 0.82%. Tick-constrained firms in test groups 1 and 2 and unconstrained firms in all groups experience no significant changes in total payouts.

In Panel C of Table V we report the DID results for the payout structure. We define payout structure as (repurchase payouts +1)/(dividend payouts +1).[7] The payout structures of tick-constrained firms in test groups 1 and 2 and unconstrained firms in all groups do not change, whereas the payout structure of the tick-constrained firms in group 3 decreases by 0.35. For these firms, the average payout structure ratio was 1.42 before the Pilot. This ratio follows the typical pattern in which repurchases dominate dividends as the main vehicle for payouts (Farre-Mensa, Michaely, and Schmalz (2014)). Following the implementation of the Pilot, the payout structure ratio decreases to 1.07. Thus, the composition of the payout becomes roughly equal between repurchase payouts and dividend payouts.

Our results for the Tick Size Pilot Program show the causal effects of changes in stock market structure (the increase in the tick size and the restriction on dark-pool trading) on corporate payout structures (firms reduce the proportion of share repurchases over dividends), indicating that the market structure change (the reduction in the tick size over years, the general increase in market liquidity, and the proliferation of trading venues) may serve as a viable interpretation of one of the most important puzzles in the corporate payout literature: the secular increase in share repurchases over dividends (Farre-Mensa, Michaely, and Schmalz (2014)) .

[7] We add 1 to both the repurchase payouts ratio and the dividend payouts ratio because the latter is often zero (Fama and French (2001))

IV. Underlying Channel

In this section, we explore the underlying channel for the reduction in corporate payouts. In Subsection IV.A, we show that the reduction does not come from announced share-repurchase amounts but from the implementation of actual share repurchases. In subsection IV.B, we show that the Pilot Program causes the reduction in liquidity in both stock exchanges and dark pools for tick-constrained firms in test group 3, which are firms that drastically reduce their payouts. In Subsection IV.C, we show the surprising result that large depth reduces share repurchases, and we rationalize this surprising result using rule 10b-18. In Subsection IV.D, we discuss the conflict between rule 10b-18 and the newly imposed trade-at rule as a driver of the dramatic reduction in payouts for tick-constrained firms in test group 3.

A. Tick Size Pilot Program and corporate repurchase announcements

In Section III, we examine firms' actual repurchases. Firms typically announce their intended repurchasing amounts without committing firmly to those amounts. In this section, we test whether the Tick Size Pilot Program reduces the amounts of share repurchases that firms announce. We define "Repurchase announced" as the annual announcement value of share repurchases (from SDC Mergers and Acquisitions data) divided by total asset value. As the results reported in Table VI indicate, we find no significant reduction in announcement repurchase values. Therefore, the dramatic reduction in share repurchases should not come from announced share repurchases but from the actual implementation of repurchases. The latter is more likely to be affected by market microstructure frictions.

Insert Table VI about Here

B. The exogenous shock on market liquidity

In this subsection, we examine the impacts of the Tick Size Pilot Program on stock market liquidity. We use percent spreads, lit turnover, and market depth as liquidity measures for lit exchanges. We use FINRA Alternative Trading System (ATS) trading to proxy for dark-pool

trading.[8] As FINRA's ATS Transparency website provides only dark-pool trading-volume data, where percent spreads and market depth are not available,[9] we use turnover to measure the liquidity in dark pools following SEC (2018).[10]

In Panels A and C of Table VII we show that percent quoted spreads and market depth increased for tick-constrained firms in test groups 1 and 2. The turnover in the lit market decreases, but the turnover in dark pools increases (although the increase is not statistically significant for test group 2). These results indicate a redistribution of liquidity from lit exchanges to dark venues for tick-constrained firms in test groups 1 and 2. The results reported in Panels B and D of Table VII show little change in liquidity measures for unconstrained firms in test groups 1 and 2.

The results reported in Panel E of Table VII show that liquidity in both exchanges and dark venues declines for constrained firms in test group 3. In particular, lit (dark) turnover decreased 0.36% (0.08%), which represents a decline of 37% (45%) compared with the pre-treatment mean.[11]

The effective spread shows little change for any group.[12] As seen in Panel 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.

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[8] We follow the definition in Tuttle (2014) according to which dark pools are any ATSs that do not provide top-of-book quotations to a public venue. Under this definition all registered ATSs are dark, with the exception of electronic communication networks (ECNs) which accounts for a very small fraction of total transaction volume (Menkveld, Yueshen, and Zhu (2017)).

[9] FINRA began publishing monthly Appendix B data on August 31, 2017, which covers data for the period beginning in April 2016. The data include realized spread and effective spread information at the stock-trading-center level and are aggregated in groups to distinguish between ATSs and non-ATSs. We do not conduct DID analysis with the data since the data cover a very short period that does not overlap with the period of our Compustat data.

[10] In our study setting, greater volume can be interpreted as a sign of better market quality because, in the thinly traded securities covered by the Pilot, excessive intermediation is not an issue (SEC (2018)).

[11] The SEC rule 10b-18 volume condition prohibits firms from purchasing more than 25% of the preceding four-week average daily volume. One another potential market liquidity channel for the share repurchase reduction is that the volume condition becomes more binding after tick size pilot for the test stocks. It is hard to test this channel directly, however, as we cannot observe daily repurchasing activity. Firms report monthly repurchasing activity in their quarterly reports, so it is difficult to determine whether the volume condition is binding before or after the pilot.

[12] The results for the effective spread are consistent with the joint assessment of the impact of the Tick Size Pilot (SEC (2018)).

In summary, for unconstrained stocks, neither liquidity in the exchange nor liquidity in dark venues changes, which is consistent with their insignificant changes in share repurchases. Liquidity in exchanges declines for tick-constrained stocks in all three test groups, but only tick-constrained stocks in test group 3 incur a reduction in dark liquidity. Therefore, our results provide further evidence that stock market liquidity is one channel that drives the drop in share repurchasing for tick-constrained stocks in test group 3. This evidence provides further support for our claim that liquidity matters for firm repurchases, and that firms use dark venues for their share repurchases.

Insert Table VII about Here

C. Increased depth and corporate share repurchases

The DID results we report in Table VII Panel E indicate that there is a significant increase (241%) in market depth for tick-constrained firms in test group 3. We split tick-constrained firms in test group 3 equally based on changes in average market depth from 2016 (before the Pilot) to 2017 and run the DID test for repurchase payouts. As shown in columns (1) and (2) of Table VIII, we find that the reduction in repurchase payouts concentrates on firms with large increases in market depth. In contrast, there are no significant changes in repurchase payouts for firms with small increases in market depth.[13]

As a market with great depth is generally considered a more liquid market, particularly for large traders (Goldstein and Kavajecz (2000)), this result is surprising. It motivates us to investigate the regulations on share repurchases. We find one possible explanation in the SEC's safe harbor rule 10b-18. The safe harbor rule protects corporations against stock price manipulation charges as long as firms' repurchasing activities comply with four conditions. One of the conditions is based on price: a repurchase price should not exceed the greater of the highest bid and the last sale price, so that firms cannot inflate prices by using aggressive market orders to demand liquidity from the offer side. This condition implicitly encourages firms to repurchase shares through buy-limit

[13] We find that there are no significant changes in repurchase payouts when we split tick-constrained stocks in test groups 1 and 2 or unconstrained stocks in test group 3 into two samples based on their increased depths (untabulated).

orders.[14] When the tick size is binding, execution priority is determined by speed competition at the same price (Yao and Ye (2018)). As firms and their brokers are not as fast as HFTs (SEC (2018)), limit orders placed by issuers may fail to be executed. Therefore, a market with great depth, especially on the bid side, can be an illiquid market for issuers.

If rule 10b-18 is the underlying driver, we would expect to observe greater reductions in share repurchases on the part of firms with large increases in bid-side depth compared with firms with large increases in offer-side depth. We conduct additional tests of this prediction by splitting tick-constrained firms in test group 3 based on changes in the average bid-side depth and offer-side depth.

In columns (3)-(6) of Table VIII the results we report show that the reduction in share repurchases is indeed greater for firms with large increases in bid-side depth than for firms with large increases in offer-side depth, in terms of both magnitude and statistical significance. In contrast, for firms with small increases in bid-side depth or offer-side depth, there are no significant changes in repurchase payouts. The results indicate that SEC regulations on corporate share repurchases combined with market microstructure frictions play an important role in corporate payout policy.

Insert Table VIII about Here

D. Discussion: Trade-at rule, dark-pool trading, and corporate repurchases

The results reported in Subsection IV.C, which imply that greater market depth harms share repurchases, are consistent with our findings that the reduction in share repurchases concentrates on tick-constrained firms in test group 3. The more binding tick size following implementation of the Pilot Program harms firms that repurchase in exchanges. On the other hand, the trade-at rule implemented for firms in test group 3 may harm their share repurchases in dark pools, because the trade-at rule conflicts with SEC rule 10b-18 for issuers. SEC rule 10b-18 discourages firms from

[14] Issuers can also place orders at the bid price, followed by purchasing at the offer price only after another participant pays offer price. However, the previous strategy creates patterns that can be easily identified by HFTs and increases issuers' overall execution costs (IEX (2018)).

buying at prices above independent bids. Without the trade-at rule, brokers for issuers may go to a dark pool to price-match independent bids. In so doing, they avoid competing on time priority with HFTs in stock exchanges. Consistent with our interpretation, SEC (2018) shows that liquidity providers respond to wider tick size in exchanges by switching trades to dark-pools to gain better position for stocks in test group 1 and 2, and the behavior is most pronounced with tick-constrained stocks. This explains why there is no significant reduction in share repurchases for tick-constrained firms in test groups 1 and 2.

The trade-at rule destroys this strategy for tick-constrained stocks in test group 3, however, by requiring their dark-pool trading to improve the best bid by 2.5 cents, with certain exceptions (SEC (2015)). Such price improvement, however, establishes a price above the independent bid, which works against SEC rule 10b-18. Therefore, interaction between regulations (the trade-at rule and rule 10b-18 in this study) can generate unintended consequences for corporations. The results also indicate that dark pools are important venues where firms repurchase shares. Since there is greater competition on speed and queue position in the limit-order book after the proliferation of HFTs, dark pools provide an alternative order-matching mechanism that enables issuers to jump ahead of the intermarket time priority queues.

V. Robustness checks

In this section we report the results of several robustness checks. In Subsection V.A we describe how we validated the parallel trend assumption and show there are no results in placebo tests; Subsection V.B shows that our results hold when we use nominal share prices as a proxy for tick constraints; in Subsection V.C we show that our results remain robust after controlling for possible alternative explainations.

A. Parallel trend and placebo tests

In this section, we show that repurchase payouts in the treatment and control groups follow parallel pre-treatment trends. In Panel A of Table IX we report the quarter-by-quarter DID results for

repurchase payouts made by tick-constrained firms in test group 3 and the counterpart control group from fiscal quarters running from 2013 Q1 through 2015 Q4. We find that the coefficients on the interaction terms are all statistically insignificant, indicating the presence of a parallel trend for payouts in the pre-treatment period.

Insert Table IX about Here

Our placebo tests also show that the estimated differences in repurchase payout changes are indistinguishable across tick-constrained firms in test group 3 and the control group from 2013 through 2015, from 2014 through 2015, and from 2013 through 2014 (Panel B of Table IX). Therefore, our test-control contrast does not appear in periods with no market-structure change.

B. Using nominal share prices as an alternative proxy for tick constraints

In the abovementioned tests, we use dollar-quoted spreads as a proxy for tick constraints. Another way to sort stocks into tick-constrained and unconstrained samples is based on the nominal share price, because a stock with a low nominal share price is constrained to a greater extent by the uniform tick size compared with a stock with a high nominal share price (SEC (2018), Yao and Ye (2018)). Thus, low-priced stocks should be affected to a greater extent by the Tick Size Pilot.

To obtain the results reported in Table A.III of the Appendix, we divide stocks equally into high-priced and low-priced samples based on their share prices at the end of fiscal quarter 2016 Q3. The stocks in the low-priced group are defined as the constrained sample and the stocks in the high-priced group are defined as the unconstrained sample. Next, we carry out the same matching procedure (except that we replace the dollar-quoted spread with the nominal share price as the matching variable) to find the matched control sample and rerun the DID tests. The results reported in Table A.III of the Appendix show that our main results still hold under this alternative proxy for tick constraints.

C. Controlling for Alternative Explanations

Farre-Mensa, Michaely, and Schmalz (2014) point out that signaling and agency conflicts cannot explain the ratio of share repurchases to dividends, and our sample period does not involve

tax changes. Thereore, we focus on three remaining channels: market timing, management stock and option holdings, and offsetting EPS dilution. We find that the results stay the same after controlling for these three channels.

Firms may time the market and repurchase more shares when their stocks are undervalued (Dittmar and Field (2015), Bond and Zhong (2016)). For example, firms may repurchase fewer shares when the share price is high. Albuquerque, Song, and Yao (2018) show that the Tick Size Pilot Program reduces share prices for firms in the test groups, which would provide them with an incentive to repurchase more shares. Therefore, the price change cannot explain why share repurchases decrease after the Tick Size Pilot Program. We also run a DID test on repurchase payouts while adding share price as an independent variable. As reported in Panel A of Table X column (1), the interaction term remains negative and significant after we control for share price, ruling out the market-timing explanation.

If share prices decrease after the implementation of the tick size pilot, it is possible that the reduction on dollar repurchase payouts could be driven by the falling repurchase price, but not by the reduction in the number of shares that firms repurchase. We then examine the change in the number of repurchasing shares. The results reported in column (2) of Table X show that there is a significant decline in the *number of shares* that firms repurchase, confirming that our results cannot be explained by changes in share prices.

Insert Table X about Here

If managers own more stocks, they may favor repurchase payouts over dividend payouts because of the relative tax advantage of share repurchases (Brown, Liang, and Weisbenner (2007)); managerial option holdings also create incentives not to pay dividends but to repurchase shares, as dividend payouts reduce per-share value (Fenn and Liang (2001)). We obtain annual management stock and option holdings data from the Compustat Execucomp database. In Table X Panel B, we report the results of DID tests for repurchase payouts using annual data to control for these alternative explanatory variables. In column (1) we present the baseline case with no controls for alterative explanations with annual data. As expected, the coefficients on the interaction term are

around three times higher than the coefficients obtained using quarterly data. The -1.42% reduction on repurchase payouts represents a 67% decline in average repurchase payouts on the part of tick-constrained firms in test group 3 before the Pilot (2.12%, untabulated). The results reported in column (2) show a -1.33% decrease in repurchase payouts after controlling for managers' stock and option holdings. Therefore, our results are robust after controlling for the managers' bonus incentive explanation.

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 enable them to meet analyst EPS forecasts. As Compustat data on exercised and exercisable options are also annual, we run the DID tests on repurchase payouts while controlling for exercisable options and exercised options using annual data and report the results in column (3) of Table X, Panel B. We find that the results remain robust, ruling out the EPS dilution explanation. Finally, the results reported in column (4) of Table X, Panel B 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, the reduction in share repurchases for tick-constrained stocks in test group 3 do not appear without Tick Size Pilot, and the reduction after the Tick Size Pilot is implemented is robust after we control for possible alternative explanations of share repurchases. All these results provide further support that market structure plays a first-order role in corporate repurchase payouts.

VI. Conclusion

Using the 2016 SEC Tick Size Pilot Program as an exogenous shock, 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 spreads and reduce liquidity. Besides

its implications for liquidity in general, our paper indicates two new important research dimensions to the literature: liquidity-for-whom and liquidity-of-where.

Regarding liquidity-for-whom, we find that regulations can change the definition of liquidity for distinct groups of agents. SEC rule 10b-18, which aims to prevent price manipulation using aggressive market orders, encourages issuers 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 issuers, 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 issuers.

Regarding liquidity-of-where, we show that a reduction in liquidity on stock exchanges does not reduce firms' payouts as long as they are not subjected to the trade-at rule in dark pools. On the other hand, firms that are constrained by both the tick size increase and the trade-at rule reduce their repurchase payouts by 67%. Insofar as they do not increase their dividend payouts, their total payouts decline by 50%. Before the implementation of the Pilot, these firms make payouts mainly through share repurchases. After the Pilot was launched, the proportions of repurchase payouts and dividend payouts become roughly equal. Our results indicate the importance of dark pools in share repurchasing, possibly because dark pools provide the opportunity to buy shares back at the best bid price while at the same time enabling firms to avoid the competition on time priority in stock exchanges. The trade-at rule destroys this price-matching strategy, because this new rule implies that firms need to repurchase shares at prices above the best bid, a practice discouraged by SEC rule 10b-18.

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 alternative trading venues may explain the secular upward trend toward paying out through repurchases over dividends. Second, market microstructure frictions always exist, which can explain why share repurchases cannot completely drive out dividend payouts.

Finally, our paper contributes to recent policy debates on tick sizes and the trade-at rule. 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 curbing HFTs. Second, we show that new and existing regulations may conflict in unintended ways. The newly imposed trade-at rule forces firms to buy back shares at prices above NBBs in dark pools, whereas the old SEC rule 10b-18 discourages firms from repurchasing shares at prices above NBBs. The conflicts between the old and new rules impose constraints on issuers. Therefore, we believe the first step toward imposing a new regulation should be to conduct due diligence to gauge how it might interact with existing regulations. It would also be fruitful for researchers and regulators to consider a new generation of regulations when accounting for the evolving market structure.

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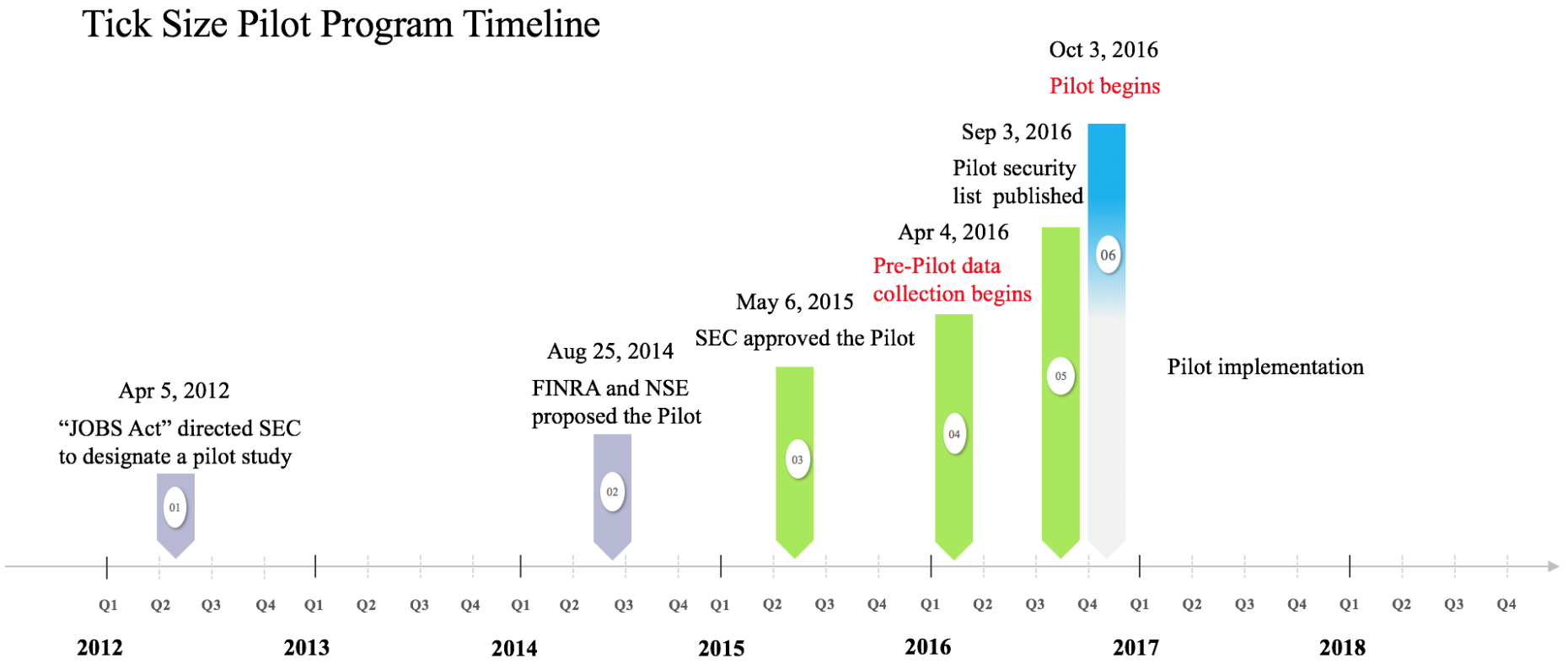

Figure 1. SEC Tick Size Pilot Program Timeline. This figure displays the major events and dates associated with the SEC Tick Size Pilot Program.

Table I

Summary of Rules for Test Groups and Control Group

In this table we summarize the rules that divide the four groups of stocks. Stocks in the control group continue to be quoted and traded at a tick size of 1 cent; stocks in test group 1 can be quoted only in $0.05 increments but can still be traded at 1 cent increments; stocks in test group 2 can be quoted and traded only in $0.05 minimum increments; stocks in test group 3 adhere to all the requirements of test group 2 and are also subject to a "trade-at" requirement, which grants execution priority to displayed orders, unless non-displayed orders can provide meaningful price improvements.

	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

Table II

Sample Selection Process

In this table we report our sample selection process. First, we keep stocks that remain in the Pilot Program in August 2018. FINRA's website provides reasons for removing a firm from the Tick Size Pilot Program, such as delisting, mergers and acquisitions, and price declines below $1. Next, we match the remaining stocks with Compustat fundamentals quarterly data. Finally, we exclude regulated utility (SIC codes 4800-4829 and 4900-4999) and financial (SIC codes 6000-6999) firms.

	Stocks in the Beginning of Pilot	Stocks Remaining in Pilot in August 2018	Merge with Compustat	Exclude Utility and Financial Firms
Control group	1199	1080	1061	780
Test group 1	400	344	337	248
Test group 2	400	334	328	232
Test group 3	400	329	323	221

Table III

Summary Statistics (Before Pilot)

In this table we present the summary statistics on key variables for test groups 1-3 and the control group before implementation of the Tick Size Pilot Program. See Appendix Table A.I for variable definitions. The sample period is fiscal quarters 2015 Q1-2015 Q4. We remove firms with missing variables or missing observations for the main test period (fiscal quarters in 2015 and 2017) to form balanced datasets. All variables are winsorized at the 1% and 99% levels.

	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	632	0.475	1.195	592	0.485	1.230	496	0.502	1.118	1968	0.375	1.073
Dividend payouts	632	0.211	0.470	592	0.238	0.580	496	0.270	0.664	1968	0.214	0.539
Total payouts	632	0.686	1.315	592	0.724	1.357	496	0.772	1.285	1968	0.590	1.230
Payout structure	632	1.292	1.079	592	1.314	1.153	496	1.330	1.090	1968	1.218	0.954
Lit turnover	632	0.773	0.622	592	0.703	0.648	496	0.735	0.589	1968	0.730	0.631
Dark turnover	632	0.144	0.118	592	0.129	0.124	496	0.136	0.113	1968	0.132	0.115
Percent quoted spread	632	0.724	0.977	592	0.809	1.016	496	0.722	0.894	1968	0.817	1.051
Percent effective spread	632	0.722	1.301	592	0.683	0.910	496	0.834	1.649	1968	0.819	1.480
Market depth	632	0.726	0.508	592	0.657	0.507	496	0.722	0.513	1968	0.654	0.442

Table IV

Changes around the Tick Size Pilot Program: Repurchase Payouts

In this table we report the difference-in-differences results for repurchase payouts. *Test* # is a dummy variable equal to one if the stock is in test group # (#indicating the numbers 1, 2, or 3) and zero if it is in the control group. *Post* is an indicator variable equal to one if the fiscal year-quarter is in 2017 Q1-Q4 and zero if it is in 2015 Q1-Q4. The tick-constrained sample includes firms if their average dollar-quoted spread during the three quarters before Pilot implementation is below their median value for each test group and other firms are in the unconstrained sample. In columns (1), (2), and (3) we report the results for the constrained sample, and in columns (4), (5), and (6) we report the results for the unconstrained sample. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). All variables are winsorized at the 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.

	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	0.0554	-0.0262	-0.362***	-0.145	-0.0259	-0.0587
	(0.40)	(-0.19)	(-2.85)	(-1.17)	(-0.17)	(-0.35)
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	1136	1120	912	1176	1096	928
R^2	0.352	0.395	0.570	0.428	0.573	0.361

Table V

Changes around Tick Size Pilot Program: Dividend Payouts, Total Payouts, and Payout Structure

In this table we report the difference-in-differences results for dividend payouts, total payouts, and payout structure. We report the results for dividend payouts in Panel A, the results for total payouts in Panel B, and the results for payout structure in Panel C. *Test #* is a dummy variable equal to one if the stock is in test group # (#indicating the numbers 1, 2, or 3) and zero if it is in the control group. *Post* is an indicator variable equal to one if the fiscal year-quarter is in 2017 Q1-Q4 and zero if it is in 2015 Q1-Q4. The tick-constrained sample includes firms if their average dollar-quoted spread during the three quarters before Pilot implementation is below their median value for each test group and other firms are in the unconstrained sample. In each panel, we report the results for the constrained sample in columns (1), (2), and (3), and those for the unconstrained sample in columns (4), (5), and (6). Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). All variables are winsorized at the 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.

Panel A: 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	0.0156	0.0722	-0.0481	-0.0186	-0.0236	-0.0387
	(0.37)	(1.42)	(-0.57)	(-0.60)	(-0.36)	(-0.87)
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	1136	1120	912	1176	1096	928
R^2	0.784	0.847	0.829	0.634	0.605	0.837

Panel B: 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	0.0711	0.0460	-0.410***	-0.164	-0.0495	-0.0974
	(0.49)	(0.31)	(-2.77)	(-1.26)	(-0.32)	(-0.55)
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	1136	1120	912	1176	1096	928
R^2	0.447	0.517	0.618	0.469	0.604	0.530

Panel C: 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	0.0724	-0.0664	-0.349***	-0.136	-0.0370	0.0171
	(0.56)	(-0.53)	(-2.78)	(-1.37)	(-0.26)	(0.11)
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	1136	1120	912	1176	1096	928
R^2	0.387	0.396	0.616	0.461	0.602	0.353

Table VI

Changes around Tick Size Pilot Program: Repurchase Announced

In this table we report the difference-in-differences results for announced repurchase payouts for firms in test group 3 using annual data. We define repurchase announced as the announcement value of share repurchases divided by total assets. The unit of measure is one percentage point. *Test* 3 is a dummy variable equal to one if the stock is in test group 3 and zero if it is in the control group. *Post* is an indicator variable equal to one if the fiscal year-quarter is in 2017 Q1-Q4 and zero if it is in 2015 Q1-Q4. All variables are winsorized at the 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.

	Tick-Constrained Sample	Unconstrained Sample
	(1)	(2)
Test 3×Post	-0.0721	0.540
	(-0.09)	(0.72)
Firm FE	Yes	Yes
Year-quarter FE	Yes	Yes
Cluster by firm	Yes	Yes
N	228	232
R^2	0.499	0.623

Table VII

Changes around Tick Size Pilot Program: Market Liquidity

In this table we report the difference-in-differences results for market liquidity measures. In Panels A-F we report the results for the tick-constrained samples and the unconstrained samples in test groups 1-3, respectively. *Test #* is a dummy variable equal to one if the stock is in test group # (#indicating the numbers 1, 2, or 3) and zero if it is in the control group. *Post* is an indicator variable equal to one if the fiscal year-quarter is in 2017 Q1-Q4 and zero if it is in 2015 Q1-Q4. The tick-constrained sample includes firms if their average dollar-quoted spread during the three quarters before Pilot implementation is below their median value for each test group and other firms are in the unconstrained sample. See Appendix Table A.I for variable definitions. All variables are winsorized at the 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.

Panel A: Test Group 1 Tick-Constrained Sample

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)
Test 1×Post	0.306***	1.206***	-0.171**	0.0304*	-0.183
	(3.88)	(12.04)	(-1.98)	(1.83)	(-0.64)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes
N	1136	1136	1136	1136	1136

R^2	0.740	0.795	0.669	0.682	0.515

Panel B: Test Group 1 Tick-Unconstrained Sample

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)
Test 1×Post	-0.125	0.329***	-0.0742	-0.00240	-0.120
	(-1.53)	(5.32)	(-0.97)	(-0.19)	(-1.31)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes
N	1176	1176	1176	1176	1176
R^2	0.883	0.789	0.636	0.693	0.815

Panel C: Test Group 2 Tick-Constrained Sample

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)
Test 2×Post	0.347***	1.068***	-0.107	0.0237	0.177
	(3.95)	(11.04)	(-1.03)	(1.34)	(1.01)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes

N	1120	1120	1120	1120	1120
R^2	0.743	0.773	0.636	0.693	0.828

Panel D: Test Group 2 Tick-Unconstrained Sample

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)
Test 2×Post	0.0284	0.444***	-0.148*	-0.00614	0.228
	(0.26)	(6.45)	(-1.73)	(-0.40)	(1.17)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes
N	1096	1096	1096	1096	1096
R^2	0.846	0.710	0.671	0.720	0.688

Panel E: Test Group 3 Tick-Constrained Sample

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)
Test 3×Post	0.338***	1.408***	-0.357***	-0.0829***	-0.251
	(3.60)	(14.07)	(-3.15)	(-4.70)	(-0.75)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes

Cluster by firm	Yes	Yes	Yes	Yes	Yes
N	912	912	912	912	912
R^2	0.789	0.801	0.629	0.653	0.675

Panel F: Test Group 3 Tick-Unconstrained Sample

	Percent Quoted Spread	Market Depth	Lit Turnover	Dark Turnover	Percent Effective Spread
	(1)	(2)	(3)	(4)	(5)
Test 3×Post	-0.0245	0.457***	-0.0517	-0.0437***	0.175
	(-0.25)	(4.90)	(-0.73)	(-3.58)	(0.85)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes
N	928	928	928	928	928
R^2	0.859	0.811	0.727	0.774	0.745

Table VIII

Split Tick-constrained Firms Based on Increase in Depth

In this table we report the difference-in-differences results for repurchase payouts when we split the tick-constrained sample in test group 3 equally into two groups based on the increase in depth measures from 2016 (before the Pilot) to 2017. The small depth sample includes firms whose increase in depth is below the median value. Other firms are defined as the large depth sample. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). *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.

	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	-0.210	-0.495***	-0.195	-0.522***	-0.243	-0.462**
	(-1.18)	(-2.79)	(-1.05)	(-2.91)	(-1.35)	(-2.60)
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	0.623	0.535	0.622	0.537	0.615	0.542

Table IX

Parallel Trend and Placebo Tests

In this table we report the results of parallel trend and placebo tests of repurchase payouts for the test group 3 tick-constrained sample. In Panel A we report the period-by-period difference-in-differences results for repurchase payouts from fiscal year-quarter 2015 Q4 going back to 2013 Q1 (see Columns (1) - (11)). In Panel B we report the results of placebo tests. Control variables include size, profitability, and growth opportunity, as in Fama and French (2001). The sample of firms in the tests is consistent with the sample in the main tests. All variables are winsorized at the 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.

Panel A: Parallel Trend Tests

	Pre: 2013 Q1 Post: 2013Q2	Pre: 2013Q2 Post: 2013Q3	Pre: 2013Q3 Post: 2013Q4	Pre: 2013Q4 Post: 2014Q1	Pre: 2014Q1 Post: 2014Q2	Pre: 2014Q2 Post: 2014Q3	Pre: 2014Q3 Post: 2014Q4	Pre: 2014Q4 Post: 2015Q1	Pre: 2015Q1 Post: 2015Q2	Pre: 2015Q2 Post: 2015Q3	Pre: 2015Q3 Post: 2015Q4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Test 3×Post	-0.0926	0.172	0.0225	-0.0817	0.00148	0.109	-0.111	-0.0703	0.0856	-0.115	0.207
	(-0.45)	(0.71)	(0.10)	(-0.52)	(0.01)	(0.49)	(-0.49)	(-0.41)	(0.41)	(-0.57)	(1.15)
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	192	190	194	200	204	214	216	226	228	228	228
R^2	0.709	0.635	0.608	0.888	0.732	0.742	0.773	0.860	0.791	0.827	0.863

Panel B: Year-by-Year Placebo Tests

	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	0.0347	-0.0874	0.0477
	(0.19)	(-0.69)	(0.32)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes
N	752	808	736
R^2	0.412	0.540	0.410

Table X

Controlling for Alternative Explanations

In this table we report results we obtain after controlling for alternative explanations. In Panel A we report the results for repurchase payouts and number of repurchasing shares after controlling for share price. In column (1) we report the results for repurchase payouts, and in column (2) we report the results for number of repurchasing shares. In Panel B we report the results for repurchase payouts while controlling for management stock and option holdings, exercisable options, and exercised options, using annual data. In column (1) we report the baseline regression results without control variables. In column (2) we report the results after controlling for management stock and options holdings. In column (3) we report the results after controlling for exercisable options and exercised options. In column (4) we report the results after controlling for management stock and options holdings, exercisable options, and exercised options simultaneously. All variables are winsorized at the 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.

Panel A: Control for Share Price

	Repurchases Payouts	Number of Repurchasing Shares
	(1)	(2)
Test 3×Post	-0.363***	-0.316***
	(-2.85)	(-2.77)
Share price	Yes	Yes
Controls	Yes	Yes
Firm FE	Yes	Yes
Year-quarter FE	Yes	Yes
Cluster by firm	Yes	Yes
N	912	912
R^2	0.570	0.460

Panel B: Control for Manager Stock and Option Holding, Exercised Options and Exercisable Options

	Repurchase Payouts			
	(1)	(2)	(3)	(4)
Test 3×Post	-1.422***	-1.331**	-1.374**	-1.311**
	(-2.66)	(-2.50)	(-2.53)	(-2.42)
Manager options	-	-0.519	-	-0.467
	-	(-0.98)	-	(-0.86)

Manager stocks	-	3.222	-	2.828
	-	(1.25)	-	(1.12)
Exercised options	-	-	-0.00220	0.0222
	-	-	(-0.02)	(0.23)
Exercisable options	-	-	0.297	0.255
	-	-	(1.06)	(0.90)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes
N	228	228	228	228
R2	0.858	0.860	0.860	0.861

Appendix

Table A.I

Variable Descriptions

Variable	Description
	Panel A: Corporate Payout Variables
Repurchase payouts	Value of common stock repurchases in current quarter divided by lagged assets in the previous quarter. The unit of measure is one percentage point. [Compustat data item: *100×(cshopq×prcraq)/L.atq, cshopq* is total shares of common stock repurchases, *prcraq* is the average repurchase price per share, *L.atq* is total assets in the previous quarter.]
Repurchase announced	Announcement value of share repurchases divided by total asset value prior to an announcement. The unit of measure is one percentage point.
Dividend payouts	Common stock dividends in the current quarter divided by lagged assets in the previous quarter. The unit of measure is one percentage point. [Compustat data item: *100×(dvyq-dvpq)/L.atq. dvyq* are total dividends; *dvpq* are preferred stock dividends.]
Total payouts	The sum of repurchase payouts and dividend payouts. [*Repurchase Payouts + Dividend Payouts*.]
Payout structure	The ratio of repurchase payouts to dividend payouts. We normalize the ratio by adding 1 to the numerator and denominator because dividend payouts are often 0 (Fama and French 2001). [(*Repurchase payouts* + 1) / (*Dividend payouts* + 1).]

Number of repurchasing shares	Total shares of common stock repurchased in the current quarter, divided by the number of common shares outstanding in the end of previous quarter. The unit of measure is one percentage point. [Compustat data item: *100×cshopq/L.cshoq. cshoq* is the total shares of common stock.]
Share price	A stock's closing price in the current quarter. [Compustat data item: *prccq.*]
	Panel B: Market Liquidity Variables
Percent quoted spread	Time-weighted difference between the consolidated offer side and the consolidated bid side divided by the midpoint of the consolidated bid side and the offer at the time of order receipt. The unit of measure is one percentage point.
Percent effective spread	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 of measure is one percentage point.
Lit turnover	Average daily share volume divided by shares outstanding of the stock in the quarter. The unit of measure is one percentage point.
Dark turnover	Average daily dark pool trading volume divided by shares outstanding of the stock in the quarter. The unit of measure is one percentage point.
Market depth	Market depth is calculated as the average of displayed dollar-depth at the NBBO. The unit of measure is one ten thousand.
	Panel C: Control Variables
Size	Natural log of the total value of book assets in the previous quarter. [Compustat data item: *log (L.atq).*]

Profitability	Income before extraordinary items plus depreciation and amortization in the current quarter, divided by lagged assets in the previous quarter. The unit of measure is one percentage point. [Compustat data item: *100×(ibq+dpq)/L.atq. ibq* is income before extraordinary items, *dpq* is depreciation and amortization]
Growth	The market value of assets in the current quarter divided by lagged assets in the 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 A.II

Test Group 3 Tick-constrained Sample Matching Results (Before Pilot)

In this table we report the summary statistics for the key variables for the test group 3 tick-constrained sample and the control group matched sample.

	Test Group 3 Constrained Sample			Control Matched Sample		
	N	Mean	Std. Dev.	*N*	Mean	Std. Dev.
Repurchase payouts	248	0.539	1.239	208	0.444	1.137
Dividend payouts	248	0.277	0.747	208	0.254	0.689
Total payouts	248	0.816	1.366	208	0.699	1.262
Payout structure	248	1.417	1.272	208	1.329	1.172
Lit turnover	248	0.961	0.679	208	0.726	0.526
Dark turnover	248	0.176	0.126	208	0.136	0.103
Percent quoted spread	248	0.390	0.427	208	0.557	0.836
Percent effective spread	248	0.673	1.689	208	0.627	1.489
Market depth	248	0.584	0.296	208	0.585	0.320

Table A.III

Using Nominal Share Price as an Alternative Proxy of Tick Constraint

The results we report in this table indicate that our main results are robust when we use the nominal share price as a proxy of the tick-constraint. We divide stocks equally into high-price and low-price samples based on their share prices in 2016 Q3. The stocks in the low-price group during the pre-Pilot period are defined as the constrained sample and the stocks in the high-price group are defined as the unconstrained sample.

Panel A: Results for Repurchase Payouts, Number of Repurchasing Shares, 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	-0.0366	-0.0333	-0.225**	-0.192	0.0309	-0.104
	(-0.33)	(-0.23)	(-2.18)	(-1.42)	(0.20)	(-0.62)
Number of	-0.0152	-0.0582	-0.234**	-0.0666	-0.0197	-0.115
repurchasing shares	(-0.15)	(-0.54)	(-2.55)	(-0.63)	(-0.17)	(-0.88)
Dividend payouts	-0.0126	0.0449	-0.0563	-0.0177	-0.0156	-0.0568
	(-0.37)	(0.84)	(-1.05)	(-0.51)	(-0.23)	(-0.74)
Total payouts	-0.0491	0.0116	-0.281**	-0.209	0.0154	-0.161
	(-0.43)	(0.07)	(-2.39)	(-1.46)	(0.10)	(-0.89)
Payout structure	-0.0385	-0.0579	-0.208**	-0.108	-0.00307	-0.0602
	(-0.36)	(-0.42)	(-2.14)	(-0.92)	(-0.02)	(-0.37)

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	1160	1072	952	1184	1096	928

Panel B: Split Tick-Constrained Firms of Test Group 3 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	-0.0738	-0.382***	-0.122	-0.323**	-0.204	-0.286**
	(-0.51)	(-2.75)	(-0.79)	(-2.52)	(-1.21)	(-2.22)
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	480	472	480	472	480	472
R^2	0.662	0.509	0.663	0.505	0.619	0.573