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PRICE CEILING, MARKET STRUCTURE, AND PAYOUT POLICIES

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ABSTRACT

To prevent firms from manipulating prices, U.S. regulators set price ceilings for open-market share repurchases. We find that market structure reforms in the 1990s and 2000s dramatically increased share repurchases because they relaxed constraints that prevent firms from competing with other traders under price ceilings. The 2016 Tick Size Pilot, a controlled experiment that partially reversed previous reforms, significantly reduced share repurchases. Market structure frictions provide a unified explanation for two puzzles: the dividend puzzle exists because previous research has overlooked market structure frictions; share repurchases increase relative to dividends over time because market structure reforms gradually reduce these frictions.

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Miller and Modigliani (1961) demonstrate that, in a frictionless market, it does not matter whether firms pay out through dividends or share repurchases. The irrelevance of the payout structure generates two fundamental puzzles that are summarized in Figure 1. The first is the dividend puzzle: Black (1976) argued that firms should not pay dividends at all because dividends are taxed more heavily (for most investors) than capital gains, and capital gains are not taxed until the gains are realized. The value of aggregated dividends was, however, about 20 times greater than that of share repurchases in his period. The second puzzle is the secular increase in share repurchases relative to dividends: Farre-Mensa, Michaely, and Schmalz (2014) show that share repurchases increased 40-fold over dividends from 1970 through 2012, even though the tax rate disadvantage of dividends gradually decreased and dropped to 0 after the 2003 dividend tax cut (Chetty and Saez 2005). This dramatic and persistent increase has even led to policy proposals designed to limit share repurchases.[1]

Insert Figure 1 about Here

In this paper we show that market structure frictions provide the first unified explanation for these two puzzles. Share repurchases do not replace dividends completely because firms encounter market structure frictions when they repurchase shares in the open market; share repurchases become more prevalent than dividends over time because market structure reforms gradually reduce these frictions.

Market structure frictions for share repurchases extend well beyond

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[1] *Limit Corporate Stock Buybacks*, accessed on June 27, 2020. https://www.nytimes.com/2019/02/03/opinion/chuck-schumer-bernie-sanders.html.

traditional channels such as bid–ask spreads. Prior to 1982, firms could barely repurchase shares because regulators may regard share repurchases as price manipulation. Securities and Exchange Commission (SEC) Rule 10b-18, which was implemented in 1982, jumpstarted repurchases because it provides a safe harbor for issuers against anti-manipulative provisions (Grullon and Michaely 2002). On the other hand, Rule 10b-18 imposes price ceilings on share repurchase: firms should buy their shares at prices that do not exceed the highest independent bids or last transaction prices. The purpose of price ceilings is to prevent firms from inflating their share prices by outbidding other traders. Price competition, as a consequence, becomes secondary to share repurchases, and market structure emerges as the first-order effect, because competition under any price ceiling depends on two market structure features: 1) Whose orders execute first at the same price? 2) How many traders compete with issuers at the same price?

Price ceilings under Rule 10b-18 also have two unique features. First, price ceilings constrain issuers but not other traders. Second, price ceilings must be satisfied at the time when repurchasing orders are executed.[2] Therefore, an issuer needs to monitor the price ceiling dynamically after she enters an order to buy back shares. When other traders increase their independent bids, an issuer's original order loses price priority of execution because other traders outbid them. When other traders decrease their independent bids, an issuer may run the risk of outbidding the price ceiling set by other traders. As a consequence, execution of share repurchases under Rule 10b-18 involves significant monitoring costs, and

[2] *SEC Division of Trading and Markets: Answers to Frequently Asked Questions Concerning Rule 10b-18*, accessed on June 27, 2020. https://www.sec.gov/divisions/marketreg/r10b18faq0504.htm.

market structure is essential in determining the size of this monitoring cost.

The price ceilings for share repurchases were surprisingly binding, which provides one explanation of the dividend puzzle. Before 1994, the U.S. market, particularly NASDAQ, was dominated by professional liquidity providers, such as dealers. In dealer-market models (Ho and Stoll 1981; Glosten and Milgrom 1985), it is impossible for firms to repurchase at the bid price because buy orders always occur at the offer price; it is also impossible to buy at a price that is equal to or less than the most recent transaction price because buy orders push prices up. Dealer markets in reality certainly do not follow these models exactly, but these models highlight the main conflicts between the dealer-market structure and share repurchases: Rule 10b-18 asks issuers to provide liquidity when they repurchase shares, but pure dealer models implicitly ban share repurchases because only dealers can provide liquidity.

One main purpose of market structure reforms in the U.S. over the past several decades has been to provide "an opportunity to obtain execution without dealer intervention."[3] Figure 1 depicts large surges in share repurchases after these reforms, each of which removes one main friction discouraging issuers from competing with other traders at the price ceiling. Before 1994, a NASDAQ dealer enjoyed execution priority over her customers. The Manning Rule of 1994 forbade a dealer from trading ahead of or through her customers, thereby increasing the execution priority for issuers. The Order Handling Rules of 1997 further strengthened customers' execution priority beyond the Manning Rule (Hasbrouck 2007). The Common Cents Pricing Act of 1997 reduced the minimum price

[3] Exchange Act Section 11A(a)(1), 15 U.S.C. 78k-1(a)(1).

variation (the tick size) from $1/8 to $1/16 in the same year, and then to 1 cent in 2001. A more continuous price grid reduces the market depth at the best price (Goldstein and Kavajecz 2000), thereby reducing the level of competition under the price ceiling. In 2003, the NYSE installed auto quotes. Issuers began using computer algorithms to monitor markets in real time. This change broke down the physical boundary around the stock exchange and leveled the playing field for issuers and market makers.

To establish the causal impact of market structure on share repurchases, we begin our analysis using a controlled experiment—the 2016 Tick Size Pilot—followed by event studies that focus on market structure reforms in the 1990s and 2000s. The Tick Size Pilot offers two unique features. First, it was designed to partially reverse the market structure reforms discussed above and its sample period falls outside the period when the two puzzles came into play. Second, the Tick Size Pilot included randomly selected test stocks and control stocks. The SEC increased the tick size for 1,200 test stocks from 1 cent to 5 cents, whereas the tick size for the 1,199 control stocks remained at 1 cent. We find that this two-year pilot reduced repurchase payouts in test firms by 21% but did not affect dividend payouts. The total payouts in test firms decreased by 14%, representing a payout reduction of $33.6 billion.

We find that the queuing channel contributes to the large reduction in share repurchases. To test this channel, we partition firms into a tick-constrained group and a tick-unconstrained group. The tick-constrained group includes firms whose pre-Pilot quoted spreads were less than 5 cents. The Tick Size Pilot therefore imposed a binding constraint on price competition and increased market depth by

214%. Queuing, or early arrival to the market to beat rivals at the same price (Kornai 1980; Shleifer and Vishny 1991, 1992; Yao and Ye 2018), became more important after the pilot than it was before the pilot. As issuers tend to lose time priority over high-frequency traders (HFTs),[4] we find that share repurchases in tick-constrained test firms dropped by 45%. In comparison, market depth changed only marginally for tick-unconstrained test firms, and we find that these firms did not experience significant reductions in share repurchases. Furthermore, among the tick-constrained test group, firms that experienced above-median increases in bid depth reduced share repurchases 24% more than below-median firms did.

The Tick Size Pilot imposed an additional trade-at rule on test group 3, preventing the execution of dark orders that do not improve the National Best Bid and Offer (NBBO) by more than 2.5 cents. The trade-at rule, which aimed to encourage market transparency, unintentionally banned share repurchases through dark pools because of the price ceiling imposed by Rule 10b-18, which regards buying above the best-bid price an indicator of price manipulation. We find that tick-constrained firms in test group 3 (groups 1 and 2) reduced share repurchases by 55% (36%). The 19% difference indicates the importance of dark pools for repurchases. Therefore, the recent proliferation of dark pools may contribute to the secular increase in share repurchases over dividends. Firms can bypass queues in stock exchanges by using dark pools, which usually do not follow the time priority rule. The trade-at rule implicitly banned share repurchases in dark pools and led to

[4] Our conversation with HFTs reveals that, even if an issuer hires an HFT, the share repurchase algorithm still cannot win time priority because a repurchase algorithm needs to check for compliance with SEC Rule 10b-18, and this additional step increases latency.

a large reduction in repurchases despite exerting modest or no effects on aggregate trading activity (Rindi and Werner 2019).

In 2018, the SEC terminated the Tick Size Pilot Program, and we find that share repurchases for tick-constrained firms bounce back by 45% once the tick size drops to the pre-Pilot level. After establishing that there is a causal relationship between market structure and share repurchases, we conduct event studies on historical market structure reforms. The reforms include major changes in market structure identified in the literature (Hasbrouck 2007). Also, these reforms evoke quasi-treatment groups and quasi-control groups because they affect some stocks severely but barely affect others. We match control firms to treatment firms based on pre-treatment firm characteristics to control for firm heterogeneity. We also include other explanations of firm payouts as control variables in our regressions to control for alternative channels.

In the Tick Size Pilot study, we find that a large tick size harms issuers because issuers may not win time priority over HFTs. The main economic intuition that emerged from the controlled experiment, however, is not that HFTs harm share repurchases, but that the priority rule at the same price plays a central role in share repurchases. Decades ago, NASDAQ dealers enjoyed much higher priority than HFTs do today. Prior to 1994, a NASDAQ dealer could trade ahead of or through her customers' limit orders even if those customers submitted the orders earlier (Hasbrouck 2007). Using matched non-NASDAQ stocks as the control group, we find that share repurchases for NASDAQ firms increased by 69% after the 1994 Manning Rule granted execution priority to customers' limit orders. The 1997 Order Handling Rules, which extended issuers' execution priority over all dealers in the market, led to another 42% increase in share repurchases by NASDAQ firms.

We find that share repurchases increased when the SEC reduced the tick size following the 1997 Common Cents Pricing Act. We assign stocks exhibiting above-median decreases in quoted spreads to the treatment group and matched remaining stocks to the control group (Fang, Tian, and Tice 2014). Treatment firms increased share repurchases by 68% following the tick size reduction from $1/8 to $1/16 in 1997. The increase was 32% following decimalization in 2001. Notice that the overall share repurchases decreased after decimalization, possibly because of the economic recession after 2001.[5] The 32% difference suggests that treatment firms reduce share repurchases to a lesser extent than matched control firms.

Finally, we examine the impact of automated trading in share repurchases using the installation of automated quotes by the NYSE in 2003 (Hendershott, Jones, and Menkveld 2013) as a quasi-natural experiment, and we use matched non-NYSE stocks as the control group. The transition from manual to automated execution breaks down the physical barrier of the market and reduces monitoring costs; issuers can now use computer algorithms to compete with exchange specialists even when issuers are not physically on the exchange floor. In addition, specialists lost their last-mover advantage because order executions no longer need their approval (MacKenzie 2017). We find that the installation of automated quotes is associated with a 24% increase in share repurchases by NYSE firms. Chetty and Saez (2005) estimate that the 12% reduction in dividend tax rates in 2003 caused a 20% increase in dividend payouts. The 24% increase in share repurchases by NYSE firms implies that the market structure effects are equivalent to a 14.4% change in

[5] See https://www.nber.org/cycles/november2001/.

tax rates.

Our paper contributes to the tax literature. Poterba and Summers (1985) and Chetty and Saez (2010) assume that share repurchases incur exogenous costs to explain why firms pay dividends despite the tax advantage of repurchases. Chetty and Saez (2010) point out that *"understanding the microeconomic foundations of the cost of share repurchases is an issue of great importance for future work, independent of its potential implications for taxation."* We show that market structure frictions provide a micro-foundation for such costs. Market structure frictions also explain why dividends decrease relative to share repurchases even though the tax disadvantage of dividends decreases over time. The most salient puzzle appears in Chetty and Saez (2005, Figure IX; 2006, Figure 5), who find that share repurchases increased more than dividends following the 2003 dividend tax cut. The transitions from manual (high-touch) executions to automated (low-touch) executions of share repurchase during the same sample period provide the first explanation of this puzzle. Our results indicate that market structure frictions can be large enough to overwhelm the tax advantages of share repurchases.

We contribute to the corporate finance literature by providing the first unified explanation for both the dividend puzzle and the secular increase in share repurchases. Prior explanations of the dividend puzzle focus on the advantages of dividends, such as their higher signaling costs (John and Williams 1985), more credible forms of corporate governance (La Porta et al. 2000), self-control (Shefrin and Statman 1984), and proportional payouts (Brennan and Thakor 1990). These interpretations cannot, however, explain the secular increase in share repurchases without assuming that such advantages continue to decrease over time.

Explanations of the secular trend in share repurchases, on the other hand, rely on their advantages, such as preserving the value of executive option compensation (Fenn and Liang 2001), offsetting earnings-per-share (EPS) dilution led by option exercise (Kahle 2002), improving agreements between investors and managers (Huang and Thakor 2013), and serving as a more flexible payout mode (Jagannathan, Stephens and Weisbach 2000). These interpretations grant additional benefits to share repurchases other than tax and cannot explain the dividend puzzle.

Explaining the secular increase in share repurchases faces two hurdles. First, why does this economic driver continue to move in only one direction? Second, why does this economic driver last for decades? These two hurdles rule out traditional payout channels, such as the signaling, agency, and tax channels as well as market timing and catering (Farre-Mensa, Michaely, and Schmalz 2014). Market structure frictions, however, overcome these two hurdles. First, one major goal of all market structure reforms is to provide executions without dealer interventions. These reforms therefore benefit issuers at the expense of professional market makers. Second, regulators did not and could not achieve this goal in one step. Instead, market structure reforms continued over several decades and are still taking place today. The two most recent policy initiatives were designed to increase price ceilings for share repurchases, and we predict that such deregulation would further boost share repurchases.[6]

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[6] The Investor Stock Exchange recently asked the SEC to allow firms to repurchase shares by matching the midpoint price in dark pools (IEX 2018). The SEC (2010) proposed using the volume-weighted average price (VWAP) as an alternative benchmark for complying with the pricing condition of Rule 10b-18. Both the midpoint price and the VWAP would increase current price ceilings for share repurchases.

Our results indicate that the impacts of market microstructure on corporate policies go beyond traditional channels such as liquidity and price discovery. Combined with other frictions such as price ceilings, market structure can impose first-order frictions that are as severe as implicit bans. Our results also point to two new dimensions of research on liquidity: "liquidity-for-whom" and "liquidity-from-where." Regarding "liquidity-for-whom," our results indicate the need to define liquidity differently for different types of traders. Although a market with greater depth is generally considered a more liquid market (Goldstein and Kavajecz 2000), it may harm share repurchases because Rule 10b-18 encourages issuers to provide liquidity while a market with greater depth crowds out issuers' limit orders. Regarding "liquidity-from-where," our results indicate that the distribution of liquidity across platforms matters. Dark pools are important for share repurchases because passive matching dovetails with the reasoning behind Rule 10b-18.

I. The Controlled Experiment

A. The U.S. Tick Size Pilot Program and the Data

In 2012, The Jumpstart Our Business Startups Act ("JOBS Act") directed the SEC to study whether reductions in U.S. stock tick sizes in the late 1990s and early 2000s could be driving the decline in the number of initial public offerings (IPOs). In 2014, the SEC ordered the national securities exchanges (NSEs) and the Financial Industry Regulatory Authority (FINRA) to develop a pilot program. On May 6, 2015, the SEC issued an order approving the plan to implement the Tick Size Pilot Program. The Program began on October 3, 2016 and ended on October 1, 2018.

The Program included 2,399 stocks, comprising all Reg NMS stocks that satisfied the following criteria during a three-month measurement period before Program implementation: a share price of at least $1.50 each day, a volume-weighted average price of at least $2, average sales volume of fewer than one million shares, market capitalization below $3 billion, and a closing price above $2 on the last day of the measurement period.[7] NSEs and FINRA then divided these stocks into 27 categories based on three criteria: (1) a low, medium, or high share price; (2) low, medium, or high market capitalization; and (3) low, medium, or high volume. Stocks were then randomly drawn to form three test groups from each category so that each test group contained 400 stocks. The remaining 1,199 stocks were assigned to a control group.

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 increments; stocks in test group 2 could be quoted and traded only at $0.05 increments. Stocks in test group 3 adhered to all the same requirements as those in test group 2 but were also subject to a "trade-at" rule, which granted execution priority to displayed orders unless non-displayed orders could improve prices by at least 2.5 cents, with certain exceptions (SEC 2015).

We obtained lists of test and control stocks from FINRA's website. We obtained quarterly share repurchases, dividends, and firm-level financial information from Compustat's North America Fundamentals Quarterly files. We define our payout variables following existing conventions (Fama and French 2001; Almeida et al. 2016): *repurchase payouts* equal total expenditures in common stock

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[7] Reg NMS stocks are listed on stock exchanges such as the NYSE and NASDAQ and are reported pursuant to the national market system plan for reporting transactions.

repurchases divided by lagged assets and *dividend payouts* equal common stock dividends divided by lagged assets. *Total payouts* equal the sum of repurchase payouts and dividend payouts. *Payout structure* equals (repurchase payouts +1) / (dividend payouts +1).[8] *Size* is the natural log of book assets. *Profitability* is income before extraordinary items plus depreciation and amortization divided by lagged assets. *Growth opportunity* is the market value of assets divided by lagged assets. We calculate spread, turnover, and depth measures using Daily TAQ data following Holden and Jacobsen (2014): *percent quoted spread* is the time-weighted difference between the NBBO divided by the midpoint. *Total turnover* is the average daily total share volume divided by shares outstanding. *Market depth* is the average of the displayed best-bid and best-offer depth at the NBBO price.

Our sample selection process is as follows. We drop stocks with missing information in the Compustat database and the Daily TAQ database. Following the literature on Tick Size Pilot studies (Albuquerque, Song, and Yao 2019; Rindi and Werner 2019), we retain only common stocks (CRSP share codes 10 or 11) that remained throughout the Tick Size Pilot period. Following the payout literature, we exclude regulated utility and financial firms (SIC codes 4200-4299 and 6000-6999) because companies in these industries face additional regulations and hence might exhibit divergent payout behavior (Fama and French 2001; Chetty and Saez 2005). Our final sample contains 602 firms in the three test groups and 654 firms in the control group.

Our difference-in-differences (DID) specification is as follows:

[8] We add 1 to both the numerator and the denominator because the latter often equals zero (Fama and French 2001).

$$y_{i,t} = \eta_i + \lambda_t + \beta \times \ Treatment_i \times Post_t + \zeta' \times Controls_{i,t} + \varepsilon_{i,t}, \qquad (1)$$

where i indexes firm, t indexes time, and $y_{i,t}$ is the dependent variable. η_i are firm fixed effects and λ_t are year-quarter fixed effects. $Post_t$ 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. $Treatment_i$ is a dummy variable that equals one if the firm is in the treatment group and zero if it is in the control group. We specify the definitions of $Treatment_i$, $Post_t$, and $X_{i,t}$ in detail for each test. $Controls_{i,t}$ are the control variables. $\varepsilon_{i,t}$ is an error term. The main coefficient of interest is β, which estimates the average treatment effects on y. All variables are winsorized at the 1% and 99% levels. *t*-statistics based on standard errors are robust to heteroskedasticity and are clustered at the firm level.

B. The Effects of the Tick Size Pilot Program on Payout Policies

In Table 1 we report the average effects of the Tick Size Pilot on the corporate payout variables following equation (1), where $Treatment_i$ equals one if a stock is in the three test groups and zero if the stock is in the control group, while $Post_t$ equals one if the observation is in the post-treatment period (2016 Q4–2018 Q3) and zero if it is in the pre-treatment period (2014 Q4–2016 Q3). *Controls* include size, profitability, and growth opportunity, as in Fama and French (2001).

Insert Table 1 about Here

The results reported in Table 1 indicate that, in the Tick Size Pilot Program, treatment firms decreased repurchase payouts by 0.092%, which represents a 21% decline compared with the pre-treatment average repurchase payout of 0.43%. Corporate dividend payouts did not change significantly. Therefore, treatment firms reduced their repurchase payouts but did not increase dividend payouts. The results are consistent with dividend-smoothing motives (Leary and Michaely 2011; Michaely and Roberts 2012). As a result, total payouts decreased by 0.097%, which represents a 14% decline compared with the pre-treatment average total payouts of 0.67%. Our back-of-the-envelope calculation demonstrates the economic magnitude of the treatment effect: treatment firms reduced their total payouts by $33.6 billion during the eight quarters of the Tick Size Pilot. In addition, the payout structure of the treatment firms decreased by 0.083, a 6.64% decrease relative to the pre-treatment mean of 1.25. Therefore, the Tick Size Pilot Program, an initiative that was designed to reverse market structure reforms enacted in previous decades, also reverses the secular increase in repurchases relative to dividends.

C. The Queuing Channel

Next, we examine the two underlying channels that cause the dramatic reduction in share repurchases: the queuing channel and the dark pool channel. In this subsection, we discuss the queuing channel. First, to account for heterogeneous treatment intensity, we partition treatment firms into tick-constrained and tick-unconstrained subsamples based on their average dollar-quoted spreads one quarter before the Pilot (2016 Q3). Tick-constrained firms had pre-Pilot quoted spreads that were lower than 5 cents, and we define the other firms as tick-unconstrained firms. Because the firms are partitioned into two subsamples, we create matched control samples for the treatment tick-constrained and tick-unconstrained subsamples based on pre-treatment repurchase payouts, dividend payouts, and the three control variables (size, profitability, and growth opportunity) to minimize the differences between the subsamples of treatment and control firms.[9]

In Panel A of Table 2, we report the summary statistics and the mean differences between the treatment and matched control sample for the payout variables in the pre-treatment period. The *t*-test results show that the mean differences are not statistically significant.

In columns (1)–(4) in Panel B we report the DID regression results for tick-constrained firms, while in columns (5)–(8) we report the results for tick-unconstrained firms. The results show that the treatment effects of the Tick Size Pilot are concentrated in tick-constrained firms. Tick-constrained firms reduced their repurchase payouts by 0.183%, which represents a 45% decline from the average pre-treatment level of 0.41%. Consistent with the dividend-smoothing hypothesis, these firms did not experience significant changes in dividend payouts. Their total payouts declined by 0.187%, which represents a 31% decline compared with the average pre-treatment total payouts. In addition, the payout structure decreased by 0.146 from 1.253. In comparison, none of the payout variables was changed significantly by the tick-unconstrained firms.

Insert Table 2 about Here

The comparison between tick-constrained and tick-unconstrained firms is consistent with the proposition that market structure frictions drive the treatment effects on repurchase payouts. The next question is to determine which market structure frictions are the main economic drivers of the dramatic decrease in share repurchases. Panel C in Table 2 presents the DID regression results for the three

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[9] All of our matching variables are measured prior to the treatment to ensure that they are unaffected by the treatment (Roberts and Whited 2013).

main candidates based on standard liquidity measures: percentage quoted spreads, share turnover, and market depth. For tick-constrained firms, the Tick Size Pilot caused a 41% increase in percentage quoted spreads (0.32/0.77), a 16% decrease in total share turnover (0.14/0.92), and a 214% increase in market depth (12.90/6.01), whereas the changes for tick-unconstrained firms are either much smaller or statistically insignificant.

We first rule out total share turnover as the main driver of the decrease in share repurchases. The volume condition in Rule 10b-18 prohibits firms from purchasing more than 25% of the preceding four-week average daily volume on any trading day, but we find that the repurchase program represents only 6% of the volume in our sample. In addition, Rule 10b-18 exempts firms from one block trade each week, which further relaxes the 25% volume constraint. Therefore, the volume constraint is not binding, making it hard for this friction to be the main driver of the 45% decrease in repurchase payouts.

The 41% increase in the proportional bid–ask spread is equivalent to only about a 2-cent increase in the nominal bid–ask spread. Our conversations with issuers and their brokers also indicate that a two-cent increase in the quoted spread is unlikely to be the main driver of the decrease in share repurchases. Firms inform us that 2 cents do not represent a strong disincentive against repurchasing shares; commissions to brokers could even be higher. Repurchasing brokers relate that a 2-cent increase in the bid–ask spread has at most secondary effects because they do not need to pay for the bid–ask spread. More surprisingly, because Rule 10b-18 encourages issuers to use limit orders in share repurchases, an increase in the bid–ask spread can benefit issuers if they can successfully execute their limit orders because a wider spread means higher revenue for limit orders conditional on execution.

Surprisingly, an increase in depth is the most likely driver of the reduction in share repurchases. We find empirical evidence, and our conversations with brokers and stock exchanges also help to confirm this interpretation. Generally, a market with greater depth is considered more liquid, particularly for large traders. Jones and Lipson (2001) find, for example, that the reduction in the tick size in 1997 reduced transaction costs for small orders but increased these costs for large orders as a result of the reduction in depth. An increase in depth, however, does not help issuers because they are discouraged from demanding liquidity on the ask side. An increase in depth on the bid side harms issuers because they face more intense competition from other liquidity providers. As issuers cannot trade as quickly as HFTs (SEC 2018), long queues are unfavorable for issuers because they may not win time priority.[10] Our discussion with HFTs reveals that, even if issuers hire HFTs for share repurchases, the repurchase algorithms cannot run as fast as other HFTs because of the additional latency caused by checking compliance with Rule 10b-18.

Next, we partition tick-constrained firms into two subgroups based on their increase in bid-side depth to further investigate the queuing channel. In Panel D in

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[10] Certainly, if the price does not move, an issuer may execute her order when orders with higher time priority all execute. The queue, however, is dynamic because the price moves. If the price moves up before the execution of an order to repurchase, the issuer needs to place the order in a new queue with a higher price. If the price moves down before the execution of an order to repurchase, the issuer needs to check whether the execution of her order at the original price may violate 10b-18. In summary, although a longer queue cannot eliminate share repurchases, it constrains them.

Table 2 we report the DID regression results. We find firms that experienced a larger increase in bid-side depth reduced share repurchases to an even greater extent: firms with an above-median increase reduced share repurchases by 56% (0.264/0.469) whereas firms with a below-median increase reduced share repurchases by only 32% (0.115/0.357), and the difference is statistically significant (p-value < 0.01). These results are consistent with the queuing channel.

D. The Dark Pool Channel

In this subsection, we test whether dark pools affect share repurchases. In dark pools, issuers can jump ahead of queues because these systems do not enforce time priority. For example, a dark pool can use broker priority (Degryse and Karagiannis 2018) and this priority can help issuers if their repurchase brokers own the dark pool. A dark pool can also follow volume priority, and this priority can help issuers if they buy back a large number of shares.[11] We hypothesize that dark pools help issuers repurchase shares. As test group 3 in the Tick Size Pilot faced an additional trade-at requirement that restricted dark-pool trading, we predict that the firms in test group 3 experienced a greater reduction in share repurchases than firms in other test groups.

The results reported in Table 3 reveal the treatment effects of the Tick Size Pilot on share repurchases for tick-constrained firms in test group 3 and tick-constrained firms in test groups 1 and 2. The treatment effect for tick-constrained firms in test group 3 is -0.26% (a 55% reduction compared with the pre-treatment mean), whereas the treatment effect for tick-constrained firms in test groups 1 and

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[11] For volume priority, see https://www.bidstrading.com/wp content/uploads/bids_greenwich_questionnaire.pdf.

2 is -0.14% (a 36% reduction compared with the pre-treatment mean). The difference is both economically (19%) and statistically significant (*p*-value < 0.01). The results also show insignificant effects on tick-unconstrained firms in both test group 3 and test groups 1 and 2.

Insert Table 3 about Here

The greater reductions in share repurchases in test group 3 imply two necessary conditions. First, firms use dark pools extensively to repurchase shares. Second, the trade-at rule significantly reduced issuers' ability to repurchase shares in dark pools. The question then arises: why does the 2.5 cent price improvement requirement in dark pools lead to the additional 19% reduction in share repurchases? The conflict between the trade-at rule and Rule 10b-18 provides the answer. Rule 10b-18 discourages firms from buying shares at prices above independent bids. Without the trade-at rule, dark pools could passively match orders using independent bid prices,[12] and issuers could avoid competing with HFTs for execution in stock exchanges. The trade-at rule requires dark pools to match orders at a price that is 2.5 cents above the independent bid.[13] However, Rule 10b-18 implies that buying shares at prices above independent bids indicates price manipulation. Therefore, tick-constrained firms in test group 3 faced an implicit ban on repurchasing in dark pools and double constraints on share repurchases in both exchanges and dark pools. The results suggest that the conflicts

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[12] Dark pools use both midpoint prices or non-midpoint prices within the NBBO as reference prices (Menkveld, Yueshen, and Zhu 2017). Anecdotal evidence suggests that firms use dark pools to repurchase shares (see, for example, https://wallstreetonparade.com/2015/06/a-closer-look-at-goldman-sachs-stance-on-share-buybacks).

[13] SEC (2015) provides a few exemptions to this requirement.

between new and old regulations can generate unintended consequences for firms.

E. Additional Tests

In column (1) of Table 4, we report results that show the reversal effects following the end of the Tick Size Pilot using the four quarters after the Pilot's end (2018 Q4 to 2019 Q3) as the post-Pilot-end period and the four quarters before the Pilot's end (2017 Q4 to 2018 Q3) as the pre-Pilot-end period. Tick-constrained firms increased their repurchases by 45% (0.122/0.271) in the post-Pilot-end period. We then conduct placebo tests using the two-year period before the Pilot implementation as a placebo shock. In column (2) we present the results. We find no significant changes in repurchases.

Insert Table 4 about Here

One limitation of our controlled experiment is that it involves only small and medium-sized stocks. To mitigate the concern that the results apply only to small stocks, we follow Yagan (2015) and split the sample equally based on pre-treatment firm size proxied by total assets. We report the results in columns (3) and (4) of Table 4. For small (large) firms, we find a 46.3% (44.9%) reduction in repurchases compared with the pre-treatment mean (0.155/0.335 vs. 0.220/0.490). Both reductions are statistically significant. The results suggest that market structure frictions do not concentrate in small firms and the economic mechanism revealed by the controlled experiment is likely applicable to a broader sample.

In column (5) of Table 4 we present the results for the *Repurchase dummy*, which equals one if a firm repurchases shares during the quarter and zero otherwise. We find no significant changes in the fraction of repurchasing firms. Our results therefore come mainly from the intensive margin, i.e. reductions in share repurchases by repurchasing firms. The results are similar when we analyze treatment groups 1 and 2 or treatment group 3 separately.

Finally, we examine the effects of the Tick Size Pilot on self-tender offers. We obtain self-tender offer data from the Securities Data Company (SDC). *Tender offer* equals the value of self-tender offers divided by the lagged assets (in percentages). The results reported in column (6) of Table 4 show that the Tick Size Pilot has no significant effects on corporate self-tender offers. Two factors contribute to this result. First, the Tick Size Pilot led to changes in the structure of the secondary market, which has no direct effect on firm incentives to make self-tender offers. Second, open-market share repurchases have been growing in popularity, and self-tender offers are rarely used by firms (Grullon and Ikenberry 2000).

II. Historical Market Structure Reforms and Payout Policies

In this section we examine whether the effects of market structure frictions on the share repurchases we identify in the controlled experiment extend to a broader sample. We conduct three market structure event studies centered on the market-structure reforms in the 1990s and 2000s. In Subsection II.A, we discuss our investigation of the effects of the 1994 Manning Rule and the 1997 Order Handling Rules. In Subsection II.B, we examine the effects of the reductions in tick size following the 1997 Common Cents Pricing Act. In Subsection II.C, we discuss the effects of the NYSE’s jumpstart of algorithmic trading in 2003.

The reforms represented in our sample include major changes in market structure identified in the literature (Hasbrouck 2007). Also, these reforms evoke quasi-treatment and quasi-control groups because they affect some stocks intensely but barely affect others. Comparing the quasi-treatment and quasi-control groups helps us to control for confounding events on share repurchases that are unrelated to market-structure frictions. To control for firm heterogeneity, we match the treatment firms with the control firms based on repurchase payouts, dividend payouts, size, profitability, and growth opportunities. Table A.1 in the Appendix presents the pre-treatment summary statistics and mean differences for our event studies. The results suggest that treatment firms and their matched controls are similar before the events. To control for alternative channels, we control for size, profitability, and growth opportunities (Fama and French 2001) as well as managerial stock holdings (Brown, Liang, and Weisbenner 2007), managerial options holdings (Fenn and Liang 2001), and exercised and exercisable options (Kahle 2002). We also control for the relative tax advantage of share repurchases, measured as the difference between the dividend tax and the capital gains tax (Chetty and Saez 2005), the financial flexibility advantage of share repurchases (Jagannathan, Stephens, and Weisbach 2000) proxied by cash-flow volatility (the standard deviation of profitability in the past five years) and non-operating cash flows (scaled by lagged total assets), and valuation-based explanations such as market timing (Dittmar and Field 2015) proxied by future three-year market-adjusted returns. We also limit our sample period to one year before and after the events. In all these tests, we use the same sample filters that we used with the Tick Size Pilot analyses and follow the DID regression using equation (1). Observations are at annual frequency.

A. Execution Priority: Manning Rule and the Order Handling Rules

In this section, we investigate the importance of execution priority using the 1994 Manning Rule and the 1997 Order Handling Rules as quasi-natural experiments. Before 1994, NASDAQ dealers could trade ahead of or through their customers' limit orders. For example, suppose that a dealer quoted a $100 bid price and a $102 offer price. A customer who wanted to buy at a bid price of $100 has lower execution than the dealer because the dealer could trade ahead of her customers. A dealer could even trade through her customers. A NASDAQ dealer who received a customer order to buy at $101 did not have to display the order as a new, more aggressive quote; the dealer could buy for his own account at prices below $101 (thus trading through the customer order). The customer was entitled to execution only when the market offer price dropped to 101, which makes the customer order marketable. The Manning Rule, approved by the SEC on June 29, 1994, prohibited dealers from trading ahead of or through their customers,[14] thereby increasing the execution priority of issuers over their own dealers.

The Manning Rule applied only to NASDAQ-listed firms. Firms listed on other exchanges were not affected. For example, NYSE specialists faced competition for order flow from floor traders and public limit orders, limit order prices were incorporated in prices displayed on the market, and limit orders took precedence over specialists (Christie and Schultz 1994). Therefore, $Treatment_i$ equals one for NASDAQ firms and zero for matched firms listed on other

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[14] The Manning Rule is a result of the 1988 Manning decision. A customer of an NASD member firm, William Manning, alleged that the dealer had accepted his limit order, failed to execute it, and violated its fiduciary duty to him by trading ahead of the order (Securities Exchange Act Release No. 44357).

exchanges, while $Post_t$ equals one if an observation is in 1995 and zero if it is in 1993.

The results reported in Panel A of Table 5 show that the Manning Rule is estimated to generate a 69% increase in repurchase payouts for NASDAQ firms (0.419/0.605). We find no significant effects on dividend payouts. In addition, total payouts increased by 33% (0.412/1.237) and the payout structure increased by 26% (0.341/1.318) for NASDAQ firms. The increase in share repurchases and total payouts as well as the shift in payout composition towards share repurchases match the long-term time-series trend in payouts (Farre-Mensa, Michaely, and Schmalz 2014) and are consistent with the results of the Tick Size Pilot and other event studies discussed in our paper.

The uniqueness of the Manning Rule is that it affects repurchases through the extensive and intensive margins, whereas other market structure reforms affect repurchases mainly through the intensive margin. We find that the fraction of repurchasing firms increased by 4.4%, representing a 20% increase over the pre-treatment level (4.4%/22.5%). These results suggest that the Manning Rule relaxed the constraints on *whether* NASDAQ firms could repurchase, whereas other market structure reforms related more directly to *how much* they can repurchase.[15]

The 1997 Order Handling Rules further increased the execution priority of customer limit orders. Prior to 1997, a NASDAQ dealer did not need to display customer's limit orders. If an issuer submitted a buy limit order at the best

[15] NASDAQ market makers began adopting odd-eighth quotes in 1994 (Christie and Schultz 1994; Christie, Harris, and Schultz 1994), which is equivalent to a reduction in the tick size. The odd-eighth is unlikely to drive the extensive margin. Also, without the Manning Rule, issuers would find it hard to compete with dealers at the bid price irrespective of the tick size.

independent bid, the order could be invisible to other dealers and their customers. The Order Handling Rules required dealers to display all public orders when these orders were at the best bid or offer.[16] Once the issuer's limit order becomes visible, it can trade with the customers of other dealers, either because they choose to transact with the limit order or because other dealers forward a customer's marketable order to the limit order to fulfill the best execution obligation. Therefore, the Order Handling Rules extended an issuer's execution priority from one dealer to all dealers.

Order Handling Rules apply to all U.S. markets, but they are specifically targeted at NASDAQ stocks (Barclay et al. 1999). $Treatment_i$ equals one for NASDAQ firms and zero for matched firms listed on other exchanges, $Post_t$ equals one if an observation is in 1998 and zero if it is in 1996.

The results we report in Panel B of Table 5 indicate a 42% (0.437/1.040) increase in repurchase payouts for NASDAQ firms; this treatment effect is insignificant for dividend payouts. We also find a 31% (0.477/1.540) increase in total payout and a 22% (0.359/1.666) increase in payout structure. The results suggest the first-order importance of execution priority when issuers face price ceilings on repurchases.

Insert Table 5 about Here

B. The 1997 Tick Size Reduction and the 2001 Decimalization

In our controlled-experiment analyses, we show that an increase in the tick size reduces share repurchases. As an external validity check on the effects of the tick

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[16] Barclay et al. (1999) note that the Order Handling Rules include four sets of rules, but the Limit Order Display Rule is the most relevant rule for issuers.

size changes, we examine the effects of the 1997 tick size reduction from \$1/8 to \$1/16 and the 2001 decimalization on firm payouts following the 1997 Common Cents Pricing Act. Goldstein and Kavajecz (2000) and Bessembinder (2003) show that these two tick size reductions decreased both the bid–ask spread and market depth. Our market structure channel, in turn, predicts increases in repurchase payouts following both tick size reductions.

We follow prior literature (e.g. Fang, Tian, and Tice 2014) and define $Treatment_i$ as equal to one for firms that experience above-median decreases in the bid–ask spread and zero for other matched firms, while $Post_t$ equals one if the observation is in one year before the tick size reduction and zero if it is in one year after the tick size reduction. In Panels C and D of Table 5 we report the results, which show that, following the 1997 tick size reduction, repurchase payouts increased by 68% in treatment firms (0.578/0.849); there were no significant effects on dividend payouts. Total payouts increased by 42% (0.555/1.321) and the ratio of repurchase payouts to dividend payouts increased by 39% (0.576/1.478). Following the 2001 decimalization, repurchase payouts increased by 32% for treatment firms (0.554/1.744); there were no significant effects on dividend payouts. Total payouts increased by 21% (0.501/2.375), and the ratio of repurchase payouts to dividend payouts increased by 26% (0.552/2.108). These results show that, following the tick-size reductions, firms faced fewer market-structure frictions and repurchased more shares.

C. 2003 NYSE Automated Quote Installation

In this subsection, we explore the importance of automated execution using NYSE automated quote installation as a quasi-natural experiment. The transition from manual to automated execution seems like a minor technical detail, but it fundamentally reshaped share repurchase business in two ways. First, auto quotes blurred the physical barrier of the market; issuers could use computer algorithms to compete with specialists on liquidity provision. When executions were manual, other liquidity providers could compete with specialists only when other liquidity providers were present, either by being on the floor or being in the limit order book. Automated execution significantly levels the playing field for issuers and specialists because issuers' computer algorithms can submit, cancel, and adjust limit orders in response to changing market conditions, just like specialists. Computer algorithms can also check compliance with Rule 10b-18 in real time. Second, auto quotes remove the last-mover advantage that specialists enjoyed. Before auto quotes were installed, NYSE specialists disseminated quotes manually and approved each transaction by pressing the 'enter' key (MacKenzie 2017). As a consequence, specialists enjoyed the last-mover advantage because they could condition their actions on incoming orders. For example, specialists could choose to participate in trades from their own accounts by improving quotes from existing limit orders, and specialists could stop the execution of incoming marketable orders by promising price improvement for such orders in the future. In both cases, specialists stepped ahead of other liquidity providers, including issuers. After automated execution became available, specialists lost their last-mover advantage because executions occurred in the absence of specialists' approval. The loss of specialists' execution privilege increased execution priority for issuers.

In this event study we define $Treatment_i$ as equal to one for NYSE firms and zero for matched firms listed on other exchanges; for example, NASDAQ stocks shifted to electronic trading before 2003 because of the proliferation of Electronic Communication Networks (Barclay, Hendershott and McCormick 2003), while $Post_t$ equals one if the observation is in 2004 and zero if it is in 2002. The results are reported in Panel E of Table 5 and show that the implementation of auto quotes on the NYSE caused a 24% (0.413/1.716) increase in repurchase payouts; it had no significant effects on dividend payouts.

These results suggest one explanation of the increase in share repurchases over dividend payouts following the 2003 dividend-tax cut, as documented in Chetty and Saez (2005; 2006). The transition of repurchase execution from manual (high-touch) execution to automatic (low-touch) execution reduced repurchasing frictions and thus increased share repurchases around 2003.

Overall, the evidence we have presented in this section is consistent with our hypothesis that market structure reforms and the resulting reductions in market structure frictions contribute to the secular increase in share repurchases we observe. On the other hand, market structure frictions associated with share repurchases have always existed, which can help explain why share repurchases do not crowd out dividend payouts completely.

III. Conclusion

When U.S. firms repurchase shares in the open market, they face price ceilings established by SEC Rule 10b-18. These price ceilings, in turn, give market structure a first-order role in share repurchases. We show that market structure frictions can reconcile two seemingly contradictory puzzles. The dividend puzzle exists because previous studies typically overlook market structure frictions; share repurchases increase relative to dividends over time because market structure reforms gradually reduce these frictions. The 1994 Manning Rule and the 1997 Order Handling Rules increased issuers' execution priority at the price ceilings. Tick-size reductions in 1997 and 2001 reduced queue competition under the price ceilings. Automated execution (e.g. the 2003 NYSE auto quote installation) helps issuers by breaking down the physical boundary around stock exchanges and eliminating the last-mover advantage enjoyed by specialists. We show that all these market reforms significantly increased share repurchases. The Tick Size Pilot Program, which partially reversed the market reforms by increasing the tick size, caused significant reductions in share repurchases.

We find that market structure can have first-order effects on corporate policies when firms trade directly on the open market and face other constraints such as price ceilings. These two conditions point out possible new directions for research at the intersection of market microstructure and corporate finance. Our results also open up two new research dimensions for liquidity: liquidity-for-whom and liquidity-from-where. Although a market with greater depth is generally considered more liquid, we find that such a market may impose constraints on repurchasing issuers because they face additional regulatory constraints imposed by Rule 10b-18. Regulations can blur the definition of liquidity for distinct groups of traders, indicating the importance of liquidity-for-whom. We find that dark pools are important for share repurchases because these platforms allow issuers to avoid queues at price ceilings. We find that the trade-at rule, which unintentionally banned share repurchases in dark pools, led to additional decreases in share repurchases, indicating the importance of liquidity-from-where.

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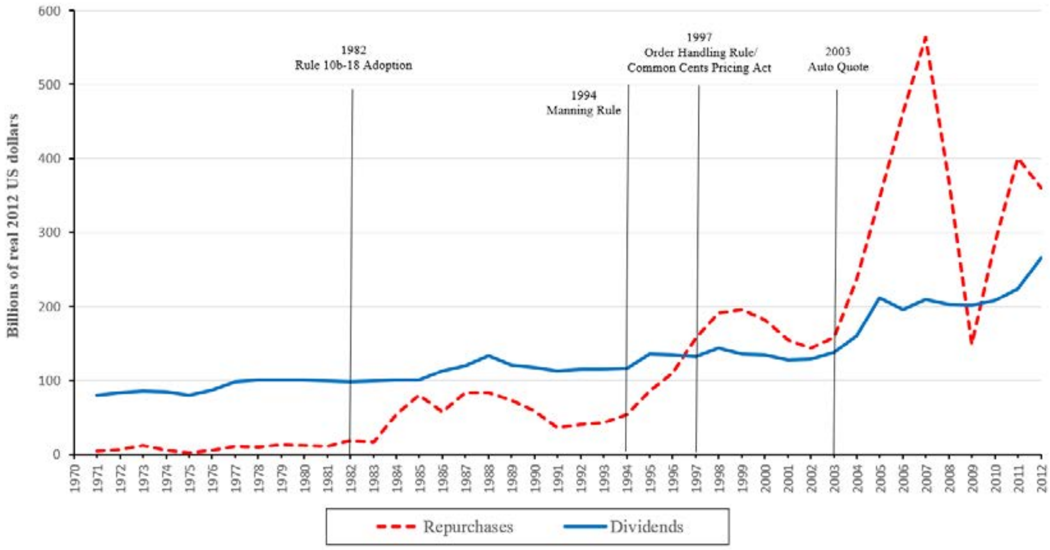

Figure 1
Market Structure Reforms and Corporate Payouts

In this figure we plot aggregate repurchases made and dividends paid by publicly listed U.S. companies from 1971 through 2012. The methodology is the same as that followed in Farre-Mensa, Michaely, and Schmalz (2014). The magnitudes are reported in billions of real 2012 U.S. purchasing power dollars. Repurchases are calculated as total expenditures on the purchase of common and preferred stocks (PRSTKC) minus any reduction in the value of the net number of preferred stocks outstanding (PSTKRV). Dividends are calculated as the total amount of dividends declared on a company's common/ordinary capital. The vertical lines show 1982 Rule 10b-18 adoption and historical market structure reforms. In 1982, the SEC adopted Rule 10b-18, which provides a safe harbor for issuers against anti-manipulative provisions. The 1994 Manning Rule increases the execution priority of issuers. The 1997 Order Handling Rules further strengthened customers' execution priority beyond the Manning Rule. The 1997 Common Cents Pricing Act reduced the minimum price variation (tick size) from $1/8 to $1/16 in the same year, and finally to 1 cent. In 2003, NYSE installed auto quotes, which broke the physical boundary around the stock exchange and leveled the playing field for issuers and market makers.

Table 1

Tick Size Pilot Program and Payout Policies

In this table we report the difference-in-differences (DID) regression results for the payout variables: *repurchase payouts, dividend payouts, total payouts,* and *payout structure*. *Treatment* is a dummy variable that equals one if a stock is in one of the three test groups and zero if it is in the control group. *Post* is an indicator variable that equals one if the year-quarter is in the post-treatment period (2016 Q4–2018 Q3) and zero if it is in the pre-treatment period (2014 Q4–2016 Q3). *Controls* 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 heteroskedasticity and clustered at the firm level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Difference-in-Differences Regression Results			
	Repurchase Payouts	Dividend Payouts	Total Payouts	Payout Structure
	(1)	(2)	(3)	(4)
Treatment×Post	-0.0919***	-0.00462	-0.0965***	-0.0832***
	(-2.72)	(-0.32)	(-2.67)	(-2.74)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes
N	19629	19629	19629	19629
R^2	0.382	0.702	0.486	0.396

Table 2

The Queuing Channel

In Panel A, we present the pre-treatment summary statistics and the mean difference test results for the treatment group and the matched control group. We partition firms into constrained and unconstrained subgroups. The tick-constrained sample includes a firm if its average dollar-quoted spread for the quarter prior to the Pilot implementation (2016 Q3) is below 5 cents, while other firms are in the unconstrained sample. In Panel B, we report the DID regression results for corporate payout variables. In Panel C, we report the DID regression results for market liquidity measures. In Panel D, we report the DID regression results for *repurchase payouts* when we partition the tick-constrained sample equally into two groups based on the increase in bid-side depth. 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 shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Pre-Treatment Summary Statistics for the Constrained Sample and the Unconstrained Sample

	Tick-Constrained Sample				Tick-Unconstrained Sample			
	Treatment	Control	*t*-test		Treatment	Control	*t*-test	
	Mean	Mean	*Diff*	*p-value*	Mean	Mean	*Diff*	*p-value*
Repurchase payouts	0.409	0.396	0.013	0.679	0.439	0.435	0.004	0.898
Dividend payouts	0.202	0.176	0.026	0.108	0.271	0.269	0.002	0.907
Total payouts	0.611	0.572	0.039	0.278	0.711	0.705	0.006	0.871
Payout structure	1.253	1.289	-0.036	0.232	1.239	1.213	0.026	0.353

Panel B: Regression Results for Payout Variables

	Tick-Constrained Sample				Tick-Unconstrained Sample			
	Repurchase Payouts	Dividend Payouts	Total Payouts	Payout Structure	Repurchase Payouts	Dividend Payouts	Total Payouts	Payout Structure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment×Post	-0.183***	-0.00479	-0.187***	-0.146***	-0.0249	-0.0240	-0.0489	-0.0427
	(-3.46)	(-0.24)	(-3.19)	(-3.10)	(-0.46)	(-1.42)	(-0.90)	(-0.93)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	8546	8546	8546	8546	10314	10314	10314	10314
R^2	0.441	0.821	0.520	0.466	0.363	0.734	0.482	0.373

Panel C: Regression Results for Market Liquidity Variables

	Tick-Constrained Sample			Tick-Unconstrained Sample		
	Percentage Quoted Spread	Total Share Turnover	Market Depth	Percentage Quoted Spread	Total Share Turnover	Market Depth
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment×Post	0.316***	-0.144***	12.90***	0.0131	-0.0292	4.652***
	(11.98)	(-3.41)	(18.15)	(0.34)	(-1.04)	(9.30)
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	8522	8522	8522	10299	10284	10299
R^2	0.756	0.587	0.611	0.851	0.600	0.702

Panel D: Results for Partitioning Samples Based on Increase in Bid-Side Depth

	Dependent Variable: Repurchase Payouts	
	Small Increase in Bid-Side Depth	Large Increase in Bid-Side Depth
	(1)	(2)
Treatment×Post	-0.115*	-0.264***
	(-1.77)	(-3.21)
Controls	Yes	Yes
Firm FE	Yes	Yes
Year-quarter FE	Yes	Yes
Cluster by firm	Yes	Yes
N	4303	4243
R^2	0.438	0.443
p-value (Small=Large)	< 0.01	

Table 3
The Dark Pool Channel

In this table we report the regression results for *repurchase payouts* by comparing firms in test groups 1 and 2 with firms in test group 3. The tick-constrained sample includes a firm if its average dollar-quoted spread for the quarter prior to the Pilot implementation (2016 Q3) is below 5 cents, while other firms are in the unconstrained sample. 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 shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The *p*-values reported in the last row are estimated based on the null hypothesis that the coefficients are equal for the two groups under consideration, using the bootstrap method (Efron and Tibshirani, 1994).

Dependent Variable: Repurchase Payouts				
	Test Groups 1 and 2		Test Group 3	
	Tick-Constrained	Tick-Unconstrained	Tick-Constrained	Tick-Unconstrained
	(1)	(2)	(3)	(4)
Treatment×Post	-0.139**	-0.0191	-0.258***	-0.0449
	(-2.18)	(-0.31)	(-2.68)	(-0.48)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes
N	6107	7006	2433	3329
R^2	0.449	0.363	0.414	0.368
p-value (test groups 1&2= test group 3, tick-constrained samples): < 0.01				

Table 4
Tick Size Pilot Program: Additional Analyses

In this table we report the results of additional analyses of the Tick Size Pilot Program. The sample includes tick-constrained firms. In columns (1) and (2) we report the results of the reversal and placebo tests, respectively. In the reversal test, we define the post-treatment period as 2018 Q4–2019 Q3 and the pre-treatment period as 2017 Q4–2018 Q3. In the placebo test, we define the post-treatment period as 2014 Q4–2016 Q3 and the pre-treatment period as 2012 Q4–2014 Q3. In columns (3) and (4) we report results of tests of sensitivity to firm size by equally partitioning the sample based on pre-treatment total assets. In column (5) we report the DID regression results on a *repurchase dummy*. In column (6) we report the DID regression results for *tender offer*. *Controls* 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 shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent Variable: Repurchase Payouts				Repurchase Dummy	Tender offer
	Reversal and Placebo Tests		Result Sensitivity on Firm Size			
	Reversal Test	Placebo Test	Small Firms	Large Firms		
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment×Post	0.122**	0.0560	-0.155**	-0.220***	0.0171	0.00350
	(2.05)	(0.88)	(2.36)	(2.75)	(0.74)	(1.00)
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	4028	7593	4288	4258	8546	8546
R^2	0.538	0.369	0.472	0.412	0.600	0.064

Table 5

Event Studies: Historical Market Structure Reforms and Payout Policies

This table reports the results of event studies designed to test the effects of historical market structure reforms. In the event study for the 1994 NASDAQ Manning Rule, *Treatment* equals one if a firm is listed on NASDAQ and zero if it is a matched firm listed on one of the other U.S. exchanges, while *Post* equals one if an observation is in 1995 and zero if it is in 1993. In the event study for the 1997 Order Handing Rule, *Treatment* equals one if a firm is listed on NASDAQ and zero if it is a matched firm listed on another U.S. exchange, while *Post* equals one if an observation is in 1998 and zero if it is in 1996. In the event study for the 1997 tick size reduction, *Treatment* equals one if a firm experiences an above-median decrease in the spread and zero otherwise, while *Post* equals one if an observation is in 1998 and zero if it is in 1996. In the event study for the 2001 decimalization, *Treatment* equals one if a firm experiences an above-median decrease in the spread and zero otherwise, while *Post* equals one if an observation is in 2002 and zero if it is in 2000. In the event study for the 2003 implementation of automated quotes on the NYSE, *Treatment* equals one if a firm is listed on the NYSE and zero if it is a matched firm listed on another U.S. exchange, while *Post* equals one if an observation is in 2004 and zero if it is in 2002. We use matched control samples by matching control firms to treatment firms based on pre-treatment average repurchase payouts, dividend payouts, size, profitability, and growth opportunity. *Control variables* include size, profitability, and growth opportunity (Fama and French 2001) as well as managerial stock holdings (Brown, Liang, and Weisbenner 2007) and managerial options holdings (Fenn and Liang 2001); exercised and exercisable options (Kahle 2002); the relative tax advantage of share repurchases measured as the difference between the dividend tax and the capital gains tax (Chetty and Saez 2005); the financial flexibility advantage of share repurchases (Jagannathan, Stephens, and Weisbach 2000) proxied by cash-flow volatility (the standard deviation of profitability in the past five years) and non-operating cash flow (scaled by lagged total assets); and valuation-based explanations such as market timing (Dittmar and Field 2015) proxied by future three-year market-adjusted returns. 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 shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Repurchase Payouts	Dividend Payouts	Total Payouts	Payout Structure	Repurchase Dummy	Tender Offer
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 1994 NASDAQ Manning Rule						
Treatment×Post	0.419***	-0.00752	0.412***	0.341***	0.0440**	0.0627
	(3.24)	(-0.21)	(3.01)	(3.28)	(2.03)	(1.28)

Panel B: 1997 Order Handling Rule						
Treatment×Post	0.437**	0.0404	0.477**	0.359**	0.00189	0.0358
	(2.33)	(1.14)	(2.51)	(2.27)	(0.09)	(0.67)
Panel C: 1997 Tick Size Reduction						
Treatment×Post	0.578**	-0.0228	0.555**	0.576***	0.0516*	0.124
	(2.31)	(-0.64)	(2.19)	(2.76)	(1.83)	(1.08)
Panel D: 2001 Decimalization						
Treatment×Post	0.554***	-0.0528	0.501***	0.552***	-0.0249	0.0453
	(3.37)	(-1.30)	(2.96)	(3.98)	(-1.10)	(0.68)
Panel E: 2003 NYSE Auto Quote						
Treatment×Post	0.413**	0.0837	0.496**	0.179	0.0237	0.152
	(1.96)	(1.26)	(2.24)	(0.82)	(0.93)	(1.58)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes	Yes

Appendix Table A.1

Pre-treatment Summary Statistics: Event Studies on Historical Market Structure Reforms

In this table we present pre-treatment summary statistics and the mean differences for the treatment group and the matched control group for the event studies of historical market structure reforms. All variables are winsorized at the 1% and 99% levels.

	Panel A: 1994 Manning Rule				Panel B: 1997 Order Handling Rule			
	Treatment	Control	*t*-test		Treatment	Control	*t*-test	
	Mean	Mean	*Diff*	*p-value*	Mean	Mean	*Diff*	*p-value*
Repurchase payouts	0.605	0.544	0.061	0.543	1.040	0.973	0.067	0.612
Dividend payouts	0.631	0.622	0.009	0.892	0.499	0.492	0.007	0.906
Total payouts	1.237	1.166	0.071	0.578	1.540	1.465	0.075	0.622
Payout structure	1.318	1.280	0.038	0.648	1.666	1.617	0.049	0.651

	Panel C: 1997 Tick Size Reduction				Panel D: 2001 Decimalization			
	Treatment	Control	*t*-test		Treatment	Control	*t*-test	
	Mean	Mean	*Diff*	*p-value*	Mean	Mean	*Diff*	*p-value*
Repurchase payouts	0.849	0.784	0.065	0.646	1.744	1.656	0.088	0.531
Dividend payouts	0.472	0.438	0.034	0.567	0.631	0.602	0.029	0.568
Total payouts	1.321	1.222	0.098	0.535	2.375	2.259	0.117	0.443
Payout structure	1.478	1.483	-0.005	0.972	2.108	2.126	-0.017	0.886

Panel E: 2003 NYSE Auto Quote

	Treatment	Control	*t*-test	
	Mean	Mean	*Diff*	*p-value*
Repurchase payouts	1.716	1.559	0.157	0.437
Dividend payouts	1.075	0.983	0.092	0.234
Total payouts	2.792	2.543	0.249	0.261
Payout structure	1.929	1.929	0.000	0.999