Market Structure and Corporate Payout Policy

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Abstract

Market structure friction has first-order effects on corporate payouts. The 1994 NASDAQ Manning Rule, the 1997 tick size reduction, the 2001 decimalization, and the jumpstart of NYSE algorithmic trading in 2003 dramatically increased share repurchases, whereas the 2016 Tick Size Pilot, which partially reversed these reforms, significantly reduced share repurchases. Our results provide the first unified interpretation that helps to resolve two puzzles in the payout literature. The dividend puzzle exists because previous research has overlooked the microstructure cost of executing share repurchases. Buybacks increase relative to dividends over time because market structure reforms gradually reduce the cost of repurchases.

Keywords: Market Microstructure, Share Repurchase, Queuing, Dark Pool, Regulation

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Miller and Modigliani (1961) find that the level of corporate payouts does not matter for firms and investors, nor does it matter whether payouts are executed through dividends or share repurchases. The irrelevance of the payout structure raises two fundamental puzzles. The first is the dividend puzzle, which raises the question why firms pay dividends at all, because the tax rate for repurchases is lower (Black 1976; DeAngelo, DeAngelo, and Skinner 2009). The second involves the secular increase in share repurchases relative to dividend payouts, which raises the question why share repurchasing has continued to increase at a higher rate than dividend payouts over recent decades (Farre-Mensa, Michaely, and Schmalz 2014). In this paper, we show that market-structure frictions provide a unified interpretation for both puzzles. Innovations in market structure have gradually reduced frictions that occur when firms buy back their shares, which explains why share repurchases gradually dominate dividend payouts. These frictions, however, have always existed, and they were surprisingly high decades ago, which explains why share repurchases never completely replace dividends.

Firms face two frictions when they buy back shares. The first friction is liquidity, because issuers and their investors need to pay the transaction costs of share repurchases. The second friction is compliance, because SEC rule 10b-18 imposes constraints on when and how firms can buy back their shares. For example, firms should buy their shares at prices that do not exceed the highest independent bids or last transaction prices, because rule 10b-18 was designed to prevent firms from inflating their share prices by aggressively demanding liquidity at ask prices. This regulatory friction can be surprisingly strong under certain market structures. For example, rule 10b-18 makes it impossible to buy back shares in the pure dealer market modeled by Ho and Stoll (1981) and Glosten and Milgrom (1985). It is impossible to buy back a share at the bid price, because buy orders always occur at the ask price; it is impossible to buy at a price that is equal to or less than the most recent transaction price, because buy orders tend to push prices up.

Almost all market-structure reforms since the 1990s have been designed to reduce the privilege of traditional market makers such as dealers, and these reforms have allowed issuers to submit limit orders at bid prices to compete with market makers, or to execute orders without the intermediation of market makers. Prior to the implementation of the Manning Rule in 1994, NASDAQ dealers were granted priority over their customers at the same price. If a dealer and an issuer both quoted a bid price of 100, an incoming seller order would execute the dealer's quote. The issuer's quote was entitled to execution only when the market ask price dropped to 100 (essentially making the customer order marketable). Therefore, the NASDAQ market was, before 1994, technically a dealer market even though issuers and other traders could submit limit orders at the bid price. The dealer's execution priority increases costs to issuers and, to make things worse, issuers violate rule 10b-18 if they buy at ask prices. The Manning Rule prohibits dealers from trading ahead of their customers at the same price, and begins transiting the NASDAQ market into a limit-order book, where issuers can compete with dealers and other traders at the bid price. For issuers, the chances of winning the competition depend on more detailed designs of the limit-order book market. For example, the tick size was $1/8 before 1997, and $1/16 between 1997 and the 2001 decimalization. These larger tick sizes created rents for providing liquidity, attracted liquidity providers seeking to profit from the bid–ask spread, led to a longer queue to provide liquidity, and could crowd out limit orders from issuers. Therefore, a small tick size along with a small market depth benefits issuers. Finally, issuers also benefit from the proliferation of alternative trading systems such as dark pools, because these platforms enable issuers to match their orders passively at bid prices. In limit-order-book markets, professional liquidity providers can still execute before issuers through time priority, if professional liquidity providers can post limit orders faster than issuers. In dark pools, even speed cannot guarantee execution priority for professional liquidity providers.

We hypothesize that these market-structure changes, which reduce market structure frictions for issuers, provide one interpretation of the secular increase in share repurchases relative to dividend payouts. We test these hypotheses in two steps. First, to rule out confounding effects involving the market-structure channel, we begin our analysis using a unique controlled experiment, which was designed to partially reverse market structure changes that took place over recent decades. The strength of the controlled experiment is that it randomly selected treatment and control groups.

Next, we conduct event studies of market-structure changes in 1990s and 2000s by comparing changes in share repurchases between quasi-treatment and quasi-control groups.

In October 2016, the Securities and Exchange Commission (SEC) included 2,399 stocks in a Tick Size Pilot Program. The SEC randomly selected 1,200 of these stocks as treated stocks and increased their tick size from 1 cent to 5 cents, whereas the tick sizes of the remaining 1,199 control stocks remained at 1 cent. The SEC also imposed an additional trade-at rule, which restricts dark pool trading for 400 treated stocks. We find that the Tick Size Pilot increases the bid–ask spread and depth for tick-constrained treated firms (firms with pre-Pilot quoted spreads of less than 5 cents), and these firms reduce repurchase payouts by 45% relative to the control group. The drop in share repurchases is concentrated in firms with larger increases in bid-side depth: firms that experience above-median increases in bid-side depth reduce share repurchases by 56%, whereas firms that experience below-median increases in bid-side depth reduce share repurchase by only 32%. In comparison, the effects do not differ between firms with large and small increases in offer-side depth. Therefore, an increase in the bid-side queue that quotes the same price reduces share repurchases.

To promote market transparency, the SEC imposed the trade-at rule on 400 stocks in test group 3. The trade-at rule prevents the execution of orders in dark pools unless those orders substantially improve the Natinal Best Bid and Offer (NBBO). We find that tick-constrained firms in test group 3 reduce share repurchases by 55%, a much larger reduction than the reduction of 36% observed in tick-constrained firms in test groups 1 and 2. The 19% difference indicates the importance of dark pools for corporate repurchases. Indeed, firms can avoid queues in the stock exchange by using dark pools, which usually do not follow price–time priority in execution. One unintended consequence of the trade-at rule is that it conflicts with SEC rule 10b-18. The trade-at rule requires dark pools to execute buy orders at higher prices than the national best bid to encourage market transparency, whereas SEC rule 10b-18 discourages this practice to prevent price manipulation. The 19% difference between test group 3 and test groups 1 and 2 indicates that dark pools matter for corporate repurchases.

In the Tick Size Pilot, longer queues harm issuers because they may not win time priority over professional liquidity providers such as high-frequency traders (HFTs). [1] Interestingly, our conversation with HFTs reveals that, even if an issuer hires an HFT as its broker, the share buyback algorithm still cannot win time priority because a buyback algorithm needs to check the compliance with SEC rule 10b-18, and this additional step increases the latency. The main economic intuition arising from the controlled experiment, however, is that the priority rule matters for share buybacks, not that HFTs harms share buybacks, because market makers decades ago enjoyed much greater priority than HFTs do today. Prior to 1994, a NASDAQ dealer could trade ahead of its customers even if those customers submitted an order earlier (Hasbrouck, 2007). The 1994 Manning Rule prohibits dealers from trading before their customers at the same price, which makes it easier for issuers to execute their limit orders at the bid. As this rule applies only to NASDAQ stocks, non-NASDAQ stocks serve as a natural control group. We find that, in the one-year window around the Manning Rule, share repurchases of NASDAQ stocks increase by 69%, whereas share repurchases for non-NASDAQ stocks barely change.

In 2018, the SEC terminated the Tick Size Pilot, and we find that in this setting the treatment firms increase share repurchases by 45% relative to the control firms after the Pilot ends. Therefore, a reduction in the tick size increases share repurchases. We reconfirm these results for the tick size reductions of 1997 and 2001, for which we assign stocks with above-median decreases in quoted spreads into the treatment group and stocks with small decreases in quoted spreads into the control group (Fang, Tian, and Tice 2014). Around the tick size reduction from 1/8 of a tick to 1/16 of a tick in 1997, treatment firms increase their share repurchases by 68% more than control firm. The number is 32% for the decimalization in 2001.

To the best of our knowledge, our paper is the first to establish the costs of share repurchases. These costs provide one explanation why share repurchases cannot completely replace dividends,

[1] The SEC (2018, p. 18) reports that "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."

which is known as the dividend puzzle (Black 1976). Existing explanations of the dividend puzzle focus exclusively on the benefits of dividends, such as their disciplinary role (Easterbrook 1984), their information content (Bhattacharya 1979), and institutional investors' preferences for them (Grinstein and Michaely 2005). These interpretations, however, fail to explain why share repurchases consistently increase over time relative to dividend payouts. According to Farre-Mensa, Michaely, and Schmalz (2014), none of the traditional theories, such as signaling theory (Grullon and Michaely 2004) or agency conflicts (Jensen 1986), can explain the secular change in share repurchases. Market timing (Dittmar and Field 2015) and catering (Baker and Wurgler 2004a, 2004b) also fail to explain this secular increase, unless we assume an increase in equity undervaluation or a preference for repurchases over time. The failure of these traditional channels motivates researchers to find alternative mechanisms for the benefits of share repurchases, 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). All these mechanisms fail, however, to explain why dividend payouts exist. The market structure costs of share repurchases provide a unified interpretation of these two important puzzles. We argue that the transaction and compliance costs of share repurchases can explain why share repurchases cannot completely crowd out dividend payouts. Innovations in market structure, which reduce transaction and compliance costs, can explain the secular increase in share repurchases relative to dividends.

The cost of share repurchases indicates that the literature on relative tax advantages overestimates the benefits of share repurchases. This insight provides one explanation why tax differences have only a second-order impact on corporate payouts (Farre-Mensa, Michaely, and Schmalz 2014). The biggest puzzle in this literature is documented by Chetty and Saez (2005), who find that share repurchases increased more than dividend payouts following the dividend tax cut of 2003. Their finding is very surprising, because a reduction in dividend tax should increase dividend payouts relative to share repurchases. Chetty and Saez (2006) suggest that understanding the microeconomic foundations of the costs of share repurchases is of great importance for future work. Our paper fills this gap by showing the first-order effects of market-structure frictions on share repurchases. Just as the dividend tax cut can reduce the cost of dividend payouts, the reduction in market structure frictions can reduce the cost of repurchase payouts. Before 2003, specialists at the New York Stock Exchange (NYSE) manually disseminated inside quotes. NYSE firms needed to hire floor brokers to execute their orders manually, using their judgment and discretion to make small purchases here and there. Manual (high-touch) execution of share repurchases is not only costly, it also makes it hard to achieve compliance with SEC rules. In 2003, the NYSE installed auto quotes, making it possible to use computer algorithms to execute (low-touch) share repurchases automatically (Hendershott, Jones, and Menkveld 2011). Firms listed on other exchanges formed a natural control group because they did not experience this autoquote update. For example, NASDAQ stocks had moved to electronic trading well before 2003 through the proliferation of electronic communication networks (ECNs) (Barclay, Hendershott, and McCormick, 2003). We find that NYSE firms increased their share repurchases by 24% relative to non-NYSE firms around 2003, whereas both groups of firms had similar changes in dividend payouts.

Our paper makes two contributions to the market microstructure literature. First, our study is the first to establish the causal impact of market liquidity 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. Our paper not only provides rigorous empirical evidence to support this claim but also shows that market liquidity can have first-order effects. Second, most previous research focuses on liquidity in general, whereas our results posit two new dimensions: “liquidity-for-whom” and “liquidity-from-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 types of traders. For example, previous studies have assumed that greater depth means higher liquidity (Goldstein and Kavajecz 2000). This is generally true for traders who demand liquidity. But we find that when regulations force repurchasing traders to supply liquidity using limit orders, greater depth can impose tighter constraints because longer queues reduce the execution probability for their orders. Regarding liquidity-from-where, our results indicate that liquidity across all markets, and its distribution across different types of platforms, is more important than liquidity provided on one platform. Brogaard and Pan (2019) and Ye and Zhu (2020) find evidence that informed traders use dark pools. In our paper, we find that dark pools, which do not impose price–time priority in execution, provide an alternative trading mechanism and alleviate liquidity constraints on stock exchanges for repurchasing traders.

I. The Controlled Experiment

A. Data Description

In 2012, The Jumpstart Our Business Startups Act ("JOBS Act") directed the SEC to study whether reductions in US stock tick sizes in the late 1990s could be driving the decline in the number of initial public offerings (IPOs). In 2014, the SEC ordered national securities exchanges and the Financial Industry Regulatory Authority (FINRA) to develop a pilot program. On May 6, 2015, the SEC issued an order approving the National Market System (NMS) plan by exchanges and the FINRA (the participants) to implement the Tick Size Pilot Program beginning on October 3, 2016, for a two-year period (SEC 2016). The Program included 2,399 stocks, comprising all Reg NMS securities that satisfied the following criteria during the measurement period (a three-month period prior to Program implementation): having a share 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, a market capitalization below $3 billion, and a closing price above $2 on the last day of the measurement period. The participants divided these stocks 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. Stocks were then drawn randomly to form three test groups from each category, so that each test group contained 400 stocks. The remaining 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 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 improve the price by at least 2.5 cents, with certain exceptions (SEC 2015). The trade-at rule prevented dark pools from executing orders by matching the NBBO. The Tick Size Pilot Program was set to end on October 1, 2018.

We obtained our lists of test and control group stocks from the FINRA's website. We obtained corporate payouts and other financial data from Compustat's North America Fundamentals Quarterly files. We calculate spread and depth measures based on Daily TAQ (DTAQ) data.

Starting with the Pilot securities with non-missing information in the Compustat Database, the DTAQ Database, and the ATS Database, we construct our sample as follows. Following Rindi and Werner (2019) and Albuquerque, Song, and Yao (2019), we keep common stocks (CRSP share codes 10 or 11) and exclude stocks that were eliminated before the end of the Tick Size Pilot. Following the payout literature (DeAngelo, DeAngelo, and Skinner 2009; Farre-Mensa, Michaely, and Schmalz 2014), we exclude regulated utility and financial firms (SIC codes 4200-4299, 6000-6999). Our final sample contains 602 stocks in the treatment group and 654 stocks in the control group.

We list our variable definitions in Appendix Table A.I. Specifically, our variables include repurchase payouts equal to total expenditures in common stock repurchases in the current quarter divided by total asset value in the previous quarter, and dividend payouts equal to common stock dividends in the current quarter divided by lagged assets in the previous quarter (both in percentages). Payout structure is defined as (repurchase payouts +1) / (dividend payouts +1). We add 1 to both the repurchase payouts ratio and the dividend payouts ratio because the latter often equals zero (Fama and French 2001).

Our difference-in-differences (DID) tests follow equation (1),

$$y_{i,t} = \eta_i + \lambda_t + \beta \times \ Treatment_i \times Post_t + \zeta' \times X_{i,t} + \varepsilon_{i,t}, \tag{1}$$

where *i* indexes the firm, *t* indexes time, $y_{i,t}$ is the dependent variable. η_i are firm fixed effects, which capture time-invariant heterogeneity across firms, and λ_t are year-quarter fixed effects, which capture time-varying shocks. $Post_t$ 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 a firm is in the treatment group and zero if it is in the control group. We specify the definitions of $Treatment_i$ and $Post_t$ in detail for each test. $X_{i,t}$ are control variables. $\varepsilon_{i,t}$ is an error term. The main coefficient of interest is β, which estimates the average effects of *Treatment* on y. 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.

B. The Effects of the Tick Size Pilot on Corporate Payouts

In Table I we report the effects of the Tick Size Pilot on the corporate payout policy variables. In Panel A we report the summary statistics and the results of mean difference tests before and after implementation of the Tick Size Pilot Program for the treatment group. Treatment firms experience a significant 36% reduction (0.155/0.430) in repurchase payouts and insignificant changes in dividend payouts. They reduce total payouts and the payout structure leans more toward dividend payouts than repurchases. In Panel B we report the difference-in-differences results following Equation (1), where $Treatment_i$ equals one if a stock is in the treatment group of the Tick Size Pilot and $Treatment_i$ equals zero if the stock is in the control group. $Post_t$ 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).

The results reported in column (1) show that corporate repurchase payouts decrease by 0.092%, which represents a 21% decline compared with pre-shock average repurchase payouts 0.43%. The results reported in column (2) show that corporate dividend payouts do not change significantly. Therefore, treatment firms reduce repurchase payouts but do not substitute for them with dividend payouts. As the Pilot lasts only for two years, the results are consistent with the dividend-smoothing motive (Leary and Michaely 2011, Michaely and Roberts 2012). The results reported in column (3) show that the aggregate effect on total payouts is -0.097%, which represents a 17% decline compared with the pre-shock average level of 0.67%. The results reported in column (4) show that the payout structure of the treatment group decreases by 0.083. For these firms, the average payout structure ratio was 1.25 before the Pilot. Following the implementation of the Pilot Program, the payout structure ratio decreases to 1.17.

Insert Table I about Here

To account for sensitivity differences, we partition the firms in each group into tick-constrained and unconstrained samples based on their average dollar-quoted spreads during one quarter before the Pilot (2016 Q3). Tick-constrained firms in the treatment group have pre-Pilot quoted spreads lower than 5 cents, we define other firms as unconstrained firms. Tick-constrained firms' market liquidities are affected more heavily than those of unconstrained firms. Because the firms are partitioned into tick-constrained and unconstrained subsamples, we created a matched sample from the control group based on average repurchase payouts, dividend payouts, and the three control variables (size, profitability, and growth opportunity) in the pre-treatment period to minimize the impacts of observable pre-treatment differences of corporate payout variables between treatment and control firms.[2] In Table II Panel A we report summary statistics and the results of *t*-tests to calculate the mean differences for our main variables in the pre-treatment period between the treatment and control groups. The *t*-test results show that most differences between matching variables are not statistically significant.

In Table II Panel B, columns (1)–(4) show the results for tick-constrained firms, while columns (5)–(8) show the results for tick-unconstrained firms. The effects of the Tick Size Pilot are

[2] 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. We use matching with replacement, following the suggestion in Roberts and Whited (2013) that matching with replacement is preferred for proper identification in empirical corporate finance studies. This method makes better matches possible and reduces estimation bias at the cost of greater variance (Abadie et al. 2004).

concentrated in tick-constrained firms. For example, tick-constrained firms show statistically significant reductions in their repurchase payouts of 0.18%, which represents a 45% decline from the average pre-treatment level of 0.41%. Consistent with the presence of dividend-smoothing motives, these firms do not experience significant changes in dividend payouts. Their total payouts decline 31% compared to the average pre-treatment total payouts, and their payout structure moves from a repurchase-dominated structure towards a half-and-half balance between repurchase payouts and dividend payouts. Therefore, firms reduce their share repurchases to a greater exent if the Tick Size Pilot imposes tighter constraints on their bid–ask spreads. In comparison, tick-unconstrained firms do not significantly change their payouts. In untabulated results, we find that firms do not switch to alternative repurchase methods such as self-tender offers or accelerated share repurchases (ASRs), a finding that is consistent with the notion that the alternative repurchase methods are more costly, less flexible, and thus much less popular compared with open-market share repurchases (Anderson and Dyl 2004; Bargeron, Kulchania, and Thomas 2011).

Insert Table II about Here

C. The Queuing Channel

In subsections C and D, we examine the underlying channels that might explain the dramatic reduction in share repurchases we observed around the Tick Size Pilot Program. We first examine the impacts of the Tick Size Pilot on stock market liquidity, measured by percent quoted spread, market depth, and total share turnover. The results reported in Table III Panel A show that, for tick-constrained firms in the treatment group, percent quoted spreads increase significantly, by 41% over the pre-treatment mean (0.32/0.77); total share turnover decreases by 16% compared with the pre-treatment mean (0.14/0.92).[3] Market depth increases by 214% compared with the pre-treatment mean (12.90/6.01). There is less change in stock market liquidity for unconstrained

[3] The SEC rule 10b-18 volume condition prohibits firms from purchasing more than 25% of the preceding four-week average daily volume. Another potential channel for explaining the share repurchase reduction is that the volume condition becomes more binding after the 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.

firms in the treatment group compared with the change for the constrained firms, a finding that is consistent with the insignificant changes observed in their share repurchases.

The change in liquidity alone, however, is unlikely to justify a 45% reduction in share repurchases. First, the 41% increase in the bid–ask spread is equivalent to only about a 2 cent increase in the nominal bid–ask spread. Also, the Tick Size Pilot significantly increases market depth for tick-constrained firms in the test groups. If firms demand liquidity using market orders when they repurchase shares, a 214% increase in market depth, particularly on the offer side, should dilute a relatively small increase in the bid–ask spread. Surprisingly, the results reported in Table III Panel B show no difference in the reduction in share repurchases between firms experiencing an above-median increase in offer-side depth and firms experiencing a below-median increase in offer-side depth. More surprisingly, firms experiencing an above-median increase in bid-side depth reduce share repurchases to an even greater extent. Firms experiencing an above-median increase in depth on the bid side reduce share repurchases by 56% (0.264%/0.469%), whereas firms experiencing a below-median increase in depth on the bid side reduce share repurchase by only 32% (0.115%/0.357%). Moreover, the *t*-test shows that the difference is statistically significant, with a p-value<0.01.

The cost of compliance with SEC rules that apply to repurchases provides one interpretation for this surprising result. The SEC's safe harbor rule 10b-18 protects corporations against stock-price manipulation charges as long as their repurchasing activities comply with four conditions. One of the conditions is based on price: a repurchase price should not exceed the greater between the highest bid and the last sale price. Therefore, depth on the offer side does not matter because rule 10b-18 discourages buy market orders that demand liquidity from the offer side. Depth on the bid side harms issuers, because issuers need to compete with other liquidity providers on the bid side.[4] As firms and their brokers cannot trade as quickly as HFTs (SEC 2018), longer queues harm issuers because they may not win time priority over professional liquidity providers such as HFTs.

[4] Another possible strategy for complying with the price condition would involve placing orders at the bid price, followed by purchasing at the offer price only after another participant pays the offer price. This strategy, however, creates patterns that can be easily identified by HFTs and increases issuers' overall execution costs (IEX 2018).

Insert Table III about Here

D. The Dark Pool Channel

One way for issuers to jump ahead in a queue is to use dark pools, because these alternative systems often do not enforce time priority. We find that dark pools have a significant impact on share repurchases. The results reported in Table IV show that tick-constrained firms in test group 3 reduce share repurchases by 0.26%, whereas tick-constrained firms in groups 1 and 2 reduce their share repurchases only by 0.14%. The difference is both economically significant (a 55% reduction in share repurchases in test group 3 compared with a 36% reduction in test groups 1 and 2) and is statistically significant (p-value<0.01).

Insert Table IV about Here

The very large reductions in share repurchases in test group 3 when compared with those in the other groups implies two necessary conditions. First, firms use dark pools extensively for share repurchases. Second, the trade-at rule significantly reduces the ability to repurchase shares in the dark pool. The question then arises, why does the 2.5 cent price improvement in the dark pool lead to a 19% reduction in share repurchases? The conflict between the trade-at rule and SEC rule 10b-18 provides an answer to this puzzle. SEC rule 10b-18 discourages firms from buying shares at prices above independent bids. Without the trade-at rule, dark pools can passively match orders using independent bids, and issuers or their brokers can avoid competing on time priority with HFTs in stock exchanges. Consistent with our interpretation, the SEC (2018) shows that liquidity providers respond to a wider tick size in exchanges by switching trades to dark pools to gain a better position to buy stocks in firms in test groups 1 and 2, and the behavior is most pronounced with tick-constrained stocks. The trade-at rule requires dark pools to match orders at a price that is 2.5 cents above the independent bid,[5] which conflicts with the rule 10b-18 requirement. Therefore, conflicts between new regulations and old regulations can generate unintended consequences for corporations.

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

E. Internal Validity Tests

We consider alternative explanations of our findings in this subsection. Farre-Mensa, Michaely, and Schmalz (2014) point out that signaling and agency conflicts cannot explain the ratio of share repurchases to dividend payouts. The catering (Baker and Wurgler 2004a, 2004b) and tax channels (Chetty and Saez 2006) cannot explain the differences in results between the test and control groups.

Firms may time the market, repurchasing more shares when their stocks are undervalued while repurchasing fewer shares when their stocks are overvalued (Dittmar and Field 2015). Thomas, Zhang, and Zhu (2019) find that the Tick Size Pilot does not affect firms' mispricing. Albuquerque, Song, and Yao (2019) show that the Tick Size Pilot reduces share prices for firms in the treatment group, which provides firms with incentives to repurchase more shares. Therefore, the price change also cannot explain why share repurchases decrease after the implementation of the Tick Size Pilot.

We test whether our results are robust after controlling for two remaining channels: managerial stock holdings, managerial option holdings, and offsetting EPS dilution. Managers who own more stock shares in their companies may favor repurchase payouts over dividend payouts because of the relative tax advantage share repurchases provide (Brown, Liang, and Weisbenner 2007); managerial option holdings also create incentives to repurchase shares rather than paying dividends, as dividend payouts reduce per-share value (Fenn and Liang 2001). Firms may engage in share repurchases to manage EPS, thereby mitigating the dilutive effects of stock-option exercises (Kahle 2002; Hribar, Jenkins, Johnson 2006). We obtain annual managerial stock-holdings data and option-holdings data from the Compustat Execucomp database and exercised and exercisable options data from Compustat. In Table V, we report the results of DID tests for repurchase payouts using annual data to control for these alternative explanatory variables. The results reported in column (1) show a -0.74% decrease in repurchase payouts after controlling for managerial stock holdings and option holdings. Therefore, our results are robust after controlling for the manager bonus incentive. We run the DID tests while controlling for exercisable options and exercised options using annual data and report the results in column (2). We find that the results remain robust, ruling out the EPS dilution explanation. Finally, as seen in column (3), our results hold when we control simultaneously for managerial stock holdings, managerial option holdings, exercised options, and exercisable options.

Insert Table V about Here

F. Additional Tests: Reversal, Placebo, and Result Sensitivity to Firm Size

We test the reversal effects following the end of the Tick Size Pilot using the four quarters following the Pilot's end (2018 Q4 and 2019 Q3) as the post-Pilot-end period and the four quarters before the Pilot's end (2017 Q4 and 2018 Q3) as the pre-Pilot-end period and conduct DID tests for the treatment group and the control group. We report the results in column (1) of Table VI. We find that tick-constrained firms increase their repurchases by 45% during the post-Pilot-end period compared with the before-Pilot-end period (0.122/0.271). We then conduct placebo tests using two years before the Pilot implementation as a placebo shock, and our results reported in column (2) of Table VI show no significant changes in repurchases.

One limitation of the controlled experiment is that it involves only medium and small stocks. To see whether our results are sensitive to firm size, we split the sample equally based on pre-treatment firm size, measured as total assets (Yagan 2015). The results reported in Table VI, columns (3) and (4) show that, for smaller firms, the change in repurchases represents a 46.3% reduction compared with the average pre-treatment repurchase level (0.155%/0.335%). For larger firms, the change in repurchases represents a 44.9% reduction compared with the average pre-treatment repurchase level (0.220%/0.490%). Both reductions are statistically significant. Therefore, market-structure frictions do not concentrate in the smallest firms. This result ensures that the economic mechanism revealed by the controlled experiment can be applied to a broader sample, and we explore such economic mechanisms in the next section, using a broader sample of stocks and time periods.

Insert Table VI about Here

II. Historical Market Structure Changes and Corporate Payout Policy

In this section, we show that the economic mechanism identified in the controlled experiment extends to a broader sample of stocks and periods. Our event studies around market structure changes in the 1990s and 2000s show that a reduction in market-structure frictions for issuers serves as one explanation of the secular increase in share repurchases relative to dividend payouts. In Section II.A, we find that the Manning Rule, which reduces the execution priority of NASDAQ dealers relative to that of other traders, including issuers, increases share repurchases of NASDAQ firms by 69% relative to non-NASDAQ firms. In Section II.B, we show that reductions in the tick size in 1997 and 2001 increase share repurchases by 68% and 32%, respectively. In Section II.C, we show that share repurchases by NYSE firms increase by 33% relative to repurchases by non-NYSE firms after the NYSE jumpstarted algorithmic trading in 2003. In all these tests, we use the same filter as we used with the Tick Size Pilot and follow the DID test using equation (1).[6] To ensure that treatment and control firms are similar ex ante, we create control samples by matching control firms to treated firms based on average repurchase payouts, dividend payouts, size, profitability, and growth opportunity in the pre-treatment period. Appendix Table A.I shows the pre-treatment summary statistics for the treatment and control samples in the four tests and suggests that treated firms and control firms are similar before the shocks.

A. 1994 NASDAQ Manning Rule

In the Tick Size Pilot, longer queues harm issuers because they may not win time priority over HFTs. Before the implementation of the Manning Rule, however, NASDAQ dealers enjoyed much more favorable execution priorities than HFTs do today. Before 1994, NASDAQ dealers could

[6] In addition to size, profitability, and growth opportunity (the market-to-book ratio), we also control for other explanatory variables in the literature: managerial stock holdings (Brown, Liang, and Weisbenner 2007), managerial options holdings (Fenn and Liang 2001); exercised options and exercisable options (Kahle 2002); the relative tax advantage of share repurchases measured as the difference between the dividend tax and the capital gain tax (Chetty and Saez 2006); cash-flow volatility (measured as the standard deviation of profitability in the past five years), and non-operating cash flow (scaled by lagged total assets, to control for the financial flexibility advantage that share repurchases generate) (Jagannathan, Stephens, and Weisbach 2000); we also include future three-year market-adjusted returns to control for market timing (Dittmar and Field 2015).

always trade ahead of their customers at the same price, even if their customers submitted the quotes earlier. Suppose that a dealer and an issuer both quote a bid price of 100; the issuer's quote is then entitled to execution only when the ask price decreases to 100, making the issuer's limit order marketable. Buying at the ask price, however, not only increases the transaction costs to the issuer but also violates SEC rule 10b-18. The Manning Rule, approved by the SEC on June 29, 1994, prohibits dealers from trading at their customers at the same price.[7] Along with the adoption of odd-eighth quotes for NASDAQ market makers (Christie and Schultz 1994; Christie, Harris, and Schultz 1994), the Manning Rule dramatically reduced the dealers' execution priority and reduced friction that firms experienced when repurchasing their shares.

To study the impact of a change in execution priority, we define $Treatment_i$ as one for NASDAQ firms. The natural control group ($Treatment_i = 0$) includes stocks listed on other exchanges, because they are not treated by the Manning Rule. $Post_t$ equals one if the observation is in 1995 (one year after implementation of the Manning Rule) and zero if it is in 1993 (one year before implementation).

Table VII Panel A shows the results. Consistent with our predictions, after the implementation of the Manning Rule, repurchase payouts of by NASDAQ firms increase by 69% compared with repurchases of non-NASDAQ firms (0.419/0.605). We find no significant differences in the change in dividend payouts between the treatment and control groups. This result helps us rule out the possibility that some non-market-structure differences, such as differences in cash flow, drive the differences in changes in repurchase payouts. We find that total payouts increase by 33% (0.412/1.237) and that the ratio of repurchase payouts to dividend payouts increases by 26% (0.341/1.318) in NASDAQ firms when compared with the ratio in non-NASDAQ firms. These results indicate that an increase in the execution priority of issuers increases share repurchases.

Insert Table VII about Here

[7] Implementation of the Manning Rule was carried out in two phases. Manning I instituted order protection for non-NASD member limit orders on June 29, 1994; Manning II instituted order protections for NASD member limit orders on May 19, 1995 (Chung and Chuwonganant, 2004). The results are similar when we extend the event study periods to two-year periods around 1994.

B. The 1997 tick size reduction and the 2001 decimalization

We show that, in the controlled experiment provided by the Tick Size Pilot Program, an increase in the tick size reduces share repurchases. As an external validity check on the effects of tick size changes, in this subsection we test the effects of the 1997 reduction in the tick size from $1/8 to $1/16 and the 2001 decimalization on corporate payouts. Goldstein and Kavajecz (2000) and Bessembinder (2003) show that these two tick size reductions decrease both the bid–ask spread and market depth. Our market microstructure channel, in turn, predicts increases in repurchase payouts following both tick size reductions.

Unlike the Tick Size Pilot study, the 1997 and 2001 tick size reductions do not include natural treatment and control firms. We follow prior literature (e.g. Fang, Tian, and Tice 2014) and define $Treatment_i$ equals one if a firm experiences above-median decreases in the bid–ask spread and zero otherwise. $Post_t$ is a dummy variable that equals one if the observation occurs one year after the tick size reduction and zero if it occurs one year before the tick size reduction. Table VII Panel B and Panel C show the results. After the 1997 tick size reduction, repurchase payouts by the treatment firms increase by 68% compared with repurchases by control firms (0.578/0.851). There are no significant effects on dividend payouts. Total payouts increase by 42% (0.555/1.323) and the ratio of repurchase payouts to dividend payouts increases by 39% (0.575/1.481) for treatment firms compared with the ratio for control firms. After the 2001 decimalization, repurchase payouts by treatment firms increase by 32% compared with repurchases by control firms (0.565/1.746). There are no significant effects on dividend payouts. Total payouts increase by 22% (0.512/2.378) and the ratio of repurchase payouts to dividend payouts increases by 26% (0.556/2.112) for treatment firms compared with the ratio for control firms. These results show that, following the tick size reductions, firms face lower market-structure costs and repurchase more shares.

C. 2003 NYSE automated quote dissemination

Our paper focuses on the market-structure costs of share repurchases, whereas the existing literature focuses on the costs of dividend payouts. Because the capital gain tax is lower than the dividend tax and the capital gain tax can be deferred, the cost of share repurchases is lower than the cost of dividend payouts if we do not include other frictions associated with share repurchases. The dividend puzzle is a consequence of this relative tax advantage. If tax is the main friction in the choice between dividend payouts and share repurchases, firms should not pay dividends at all. Easterbrook (1984), Bhattacharya (1979), and Grinstein and Michaely (2005) provide explanations of the dividend puzzle by adding the benefits of paying dividends to their models. These benefits, however, do not explain why share repurchases consistently increase relative to dividend payouts, unless we assume the consistent decay of such benefits. Holding these benefits fixed, we should observe a secular decrease in share repurchases because the dividend tax decreases relative to capital gain tax over time.

The biggest unsolved puzzle in the tax advantage literature is documented by Chetty and Saez (2005). They find that the dividend tax cut in 2003 increased dividend payouts, but share repurchases increased even more. The origin of this puzzle, according to Chetty and Saez (2006), is the lack of understanding of the microeconomic foundations of the costs of share repurchases. We contribute to the literature by identifying market-structure frictions as a microeconomic foundation of the costs of share repurchases. Just as a dividend tax cut can reduce the costs of dividend payouts, so a reduction in market-structure frictions can reduce the costs of share repurchases. We find evidence that is consistent with this hypothesis by showing that NYSE stocks, which experience dramatic decreases in market-structure friction during the same time period as that of the dividend tax cut, constitute the main driver of increases in share repurchases.

In 2003, the NYSE installed autoquotes, which makes it possible for issuers and other traders to use computer algorithms to execute their trades. Before autoquotes, NYSE specialists manually disseminated quotes, making it extremely hard for computer algorithms to respond to changes in market conditions and to submit orders. The advent of autoquote jumpstarted algorithmic trading by providing real-time feedback on market information for computer algorithms, and it also allowed computer algorithms to respond to order flow and price information quickly by submitting orders automatically (Hendershott, Jones, and Menkveld 2011).

Autoquotes help issuers in two ways. First, Hendershott, Jones, and Menkveld (2011) find that autoquotes reduce the bid–ask spread and depth, and we have shown in our analysis that both economic factors increase share repurchases. Second, and probably even more important, autoquotes transit share repurchases from manual (high-touch) execution to automatic (low-touch) execution. Before the implementaiton of autoquotes, the NYSE issuers needed to hire floor brokers to repurchase their shares manually. Manual execution of share repurchases is not only costly but also makes it hard to achieve compliance with SEC rules. Autoquotes make it possible to use computer algorithms to execute share repurchases and to check compliance automatically with limited human intervention. This shock does offer a natural control group. Insofar as trading in firms listed on other exchanges was not subject to the autoquote update in 2003, we set $Treatment_i$ at one if a stock is listed on NYSE at zero if a stock is listed on other exchanges. For example, NASDAQ moved to electronic trading well before 2003 through the proliferation of ECNs (Barclay, Hendershott, and McCormick 2003). $Post_t$ equals one if the observation is in 2004 and zero if it is in 2002.

The results reported in Table VII Panel D show that, after the implementation of autoquotes on the NYSE, repurchase payouts by NYSE firms increase by 24% compared with repurchases by non-NYSE firms (0.413/1.716). The autoquote implementation has no significant effects on dividend payouts. Total payouts increase by 18% (0.496/2.792) more in NYSE firms than in non-NYSE firms. The ratio of repurchase payouts to dividend payouts increases by 10% (0.179/1.929) for treatment firms compared with the ratio in control firms, although this result is not statistically significant. These results provide one explanation why share repurchases increase more than dividend payouts after the 2003 dividend tax cut. Our paper suggests that the transition of repurchase execution from manual (high-touch) execution to automatic (low-touch) execution reduces the frictions associated with share repurchases and thus increases corporate share repurchases around the 2003 dividend tax cut.

Overall, the evidence presented in this section provides support for our hypothesis that market-structure innovations and 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 cannot completely crowd out dividend payouts.

III. Conclusion

We show that market-microstructure frictions can reconcile two seemingly contradictory puzzles in the corporate payout literature. The dividend puzzle exists because the previous literature underestimates the market-structure costs of share repurchases. SEC rule 10b-18 requires issuers to buy at a price that is no higher than the independent bid or previous sale price. The cost of complying with SEC rule 10b-18 is prohibitively high in a pure dealer market in the models of Ho and Stoll (1981) and Glosten and Milgrom (1985), because all buy orders execute at the ask price and buy orders also move the price up. Issuers can buy back their shares if they can submit limit orders at the bid price and compete with professional market makers in liquidity provision. There have been many market microstructure reforms since the 1990s, almost all of which were designed to reduce the privileges enjoyed by professional market makers. This trend in disintermediation reduces frictions for issuers seeking to buy back shares and leads to the secular increase in repurchases over dividend payouts.

We demonstrate the causal impact of market structure on share repurchases using both event studies and a controlled experiment. Our event studies follow a timeline. The 1994 Manning Rule shows the importance of execution priority. After the Manning Rule prohibits NASDAQ dealers from trading ahead of their customers at the same price, share repurchases by NASDAQ firms increase by 69% relative to repurchases by non-NASDAQ firms. Next, we find that the 1997 tick size reduction increases share repurchases by 68%, while the 2001 decimalization increase shares repurchases by 32%. Finally, we show that NYSE firms increase share repurchases by 24% relative to repurchases by non-NYSE firms after the NYSE installed autoquotes in 2003. This result is consistent with the notion that computer algorithms reduce the transaction and compliance costs of share repurchases, and this reduction in the costs of repurchases provides the first explanation why share repurchases increase to a greater exent than dividend payouts after 2003 dividend tax cut.

The controlled experiment we exploit for our analysis, the Tick Size Pilot Program, reveals similar economic mechanisms. Relative to the randomly selected control group, an increase in the tick size reduces share repurchases by 21%, and the number is as high as 45% for tick-constrained treatment firms. The result is even stronger for tick-constrained firms that experience an above-median increase in bid-side depth (56% vs. 32%), which reinforces the insight that a long queue reduces share repurchases. Finally, dark pools are important for share repurchases, possibly because this platform makes it possible for issuers to buy shares back at the independent bid price while at the same time avoiding queues on stock exchanges. The newly imposed trade-at rule for firms in test group 3 requires dark pools to match orders at a price that is at least 2.5 cents higher than the independent bid. This contradicts SEC rule 10b-18, which requires firms to buy back shares at a price that is no higher than the independent bid. We find that firms in test group 3 reduce their share repurchases 19% more than those in test groups 1 and 2.

In addition to contributing to the payout literature, our paper indicates two new important research dimensions for market microstructure literature: liquidity-for-whom and liquidity-from-where. Regarding liquidity-for-whom, we find that regulations can change the definition of liquidity for distinct groups of agents. Although a market with great depth is generally considered a liquid market, such a market, particularly on the bid side, may impose tighter constraints on repurchasing firms because of rule 10b-18. Regarding liquidity-from-where, the dramatic reduction in share repurchases in test group 3, accompanied by a relatively modest change in overall liquidity (Rindi and Werner 2019), shows the importance of dark pools for share buybacks. As dark pools match orders based on prices set by exchanges, their passive price-determination approach dovetails nicely with the philosophy behind SEC rule 10b-18, and the SEC even discussed whether they should exempt dark pools from rule 10b-18 when the matching price is higher than the bid price (SEC 2010).

Finally, our paper contributes to recent policy debates over tick sizes and the trade-at rule. First, our results show that an increase in the tick size harms firms. Yao and Ye (2018) show that an increase in the tick size benefits HFTs, these results show that this policy initiative may harm long-term investors and firms while benefiting HFTs. Second, as the existing stock market structure is already complex, we show that new and existing regulations may conflict in unintended ways. 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 evolving market structures.

REFERENCES

Abadie, Alberto, David Drukker, Jane Leber Herr, and Guido Wilhelmus Imbens, 2004, Implementing matching estimators for average treatment effects in Stata, *Stata Journal* 4, 290-311.

Albuquerque, Rui A., Shiyun Song, and Chen Yao, 2019, The price effects of liquidity shocks: A study of SEC's tick-size experiment, *Journal of Financial Economics* forthcoming.

Anderson, Anne M., and Edward A. Dyl, 2004, Determinants of premiums on self-tender offers. Financial Management 33, 25-45.

Baker, Malcolm, and Jeffrey Wurgler, 2004a, A catering theory of dividends, *Journal of Finance* 59, 1125-1165.

Baker, Malcolm, and Jeffrey Wurgler, 2004b, Appearing and disappearing dividends: The link to catering incentives, *Journal of Financial Economics* 73, 271-288.

Barclay, Michael J., Terrence Hendershott, and D. Timothy McCormick, 2003, Competition among trading venues: Information and trading on electronic communications networks, *Journal of Finance* 58, 2637-2665.

Bargeron, Leonce, Manoj Kulchania, and Shawn Thomas, 2011, Accelerated share repurchases, *Journal of Financial Economics* 101, 69-89.

Bessembinder, Hendrik, 2003, Trade execution costs and market quality after decimalization, *Journal of Financial and Quantitative Analysis* 38, 747-777.

Bhattacharya, Sudipto, 1979, Imperfect information, dividend policy, and "the bird in the hand" fallacy, *Bell Journal of Economics* 10, 259-270.

Black, Fischer, 1976, The Dividend Puzzle, *Journal of Portfolio Management* 2, 5-8.

Brav, Alon, John R. Graham, Campbell R. Harvey, Roni, Michaely, 2005, Payout policy in the 21st century, *Journal of Financial Economics* 77, 483-527.

Brogaard, Jonathan, and Jing Pan, 2019, Dark trading and the fundamental information in stock prices, Working paper, University of Utah, and Southern Methodist University.

Brown, Jeffrey R., Nellie Liang, and Scott Weisbenner, 2007, Executive financial incentives and payout policy: Firm responses to the 2003 dividend tax cut, *Journal of Finance* 62, 1935-1965.

Chetty, Raj, and Emmanuel Saez, 2005, Dividend taxes and corporate behavior: Evidence from the 2003 dividend tax cut, *Quarterly Journal of Economics* 120, 791-833.

Chetty, Raj, and Emmanuel Saez, 2006, The effects of the 2003 dividend tax cut on corporate behavior: Interpreting the evidence, *American Economic Review* 96, 124-129.

Christie, William G., and Paul H. Schultz, 1994, Why do NASDAQ market makers avoid odd-eighth quotes?, *Journal of Finance* 49, 1813-1840.

Christie, William G., Jeffrey H. Harris, and Paul H. Schultz, 1994, Why did NASDAQ market makers stop avoiding odd-eighth quotes?, *Journal of Finance* 49, 1841-1860.

Chung, Kee H., Chairat Chuwonganant, and D. Timothy McCormick, 2004, Order preferencing and market quality on NASDAQ before and after decimalization, *Journal of Financial Economics* 71, 581-612.

DeAngelo, Harry, Linda DeAngelo, and Douglas J. Skinner, 2009, Corporate payout policy. *Foundations and Trends in Finance* 3, 95-287.

Dittmar, Amy, and Laura C. Field, 2015, Can managers time the market? Evidence using repurchase price data, *Journal of Financial Economics* 115, 261-282.

Easterbrook, Frank H, 1984, Two agency-cost explanations of dividends, *American Economic Review* 74, 650-659.

Fama, Eugene F., and Kenneth R. French, 2001, Disappearing dividends: changing firm characteristics or lower propensity to pay? *Journal of Financial Economics* 60, 3-43.

Fang, Vivian W., Xuan Tian, and Sheri Tice, 2014, Does stock liquidity enhance or impede firm innovation?, *Journal of Finance* 69, 2085-2125.

Efron, Bradley, and Robert J. Tibshirani, 1994, *An introduction to the bootstrap*, CRC press.

Farre-Mensa, Joan, Roni Michaely, and Martin Schmalz, 2014, Payout policy, *Annual Review of Financial Economics* 6, 75-134.

Fenn, George W., and Nellie Liang, 2001, Corporate payout policy and managerial stock incentives, *Journal of Financial Economics* 60, 45-72.

Glosten, Lawrence R., and Paul R. Milgrom, 1985, Bid, ask and transaction prices in a specialist market with heterogeneously informed traders, *Journal of Financial Economics* 14, 71-100.

Goldstein, Michael A., and Kenneth A. Kavajecz, 2000, Eighths, sixteenths, and market depth: changes in tick size and liquidity provision on the NYSE, *Journal of Financial Economics* 56, 125-149.

Grinstein, Yaniv, and Roni Michaely, 2005, Institutional holdings and payout policy, *Journal of Finance* 60, 1389-1426.

Grullon, Gustavo, and Roni Michaely, 2004, The information content of share repurchase programs, *Journal of Finance* 59, 651-680.

Hasbrouck, Joel, 2007, *Empirical market microstructure: The institutions, economics, and econometrics of securities trading*, Oxford University Press.

Hendershott, Terrence, Charles M. Jones, and Albert J. Menkveld, 2011, Does algorithmic trading improve liquidity?, *Journal of Finance* 66, 1-33.

Ho, Thomas, and Hans R. Stoll, 1981, Optimal dealer pricing under transactions and return uncertainty, *Journal of Financial Economics* 9, 47-73.

Hribar, Paul, Nicole Thorne Jenkins, and W. Bruce Johnson, 2006, Stock repurchases as an earnings management device, *Journal of Accounting and Economics* 41, 3-27.

Investors Exchange, 2018, Petition for rulemaking to amend rule 10b-18, New York, NY.

Jagannathan, Murali, Clifford P. Stephens, and Michael S. Weisbach, 2000, Financial flexibility and the choice between dividends and stock repurchases, *Journal of Financial Economics* 57, 355-384.

Jensen, Michael C., 1986, Agency costs of free cash flow, corporate finance, and takeovers, *American Economic Review* 76, 323-329.

Kahle, Kathleen M., 2002, When a buyback isn't a buyback: Open market repurchases and employee options, *Journal of Financial Economics* 63, 235-261.

Leary, Mark T., and Roni Michaely, 2011, Determinants of dividend smoothing: Empirical evidence, *Review of Financial Studies* 24, 3197-3249.

Michaely, Roni, and Michael R. Roberts, 2012, Corporate dividend policies: Lessons from private firms, *Review of Financial Studies* 25, 711-746.

Miller, Merton, and Franco Modigliani, 1961, Dividend policy, growth, and the valuation of shares, *Journal of Business* 34, 411-433.

Rindi, Barbara, and Ingrid M. Werner, 2019. U.S. tick size pilot. Working paper. Bocconi University and Ohio State University.

Roberts, Michael R., and Toni M. Whited, 2013, Endogeneity in empirical corporate finance, *Handbook of the Economics of Finance* 2, 493-572.

Securities and Exchange Commission, 2010, Proposed rule: Purchases of certain equity securities by the issuer and others, Washington, DC.

Securities and Exchange Commission, 2015, Plan to implement a tick size pilot program, Washington, DC.

Securities and Exchange Commission, 2016, Investor alert: Tick size pilot program-what investors need to know, Washington, DC.

Securities and Exchange Commission, 2018, Assessment of the plan to implement a tick size pilot program, Washington, DC.

Thomas, Jacob K., Frank Zhang, and Wei Zhu, 2019, Off-exchange trading and post earnings announcement drift, Working Paper, Yale University, and University of Illinois.

Yagan, Danny, 2015, Capital tax reform and the real economy: The effects of the 2003 dividend tax cut, *American Economic Review* 105, 3531-63.

Yao, Chen, and Mao Ye, 2018, Why trading speed matters: A tale of queue rationing under price controls, *Review of Financial Studies* 31, 2157-2183.

Ye, Mao and Wei Zhu, 2020, Where do hedge fund activists trade?, Working Paper, University of Illinois.

Table I

Tick Size Pilot Program and Corporate Payout Policy

In Panel A we present the summary statistics and the results of mean difference tests of payout policies before and after implementation of the Tick Size Pilot Program for the treatment group. In Panel B we report the regression results for corporate payout variables— *repurchase payouts, dividend payouts, total payouts,* and *payout structure*. *Treatment* is a dummy variable that equals one if a stock is in the treatment group 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 heteroscedasticity and clustered at the firm level are shown in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Summary Statistics for the Tick Size Pilot Program Treatment Sample

			t-test	
	Pre Mean	Post Mean	*Diff*	*p-value*
Repurchase payouts	0.430	0.275	-0.155	<0.01
Dividend payouts	0.242	0.226	-0.016	0.149
Total payouts	0.672	0.501	-0.171	<0.01
Payout structure	1.248	1.120	-0.128	<0.01

Panel B: 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 II

Tick-Constrained Sample vs. Tick-Unconstrained Sample

In Panel A we present the pre-treatment summary statistics and the results of mean difference tests for the treatment group and the matched control group after partitioning the data into a constrained sample and an unconstrained sample. 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 regression results. *Treatment* is a dummy variable that equals one if the stock is in the treatment group 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 heteroscedasticity and clustered at the firm level are shown in parentheses. *, **, and *** represent 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: Results for the Tick-Constrained Sample and the Tick-Unconstrained Sample

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

Table III

The Queuing Channel

In Panel A we report the results for market liquidity measures. In Panel B we report the results for *repurchase payouts* when we partition the treatment-group tick-constrained sample equally into two groups based on the increase in depth measures. The tick-constrained sample includes a firms 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. *Treatment* is a dummy variable that equals one if the stock is in the treatment group 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 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 heteroscedasticity and clustered at the firm level are shown in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively. The last row in Panel B reports the *p*-values, which 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).

Panel A: Results for Market Liquidity Measures

	Tick-Constrained Sample			Tick-Unconstrained Sample		
	Percent Quoted Spread	Total Share Turnover	Market Depth	Percent 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 B: Results for Partitioning Samples Based on Increase in Depth

	Dependent Variable: *Repurchase Payouts*			
	Increase in Bid-Side Depth		Increase in Offer-Side Depth	
	Small	Large	Small	Large
	(1)	(2)	(3)	(4)
Treatment×Post	-0.115*	-0.264***	-0.197***	-0.193**
	(-1.77)	(-3.21)	(-2.72)	(-2.52)
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	4303	4243	4318	4228
R^2	0.438	0.443	0.470	0.426
p-value (Small=Large)	<0.01		0.400	

Table IV

The Dark Pool Channel

In this table we report the results for *repurchase payouts* by tick-constrained firms and tick-unconstrained firms in test groups 1 and 2 and 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. *Treatment* is a dummy variable that equals one if the stock is in the treatment group 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 heteroscedasticity and clustered at the firm level are shown in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively. In the last row we report *p*-values, which 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 group 1&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 and 2 tick-constrained = test group 3 tick-constrained): <0.01				

Table V

Controlling for Alternative Explanations

In this table we report results for *repurchase payouts* after controlling for managerial stock holdings, managerial options holdings, exercisable options, and exercised options, using annual data for the treatment-group tick-constrained sample. 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. *Treatment* is a dummy variable that equals one if the stock is in the treatment group 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 heteroscedasticity and clustered at the firm level are shown in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable: *Repurchase Payouts* (Annual Data, Tick-Constrained Sample)			
	(1)	(2)	(3)
Treatment×Post	-0.740***	-0.711***	-0.716***
	(-2.68)	(-2.59)	(-2.62)
Manager options	0.032	-	0.209
	(0.10)	-	(0.66)
Manager stocks	0.867	-	0.796
	(1.30)	-	(1.21)
Exercised options	-	0.548***	0.558***
	-	(2.96)	(2.99)
Exercisable options	-	-0.0376	-0.0570
	-	(-0.71)	(-1.06)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes
N	2031	2031	2031
R^2	0.665	0.670	0.671

Table VI

Additional Analyses of the Tick Size Pilot

In this table we report results for additional analyses of the Tick Size Pilot for the tick-constrained sample. In columns (1) and (2) we report the results of a reversal test and a placebo test, respectively. In columns (3) and (4) we report the results regarding sensitivity to firm size by splitting the sample equally based on pre-treatment firm size. 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. *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 reported in parentheses below the coefficient estimates. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent Variable: *Repurchase Payouts*			
	Reversal and Placebo Tests		Result Sensitivity on Firm Size	
	Reversal Test 2017Q4-2018Q3 vs. 2018Q4-2019Q3	Placebo Test 2012Q4-2014Q3 vs. 2014Q4-2016Q3	Small Firms	Large Firms
	(1)	(2)	(3)	(4)
Treatment×Post	0.122**	0.0560	-0.155**	-0.220***
	(2.05)	(0.88)	(2.36)	(2.75)
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	4028	7593	4288	4258
R^2	0.538	0.369	0.472	0.412

Table VII

Event Studies: Historical Market Structure Changes and Corporate Payout Policy

In this table we report the results of event studies of the historical market-structure changes. In the event study of the effects of the 1994 NASDAQ Manning Rule, *Treatment* equals one if a firm is listed on NASDAQ and zero if it is listed on another U.S. exchange. *Post* equals one if the observation is in 1995 and zero if it is in 1993. In the event study of the effects of the 1997 tick size reduction, *Treatment* equals one if a firm experiences an above-median decrease in the spread and zero otherwise. *Post* equals one if the observation is in 1998 and zero if it is in 1996. In the event study of the effects of the 2001 decimalization, *Treatment* equals one if a firm experiences an above-median decrease in the spread and zero otherwise. *Post* equals one if the observation is in 2002 and zero if it is in 2000. In the event study of the effects of 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 listed on another U.S. exchange. *Post* equals one if the observation is in 2004 and zero if it is in 2002. *Controls* include size, profitability, and growth opportunity; managerial stock holdings and managerial options holdings; exercised options and exercisable options; the relative tax advantage of share repurchases; cash flow volatility; non-operating cash flow; and 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 heteroscedasticity and clustered at the firm level are shown in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	Repurchase Payouts	Dividend Payouts	Total Payouts	Payout Structure
	(1)	(2)	(3)	(4)
Panel A: Event Study Result of 1994 NASDAQ Manning Rule				
Treatment×Post	0.419***	-0.00757	0.412***	0.341***
	(3.24)	(-0.21)	(3.01)	(3.28)
Panel B: Event Study Result of 1997 Tick Size Reduction				
Treatment×Post	0.578**	-0.0229	0.555**	0.575***
	(2.30)	(-0.65)	(2.18)	(2.75)
Panel C: Event Study Result of 2001 Decimalization				

Treatment×Post	0.565***	-0.0527	0.512***	0.556***
	(3.40)	(-1.29)	(3.00)	(3.97)
Panel D: Event Study Result of 2003 NYSE Autoquote				
Treatment×Post	0.413**	0.0837	0.496**	0.179
	(1.96)	(1.26)	(2.24)	(0.82)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes

Appendix Table A.I

Event Studies: Pre-treatment Summary Statistics for Analyses of Historical Market-Structure Changes

In this table we present pre-treatment summary statistics and the results of mean difference tests for the treatment group and the matched control group before implementation of the historical market structure changes. All variables are winsorized at the 1% and 99% levels.

	Panel A: 1994 NASDAQ Manning Rule				Panel B: 1997 Tick Size Reduction			
	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	0.851	0.788	0.063	0.657
Dividend payouts	0.631	0.622	0.009	0.892	0.473	0.439	0.034	0.567
Total payouts	1.237	1.166	0.071	0.578	1.323	1.226	0.097	0.544
Payout structure	1.318	1.280	0.038	0.648	1.481	1.486	-0.005	0.962
	Panel C: 2001 Decimalization				**Panel D: 2003 NYSE Autoquote**			
	Treatment	Control	*t*-test		Treatment	Control	*t*-test	
	Mean	Mean	*Diff*	*p-value*	Mean	Mean	*Diff*	*p-value*
Repurchase payouts	1.746	1.655	0.091	0.515	1.716	1.559	0.157	0.437
Dividend payouts	0.632	0.604	0.028	0.583	1.075	0.983	0.092	0.234
Total payouts	2.378	2.259	0.119	0.434	2.792	2.543	0.249	0.261
Payout structure	2.112	2.119	-0.007	0.957	1.929	1.929	0.000	0.999