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Make-Take Structure and Market Quality: Evidence from the U.S. Options Markets

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We examine the make-take structure, which compensates liquidity suppliers and charges liquidity demanders, in the options markets where it competes with a traditional structure that uses payments for order flow. Using the introduction of the make-take structure as an event, we find that execution costs (including fees) for liquidity demanders decline after the event for the affected options, that the make-take structure encourages market makers to improve quoted prices, and that brokers change their routing behavior to include fees in the routing decision. The decline in execution costs is consistent with the benefits of the increased quote competition from the make-take structure prevailing over the fees the structure charges to liquidity demanders.

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1. Introduction

Make-take pricing marks a significant recent innovation in securities market structure. In the typical implementation of make-take pricing, the exchange charges a fee to the liquidity demander in a trade while paying a rebate to the liquidity provider. The fees charged tend to be higher than the rebates provided, netting the difference for the exchange. In the U.S. markets, make-take pricing has been adopted by all equity exchanges. Proponents of make-take pricing argue that it encourages liquidity provision and lowers execution costs for investors. However, make-take pricing is increasingly in the media and regulatory cross-hairs, with numerous market participants calling for the curbing, or outright banning, of the practice.[1] Angel et al. (2011, 2015) highlight the potential problems associated with make-take pricing, including the obfuscation of true economic spreads. Thus, it appears that the market structure that economic forces have made dominant may not be in the best interests of the investors. This concern is especially relevant as exchanges have moved to a "for-profit" model.[2]

We study the make-take structure in the context of the U.S. options markets, where the make-take structure competes directly with an alternative ("traditional") structure with very different pricing and, consequently, incentives. The traditional structure not only does not charge any fees for "customer" orders but also actually pays for such order flow through payment for order flow arrangements.[3] We use the introduction of make-take pricing into the options markets to study the impact of the make-take structure on investors' execution costs in a fragmented market. In a theoretical analysis, Colliard and Foucault (2012) show that the breakdown of exchange

[1] Make-take pricing has been the subject of recent hearings in the U.S. Senate (see http://www.hsgac.senate.gov/subcommittees/investigations/hearings/conflicts-of-interest-investor-loss-of-confidence-and-high-speed-trading-in-us-stock-markets, accessed December 15, 2015). Also see Patterson and Ackerman (2014) and Michaels (2014). Responding to these concerns, the New York Stock Exchange (NYSE) has proposed a steep reduction in make-take fees in a "grand bargain" (Hope and Patterson 2014).

[2] In his testimony to the Senate Banking Committee, Mr. Andrew Brooks, head of U.S. equity trading at T. Rowe Price, notes, "It seems clear that since the exchanges have migrated to 'for-profit' models, a conflict has arisen between the pursuit of volume (and the resulting revenue) and the obligation to assure an orderly marketplace for all investors" (Brooks 2014).

[3] Customer orders are orders originating from nonprofessional traders. Exchanges exclude broker-dealers and other professional traders who trade more than a frequency threshold from the customer classification. In our analysis, we use customer fees to adjust execution costs and assume that execution fees or payments are passed through to customers either directly, or indirectly (through commissions and/or trading functionality).

fees into make and take components is neutralized by market participants through the adjustment of the quoted bid–ask spread, thus leaving execution costs unchanged. Foucault et al. (2013) note that a discrete minimum price increment in securities markets prevents this simple adjustment, and they show that the make-take structure provides a greater incentive for market makers to monitor the market and be more opportunistic in providing liquidity and posting better prices. In their framework, make-take structures may improve market quality if liquidity suppliers are relatively scarce compared to liquidity demanders. In contrast, Angel et al. (2011, 2015) posit that the make-take structure provides no real benefits but potentially obscures the true economic spreads, especially if traders pay attention to quoted prices and not the net (of fees) prices. In that scenario, the make-take structure would simply match the best quoted prices in the market and provide worse executions for liquidity demanders after adjusting for fees, increasing execution costs in the market. Thus, the make-take structure has been hypothesized to lead to no change, a decrease, or an increase in execution costs for investors.

We explore the possible mechanisms underlying any changes in execution costs as a result of the introduction of the make-take structure. We test whether market makers are more likely to improve quoted prices after the introduction of the make-take structure. If the proponents of the make-take structure are correct that the structure encourages the quoting of better prices, then the increase in quote competition would benefit investors. The benefit would accrue to trades not only on the make-take structure but also on the traditional structure, because U.S. market regulation prevents a market from executing a trade at a price inferior to that in another market (the "trade-through" rule). On the other hand, if orders are routed based on quoted prices, instead of net (of fees) prices, then the obfuscation of true prices would be to the detriment of investors. Accordingly, we examine whether brokers change their routing practices to incorporate fee differences in their routing decisions after the introduction of the make-take structure.

The options market structure provides certain advantages for our analysis. Make-take pricing is relatively recent in options markets. This allows us to use natural experiments related to the introduction of make-take pricing by the largest, and the first, make-take exchange, NYSE Arca, to study the effect of the make-take structure on investors' execution costs. Furthermore, make-take pricing is introduced into a market where it competes with the traditional structure, which rewards marketable orders through payments for order flow. This contrast allows us to examine whether the make-take structure is beneficial in a fragmented market structure. Finally, most liquidity in options is provided by exchange market makers.[4] In this respect, the market used in our analysis is close to the one envisioned by Foucault et al. (2013) where there are no agency conflicts in routing of liquidity supplying orders, and liquidity demanders and suppliers do not switch their roles.

Our study complements studies of make-take structure in other contexts. At its most specific, the study provides an analysis of the impact of the make-take structure in the U.S. options markets, which is relatively understudied in the academic literature. The lack of empirical evidence on the market raises concerns about extending the results from equities into options.[5] More broadly, our analysis offers insights into the performance of the make-take structure in a fragmented market, where it competes with a structure relying on payment for order flow.

We analyze changes in execution costs around NYSE Arca's decision to expand make-take pricing in options on November 1, 2012. NYSE Arca pioneered make-take pricing in options markets by moving option classes to the make-take structure as they were added to the "Penny Pilot" from 2007 to 2010. Penny Pilot options trade in lower minimum price increments (or "tick sizes") than "non-penny" options. On November 1, 2012, NYSE Arca expanded make-take pricing to non-penny options. We use the 2012 change as our primary event since the initial implementation of make-take pricing in the 2007–2010 period is accompanied by a reduction in the minimum price increment. Customer execution costs are measured by "net effective spreads," which are calculated by adding twice the take fee to effective spreads for trades in the make-take structure and subtracting twice the payment for order flow from effective spreads for trades in the traditional

[4] Page 22 of Appendix A of U.S. Commodity Futures Trading Commission (2010) notes, "Generally, however, investors in listed options depend upon the liquidity supplied by professional liquidity providers, such as market makers, to a greater extent than in the market for NMS [National Market System] stocks. This is due in part to the greater dispersion of trading interest across the thousands of series of listed options."

[5] For example, such concerns were expressed regarding a rule proposed by the U.S. Securities and Exchange Commission (SEC) to establish fee caps in options at levels similar to those in equities at $0.0030 per share. See Proposed Amendments to Rule 610 of Regulation NMS, 17 CFR Part 242 (April 20, 2010), and comments submitted on the rule. As examples, the comment letter from Citadel Investment Group argues for extending equity market rules to options, whereas the comment letter from William J. Brodsky, chief executive officer of CBOE Holdings, argues against applying those rules in options. These letters, among others, are available at http://www.sec.gov/comments/s7-09-10/s70910.shtml (accessed December 15, 2015).

structure.[6] We find that net effective spreads (measured over all trades in the market, regardless of where they occur) decline for our sample of 1,998 equity option classes that switch from traditional to make-take pricing.[7] The difference-in-differences between the options affected by the changes and those that are not is greater than two cents, which is a 10.5% reduction over the preswitch period average net effective spread for the options undergoing the switch. These results exist in a multivariate analysis. We confirm the robustness of the decline in net effective spreads by studying the initial implementation of the make-take structure by NYSE Arca in Penny Pilot options over the 2007–2010 period.

Why do execution costs decline after make-take pricing is introduced? We examine changes in quote competition around the introduction of make-take pricing, and find that market makers on NYSE Arca are more likely to improve quoted prices after the switch to make-take pricing. In the presence of trade-through protections, more competitive quoting by the make-take structure can lower execution costs across the market, not just in the make-take structure, as traditional markets match the best quotes in the market.

We compare the two market structures after the switch to make-take pricing to characterize the equilibrium when the two market structures coexist. For this analysis, we focus on a matched sample of equity option series that trade on NYSE Arca and the traditional market structure on the same day during a three-month period between November 2012 and January 2013. The matched sample includes 155,892 option series on 2,338 option classes. We find that net effective spreads paid by customers are similar in the two structures for the overall sample. However, the overall average hides significant differences by price levels. Net effective spreads are higher on NYSE Arca than on the traditional structure in lower-priced options and lower than the traditional structure in higher-priced options (those above $3).

Are these differences in net effective spreads a result of brokers ignoring fee differences across markets and routing based on quoted prices only? We find that brokers take fees into account in routing liquidity demanding orders. In this analysis, we use the fact that the traditional structure offers a cost advantage when quoted prices are equal in the two structures, whereas the make-take structure does so only when it is quoting a better price, since the minimum price increment is higher than the difference in the fees. Consistent with this, there is a significant increase in the proportion of NYSE Arca's trades that occur when it is at a better quoted price than the traditional structure after the switch to make-take pricing on November 1, 2012. Correspondingly, there is a decline in the proportion of NYSE Arca's trades that occur when its quoted price is equal to that in the traditional structure. Additionally, in the sample where the two structures coexist, approximately 84% of trades arriving in the market when the two structures are quoting the same price are routed to traditional markets; a majority of NYSE Arca's trades (69%) occur when it is quoting a better price, whereas a majority of traditional structure's trades (64%) occur when the quoted prices in the two structures are equal. These results suggest that suboptimal order routing decisions are not causing the differences in net effective spreads.

In exploring other reasons for the observed differences in net effective spreads in equilibrium, we find that the comparison of net effective spreads is influenced by the difference between the minimum allowed price improvement and the fee difference in the two structures. Briefly, if the make-take structure competes by improving the quoted price by the minimum possible amount (which is determined by the tick size) only on one side of the quote, it offers a better net (of fees) price on that side of the quote since the tick size is greater than the fee difference (take fee plus payment for order flow) applicable to the trader deciding on the venue. However, the changed quote midpoint as a result of the one-sided quoted price improvement essentially halves the magnitude of the one-tick price improvement in the calculation of effective spreads. This reduced price improvement can make the net effective spreads appear to be larger on the make-take structure even when it provides a better net (of fees) price. The impact of this effect diminishes as the minimum price improvement required increases with higher tick sizes. Since tick sizes increase with option prices, we are likely to find different results across price categories. When we adjust for this effect, we find lower net effective spreads on NYSE Arca in all price categories. This analysis provides a point of caution to researchers comparing execution costs across exchanges with different fee structures.

The differences in net effective spreads do not indicate that one structure is better than the other, but rather reflect how the two structures compete for order flow. Recall that trades are routed to the lower-cost venue. In addition, we find that the traditional structure maintains greater market presence (i.e., traditional quoted prices are at the better net (of fees) prices for a significant majority (80%) of the observed

[6] We use $2\times$ fees for the fee adjustment to be consistent with the calculation of effective spreads, which are based on round-trip trades.

[7] An *option class* includes all options traded on a common underlying instrument. An *option series* specifies a unique combination of underlying stock, put/call, strike price, and expiration date.

quotes), quotes significantly higher depths, and executes larger trade sizes than NYSE Arca.

Overall, our results indicate that the introduction of the make-take structure improves outcomes for investors in the options markets. We note that conflicts of interest associated with broker routing of limit orders to venues with higher make rebates may be less relevant for options markets than equity markets since most liquidity in options is provided by exchange market makers. At the very least, our results suggest that the structure can be beneficial in some contexts. Regulators and the Congress currently considering changes to the structure need to be circumspect about the scope of their recommendations curbing the practice.

2. Related Literature

Our study is a part of the growing empirical literature on the make-take structure. Malinova and Park (2015) find that market quality improves when make-take pricing is introduced on the Toronto Stock Exchange. Lutat (2010) documents unchanged spreads but improved depths on the SWX Europe exchange after the introduction of make-take pricing. Cardella et al. (2013) find that market participants do not neutralize the make-take fees. Further, they find that higher net fees charged by an exchange[8] lead to higher quoted spreads but that the breakdown of these fees into make and take components does not affect spreads. These studies examine make-take pricing when it is the only market structure used in all the exchanges, and Malinova and Park (2015) and Lutat (2010) focus on consolidated markets where the central exchange adopts make-take pricing.

In a contemporaneous paper, Battalio et al. (2011) compare effective spreads in make-take and traditional structures in options markets and find that the traditional structure offers lower net percentage effective spreads. Our results on net percentage effective spreads in a static framework are consistent with theirs. However, our main contributions do not overlap with Battalio et al. (2011). Specifically, we use an event study framework to assess the impact of the make-take structure on execution quality in a fragmented market. In addition, we analyze changes in quote competitiveness and order routing associated with the introduction of the make-take structure.

A number of prior studies examine intermarket competition. In options markets, Vijh (1990), Neal (1992), and Mayhew (2002) compare the liquidity facilitated by a designated specialist versus that in a crowd of market makers. Neal (1987) and De Fontnouvelle et al. (2003) find that options exchange competition lowers execution costs. Battalio et al. (2004) study the state of intermarket linkages in options markets after the increase in multiple listings in 1999. We shed light on the evolving structure in options markets, which has remained understudied in the face of remarkable changes in the last decade, including the increased prevalence of the make-take structure.

In equities, a number of studies compare execution quality on NYSE and Nasdaq (for example, Barclay 1997; Bessembinder and Kaufman 1997a; Bessembinder 1999, 2003b). Bessembinder and Kaufman (1997b) and Blume and Goldstein (1997) compare the quote competitiveness of NYSE with other markets. Huang (2002) and Barclay et al. (2003) focus on the differences arising from the speed and anonymity offered by electronic communication networks in the NASDAQ market. Foucault and Menkveld (2008) analyze the impact of the introduction of a new market, EuroSETS, to the Dutch equity market. Bessembinder (2003a) and Goldstein et al. (2008) analyze routing behavior in equities. We follow these studies in examining the impact of important market structure developments. Make-take pricing is central to current debates regarding market structure. Our analysis provides evidence on changes in market quality, order routing, and quoting competitiveness associated with make-take pricing.

Studies of order preferencing arrangements in equities have focused on their potential to degrade liquidity resulting from a decrease in market maker competitiveness. Using experimental and theoretical analyses, Bloomfield and O'Hara (1998) and Parlour and Rajan (2003) find that market quality deteriorates with order preferencing. The empirical evidence in equities is mixed. Chung et al. (2004, 2006) document less aggressive quotes from dealers and wider spreads with increasing levels of preferencing, whereas Battalio et al. (1997) and Hansch et al. (1999) do not find adverse effects associated with preferencing.

3. Recent Developments in Options Market Structure

The structural differences across options exchanges center on their use of a traditional or a make-take structure for trading an option. Our various analyses are conducted using data over a long time period (2007–2013) during which new exchanges entered the market and exchanges made changes to their pricing structures. By the end of our sample period in January 2013, there are 11 options exchanges. Of these, six (BATS, C2, International Securities Exchange (ISE), NASDAQ Options Market (NOM), NYSE Arca, and

[8] Exchange net fees are the difference between the liquidity taking fees and the liquidity making rebates.

the Philadelphia Stock Exchange (PHLX)) use make-take pricing for at least some of their listed option classes. Boston Options Exchange (BOX) and NASDAQ OMX BX use inverted make-take (take-make) pricing. Chicago Board Options Exchange (CBOE), MIAX options exchange, and NYSE Amex operate purely under the traditional model. PHLX, ISE, and NOM use both models.[9]

The traditional model developed after the start of multiple listings of options in August 1999 and in response to significant competition from the launch of the first electronic options exchange (ISE). Within a year, from August 1999 to August 2000, the share of retail order flow that is routed subject to payment for order flow arrangements rose from almost 0% to 78%.[10] Payment from order flow in options is organized differently than in equities. Equities order flow is fragmented among exchanges (which primarily use the make-take structure), as well as across off-exchange venues including dark pools, which do not display any quotes in the publicly disseminated quote feed, and internalization pools, where brokers pay for retail order flow. The internalizing entities typically guarantee a price equal to (or marginally better) than the best prices in the market, but they do not use publicly disseminated quotes to attract this internalized order flow. By contrast, off-exchange trading is disallowed in options. Payment for order flow in options is sponsored by exchanges that use the mechanism to attract orders to the exchange where they typically trade against the best available market maker quotes.[11] Thus, market makers on traditional options exchanges are frequently at the marketwide best bid and offer quotes.

Payment for order flow arrangements came under significant pressure with the reduction of the tick size for options added to the Penny Pilot. Penny Pilot option classes are priced in minimum increments of \$0.01 (for option series priced below \$3) or \$0.05 (for option series with prices of \$3 or more). The corresponding price increments for non-penny option classes are \$0.05 and \$0.10. The Penny Pilot program started in January 2007 with 13 option classes and was expanded over time to include 348 equity option classes, representing 83% of equity options volume.

NYSE Arca introduced make-take pricing to options markets in 2007 by moving options to the make-take structure as they were gradually added to the Penny Pilot. In November 2012, NYSE Arca expanded make-take pricing to non-penny options as well, thus moving entirely to the make-take structure. We use these introductions of make-take structure by NYSE Arca as exogenous events in our analysis. PHLX and ISE use the make-take structure for some option classes while retaining the traditional structure for the majority. Newly launched exchanges have tended to use the make-take structure. By January 2013, the make-structure accounted for 47% of equity options volume. The make-take fees differ across exchanges, but typically the make rebates tend to be higher for market makers than for other market participants and the take fees tend to be the lowest for customers relative to other market participants. Appendix Table A.1 provides an illustration of the impact of fees on net effective spreads paid by customers on trades executed on different exchanges. The appendix reflects adjustments for customer take fees on make-take markets and payments for order flow on traditional markets using the pricing for Penny Pilot options. In our analysis, we assume that brokers pass on all fees or payments to traders.[12]

Similar to the Regulation National Market System for equities, options exchanges are required to match the best price or route orders to the exchange with the best price. The private intermarket linkage plan approved by the SEC in August 2009 (Options Clearing Corporation 2009) requires each exchange to develop private linkages to prevent trade-throughs and incidents of locked and crossed markets.

4. Data and Sample

Our various analyses use data between 2007 and 2013. Specifically, we analyze two different natural experiments related to the introduction of the make-take structure by NYSE Arca. We focus on the adoption of the make-take structure on NYSE Arca since it is the largest make-take exchange and the first to introduce make-take pricing in options markets. The first event analyzed is the recent decision by NYSE Arca to switch non-penny option classes to the make-take structure on November 1, 2012 (the "2012 event"). This decision makes NYSE Arca a purely make-take exchange. We study changes in 1,998 equity option classes in this analysis. The second event is the initial introduction of the make-take structure in options when NYSE Arca moved option classes to the

[9] Some of the newer options exchanges have a small share of the market. For example, Nasdaq OMX BX, MIAX, and C2 have less than 1.5% of the market share in January 2013, with MIAX close to 0%.

[10] U.S. Securities and Exchange Commission (2004) provides a detailed discussion of changes brought about by the increase in competition following multiple listings and the launch of the ISE, and the increase in payment for order flow arrangements.

[11] "Flash" orders are sometimes used in options markets. If an exchange receives an order when it is not quoting the best price, market makers can be given an opportunity to step up and offer the marketwide best price. Based on exchanges' estimates, these orders constitute 1% of order flow (see, for example, CBOE's comment letter regarding flash orders, Brodsky 2010). Thus, the mechanism is not the dominant form of trading.

[12] Appendix Table A.2 summarizes other key features differentiating the two market structures.

make-take structure as they were added to the Penny Pilot in the 2007–2010 period (the "2007–2010 event"). We study 283 equity option classes that were added over 9 event dates during this period. We also study a period (November 2012 to January 2013) after the full implementation of make-take pricing by NYSE Arca when the two market structures coexist.

For these analyses, we obtain Options Price Reporting Authority (OPRA) data preprocessed by Baruch College Options Data Warehouse. OPRA is the securities information processor responsible for collecting and disseminating all market data related to U.S. options markets. These data include all trades, as well as the quote from each exchange at the time of the trade. The database is similar to that used by Battalio et al. (2011). The trades data include the option series, a trade type indicator, the time of the trade to the nearest millisecond, the exchange on which the trade occurs, the trade price, and traded volume. We restrict our analysis to trades marked as "regular" (including "automated"), "ISO," or "stopped," effectively excluding complex trades (multileg trades such as spreads and straddles), trades marked late, and opening (or reopening) trades. "Regular" and "automated" are used interchangeably and represent regular trades with no special conditions. "Stopped" trades are briefly held by the market while guaranteeing the best price, allowing for possible price improvement. "ISO" (or "intermarket sweep orders") trades are submitted by a broker to remove the best price from the market; the remainder of the order is simultaneously submitted to another market that is quoting an inferior price. The ISO trade designation relieves the market with the inferior price of trade-through rule obligations, and it is used by traders seeking immediate executions in sizes larger than the depth available at the best quotes. Together, the included trade categories account for 86% of trades and 74% of volume in the period from November 2012 to January 2013.

In addition to the OPRA data, we use daily OptionMetrics data to obtain additional information on the characteristics of the underlying securities and the traded options series. We merge the two datasets by option series each day. We describe other data filters in the appendix.

We describe the 2012 event sample in Table 1, panel A. Our test sample for the 2012 event includes 1,998 equity option classes, which switch from the traditional structure to the make-take structure on NYSE Arca. The control sample for this event includes the 340 Penny Pilot equity option classes that already trade under the make-take structure on NYSE Arca at the time.[13] We include all trades within these option classes, regardless of where they occur, to examine whether overall customer execution costs change as a result of the switch to make-take pricing by NYSE Arca. Non-penny option classes tend to be less liquid compared with Penny Pilot options, and this is reflected in the two samples. The 1,998 switching non-penny option classes have underlying stocks with an average market capitalization of approximately $17 billion. The 340 Penny Pilot options in the control sample trade more frequently than the non-penny options and are on larger stocks with an average market capitalization of $38 billion.[14]

For the analysis comparing NYSE Arca with the traditional structure in the period from November 2012 to January 2013, we follow Mayhew (2002) in constructing a matched sample at the option series-day level. That is, we construct a matched sample of option series-days composed of the same option series that trade on the same day on NYSE Arca and the traditional structure, allowing us to control for underlying stock characteristics, option characteristics, and the prevailing market conditions on a given day. Table 1, panel B describes the matched sample. The sample includes 155,892 option series in 2,338 option classes with an average of 14,357 option series per day.

5. Results

5.1. Make-Take Structure's Impact on Execution Costs

We analyze changes around the introduction of the make-take structure to examine the impact of the make-take structure on the overall execution costs in options markets. As discussed above, market makers could net out the fee differences by adjusting quoted prices; the introduction of the make-take structure could lower execution costs if it encourages liquidity provision; or increase costs if it obfuscates the true spread and trades in make-take structure occur at the same quoted spreads, but higher net spreads, as trades on traditional markets. We use net effective spreads as our measure of execution costs. Effective spreads are calculated as twice the absolute value of the difference between the execution price and the quote midpoint.[15] Net effective spreads adjust for fee

[13] The number of Penny Pilot option classes changes in our analyses as options are added to the Penny Pilot.

[14] As mentioned earlier, in contrast to the 2012 event, the 2007–2010 event affects Penny Pilot options. For the robustness tests using the 2007–2010 event, we use the unaffected non-penny options as the control sample.

[15] Our definition of effective spreads is similar to that used by Bacidore and Sofianos (2002). We replicate our results using an alternative definition where we multiply the difference between the execution price and the quote midpoint by a variable that equals positive one for buyer-initiated trades and negative one for seller-initiated trades. The results are unaffected by the change.

Table 1 Descriptive Statistics

Panel A: 2012 event sample

	Switching (non-penny) options	Control (Penny Pilot) options
Option classes	1,998	340
Option series	141,078	120,641
Daily volume per option class (contracts)	652.13	11,522.11
Daily number of trades per option class	55.41	862.78
Market cap. of underlying stocks (in millions)	17,021.76	38,353.06
Daily volume of underlying stocks (in thousands)	1,154.11	8,876.14

Panel B: November 2012 to January 2013 matched sample

	Overall sample	Non-penny options	Penny Pilot options
Option series	155,892	68,086	88,539
Option series per day	14,357	3,971	10,386
Option classes	2,338	1,998	348
Option classes per day	1,202	872	331
Daily volume per option class (contracts)	3,814.91	815.61	11,718.87
Daily number of trades per option class	287.27	65.73	871.08
Market cap. of underlying stocks (in millions)	20,608.06	17,460.40	38,651.43
Daily volume of underlying stocks (in thousands)	2,311.03	1,159.07	8,914.40

Notes. The table presents descriptive statistics for the 2012 event sample (panel A) and the November 2012 to January 2013 matched sample (panel B). The 2012 event sample includes 30 trading days before and after the event date of November 1, 2012. On this date, NYSE Arca started trading all non-penny options in the make-take structure. Penny Pilot options, previously traded in the make-take structure, form the control sample. For panel B, we match option series across the traditional structure and NYSE Arca based on a trade in an option series in each market structure on a given day. We exclude all option series that are candidates for dividend capture strategies. The number of Penny Pilot option classes is higher in panel B because eight option classes were added to the Penny Pilot in January 2013.

differences by subtracting two times the payment for order flow from the effective spreads for traditional exchanges and adding two times the take fees for make-take exchanges. The fee adjustments are made using the fee structure for liquidity taking customers.

On November 1, 2012, NYSE Arca expanded the make-take structure to non-penny options. There are no other market structure changes around this event. Table 2, panel A presents the changes in net effective spreads for the options switching to make-take pricing on NYSE Arca. We calculate volume-weighted net effective spreads for an option series-day and then equally weight across option series to obtain option class-day net effective spreads. Panel A presents equally weighted averages across option class-days for the pre- and postswitch periods. We analyze option class-level spreads since characteristics of particular option series change over time, making it infeasible to compare individual series in the pre- and postswitch periods. We find that average net dollar effective spreads decline from 19.7 cents in the 30 trading days before the switch to 18.2 cents in the 30 trading days after the switch for the switching options in the overall sample. The decline is statistically significant (at the 1% level) within the non-penny classes, as well as when compared with the change in the control sample of Penny Pilot options, which were already trading under the make-take structure. Significance tests use standard errors clustered on option class and date. Within price categories for the difference-in-differences comparison, we find that options switching to make-take pricing uniformly experience declines, but the declines are statistically significant at the 1% level for options priced between \$0.50 and \$1, \$1 and \$3, and \$3 and \$5 and at the 5% level for options priced greater than \$5. The category of very-low-priced options does not show a statistically significant decline. Net percentage effective spreads show similar patterns.

In Table 2, panel B, we confirm these results in a multivariate framework over the 30-day pre- and postswitch periods. Specifically, we estimate the following panel regression at the option class-day level:

$$NetEffectiveSpread_{j,t} = \beta_1 mt_{j,t} + \beta_2 X_{j,t} + SECID_j + Date_t + \varepsilon_{j,t}, \quad (1)$$

where $SECID_j$ is an option class fixed effect; $Date_t$ is a date fixed effect; and $X_{j,t}$ is the set of control variables, which includes *elnvol*, *lnvol*, and *evolat*. We denote by *elnvol* the log of underlying stock volume on the day, *lnvol* the log of option class volume, and *evolat* the underlying stock volatility calculated as the difference between the high and low prices of the day divided by the closing price. The variable of interest is *mt*, which equals 1 in the postswitch period for

Table 2 Impact of NYSE Arca's Introduction of Make-Take Structure on Net Effective Spreads: 2012 Event

Panel A: Net effective spreads

	Switching (non-penny) options				Control (Penny Pilot) sample					
	Pre	Post	Change	*p*-Value	Pre	Post	Change	*p*-Value	Diff-in-diff	*p*-Value
					Net effective spread ($)					
All	0.197	0.182	−0.016	0.00	0.065	0.070	0.005	0.00	−0.021	0.00
$Price \leq 0.5$	0.118	0.109	−0.009	0.11	0.026	0.026	−0.001	0.18	−0.008	0.16
$0.5 < Price \leq 1$	0.139	0.132	−0.007	0.01	0.035	0.039	0.004	0.13	−0.010	0.00
$1 < Price \leq 3$	0.201	0.187	−0.014	0.00	0.057	0.064	0.007	0.01	−0.022	0.00
$3 < Price = 5$	0.331	0.317	−0.014	0.07	0.118	0.136	0.017	0.00	−0.032	0.00
$Price > 5$	0.519	0.514	−0.005	0.72	0.227	0.262	0.034	0.00	−0.039	0.02
					Net effective spread (%)					
All	22.36	21.99	−0.37	0.15	8.50	9.54	1.04	0.00	−1.42	0.00
$Price \leq 0.5$	38.90	38.83	−0.07	0.86	19.72	20.55	0.83	0.00	−0.90	0.04
$0.5 < Price \leq 1$	18.34	17.22	−1.12	0.00	4.89	5.30	0.41	0.04	−1.53	0.00
$1 < Price \leq 3$	12.15	11.20	−0.94	0.00	3.31	3.68	0.37	0.00	−1.31	0.00
$3 < Price \leq 5$	8.89	8.54	−0.34	0.16	3.14	3.57	0.43	0.00	−0.77	0.01
$Price > 5$	6.94	6.87	−0.07	0.78	2.74	3.20	0.47	0.01	−0.53	0.07

Panel B: Regression analysis

	Net effective spread (%)	Net effective spread ($)
mt	−0.008	−0.014
	(0.00)	(0.00)
elnvol	−0.001	0.013
	(0.42)	(0.00)
lnvol	−0.004	−0.009
	(0.00)	(0.00)
evolat	0.225	0.377
	(0.00)	(0.00)
Class fixed effects	Yes	Yes
Date fixed effects	Yes	Yes
N	106,450	106,450
R^2	0.321	0.377

Notes. This table presents the impact of NYSE Arca's expansion of make-take structure to non-penny options on November 1, 2012 on net effective spreads. Panel A summarizes the changes in net effective spreads. Effective spreads are calculated as twice the absolute value of the difference between the execution price and the quote midpoint. Net effective spreads adjust for the fee differences by subtracting two times the payment for order flow from the effective spreads for trades on the traditional structure and adding two times the customer take fees for trades on the make-take structure. The preswitch ("Pre") and postswitch ("Post") periods are defined as 30 trading days before and after the switch, respectively. The switching (non-penny) group includes 1,998 option classes, and the control (Penny Pilot) sample includes 340 option classes. All option series within the option classes are included. We calculate volume-weighted net effective spreads for an option series-day, and then we equally weight across option series to obtain option class-day net effective spreads. All trades, regardless of where they occur, are included in the analysis. Panel A presents equally weighted averages across option class-days for the pre- and postswitch periods, overall and separately for price categories (based on option series price). Panel B presents a regression analysis examining changes in net effective spreads using option class-day observations. The dependent variable is the net effective spread on an option class-day. *elnvol* is the log of underlying stock volume on that day, *lnvol* is the log of option class volume, *evolat* is the underlying stock volatility calculated as the difference between the daily high and low prices divided by the closing price, and *mt* is a dummy variable that equals 1 in the postswitch period for the options switching to make-take and 0 otherwise. Date and option class fixed effects are included. *p*-Values (in parentheses) are calculated using standard errors clustered on option class and date.

the options switching to make-take and 0 otherwise.[16] The standard errors are double-clustered on option class and date. Note that *mt* captures the effect on the switching options relative to any marketwide changes that would also affect the nonswitching options. The variable is negative and significant (at the 1% level) for net dollar effective spreads as well as net percentage effective spreads showing a decline in customer execution costs following NYSE Arca's switch to make-take pricing.

5.2. Changes in Execution Costs: 2007–2010 Event

As a robustness check, we analyze changes in execution costs around the initial implementation of the make-take structure in options over the 2007–2010 period. This event has the advantage of a staggered

[16] Thus, *mt* is essentially an interaction between dummy variables for the switching options and the postswitch period. We cannot individually include the dummy variables for switching options and the postswitch period because these are subsumed by the option class and date fixed effects.

Table 3 Changes in Net Effective Spreads: 2007–2010 Event

	Net effective spread (%)	Net effective spread ($)
mks × *mt*	−0.068	−0.209
	(0.09)	(0.10)
mt	−0.033	−0.047
	(0.00)	(0.01)
elnvol	−0.002	0.008
	(0.01)	(0.00)
lnvol	−0.009	−0.009
	(0.00)	(0.00)
evolat	0.002	0.010
	(0.24)	(0.00)
Class fixed effects	Yes	Yes
Date fixed effects	Yes	Yes
N	956,060	956,060
R^2	0.233	0.290

Notes. This table presents a regression analysis of changes in net effective spreads around NYSE Arca's introduction of make-take structure in Penny Pilot options over nine dates during the 2007–2010 period. The regression is estimated using option class-day measures for 30 trading days before and after each of the nine switch dates. All option series within the option classes are included. There are 283 Penny Pilot options that switch to make-take structure during this period and an average of 2,128 options per switch date that are unaffected. Effective spreads are calculated as twice the absolute value of the difference between the execution price and the quote midpoint. Net effective spreads adjust for the fee differences by subtracting two times the payment for order flow from the effective spreads for trades on the traditional structure and adding two times the customer take fees for trades on the make-take structure. We calculate volume-weighted net effective spreads for an option series-day, and then we equally weight across option series to obtain option class-day net effective spreads. All trades, regardless of where they occur, are included in the analysis. The term *mt* is a dummy variable that equals 1 in the postswitch period for the options switching to make-take and 0 otherwise; *mks* × *mt* is the interaction between NYSE Arca's preswitch period market share in the option class; *mt, elnvol* is the log of underlying stock volume on that day; *lnvol* is the log of option class volume; and *evolat* is the underlying stock volatility calculated as the difference between the daily high and low prices divided by the closing price. Date and option class fixed effects are included. p-Values (in parentheses) are calculated using standard errors clustered on option class and date.

implementation over nine dates but the disadvantage of being coincident with the switch to lower tick sizes in the Penny Pilot. Hence, for this analysis, we focus on the incremental effect of NYSE Arca's preswitch period market share on the change in net effective spreads. This test assumes that options where NYSE Arca has a higher market share will be affected to a greater degree by its decision to implement make-take pricing. This effect is likely to be unrelated to the change to lower tick sizes. Table 3 presents results for net dollar and percentage effective spreads. The estimation is similar to Equation (1) except for the inclusion of the $mks \times mt$ interaction variable, where mks is NYSE Arca's preswitch period market share in the option class. We base our estimation on the 30 days before and after each of the nine switch dates. As expected, we find that the change to lower tick sizes is accompanied by a significant decline in both dollar and percentage net effective spreads. More importantly for our analysis, we find that the decline in spreads is larger for option classes with higher NYSE Arca market share in the preswitch period. The interaction variable ($mks \times mt$) captures the change in net effective spreads for options with higher versus lower NYSE Arca market share within the switching options only. The variable is negative and significant at the 10% level for both net dollar and percentage effective spreads.[17]

Our combined results from switches to make-take pricing on NYSE Arca show that investors across the market benefit from the introduction of make-take pricing.

5.3. Changes in Quote Competitiveness

Why do execution costs decline after make-take pricing is introduced into the options markets? We test whether market makers on NYSE Arca are more likely to improve quoted prices after options start trading in the make-take structure. An increase in quoting competitiveness from the make-take structure can benefit traders across the entire market as a result of the extra competition to improve quoted prices and the existence of the trade-through rule. As mentioned earlier, our data are limited in that we only observe exchange quotes at the time of a trade. We use these available quotes at the time of all trades in this analysis, regardless of where a trade takes place. Table 4, panel A summarizes the results. We find that there is a significant increase in the propensity of NYSE Arca to be at a better quote than the best quote across all traditional markets after the switch to the make-take structure. The proportion of NYSE Arca quotes that are better than the best traditional quotes increases to 15.5% in the 30 trading days after the switch from 11.2% in the 30 trading days before the switch for the overall sample. Difference-in-differences tests show that the increase for switching options is statistically significantly higher than those for the control sample at the 1% level.[18] We verify that these results exist in a regression setting. Specifically, we estimate the following model:

$$QC_{j,t} = \beta_1 mt_{j,t} + \beta_2 X_{j,t} + SECID_j + Date_t + \varepsilon_{j,t}, \quad (2)$$

[17] We also estimate an alternative specification within switching option classes only and find similar results.

[18] Our focus in this analysis is on the change in NYSE Arca's propensity to be alone at the best quote. The numbers for equal and worse quotes are high for NYSE Arca in Table 4, panel A. However, we are comparing NYSE Arca alone with quotes across all traditional markets. Further, we calculate the measure for all trades in our sample of option classes even if NYSE Arca is not active in a particular option series. If NYSE Arca quotes are missing, we count them as worse than traditional market quotes.

where $QC_{j,t}$ is the proportion of all quotes where NYSE Arca is better, equal, or worse than the best price in traditional markets (our quote competitiveness measure). The other variables are similar to those in Equation (1). The dummy variable *mt* is equal to 1 for option classes affected by the switch in the postswitch period and 0 otherwise. The dummy variable captures the effect of the switch after controlling for any marketwide changes. The results are presented in Table 4, panel B and are consistent with the results in Table 4, panel A.

In unreported results, we find a large and significant increase in NYSE Arca's quote competitiveness around the introduction of the make-take structure

Table 4 **Impact of NYSE Arca's Introduction of Make-Take Structure on Quote Competition, 2012 Event**

Panel A: Change in NYSE Arca's quote competitiveness

	Switching (non-penny) options				Control (Penny Pilot) sample					
	Pre	Post	Change	*p*-Value	Pre	Post	Change	*p*-Value	Diff in diff	*p*-Value
					NYSE Arca quotes better than traditional					
All	11.13	15.47	4.34	0.00	15.86	16.91	1.06	0.00	3.28	0.00
$Price \leq 0.5$	10.62	14.95	4.34	0.00	14.80	15.82	1.01	0.00	3.33	0.00
$0.5 < Price \leq 1$	11.23	15.60	4.37	0.00	16.87	18.09	1.22	0.00	3.16	0.00
$1 < Price \leq 3$	10.98	15.30	4.32	0.00	17.59	18.56	0.96	0.00	3.35	0.00
$3 < Price \leq 5$	7.25	11.50	4.25	0.00	10.07	12.12	2.05	0.00	2.20	0.00
$Price > 5$	6.83	11.43	4.60	0.00	10.40	13.27	2.87	0.00	1.73	0.01
					NYSE Arca quotes equal to traditional					
All	45.05	46.26	1.22	0.00	67.66	67.80	0.14	0.00	1.08	0.00
$Price \leq 0.5$	47.18	49.51	2.33	0.00	71.19	71.71	0.52	0.00	1.81	0.00
$0.5 < Price \leq 1$	46.35	47.73	1.38	0.00	67.19	66.99	−0.20	0.00	1.58	0.00
$1 < Price \leq 3$	44.54	45.23	0.69	0.00	62.49	62.29	−0.20	0.00	0.89	0.00
$3 < Price \leq 5$	47.50	48.35	0.84	0.00	67.03	65.93	−1.10	0.00	1.95	0.00
$Price > 5$	41.81	41.86	0.05	0.00	57.11	56.17	−0.94	0.00	1.00	0.01
					NYSE Arca quotes worse than traditional					
All	44.55	38.87	−5.69	0.00	16.50	15.31	−1.19	0.00	−4.50	0.00
$Price \leq 0.5$	43.96	37.14	−6.82	0.00	14.03	12.49	−1.54	0.00	−5.29	0.00
$0.5 < Price \leq 1$	44.05	38.17	−5.88	0.00	15.96	14.96	−1.00	0.00	−4.88	0.00
$1 < Price \leq 3$	46.11	40.95	−5.16	0.00	19.95	19.19	−0.76	0.00	−4.40	0.00
$3 < Price \leq 5$	46.36	41.29	−5.08	0.00	22.94	22.00	−0.94	0.00	−4.14	0.00
$Price > 5$	52.19	47.59	−4.61	0.00	32.54	30.65	−1.89	0.00	−2.71	0.01

Panel B: Control regression for change in quote competition: 2012 event

	Quote competitiveness		
	Better	Equal	Worse
mt	0.034	0.010	−0.044
	(0.00)	(0.03)	(0.00)
elnvol	0.001	0.001	−0.002
	(0.32)	(0.53)	(0.29)
lnvol	−0.002	0.003	−0.002
	(0.00)	(0.00)	(0.02)
evolat	−0.017	−0.028	0.053
	(0.46)	(0.38)	(0.10)
Class fixed effect	Yes	Yes	Yes
Date fixed effect	Yes	Yes	Yes
N	106,450	106,450	106,450
R^2	0.606	0.542	0.496

Notes. This table presents changes in quote competitiveness at NYSE Arca around the introduction of make-take pricing for non-penny options in November 2012. Pre- and postswitch periods are defined as 30 trading days before and after the switch, respectively. The switching (non-penny) group includes 1,998 option classes, and the control (Penny Pilot) sample includes 340 option classes. We calculate the measures at the option class-day level and present the averages across option class-days for the pre- and postswitch periods. We calculate the quote competitiveness measure using quotes at the time of all trades in the data, regardless of execution venue. At the time of each trade, we compare the relevant quote (bid or offer) on NYSE Arca with the best quote across all traditional markets, and we categorize the quotes as better, equal, or worse for NYSE Arca. Panel A presents equally weighted averages across option class-days for the pre- and postswitch periods overall and separately for price categories (based on option series price). Panel B presents a regression analysis of quote competition using option class-day observations. The term *mt* is a dummy variable that equals 1 in the postswitch period for the options switching to make-take and 0 otherwise; *elnvol* is the log of underlying stock volume on that day; *lnvol* is the log of option class volume; and *evolat* is the underlying stock volatility calculated as the difference between the daily high and low prices divided by the closing price. Date and option class fixed effects are included. *p*-Values (in parentheses) are calculated using standard errors clustered on option class and date.

Table 5 Net Effective Spreads, November 2012 to January 2013 Sample

	Dollar				Percentage			
	T	NYSE Arca	Diff	*p*-Value	T	NYSE Arca	Diff	*p*-Value
				Effective spread				
All	0.073	0.055	0.018	0.00	8.09	6.45	1.64	0.00
Price < 0.5	0.029	0.023	0.006	0.00	18.45	15.09	3.37	0.00
0.5 < *Price* ≤ 1	0.044	0.033	0.011	0.00	6.16	4.69	1.48	0.00
1 < *Price* ≤ 3	0.062	0.047	0.015	0.00	3.67	2.78	0.88	0.00
3 < *Price* ≤ 5	0.114	0.085	0.029	0.00	3.01	2.23	0.77	0.00
Price > 5	0.216	0.163	0.053	0.00	1.91	1.44	0.46	0.00
				Net effective spread				
All	0.065	0.067	−0.001	0.00	6.14	9.64	−3.50	0.00
Price < 0.5	0.022	0.034	−0.012	0.00	12.99	24.22	−11.23	0.00
0.5 < *Price* ≤ 1	0.036	0.045	−0.009	0.00	5.03	6.33	−1.30	0.00
1 < *Price* ≤ 3	0.054	0.058	−0.004	0.00	3.18	3.49	−0.31	0.00
3 < *Price* ≤ 5	0.106	0.096	0.011	0.00	2.81	2.53	0.27	0.00
Price > 5	0.209	0.174	0.035	0.00	1.82	1.56	0.26	0.00

Notes. This table compares net effective spreads on NYSE Arca and the traditional structure based on a matched sample of option series-days (described in Table 1, panel B) over the period from November 2012 to January 2013. Effective spreads are calculated as twice the absolute value of the difference between the execution price and the quote midpoint. Net effective spreads adjust for the fee differences by subtracting two times the payment for order flow from the effective spreads for traditional exchanges and adding two times the customer take fees for NYSE Arca. We present results separately for price categories based on the price for each series on each day in the sample. *T* refers to the traditional market structure. Both dollar and percentage measures are presented. *p*-Values are calculated by using standard errors clustered on option series and date.

over the 2007–2010 period. We note that the coincident reduction in tick size around the 2007–2010 event does not contaminate the analysis of quote competitiveness since there is no obvious link between smaller tick sizes and quote competitiveness of one exchange. Thus, the changed incentives of the make-take structure have a significant impact on the quoting patterns of market makers.

5.4. Comparison of Execution Costs When Market Structures Coexist

We compare the execution costs on the traditional structure and NYSE Arca after the full introduction of the make-take structure by NYSE Arca in November 2012. This comparison allows us to characterize the equilibrium when the two structures compete for order flow and describe the nature of the competition.

For the analysis, we use a matched sample of option series-days over the period from November 2012 to January 2013, where the same option series trades in the traditional structure and NYSE Arca on the same day. Table 1, panel B describes the sample. All statistics are equally weighted across option series-days, and significance tests are based on standard errors clustered on option series and date. Table 5 shows that unadjusted effective spreads are lower on NYSE Arca. Adjusted for fees, the overall net dollar effective spreads are of economically similar magnitudes.[19] Similar to the results in Battalio et al. (2011), the net percentage effective spreads are significantly higher on the make-take structure. The apparent inconsistency between net dollar and percentage effective spreads is a result of the influence of the fees in the lowest-priced options. When we disaggregate our results by price categories, we obtain similar patterns for net dollar and percentage spreads: higher net effective spreads for NYSE Arca in the lower-price categories (price categories below $3) and lower net effective spreads for NYSE Arca in higher-price categories.

In our matched sample analysis, the same securities trade in interlinked markets where trade-through rules prevent a market from executing a trade at a price inferior to that available in another market. This observation brings up an important question: Why do net effective spreads differ when markets quote the same securities, trade-through rules prevent inferior executions, the pricing and fees are known to market participants, and brokers have a best-execution obligation to their clients?

5.5. Order Routing

Angel et al. (2011) point out that trade-through rules apply only to quoted spreads and not to net spreads. Hence, the obfuscation of true prices can lead to suboptimal executions if brokers route based on quoted,

[19] In unreported results, we include all make-take exchanges to calculate the execution costs for the make-take structure. The inferences from the analysis are identical to the ones presented in Table 5. Also, the results from a different matched sample over the period from October 2010 to December 2010 that followed the 2007–2010 event are similar.

instead of net, prices. We analyze whether brokers account for fees in their routing decisions. We base this analysis on the customer fee differences between make-take and traditional markets, which imply that when quoted prices are equal in the two market structures, the net (of fees) price at the traditional market is better for investors. The make-take structure provides a better net (of fees) price only when it is quoting a better price, since the minimum price increment is higher than the difference in the fees. Thus, if brokers route orders appropriately based on net (of fees) prices, we expect to see executions in the make-take structure primarily occur when it is at a better quoted price than the traditional structure. Executions in the traditional structure are relatively more likely when it is quoting prices equal to the make-take structure.

We use the introduction of make-take pricing in November 2012 to examine whether brokers change their routing behavior in response to the change in fees.[20] If order routing decisions are based on the net (of fees) prices, then we should find an increase in the proportion of NYSE Arca's trades that occur when it is at a better quoted price than traditional markets and a decrease in the proportion of NYSE Arca's trades that occur when it is quoting a price equal to traditional markets. We use a difference-in-differences approach to compare the changes in the options that switch to make-take pricing with others that do not switch. Table 6, panel A shows the proportion of NYSE Arca's trades that occur when it is quoting a price better than the best quoted price across traditional markets, and when its quoted price is equal to the best quoted price in traditional markets, in the period before and after the change. We calculate the measures over a period of 30 trading days each in the pre- and postswitch periods. For this analysis, we analyze only trades that occur at the national best bid and offer (NBBO), and only compare the relevant side of the quote, i.e., bids for trades at the national best bid and offers for trades at the national best offer. The results show a sharp increase, from 60.1% to 72.1%, in the proportion of NYSE Arca's trades that occur when it is quoting a better price than traditional markets. The proportion increases in all price categories for the switching options, and it is significantly higher than the changes for nonswitching options. Thus, brokers adjust their routing practices as the relative fees change in the market. The event is also associated with a decline in the proportion of trades that are executed when the NYSE Arca quoted price is equal to the best quoted price in the traditional structure. In unreported results on the traditional markets, we find, as expected, opposite results: the proportion of traditional markets' trades, when their quotes are equal to NYSE Arca quotes, increases as their quotes become more attractive net of fees. We also find that the results are robust to a multivariate specification similar to Equation (2).

We conduct additional robustness tests on order routing. First, in Table 6, panel B, we examine the matched sample from November 2012 to January 2013 to test whether order routing is consistent with the above results when the two market structures compete with one another. We find that 69% of NYSE Arca's trades occur when it is at a better quoted price than the traditional structure. By contrast, only 29% of the traditional structure's trades occur when it is quoting the better price, whereas 64% of traditional structure's trades occur when the two structures are quoting the same price. These results are consistent with brokers routing based on net (of fees) prices since a significant majority of trades are routed to the appropriate venue. Note that 26% of trades on NYSE Arca execute when the prices are equal across the two structures. Because of data limitations, it is difficult to definitively attribute these executions to suboptimal routing decisions because some quotes may have changed close to the time the order was routed (i.e., quoted prices changed between the order routing decision time and execution time) and because the fee differentials between the two structures exist only for customer orders (i.e., the trades may originate from traders classified as professionals or firms, instead of customers).

Second, we examine order routing from the perspective of an arriving trade into the market when the two structures are at the same quoted price. When the best quoted price (on the relevant side of the trade) on the traditional structure is equal to the best quoted price at NYSE Arca, 84.3% of trades execute in the traditional structure. The proportions are similar across price categories. Thus, a large majority of trades are routed to the best net (of fees) price. These results on order routing are also consistent with our earlier analysis of changes in quote competitiveness. Since order routing decisions account for differences in fees, market makers in the make-take structure need to improve quoted prices to attract order flow.

Thus, it does not appear that suboptimal order routing decisions contribute to the observed differences in net effective spreads between the traditional structure and NYSE Arca. As a final test, we compare net effective spreads for trades that are clearly identifiable as having been routed to the lower-cost venue in our analysis—that is, trades that occur at the NBBO and execute in the traditional structure when the quoted prices in the traditional structure are *better than or equal to* the quoted prices on NYSE Arca or trades that execute at NYSE Arca when its quoted price is *better*

[20] The 2007–2010 event yields similar results. The results are available from the authors.

Table 6 Order Routing Analysis

Panel A: Proportion of NYSE Arca volume executed by relative quote position, 2012 event

	Switching (non-penny) options				Control (Penny Pilot) sample					
	Pre	Post	Change	*p*-Value	Pre	Post	Change	*p*-Value	Diff-in-diff	*p*-value
					NYSE Arca quotes better than traditional					
All	60.08	72.08	12.01	0.00	65.29	69.65	4.37	0.00	7.64	0.00
Price $\leq$ 0.5	56.91	70.08	13.17	0.00	61.98	65.48	3.50	0.00	9.67	0.00
0.5 < *Price* $\leq$ 1	58.22	69.41	11.19	0.00	67.11	72.10	5.00	0.00	6.19	0.00
1 < *Price* $\leq$ 3	58.86	71.32	12.46	0.00	69.58	74.05	4.47	0.00	7.99	0.00
3 < *Price* $\leq$ 5	58.90	72.59	13.69	0.00	73.20	76.98	3.78	0.00	9.91	0.00
Price > 5	60.65	74.21	13.56	0.00	76.58	80.51	3.93	0.00	9.62	0.00
					NYSE Arca quotes equal to traditional					
All	33.49	22.95	−10.54	0.00	30.17	26.35	−3.82	0.00	−6.72	0.00
Price $\leq$ 0.5	36.31	24.62	−11.69	0.00	33.17	30.12	−3.05	0.00	−8.64	0.00
0.5 < *Price* $\leq$ 1	34.93	25.21	−9.71	0.00	28.82	24.45	−4.37	0.00	−5.35	0.00
1 < *Price* $\leq$ 3	34.86	23.32	−11.53	0.00	26.55	22.55	−4.00	0.00	−7.53	0.00
3 < *Price* $\leq$ 5	34.34	23.00	−11.34	0.00	23.25	20.35	−2.90	0.00	−8.44	0.00
Price > 5	32.73	21.44	−11.29	0.00	20.59	17.19	−3.40	0.00	−7.89	0.00

Panel B: Proportion of volume executed by relative quote position: November 2012 to January 2013

	Traditional			NYSE Arca			*p*-Value of difference		
	T better	Equal	*T* worse	Arca better	Equal	Arca worse	Better	Equal	Worse
Overall	28.85	64.00	7.15	69.43	25.55	5.17	0.00	0.00	0.00
Price $\leq$ 0.5	20.48	71.05	8.47	64.33	29.71	6.11	0.00	0.00	0.00
0.5 < *Price* $\leq$ 1	26.70	65.92	7.39	71.03	24.56	4.56	0.00	0.00	0.00
1 < *Price* $\leq$ 3	31.98	60.68	7.35	72.51	23.07	4.57	0.00	0.00	0.00
3 < *Price* $\leq$ 5	33.29	62.25	4.47	71.22	24.30	4.70	0.00	0.00	0.07
Price > 5	43.11	52.21	4.68	70.86	23.64	5.60	0.00	0.00	0.00

Panel C: Net effective spreads for trades executed at the venue with the best net (of fees) price: November 2012 to January 2013

	Net effective spreads ($)				Net effective spreads (%)			
	T	NYSE Arca	Diff	*p*-Value	*T*	NYSE Arca	Diff	*p*-Value
All	0.062	0.061	0.000	*0.23*	6.06	9.41	−3.35	0.00
Price < 0.5	0.022	0.033	−0.012	*0.00*	12.57	23.17	−10.60	0.00
0.5 < *Price* $\leq$ 1	0.034	0.042	−0.008	*0.00*	4.84	5.99	−1.15	0.00
1 < *Price* $\leq$ 3	0.051	0.053	−0.002	*0.00*	3.06	3.23	−0.17	0.00
3 < *Price* $\leq$ 5	0.108	0.096	0.012	*0.00*	2.86	2.55	0.31	0.00
Price > 5	0.209	0.166	0.043	*0.00*	1.85	1.52	0.33	0.00

Notes. This table presents our analysis of order routing practices. Panel A summarizes changes at NYSE Arca around the introduction of make-take pricing for non-penny options in November 2012. Pre- and postswitch periods are defined as 30 trading days before and after the switch, respectively. The switching (non-penny) group includes 1,998 option classes, and the control (Penny Pilot) sample includes 340 option classes. We calculate the measures at the option class-day level and present the averages across option class-days for the pre- and postswitch periods. We also present results separately for price categories based on the price of an option series. Panel A shows the proportion of NYSE Arca's order flow executed when it is quoting a better price than the best price across traditional markets and when the quoted prices are equal. At the time of each trade, we compare the relevant quote (bid or offer) on NYSE Arca with the best quote across all traditional markets, and we categorize the quotes as better, equal, or worse for NYSE Arca. Panel B summarizes the proportion of a structure's (traditional or NYSE Arca) order flow that is executed when it is quoting a better price than the other, when the quoted prices are equal, and when it is quoting an inferior price for the matched sample from November 2012 to January 2013. Panel C presents net effective spreads for the subsample of trades that we identify as being routed appropriately for the matched sample from November 2012 to January 2013. *T* refers to the traditional market structure. For panel A, *p*-values are calculated using standard errors clustered on option class and date. For panels B and C, *p*-values are calculated using standard errors clustered on option series and date.

than the quoted price in the traditional structure. Comparisons of execution costs in this subsample are not likely to be affected by suboptimal routing decisions. In Table 6, panel C, we find the same cross-sectional pattern for this subsample: net effective spreads are higher for NYSE Arca than the traditional structure in lower-price categories and lower in higher-price categories. We use this subsample for further exploration of factors that may explain the observed differences in comparisons across price categories.

5.6. Other Factors Explaining Differences in Net Effective Spreads

The results on order routing indicate that customer trades tend to execute in the venue where the trade would receive the best net (of fees) price. If the trade is routed to the venue with the best price at the time of order arrival, why do we observe systematic differences in net effective spreads? In this subsection, we explore other possible reasons for the differences.

5.6.1. Characteristics of the Order Flow. We examine the assumption implicit in our comparisons that there are no systematic differences in the types of order flow directed to the competing structures. The potential for such differences exists since payments for order flow arrangements are more likely to attract the uninformed and less strategic order flow to the traditional exchanges. In Table 7, we compare a modified price impact measure of trades to analyze differences in order flow. Typically, price impact is calculated as the difference in the NBBO quote midpoint five minutes after the trade and the NBBO quote midpoint immediately before the trade, multiplied by an indicator variable that equals $+1$ for buyer-initiated trades and -1 for seller-initiated trades. Given the data constraints for the sample from November 2012 to January 2013, we use the midpoint at the market close from OptionMetrics instead of the midpoint five minutes after the trade. We find that the price impact of trades on NYSE Arca is significantly higher than that of trades on the traditional structure.[21] These results point to the more strategic trades (which precede favorable price movements) occurring on NYSE Arca.

Do these differences in order flow explain the difference in net effective spreads? We conduct a regression analysis where we regress the difference in net effective spreads between NYSE Arca and the traditional structure on price dummy variables for each of the price categories and the difference in the price impact of trades on the two structures. We find that the coefficients of the price dummy variables are unaffected by the inclusion of the difference in price impact variable, even though the price impact variable is highly significant. In an alternative specification, we use option class volume, underlying stock volume, and class and date fixed effects as control variables and find similar results. The regression results indicate that price impact differences do not adequately explain the differences in net effective spreads.[22]

5.6.2. The Role of the Minimum Price Improvement and the Fee Adjustment. In a simplistic framework where the make-take structure has to improve the quoted price to attract order flow, and assuming no other differences, we would expect that the average execution cost on the make-take structure is lower than that on the traditional structure. When we compare the unadjusted effective spreads between NYSE Arca and the traditional structure, we find that to be the case. However, net effective spread differences show inconsistent patterns, with higher net effective spreads on NYSE Arca for lower-priced options. In this subsection, we explore whether the interplay between the minimum price improvement that NYSE Arca must offer (dictated by the tick size) and the fee adjustment influences the comparisons of net effective spreads in coexisting market structures.

To begin with, it is useful to reiterate that our calculation of the net effective spread measure adjusts for fees by adding $2 \times$ take fees to effective spreads on the make-take structure and subtracting $2 \times$ payment for order flow from effective spreads on the traditional structure. Therefore, the price improvement in the quoted price offered by the make-take structure needs to exceed the fee difference of $2 \times$ (take fees + payment for order flow) for the net effective spreads to be lower on the make-take structure. If the make-take structure competes by improving the quoted price by the minimum possible amount (which is determined by the tick size), then the comparison of net effective spreads is affected by the difference between the tick size and the fee difference. Specifically, when the make-take structure improves prices only on one side of the quote by the minimum allowed price improvement, it offers a better net (of fees) price on that side of the quote since the tick size is greater than the fee difference (take fee + payment for order flow) applicable to the trader deciding on the venue.[23] However, the changed quote midpoint as a result of the one-sided quoted price improvement halves the magnitude of the one-tick price improvement in the calculation of effective spreads. This reduced price improvement, when compared with the fee difference between the two structures, can make the net effective

[21] Our analysis of price impact is limited to testing for differences in relative informativeness of order flow. We do not analyze whether options market makers bear these costs or transfer them to the underlying markets through their hedging activities. We also do not test for informed trading in options versus equities markets, which is a focus in many studies, including Chakravarty et al. (2004), who find that options trades are informed, and Hu (2014), who finds that it is primarily the equities order imbalance generated by hedging of options market makers that is correlated with future returns. Muravyev et al. (2013) find that options quotes do not contain any information in addition to those in underlying stock quotes.

[22] We replicate this analysis in the period from October 2010 to December 2010, when quote midpoints five minutes after the trade (instead of closing quote midpoints) are available to us. The results are similar.

[23] In our sample from November 2012 to January 2013, we find that when NYSE Arca is at the better net (of fees) price on the side where the trade occurs, it is at the better net (of fees) price on the other side of the quote for only 4.8% of the observations. This is consistent with the exchange improving the quoted price on one side of the quote.

Table 7 **Price Impact**

	Price impact ($)				Price impact (%)			
	T	NYSE Arca	Diff	*p*-Value	*T*	NYSE Arca	Diff	*p*-Value
All	0.035	0.056	−0.021	0.00	4.38	7.42	−3.04	0.00
Price < 0.5	0.016	0.025	−0.009	0.00	9.32	16.34	−7.02	0.00
0.5 < *Price* ≤ 1	0.024	0.038	−0.014	0.00	3.48	5.81	−2.33	0.00
1 < *Price* ≤ 3	0.036	0.055	−0.019	0.00	2.26	3.49	−1.23	0.00
3 < *Price* ≤ 5	0.066	0.099	−0.033	0.00	1.76	2.68	−0.92	0.00
Price > 5	0.080	0.142	−0.062	0.00	0.88	1.41	−0.53	0.00

Notes. This table compares the price impact of trades executed on the traditional structure and NYSE Arca. The analysis is based on the subsample of appropriately routed trades used in Table 6, panel C. Price impact is calculated as the difference in the NBBO midpoints at the close of the trading day and the midpoint immediately before the trade, multiplied by an indicator variable that equals +1 for buyer-initiated trades and −1 for seller-initiated trades. We present results separately for price categories based on the price for each series on each day in the sample. *T* refers to the traditional market structure. Both dollar and percentage measures are presented. *p*-Values are calculated using standard errors clustered on option series and date.

spreads appear to be larger on the make-take structure. To provide an illustration of this issue, we use the fees for Penny Pilot options where the take fee is $0.0045 on NYSE Arca and the typical payment for order flow is $0.0025. Then the following assumptions apply.

—Assume that a trade occurs at the ask price on the traditional structure when the best bid and ask prices are $2.00 and $2.02, respectively. The effective spread for this trade is $0.02 (2 × (ask price of 2.02 − midpoint of 2.01)), and the net effective spread is $0.015 (effective spread − 2 × payment for order flow of $0.0025).

—Further, assume that NYSE Arca improves the ask side of the quote, by the minimum price increment of $0.01, to $2.01, and a trade occurs at this ask price. The best bid price in the market is unchanged at $2.00. Now, the unadjusted effective spread is $0.01 (2 × (ask price of 2.01 − midpoint of 2.005)), and the net effective spread is $0.019 (effective spread + 2 × take fees of $0.0045).

In this admittedly very specific example, the trader makes the correct decision to execute on NYSE Arca and receives the better price but appears to pay a larger net effective spread. This effect gets less significant as the magnitude of the fee difference gets smaller relative to the minimum allowed price improvement. That is, if NYSE Arca is forced to improve prices by a larger amount, then the calculated net effective spread would also be smaller on NYSE Arca. Since tick sizes increase with price levels, the effect is less significant in higher-priced options and may explain the different results in low- and high-priced options. For example, with the same fees as above, assume that the following trades occur in a Penny Pilot option series above $3, which has a tick size of $0.05:

—A trade occurs at the ask price on the traditional structure when the best bid and ask prices are $3.50 and $3.60, respectively. Then, the effective spread is $0.10 (2 × (ask price of 3.60 − midpoint of 3.55)), and the net effective spread is $0.095 (effective spread − 2 × payment for order flow of $0.0025).

—NYSE Arca improves the ask side of the quote, by the minimum price increment of $0.05, to $3.55, and a trade occurs at this ask price. The best bid price in the market is unchanged at $3.50. Now, the unadjusted effective spread is $0.05 (2 × (ask price of 3.55 − midpoint of 3.525)), and the net effective spread is $0.059 (effective spread + 2 × take fees of $0.0045).

Thus, the comparison of coexisting market structures is affected by the systematic differences in the way the two structures compete for order flow.[24] We believe that this discussion further underscores the need to study the impact of the make-take structure around events where the make-take structure is introduced, and it provides a point of caution to researchers comparing execution costs across exchanges employing different pricing structures.

5.6.3. Other Dimensions of Market Quality. If the make-take structure narrows spreads to attract order flow, and trades are routed to the venue with the better price, why do trades execute on the traditional structure? The results suggest that the traditional structure maintains greater market presence. We find evidence consistent with this expectation. In the sample from November 2012 to January 2013, we find that the traditional structure is at a better net (of fees) price for more than 80% of the observations.

[24] In an unreported analysis, we construct an alternative effective spread measure that attempts to nullify the change in the midpoint as a result of price improvement on one side of the quote by the exchange where the trade occurs. Specifically, we construct the bid–ask spread that would have existed if the exchange (where the trade occurs) had not improved the quoted price on the side of the trade. That is, we use the NBBO quoted price on the side opposite to the trade, but the best available quoted price across all exchanges, excluding the exchange of trade execution, for the quoted price on the side of the trade. When these alternative benchmark quotes are used, the net effective spreads are smaller on NYSE Arca in the overall sample and in every price category.

Table 8 **Comparison of Market Depth and Trade Size: November 2012 to January 2013 Sample**

	Quoted depth				Trade size			
	T	NYSE Arca	Diff	*p*-Value	*T*	NYSE Arca	Diff	*p*-Value
All	222.8	55.7	167.1	0.00	13.6	10.6	3.1	0.00
Price < 0.5	356.9	84.1	272.7	0.00	18.3	14.0	4.3	0.00
0.5 < *Price* ≤ 1	222.0	58.2	163.8	0.00	14.4	11.3	3.1	0.00
1 < *Price* ≤ 3	147.8	44.4	103.4	0.00	12.0	9.5	2.5	0.00
3 < *Price* ≤ 5	230.0	44.2	185.8	0.00	10.8	8.4	2.4	0.00
Price > 5	99.0	23.1	75.9	0.00	7.6	5.7	1.9	0.00

Notes. This table compares market depth and trade size on NYSE Arca and traditional markets based on a matched sample of option series-days (described in Table 1, panel B) over the period from November 2012 to January 2013. Depth is the average number of contracts available on an exchange when its observed quote (bid or offer) equals the NBBO. We only observe quotes at trade times and include all observations in the quoted depth calculations regardless of where the trade executes. Trade size measures the number of contracts in an average trade. We present results separately for price categories based on the price for each series on each day in the sample. *T* refers to the traditional market structure. *p*-Values are calculated using standard errors clustered on option series and date.

In addition, Table 8 examines other dimensions of market quality. Table 8 shows that the quoted depth available at an exchange when its quote equals the NBBO is significantly higher in the traditional structure. For the overall sample, the average quoted depth for quotes at the NBBO in the traditional structure is 223 contracts, whereas on NYSE Arca it is 56 contracts. The difference exists in all price categories. Furthermore, although the differences are less pronounced, the average size of a trade executed on the traditional structure is consistently larger than that of a trade executed on NYSE Arca.

5.7. Cross Subsidization

Sofianos (1995) and Cao et al. (1997) show a cross subsidy in liquidity provision from liquid to illiquid stocks in the NYSE specialist system. The possibility of such a cross subsidy in the established traditional structure raises the concern that the introduction of make-take pricing for the liquid (Penny Pilot) options leads to a loss of coverage for the illiquid (non-penny) options. Our data do not allow us to observe individual market maker trades, profitability, or portfolios (as, for example, in Corwin and Coughenour 2008). Therefore, we focus on changes in coverage on NYSE Arca around its introduction of make-take pricing. Around the 2007–2010 introduction of make-take structure for Penny Pilot options, we find that the propensity of NYSE Arca to trade non-penny options in the 30 days after the switch is modestly higher than in the 30 days before the switch. We test for cross-sectional differences by dividing the non-penny sample into quintiles based on market capitalization of underlying stocks and see modest increases across quintiles. The propensity is calculated as the daily number of option classes traded on NYSE Arca divided by the total number of option classes traded in the market on the day. We also examine changes in the coverage of option series within option classes. For this analysis, we measure the proportion of the total option series within option classes that are traded by NYSE Arca in the 30 days before and after the change. We also require these option classes to be traded by traditional markets for an appropriate control sample. We again find no evidence that coverage drops in NYSE Arca after the switch. We analyze these measures around the 2012 introduction to test the possibility that as the less liquid, non-penny options are added to the make-take structure, market makers on NYSE Arca stop trading some of those options. We find significant increases in the coverage of the switching non-penny option classes across market capitalization quintiles. Within option classes, the coverage of option series shows significant increases for the switching options. These increases exist across moneyness categories, which we use to serve as a proxy for liquidity of the option series. Thus, it does not appear that the make-take structure leads to a loss of coverage, holding other factors constant.

5.8. Other Robustness Tests

Where possible, we have conducted our analysis for two event-related samples and two equilibrium samples to study the impact of the make-take structure. Our main emphasis has been on results related to the 2012 event and the sample from November 2012 to January 2013 comparing the traditional structure and NYSE Arca. Conducting similar tests for the 2007–2010 event and the matched sample from October 2010 to December 2010, we find similar results. That is, quote competition from NYSE Arca increases, and order routing changes around the 2007–2010 event. The patterns in spread comparisons documented in the sample from November 2012 to January 2013 also exist in the sample from October 2010 to December 2010. Additionally, for the analyses where the two structures coexist, we repeat the analysis using all make-take markets (instead of NYSE Arca alone) to compare with the traditional structure.

None of our inferences change with this additional analysis.

We test whether our results are sensitive to other empirical choices. First, we recalculate our results for the equilibrium sample from November 2012 to January 2013 by aggregating the results at the option class level rather than the series level, similar to the approach in Battalio et al. (2011). The results are substantively similar with this change, which is not unexpected given that our percentage spread results in Table 5 are consistent with the results documented by Battalio et al. (2011). Second, we reconsider our choice of restricting the sample to equity options only. We calculate our measures for the equilibrium samples for exchange-traded fund options and find results similar to those documented for equity options in the paper. We do not include index options because these tend to be proprietary, are overwhelmingly concentrated on the CBOE, and often have very different fee structures in that they charge royalty fees. Third, we have excluded BOX from our analysis of the equilibrium samples. The reason for the exclusion is that approximately two-thirds of the volume on BOX trades on their price improvement auction (the price improvement period, or PIP). The auction is structured to help internalization of trades as the market maker bringing a customer trade to the PIP also submits a contra order. Other market makers can compete with the submitting market maker within a small time period. BOX is structured as a take-make market that effectively pays a rebate to the customer trade in the PIP and charges a fee to the market maker. In this respect, the fee structure is similar to the traditional market where markets makers are charged a fee that is passed on to the brokers as payment for order flow. As a robustness check, we include BOX as a traditional market and find results very similar to those documented in the paper.

6. Discussion and Conclusion

The make-take pricing structure has been the subject of recent criticism as a potential source of problems with the U.S. securities market structure. Although the evidence on the performance of the make-take structure is growing, the debate reflects the need for more empirical evidence. For example, the current state of the equities markets where equities exchanges using make-take pricing compete with dark venues, including internalization venues, makes it difficult to draw conclusions on whether make-take pricing helps or hurts investors. Nonexchange venues currently account for more than 40% of executed volume in equities. Although internalization venues frequently do not charge fees, they base the transaction prices on the best prices available in the exchanges at the time of order arrival. Thus, it is important to know whether overall execution costs in the market are different in the presence of the make-take structure.

We analyze natural experiments to test for changes in execution costs across the entire market when the make-take structure is introduced in options. We find that execution costs (net of fees) decline as a result of the introduction of the make-take structure. We attribute the lower costs to increased quote competition from market makers in the make-take structure, which outweighs the additional take fees charged on trades executing in the structure. We also find that brokers route based on net (of fees) prices, not on quoted prices, and that a comparison of effective spreads observed in a static equilibrium may not provide accurate inferences. Our results complement earlier studies in equities markets, since we show improvements in execution costs in a fragmented market.

Our results are relevant to the current regulatory debate surrounding the make-take structure. We find benefits associated with the make-take structure, especially when it competes with execution venues relying on payment for order flow. Although the mechanics of payment for order flow are different in options and equities, the practice is widely prevalent in both markets. Earlier literature has pointed to reduced incentives for market makers to quote aggressive prices when they attract order flow through payment for order flow arrangements. Our results indicate that the make-take structure can counter the effects of these lower incentives by improving quoted prices, thus benefitting liquidity demanding traders across the entire market. It is therefore important that both be considered together, rather than separately, in any proposed changes to the market structure.

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Appendix

Table A.1 An Illustration of the Effects of Fees on Customer Effective Spreads

Exchange	Customer take fee	Customer payment for order flow	Effective spread	Net effective spread
Amex		−0.0025	0.05	0.045
Arca	0.0045		0.05	0.059
BATS	0.003		0.05	0.056
BOX		−0.0005	0.05	0.049
C2	0.0015		0.05	0.053
CBOE		−0.0025	0.05	0.045
ISE-MT	0		0.05	0.05
ISE-Non MT		−0.0025	0.05	0.045
NOM	0.0043		0.05	0.0586
PHLX-MT	0.0025		0.05	0.055
PHLX-Non MT		−0.0025	0.05	0.045

Notes. In this table, we provide an example to illustrate the impact of fees on liquidity demanders using constant round-trip traded effective spreads of $0.05. Effective spreads are equal to twice the absolute value of the difference between the execution price and the quote midpoint. Net effective spreads adjust for the fee differences by subtracting twice the payment for order flow from the effective spreads for traditional exchanges and adding twice the customer take fees for make-take exchanges. All fees and payments reflect the fee structure for Penny Pilot options. We assume that all fees and payments are passed on to traders directly or indirectly (through lower commissions and better trading technology). The net effective spreads are presented for each exchange and separately by market structure for ISE and PHLX, which trade some options in the make-take structure and others in the traditional structure. Information on exchange fees was collected from exchange filings with the SEC available on the SEC website under self-regulatory organization filings for each exchange. One-way take fees for customers are summarized in the second column, and one-way payments for order flow are summarized in the third column for each exchange. A negative number indicates a payment to the liquidity-taking customer, and a positive number indicates a payment from the liquidity-taking customer to the exchange.

Data Filters

We only keep option series for a day for which we have information in the OptionMetrics data on the particular day. This filter primarily removes series associated with underlying stocks that have undergone certain corporate events such as bankruptcy or acquisitions. We remove option series with nonstandard settlements, and finally, we remove all series that could be candidates for trading related to dividend strategies. Hao et al. (2010) describe market makers' trading (taking simultaneous large long and short positions) of in-the-money call options on the day before the ex-dividend day. The trades are designed to capture the gains from unexercised call options by customers. Since these trades do not represent volume or liquidity available to other traders, are essentially zero net position trades as a result of offsetting long and short positions, and serve a very specific purpose, we do not include them in our analysis. Specifically, we remove all in-the-money call option series for the day before the ex-dividend day of an underlying security. We eliminate cancelled trades, trades with zero price or volume, trades executed when market quotes are crossed, nonfirm quotes, quotes where the ask price equals zero, quotes with missing bid or ask sizes, and quotes with spreads wider than $5. We combine trades in the same series of the same type that are reported in the same millisecond on a particular exchange. We believe these combined trades appropriately account for a trade that may have been split during execution.

Table A.2 Summary of Key Market Structure Characteristics

Characteristic	Traditional markets (T)	Make-take markets (MT)
Exchanges	CBOE, NYSE Amex, ISE, PHLX, MIAX —CBOE, Amex, and MIAX use only the traditional structure for all their option classes. —ISE and PHLX trade most option classes under the traditional structure.	NYSE Arca, NOM, BATS, PHLX, ISE, C2 —ISE and PHLX trade a small number of high-volume option classes as MT. In November 2012, there are 40 MT options on PHLX and 155 on ISE. —NYSE Arca traded non-penny options under the traditional model until November 2012. After November 2012, it is a purely make-take exchange.
Fee structure	Customers are not charged any fees. Other traders pay fees for each traded contract. Typically, exchange market makers pay lower fees than other professional traders.	Liquidity providers receive a rebate; liquidity demanders are charged. —Make rebates and take fees are typically higher for exchange market makers.
Payment for order flow (PFOF) fees	Market makers pay a PFOF fee for each trade.	No PFOF fees.
Market maker (MM) quoting requirements	Exchanges have different levels of MMs. The primary MM (variously called "PMM" on ISE, "DPM" on CBOE, and "Specialist" on PHLX and Amex) has higher levels of quoting obligations. —Typically, the primary MM is required to quote 90%, or higher, of the option series. Lower-level MMs are required to quote 60% of the option series.	MT exchanges have typically lower requirements for MMs. —ISE and PHLX do not differentiate between MT and traditional classes in this dimension and have similar quoting requirements. —BATS has the lowest quoting requirements of its MMs.

Table A.2 (Continued)

Characteristic	Traditional markets (T)	Make-take markets (MT)
Priority/ Allocation rules	All exchanges give priority to customers at a price (i.e., after price priority). After customers, the primary MM, or the directed MM, is guaranteed a fixed proportion of incoming orders (typically 40%). —On CBOE, ISE, and PHLX, the primary MM has 100% allocation priority for orders of fewer than five contracts. —CBOE provides 50% allocation to MMs setting the NBBO. —After the primary MM, remaining MMs are allocated order flow. —Non-MMs rank last in priority.	Most exchanges give customers priority. —NYSE Arca provides a guaranteed 40% allocation to primary MMs. All traders are treated equally after the customer and primary MM allocation. —Price-time priority is more common on MT exchanges, except on ISE and PHLX where make-take option classes follow the same allocation priority as the traditional structure option classes.

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