

## To Pay or be Paid?

### The Impact of Taker Fees and Order Flow Inducements on Trading Costs in U.S. Options Markets\*

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**Abstract:** Equity options exchanges in the United States use one of two models to execute marketable orders: the maker-taker model or the payment for order flow (PFOF) model. Exchanges utilizing the maker-taker model charge liquidity demanders a taker fee to access their liquidity. Exchanges utilizing the PFOF model use order flow payments to attract marketable retail orders. We examine whether the agency problems associated with PFOF manifest themselves in the equity options markets. Focusing solely on execution prices, we find that the cost of liquidity on exchanges utilizing the PFOF model is 80 bps higher than on exchanges utilizing maker-taker pricing. Nevertheless, when taker fees are incorporated into the analysis, the cost of liquidity on the PFOF exchanges is 74 bps lower. Our results have two implications: (i) transparency and competition in equity options markets appear to have limited the potential agency problems, and (ii) evaluations of market quality that ignore taker fees can be misleading.

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## 1. Introduction

Recent structural changes in the U.S. options markets have resulted in a unique trading landscape in which more than 70% of options volume executes on exchanges that employ the *Payment for Order Flow* (PFOF) model. In this model, liquidity is supplied by market makers, who naturally prefer executing against uninformed orders. To attract such orders, the PFOF exchanges pay brokers to route retail liquidity-demanding orders to the exchange. The remaining options volume executes on trading venues that use the *maker-taker* model. In this model, designated market makers play a trivial role in providing liquidity. Instead, liquidity is attracted by charging access fees to liquidity demanders and rebating a portion of these fees to liquidity suppliers – the limit order traders. Markets using the maker-taker model do not purchase retail liquidity demanding orders.

Since the PFOF markets pay brokers for retail orders while the maker-taker markets charge when their quotes are hit, brokers have a clear incentive to route to the PFOF venues.<sup>1</sup> The existence of this incentive is potentially problematic, because the equity trading literature proposes that maker-taker venues often offer lower effective spreads (e.g., Barclay, Hendershott, and McCormick, 2003; Goldstein et al., 2008). If the maker-taker venues have a similar advantage in the options market, routing retail customer orders to the PFOF exchanges may conflict with a broker's fiduciary duty to obtain the best execution for her clients.<sup>2</sup> Anecdotal evidence suggests that brokers in the options markets eagerly respond to the abovementioned incentive. TD Ameritrade, for instance, generates an estimated "\$78 million annually for options

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<sup>1</sup> During our sample period, a broker pays up to \$0.55 per contact (\$0.0055 per option) to access maker-taker quotes, whereas the PFOF markets pay the broker up to \$0.70 per contact for retail orders.

<sup>2</sup> In an October 2011 *Proposed Guidance on the Practice of 'Payment for Order Flow'*, the U.K.'s Financial Services Authority writes: "... we believe PFOF arrangements create a clear conflict of interest between the clients of the [brokerage] firm and the firm itself."

payment for order flow.”<sup>3</sup> In a similar fashion, Interactive Brokers (IB) notes that when multiple options exchanges are quoting at the National Best Bid and Offer (NBBO), IB will generally send the order “to an exchange where it will receive the most payment for the order.”<sup>4</sup>

Given the potential for agency conflicts induced by the fee structure in the U.S. options markets, it is important to assess execution cost differences between the PFOF and the maker-taker models. Our data are uniquely suited for such assessment; we obtain a previously unexplored set of access fees and marketing fees (i.e., fees paid by market makers on the PFOF exchanges to fund order flow payments) from each of the major options exchanges.<sup>5</sup> By incorporating these fees into the conventional measure of execution quality (i.e., effective spread), we not only expect to shed new light on the competitive landscape of the options markets, but also to enhance the extant literature that largely ignores the effect of access fees and order flow inducements on execution costs.

Our initial results are consistent with those obtained by equity market studies. When we base trading cost comparisons on unadjusted effective spreads, we find that an average liquidity demanding trader pays 80 bps more per option in the PFOF model than she pays in the maker-taker model. This comparison, however, ignores the taker fees that must be paid by brokers to access maker-taker quotes. Therefore, the conventional effective spread measure conceals a potentially significant portion of true costs. As noted by Angel, Harris, and Spatt (2010), if the market for order flow is sufficiently competitive, access fees are passed onto liquidity demanders either explicitly or, more likely, implicitly via higher commissions and/or reduced services.

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<sup>3</sup> See September 2010 GETCO letter to the SEC.

<sup>4</sup> [http://investors.interactivebrokers.com/download/1Q\\_2010\\_IB\\_ORDER\\_ROUTING\\_REPORT.pdf](http://investors.interactivebrokers.com/download/1Q_2010_IB_ORDER_ROUTING_REPORT.pdf)

<sup>5</sup> In an August 24, 2010 comment letter to the U.S. Securities and Exchange Commission, Edward Joyce, President and Chief Operating Officer of the Chicago Board Options Exchange (CBOE) notes that “for many years CBOE has had in place a marketing fee whereby a charge is assessed against CBOE market makers when they trade against customer orders. The monies collected through this charge are pooled so that CBOE DPMs and market makers may distribute the funds to order-sending firms (this practice, which can be structured in different ways and administered by exchanges and/or market making firms, is called payment for order flow).”

To gauge the influence of taker fees on the trading cost comparison, we obtain a comprehensive set of such fees from a large options trading firm. To our knowledge, ours is the first study that analyses such data. Once we incorporate taker fees into the trading costs measures, the advantage of the maker-taker venues suggested by the analysis of the effective spreads fully reverses – an average liquidity demanding trader pays 74 bps *less* per option in the PFOF model than she pays in the maker-taker model.

This result is important on two levels. First, our findings show that the conventional cross-market comparisons of execution quality that often rely on unadjusted effective spreads should be interpreted with caution. This result is consistent with comments by Angel et al. (2010) in that one should not evaluate execution quality in a market with competing exchange models by simply comparing unadjusted effective spreads. Second, our results imply that the routing of retail orders to PFOF exchanges is consistent with a broker's fiduciary responsibility to obtain best execution for her clients.

Next, we examine the potential effect of order flow inducements. The theoretical predictions of Battalio and Holden (2001) suggest that competition for retail order flow will force brokerages to disburse the marketing payments obtained from the PFOF markets. We note that the payments may not be channelled to retail traders exclusively, especially given the current brokerage fee structure. This is because most options brokers charge a single fixed price commission to all of their customers. Instead, the order flow inducements may be distributed among a wider set of brokerage clients.

Based on this logic, we introduce a third measure of execution quality – that accounts for the possibility that marketing fees evenly reduce trading costs for all trades in the PFOF markets. This new measure highlights the cost advantage of the PFOF markets even further. An average

liquidity demanding trader pays 249 bps less to trade in the PFOF model than she pays in the maker-taker model.

We caution that our results must not be interpreted as suggestive of the superiority of the PFOF model due to the notably lower trading costs that it offers. It is quite likely that the low trading costs on the PFOF exchanges are attributable to the higher proportion of retail order flow on these exchanges. Our findings are consistent with what one might expect to find in a competitive, transparent market, in which exchanges specialize in the type of orders that they execute.

The remainder of our paper is as follows. In the next section, we provide the institutional background and elaborate on the related literature. In Section 3, we describe our data and generate descriptive statistics. In Section 4, we compare and contrast the effective spreads generated each month by the options exchanges with the spreads that we compute using public trade and quote data. In Section 5, we present the results of our analysis of trading cost differences between the PFOF and maker-taker models. Section 6 concludes.

## **2. Institutional background and related literature**

The introduction of pennies to the U.S. equity option markets in 2007 coincides with the first use of the maker-taker model by an options exchange. Prior to pennies, all exchanges used the traditional dealer-driven customer priority model (also known as the PFOF model), in which exchanges charge brokers little or nothing to execute customer orders, but charge liquidity providers ‘marketing’ fees on trades with retail customer orders. These marketing fees are then used to pay for retail order flow.

Unlike equity market makers, options market makers often do not execute all of the liquidity demanding orders they purchase. On PFOF exchanges, the percentage of the order that a purchasing market maker (PMM) can interact with depends on the number of competing market makers who are willing to match the PMM's price. For example, the CBOE's Automated Improvement Mechanism (AIM) allows its market makers to interact with at least 40% of purchased orders. Market makers executing orders via AIM must improve the NBBO by at least \$0.01 (match the NBBO) if the marketable order is for less than 50 contracts (for at least 50 contracts). Programs on the Philadelphia Stock Exchange (the Directed Order Flow Program) and on the International Securities Exchange (Rule 713) allow market makers to interact with purchased orders in a similar fashion.

Alternatively, in the maker-taker model, the spread revenue is supplemented by rebates to orders that provide liquidity. These rebates are funded by charging a fee to orders that demand liquidity. As in equity markets, the fee structure on the options exchanges employing the maker-taker model provides incentives for market participants to quote aggressively, which attracts order flow. While maker-taker exchanges typically follow price-time priority, exchanges using the PFOF model generally give customer orders priority at the best price over other trading interests at that price. The maker-taker model seems to have found a home in equity options markets, as its popularity notably increased in recent years. The percent of option contracts transacted on exchanges using maker-taker pricing increased from 12% in the first quarter of 2009<sup>6</sup> to more than 22% in our 2010 sample.

What are the implications of the two competing trading models for liquidity demanding investors? In this paper, we examine whether the agency problems associated with payment for

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<sup>6</sup> See "BATS Aims to Mirror Equities Success in Options," by Nina Mehta in the July 10, 2009 edition of the *Traders Magazine*.

order flow in equity options result in inferior execution prices on the PFOF exchanges relative to the execution prices on maker-taker exchanges. Given the magnitude of order flow inducements in the options market and the dominant market share of the PFOF exchanges, the options market gives us an ideal opportunity to identify the adverse effects of order flow inducements.

Despite convincing evidence that order flow routed pursuant to payment for order flow arrangements is less informed, research has not arrived at a consensus as to whether uninformed retail investors are harmed by these arrangements. Early equity market studies examining trade and quote data (e.g., Lee, 1993; Petersen and Fialkowski, 1994; Easley, Kiefer, and O'Hara, 1996; Bessembinder and Kaufman, 1997) suggest the orders routed pursuant to PFOF arrangements pay higher effective spreads than comparable orders. Contemporaneous studies by Battalio (1997), Battalio, Greene and Jennings (1997), and Battalio, Greene and Jennings (1998) show that the introduction of market makers who respectively purchase, preference, and internalize orders in the NYSE-listed stocks is associated with a tightening of the National Best Bid and Offer (NBBO).

Battalio and Holden (2001) argue that net costs should be considered when evaluating execution quality and show that, depending upon the amount of payment that ultimately reaches the retail investor, brokers who route orders pursuant to payment for order flow agreements may offer lower net trading costs. Battalio, Jennings, and Selway (2001) show that the net cost of liquidity offered by some brokers who sell orders in NASDAQ stocks to Knight Securities is lower than the net cost of trading through Trade Fast, the only broker in their sample that does not receive inducements for its equity order flow.

In equity markets, Barclay et al. (2003) and Goldstein et al. (2008) find that electronic trading venues that use the maker-taker model are associated with tighter quoted spreads and, in

general, lower effective spreads. We extend this literature by examining the impact of maker-taker exchanges in options markets and by conducting a comprehensive analysis of the impact of taker fees on trading costs.

More recently, O'Hara and Ye (2011) find that increased fragmented trading in the U.S. equity markets circa 2008 is associated with lower transaction costs, faster execution speeds, and greater market efficiency. On the contrary, Weaver (2011) focuses on fragmentation caused by internalization and finds it to be associated with wider quoted and effective spreads. Our study complements the extant research by examining how two factors that influence order routing decisions – order flow inducements and taker fees – affect execution quality.

Finally, Malinova and Park (2011) examine the Toronto Stock Exchange's decision to change from a value to a volume-based fee structure. Their findings support the predictions by Colliard and Foucault (2011) that the bid-ask spread decreases when the take fee or the liquidity rebate increases. We extend this strand of literature by employing cross sectional analysis to examine measures of gross and net trading costs in a market where exchanges utilizing the maker-taker model are in competition with those employing the PFOF model.

As a by-product of our research, we find that the execution quality statistics currently published monthly on a voluntary basis by the eight options exchanges are not reliable. When we compare the exchange-generated effective spreads with spreads that we compute using publicly available trade and quote data, we find large discrepancies for several of the exchanges that produce their numbers internally. Conversely, our monthly average spread estimates are consistently close to those produced by an external firm, S3, for the AMEX and for the NYSE

Arca.<sup>7</sup> Based on this finding, we conduct our analysis using relative effective spreads generated using public trade and quote data rather than using the exchange-generated statistics.

### **3. Data and descriptive statistics**

Options exchanges report trade and quote data via the Options Price Reporting Authority (OPRA). In turn, OPRA provides price and volume information on trades and on current bids and offers in eligible securities from 7:30 a.m. to 6:00 p.m. Eastern time on any regular trading day (see SEC Release No. 34-43621). Using OPRA data, a data technology company – LiveVol – creates historical data files that contain information on every option trade each day, including the bid and ask quotations prevailing at each of the eight options exchanges when the trade is reported to OPRA.<sup>8</sup> We obtain historical data from LiveVol for a period from March 1, 2010 through June 30, 2010. Due to data corruption issues, we drop March 22 and March 25 trading days.

Our initial sample contains trade and matched quote data for 3,233 option classes. These classes trade on eight options exchanges: NASDAQ, AMEX, CBOE, ISE, NYSE Arca, PHLX, BOX, and BATS. Among these, the AMEX, the CBOE, and the ISE use the PFOF model; NASDAQ, the BOX, and BATS use the maker-taker model; and the NYSE Arca and the PHLX use a mix of the two models. To ensure proper comparison among exchanges, we restrict the sample to option classes that trade on all exchanges other than BATS.<sup>9</sup> This screen retains 550 option classes. After eliminating option classes that have fewer than 10 trades per day, we are left with 314 classes. We next exclude options on foreign stocks, ADRs, and REITs, and option

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<sup>7</sup> <https://www.s3.com>

<sup>8</sup> <http://www.livevol.com/index.html>

<sup>9</sup> Our decision to exclude BATS is due to its trivial (less than 1%) share of contract volume during the sample period.

classes that switch to trading in pennies during our sample period. Our final sample consists of 239 option classes, with 32 option classes on ETFs and 207 classes on common stocks. Out of 239 classes, 122 trade in pennies during the entire sample period (with 27 out of the 32 ETF option classes trading in pennies). Panels A and B of Table 1 contain summary statistics for our data filters and our resulting sample.

**[Insert Table 1 about here]**

The sample trade records contain the date and to-the-second time, option class, strike price, expiration date, put/call indicator, trade price, trade size, trade condition identifier, National Best Bid (NBB) price and size and the National Best Offer (NBO) price and size prevailing when the trade is executed, bid price, bid size, offer price, and offer size prevailing at each of the eight exchanges when the trade executes, and the underlying stock's NBBO when the trade executes. At any point in time, the NBB is the highest bid price and the NBO is the lowest offer price across the eight option exchanges.

As noted by Battalio, Hatch and Jennings (2004), it is common for orders arriving on PFOF exchanges to be divided among all counterparties willing to match the best available price. Similarly, orders arriving at maker-taker exchanges may execute against multiple liquidity suppliers at a given price. Thus, a single order often produces several trade records. We follow Battalio et al. (2004) and combine multiple executions in the same option series, executing on the same exchange at the same price at the same time with the same trade condition identifier into a single trade.

As noted in Panel C of Table 1, our initial sample contains over 21 million trades. To avoid trades involved in the opening and closing rotations, we eliminate trades reported before 9:45 a.m. and after 3:55 p.m. each day. Across the eight exchanges in our sample, this screen

eliminates between 6.71% (BATS) and 12.57% (PHLX) of reported trades. Since complex trades (e.g., spreads and straddles) are priced as a package, we eliminate them from the sample. Three of the maker-taker exchanges trade no spreads or straddles during our sample period, while the ISE reports that over 35% of its trades are spreads or straddles. Overall, this screen eliminates about 10.5% of the sample trades. We next eliminate trades with benchmark execution-time NBBOs that are crossed and trades with benchmark execution-time NBBs that are equal to zero, reasoning that the execution-time NBBO may not be an appropriate execution quality benchmark for these trades. Together, the crossed markets screen and the zero NBB screen eliminate less than 0.5% of our sample. After applying these screens and then bunching trades as described in the prior paragraph, we are left with a little more than 61% of the trades in our initial sample for a total of nearly 13 million trades.

Next, we turn our attention to the distribution of trading activity among sample venues. Panel A of Table 2 contains statistics on the percentage of trades and volume while grouping the sample venues into pure PFOF, mixed, and pure maker-taker models. Overall, the three exchanges that operate solely under the PFOF model (i.e., CBOE, ISE, and AMEX) execute 56.22% of the trades and 58.54% of the contract volume. Their market share is around 55% of contract volume for ETF options and over 63% of contract volume for options that do not trade in pennies. Overall, the CBOE has the dominant market share, whereas the AMEX and the ISE execute roughly the same percentage of trades.

**[Insert Table 2 about here]**

Panel B of Table 2 reports the percentage of class days during which each sample exchange is the dominant market and the percentage of class-days during which each exchange has no trading activity in our sample. Consistent with their overall market share, the CBOE and

the ISE are the dominant markets for the majority of trading days. One of these two exchanges is the dominant market during over 61% of the class-days. On 13.35% of the class-days, the NYSE Arca is the dominant market, while the ‘pure’ maker-taker markets have the dominant market share during only 1.7% of the class-days. BATS is never the dominant market and has no trading activity during about 89% of class-days. NASDAQ and the BOX have no trading activity on 7.2% and 3.7% of the class-days, respectively, while the NYSE Arca is inactive on 2.5% of the class-days. The traditional PFOF exchanges each have no trading activity on less than 0.3% of the class-days.

Panel C of Table 2 describes the distribution of trade sizes across exchanges. The exchanges that solely employ the PFOF model execute over 55% of the trades for up to 50 contracts. These trades most likely represent the execution of retail trading interest. The aggregate market share for these exchanges jumps to about 63% for trades of more than 50 contracts. This increased market share may be attributable to depth guarantees made by the PFOF exchanges to the retail brokers from whom they purchase orders and to the fact that liquidity providers generally do not have to improve upon the NBBO to interact with large orders. The pure maker-taker exchanges execute more trades between 2 and 50 contracts (12.26%) than they do trades of 1 contract (8.26%) or trades of more than 50 contracts (5.25%). The NYSE Arca’s market share is greatest in 1 contract trades (20.97%) and falls to a market share of 14.70% for trades of more than 50 contracts. Finally, the PHLX executes 14.02% of trades for 2 to 50 contracts and just over 17% of trades for more than 50 contracts.

In Figure 1, we provide an illustration of the daily share of contract volume executed on the PFOF exchanges during our sample period. The percentage of contracts that execute on exchanges using the PFOF model declines from just under 77.5% on March 1 to just under

71.4% on June 30, perhaps reflecting the fact that the PHLX moves many of its actively traded option classes from the PFOF model to the maker-taker model during our sample period. There is a similar decline in the PFOF market share in the penny option classes over our sample period; the PFOF exchanges' market share peaks at 67.8% on March 10 and reaches a low of 55.7% on May 27.<sup>10</sup> Overall, in stark contrast to equity markets, option exchanges offering order flow inducements to liquidity demanders have a dominant market share.

**[Insert Figure 1 about here]**

#### **4. Execution quality measures produced by the options exchanges**

Using two weeks of the NYSE equity order data from the late 1990s, Peterson and Sirri (2003) examine the accuracy of execution cost estimates created using trade and quote data. The authors note that the users of these data are forced to use the execution time NBBO rather than the order receipt time NBBO when estimating the trade direction and computing effective spreads. Depending on the time it takes for a marketable order to execute, these assumptions will cause researchers to misclassify some orders, thereby inflating estimates of effective spreads. For a sample of equity trades that execute on the NYSE, Peterson and Sirri find that “estimates of the effective spread overstate actual execution costs by up to 17%.” While Bessembinder (2003) concludes that effective spreads computed using trade and quote data can still be used to compare execution costs across venues, we next inquire whether alternative (not based on publicly available trade and quote data) sources of execution quality statistics in the options markets might be available.

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<sup>10</sup> Perhaps surprisingly, we do not observe significant migration of trades from the maker-taker exchanges (the exchanges without traditional market makers) to the PFOF exchanges (the exchanges with traditional market makers) on May 6, the day of the flash crash.

While venues trading equities in the United States are required to publish effective spreads each month (e.g., Boehmer, 2005), an equivalent requirement for the option exchanges does not exist. On July 17, 2008, the Equity Options Trading Committee of the Securities Industry and Financial Markets Association (SIFMA) recommended that each of the options exchanges begin voluntarily publishing monthly standardized execution quality reports according to its guidelines.<sup>11</sup> The SIFMA guidelines require each exchange to use the order receipt time quote to compute effective spreads until the order exhausts the depth at the exchange's inside quote. Once this happens, the benchmark quote is reset to the new inside quote. Exchanges are to compute effective spreads as twice the signed difference between the execution price and the midpoint of the benchmark NBBO. Most of the eight options exchanges (BATS being the only exception) publish execution quality reports (hereafter, SIFMA reports) each month, and at least two exchanges – the NYSE Arca and the AMEX – use an external firm to compute the statistics contained in these reports. Most options exchanges present average monthly effective spreads for each of the option classes they trade.<sup>12</sup> In light of the potential biases associated with using LiveVol trade and quote data, we may be better off using monthly SIFMA reports produced by the options exchanges to evaluate relative execution quality.

To better understand the execution quality statistics voluntarily provided by seven of the eight options exchanges, we compare the exchange-generated effective spreads with those computed using LiveVol data. The SIFMA guidelines direct option exchanges to analyze and report execution quality for all market and marketable orders that (i) are designated as retail

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<sup>11</sup> This recommendation by SIFMA was, in part, aimed to forestall an implementation of mandatory execution quality disclosure in options markets similar to that in equity markets. See July 17, 2008 letter from the SIFMA Equity Options Trading Committee to the U.S. Options Exchanges.

<sup>12</sup> One potential shortfall of using effective spreads computed by the exchanges is that they are not normalized by the price of the option. Thus, if Exchange A tends to execute more orders in low-priced options than Exchange B, all else equal, one would expect Exchange A's effective spreads to be lower than Exchange B's since spreads tend to be tighter for lower priced options.

customer orders and (ii) are entered after the entire options class is available for trading and two minutes before the close. SIFMA advises exchanges to exclude the following types of orders: stop orders, not held orders, orders with special instructions, flex options, contingency orders, and manually-entered orders. While the filters described in Panel C of Table 1 eliminate many of the same trades, the level of detail of our data does not allow us to apply data screens that precisely match those recommended by SIFMA. For example, our data do not allow us to distinguish whether it is a retail customer or a market professional who initiates a trade. As a result, it is likely that our sample of trades from LiveVol will be larger than the sample of trades in the SIFMA reports. We also expect that the LiveVol figures will be closer to the volume figures reported by the PFOF exchanges, as retail customer transactions should comprise a larger fraction of total volume on the PFOF venues.

Panel A of Table 3 details the number of contracts that are used in the SIFMA reports and the number of contracts in our study. Mostly consistent with our expectations, the LiveVol sample is much larger than the SIFMA sample analyzed by six of the seven exchanges that produce execution quality reports. The discrepancy is largest for the NYSE Arca, where our sample is 13 times larger than the sample analyzed by the exchange. As we suggested earlier, this result possibly reflects a larger concentration of professional trading interests on the NYSE Arca. The PHLX also has a relatively large discrepancy – we analyze more than nine times the volume. As with the NYSE Arca, this may reflect heightened professional trading interest, or it may reflect an abundance of manually entered orders.<sup>13</sup> The discrepancy between the two

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<sup>13</sup> Note that if one computes market shares using the *LiveVol* figures in Panel A of Table 3, the PHLX would appear to have a 28.5% share of contract volume. This number is significantly different from the 17.5% figure reported in Panel A of Table 2. The difference between these two figures is caused by rare, yet exceptionally large, surges of dividend capture volume on the PHLX during a few sample class-days. In a December 17, 2010 *Bloomberg* article, Elizabeth Stanton and Jeff Kearns report that option trading by dividend capture traders often concentrates on the PHLX because it is one of the venues that will cap fees for these traders. Given that the averages reported in Table 2

samples is smaller when it comes to the PFOF exchange volumes. For instance, the SIFMA volumes reported by the CBOE and the AMEX are only 2 to 3 times smaller than the corresponding LiveVol figures. Surprisingly, our sample is smaller than that analyzed by the ISE. In addition, it is not clear why the difference between the samples is not larger for NASDAQ and the BOX.

**[Insert Table 3 about here]**

Although some of the results that emerge from the comparison of LiveVol and exchange-reported figures are expected, a nontrivial set of results is difficult to explain, casting a shadow over the credibility of voluntarily reported statistics. To shed additional light on this issue, we next compare the effective spread statistics computed from the two datasets.

We compute effective spreads as twice the absolute difference between the trade price and the execution time NBBO for all trades in our 239 option classes. We then weight these spreads by the executed volume to arrive at a volume-weighted dollar effective spread for each exchange for each of the four months in our sample period. We next use the data provided in the option exchange's SIFMA reports to compute volume-weighted average dollar effective spreads for our sample options each month for each exchange. As noted earlier, for orders that do not exhaust the depth available at the inside quote, these effective spreads are supposedly computed by multiplying the signed difference between the order receipt time NBBO and the trade price.

Panel B of Table 3 reveals that the dollar effective spreads computed using LiveVol trade and quote data are within a tenth of a cent of the SIFMA statistics reported by the NYSE Arca and are within five tenths of a cent of the statistics reported by the AMEX in each of four sample

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are computed across stock-days, the effect of the rare surges of dividend capture volume is mitigated. In unreported results (available from the authors upon request), we confirm that an exceptionally significant portion of the PHLX volume executes on a few days during the dividend capture period.

months. This result is encouraging, because the two abovementioned exchanges outsource execution quality statistics estimation to a well-respected third party. The LiveVol effective spreads are also within several tenths of a cent of those produced by the CBOE, the BOX, and NASDAQ in at least one of our sample months. Conversely, the monthly effective spreads computed by the ISE are two to three times higher than those computed using LiveVol data, while those computed by the PHLX are around twice as large as our LiveVol effective spreads. It is also curious that, with the exception of the PHLX, in each case where the effective spread estimates differ, the estimates produced by the exchanges are (significantly) higher. On the PHLX, the differences between the exchange-computed and the LiveVol effective spreads are similar to those that would arise if the PHLX did not multiply the signed difference between the trade price and the midpoint of the benchmark NBBO by two.

Particularly notable are the inflated effective spreads reported by the exchanges in May 2010. While the magnitude of the spreads in May relative to the other months may be due in part to the Flash Crash on May 5<sup>th</sup>, it is not clear why the differences between SIFMA effective spreads and the LiveVol effective spreads are so pronounced in May. For example, although the CBOE's effective spreads are very close to the LiveVol effective spreads in March, April and June, in May the CBOE's spreads are seven times higher than those produced with the LiveVol data. Similar divergences occur for NASDAQ, whose effective spreads are 31 times higher than the LiveVol effective spreads and on the BOX, where the exchange's spreads are 10 times higher than the LiveVol spreads. Given that the average option price in our sample is \$3, it is rather implausible that the average dollar effective spread on NASDAQ is \$1.08 in May 2010.

In addition to the unexpected magnitudes of the self-reported execution quality statistics, the differences in costs among exchanges are surprising and, in our opinion, inconsistent with a

notion of a competitive market. It is difficult to believe that equilibrium effective spreads on the CBOE and on the ISE, two exchanges that exclusively use the PFOF model, can be as divergent as suggested by the voluntary execution quality statistics (respectively, \$0.025 and \$0.077 in March 2010). Coupled with the fact that there is little difference between the LiveVol effective spreads and those produced by an external company for the NYSE Arca and the AMEX, these results lead us to conclude that the voluntarily reported SIFMA statistics are not of sufficient quality to use in our study, and that our own figures derived from LiveVol data may be preferable. This said, the similarities between the effective spreads computed using publicly available trades (retail and professional) and those computed by an external firm using retail order data from the NYSE Arca and from the AMEX suggest that the use of all trades to estimate the liquidity costs of retail investors may be appropriate.

As a side note, our correspondence with the options exchange officials revealed that eliminating errors in voluntary execution quality reports is not a priority for most of the exchanges, a result that stands in stark contrast to the behaviour of equity exchanges, whose mandated disclosure is regarded as highly dependable by the market (Boehmer, Jennings, and Wei, 2007).

## **5. Execution quality on maker-taker and PFOF exchanges**

### *5.1 Fees and rebates*

The goal of this study is to compare the net execution costs between the PFOF and market-maker models. We therefore obtain information on maker-taker fees and rebates (Panel A of Table 4) and on marketing fees (Panel B) for each exchange other than BATS from a major options market maker. As suggested in the SEC's April 2010 rule proposal, there is a clear

bifurcation in the data; each exchange trades a specific option class under either the maker-taker model or the PFOF model.<sup>14</sup> As indicated in Panel A, the CBOE, the ISE, and the AMEX do not charge maker-taker fees. In the meantime, each of these exchanges charges market makers a fee of \$0.25 per contract (\$0.65 per contract) when they provide liquidity to retail customers trading options (not) participating in the penny pilot (Panel B). Conversely, NASDAQ and the BOX do not charge marketing fees during our sample period, but they do charge maker-taker fees. For instance, in penny pilot options, taker fees are \$0.35 per contract on NASDAQ and \$0.15 on the BOX and maker rebates are \$0.25 on NASDAQ and \$0.15 on the BOX.

The remaining two exchanges do not exclusively use the maker-taker or the PFOF model. The NYSE Arca uses the PFOF model when trading options not participating in the penny pilot, and it uses the maker-taker model for penny pilot options. The PHLX began using the maker-taker model for 27 actively traded option classes on March 1, 2010, then added an additional 24 actively traded option classes on April 13, 2010, 4 actively traded option classes on May 6, 2010, and 23 actively traded option classes on June 4, 2010. The NYSE Arca charges taker fees of \$0.45 per contract and offers rebates of between \$0.25 and \$0.30 per contract. The PHLX charges taker fees of \$0.25 per contract and offers rebates of \$0.20 per contract. For those option classes trading under the PFOF model, the NYSE Arca charges marketing fees of \$0.65 per contract, while the PHLX charges \$0.25 per contract (\$0.70 per contract) for options (not) trading in the penny pilot program.

**[Insert Table 4 about here]**

In the remaining analysis, we classify trades as occurring either on an exchange utilizing the PFOF model or the maker-taker model. All trades reported on the CBOE, the ISE, and the AMEX are classified as occurring on a PFOF market. Also classified as PFOF are the trades in

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<sup>14</sup> See SEC Release 34-61902, "Proposed Amendments to Rule 610 of Regulation NMS," dated April 14, 2010.

non-penny option classes on the NYSE Arca and trades in the PFOF option classes on the PHLX. All trades reported on the NASDAQ options market, the BOX, and BATS are classified as occurring on a maker-taker market, as well as trades in options trading in pennies on the NYSE Arca and trades in the maker-taker option classes on the PHLX.

In what follows, we begin by examining whether there are systematic differences in execution costs across maker-taker and PFOF exchanges. We first use relative effective spreads as our summary measure of execution quality. Next, we adjust relative effective spreads to reflect the taker fees paid on exchanges utilizing the maker-taker model. Our final measure of execution quality assumes that the entire marketing fee paid by liquidity suppliers on PFOF exchanges is paid to brokers and is then passed onto liquidity demanders. We conclude this section by examining these issues in a multivariate framework.

## 5.2 *Relative effective spreads*

To examine if the PFOF markets offer inferior executions, we compute, for each trade in our sample, the relative effective spread as twice the absolute difference between the trade price and the execution time NBBO divided by the midpoint of the execution time NBBO. We then compute equal-weighted spreads as follows. Each trading day, we compute an option class's average relative effective spread as the average of the underlying option series' relative effective spreads. We then compute the average spread across all option classes on that day. The equal-weighted relative effective spread is the time series average of the across-class average spreads. We average effective spreads for the maker-taker and PFOF exchanges in columns 1 and 3 of Table 5.

**[Insert Table 5 about here]**

Easley and O'Hara (1987) propose that smaller orders will be less informed. This suggests that smaller trades may get better execution prices than larger trades. Since the PFOF exchanges' market share is not constant across trade sizes, we begin by presenting relative effective spreads conditional on trade size in the first three rows of Table 5. For each trade-size bin, the PFOF exchanges have higher equally-weighted relative effective spreads than the maker-taker venues. On average, liquidity demanding investors paid 6.82% above the execution-time NBBO midpoint when purchasing one contract in our sample options on a PFOF exchange, while they only paid 4.78% on a maker-taker exchange. For an option with a price of \$1.00, the difference is just over \$0.02 per option, which is greater than the amount of price improvement that CBOE market makers must provide to interact with marketable retail orders for 49 contracts or less. Investors trading more than 50 contracts paid around 2% of the transaction price more for liquidity than those trading a single contract. If execution quality is measured solely by trade price, these results suggest that brokers routing to the PFOF exchanges are not fulfilling their fiduciary responsibility to get best execution for their customer orders.<sup>15</sup>

Our results further show that the maker-taker exchanges have significantly lower relative effective spreads than the PFOF exchanges for both options on ETFs and options on equities. In addition, since it is easier to improve prices when options trade in pennies than it is when they trade in nickels, and since the option classes chosen to trade in pennies tend to be more actively traded, we present effective spreads conditioning on whether the option class trades in pennies during our sample period. Rows 6 and 7 of Table 5 reveal that the penny pilot options have significantly lower relative effective spreads than the less actively traded options that do not trade in pennies. For the penny pilot options, the relative effective spread is, on average, significantly lower on the maker-taker exchanges. Perhaps surprisingly, the relative effective

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<sup>15</sup> See Macey and O'Hara (1997).

spread for options that do not trade in pennies is actually lower on the PFOF exchanges by an average of 38 basis points. This difference, however, is only significant at the 0.08 level.

Next, we inquire whether execution cost differences between the maker-taker and the PFOF models are affected by option moneyness. In row 8, we report the relative effective spreads for the actively-traded option series – those with stock-to-strike price ratios between 0.9 and 1.1. While the average spread for these ‘near-the-money’ options is 29 basis points lower on the maker-taker exchanges, this difference is statistically insignificant. Finally, row 9 contains the overall average relative effective spreads for the PFOF and the maker-taker exchanges. On average, relative effective spreads are 80 basis points lower on the maker-taker exchanges than they are on the PFOF exchanges.

As shown in Panel A of Table 2, trades on the NYSE Arca make up the majority of the trades in the maker-taker model. To ensure that our results are generalizable beyond the NYSE Arca, we present relative effective spreads for the maker-taker and the PFOF exchanges *excluding* trades on the NYSE Arca in row 10 of Table 5. Consistent with the overall results, relative effective spreads on the maker-taker markets are, on average, 47 basis points lower than those on the PFOF exchanges. We obtain similar results when we exclude the PHLX trades from the analysis (row 12). Next, utilizing the fact that the NYSE Arca trades some options (the penny pilot options) in the maker-taker model and some (the non-penny pilot options) in the PFOF model, we present relative effective spreads for the NYSE Arca trades conditional on whether or not they execute using the maker-taker model. We conduct the same analysis for the PHLX, which moved some options from the PFOF model to the maker-taker model during our sample period. Again, consistent with the overall results, trades that execute under the maker-taker

model on the NYSE Arca and on the PHLX have statistically lower relative effective spreads than trades that execute using the PFOF model on the respective exchanges.

To summarize, with the exception of the relatively inactive option classes that do not trade in pennies, maker-taker exchanges have lower relative effective spreads than the PFOF exchanges. This result holds across different trade-size bins, for options on both equities and ETFs, and for options trading in pennies. Thus, despite the fact that the PFOF exchanges receive order flow that is, on average, less informed, our results suggest that the average liquidity demanding investor pays an extra 0.80% of the option price when trading on a PFOF exchange rather than on a maker-taker exchange. In Section 4.5 we investigate whether this conclusion holds in a multivariate framework.

### *5.3 Relative effective spreads adjusted for taker fees*

Angel et al. (2010) note that to earn liquidity rebates, liquidity providers on maker-taker exchanges tend to offer better prices, which leads to tighter bid ask spreads. In competitive markets, the taker fees charged by the maker-taker venues should offset the tighter spreads on these venues so that the cost of liquidity net of the taker fees is the same on PFOF and maker-taker markets. This argument suggests that there should be no difference in the effective spreads on PFOF and maker-taker exchanges after fees are taken into account. In this section, we test whether this conjecture holds in the equity option market.

To address this issue, we compute the relative round trip taker fee for each trade on a maker-taker exchange. We begin by dividing the taker fee by 100 so that it is on a per contract basis. We next multiply the adjusted taker fee by two so that it reflects the per contract fee paid on a round trip liquidity demanding trade. We then divide this amount by the midpoint of the

execution-time NBBO. We arrive at our ‘fee-adjusted’ relative effective spread (column 4 of Table 5) by adding this amount to the trade’s relative effective spread.

After adjusting for taker fees, spreads for trades of one contract on the maker-taker exchanges are still significantly lower than comparable trades on the PFOF exchanges (compare the first row of column 1 with the first row of column 4). Nonetheless, the difference in trading costs is down from 204 basis points to 69 basis points. More importantly, incorporating fees reverses the trading cost differential for trades of 2 to 50 contracts and for trades of more than 51 contracts. These results reveal the importance of taker fees in evaluating execution quality.

Unadjusted relative spreads on the PFOF exchanges are significantly lower, on average, than their fee-adjusted counterparts on the maker-taker exchanges for options on both ETFs and equities as well as for options that trade in pennies, options that do not trade in pennies, and near-the-money options. We note that, ignoring fees, the average equal-weighted relative effective spread across all trades in our sample was about 80 basis points lower on maker-taker exchanges. After incorporating fees, this conclusion reverses, and the PFOF exchanges appear to have lower equal-weighted fee-adjusted spreads by an average of 74 basis points.

We next examine the impact that the NYSE Arca and the PHLX have on our inferences. When trades on the NYSE Arca or the PHLX are excluded from our analysis, results are quite similar to those for the entire sample. We note that, when we focus solely on the NYSE Arca and the PHLX trades, the PFOF model seems to result in more expensive executions than the maker-taker model even after accounting for the taker fees. We suspect that this result might be due to the selection of option classes that trade in each model. For instance, given that the NYSE Arca uses the maker-taker model to trade penny options, the difference in trading costs between the

maker-taker and PFOF models on this exchange might be attributable to the effect of penny trading. We expect to reconcile these effects in the multivariate analyses that follow.

#### 5.4 *Relative effective spreads adjusted for taker fees and potential order flow payments*

Battalio and Holden (2001) argue that if the market for order flow is competitive, payments made by market makers for uninformed orders will dissipate most, if not all, of the profits associated with executing uninformed orders. Despite the potential for wider spreads in the presence of order flow inducements, Battalio and Holden show that if the brokerage industry is competitive and if payments are transparent, competition forces brokers to pass order flow inducements to their customers in the form of lower brokerage commissions. Because the SEC Rule 606 requires brokers to disclose information regarding the order flow inducements they receive, the *net cost* of trading should be lower on PFOF exchanges if there is sufficient competition in the brokerage industry.

In this sub-section, we examine relative effective spreads adjusted for both taker fees and marketing fees under the assumption that 100% of each of these fees is passed on by brokers to retail liquidity demanders.<sup>16</sup> This assumption is clearly an upper bound, and it presumes that there is no cross-subsidization across a broker's clientele (e.g., market order traders versus limit order traders, professional traders versus retail investors). Unlike taker fees, marketing fees are negative and will reduce the overall cost of liquidity. We first compute a relative round trip order flow payment for each trade on a PFOF exchange by dividing the marketing fee by 100 so that it is on a per contract basis. We next multiply the adjusted marketing fee by two so that it reflects the per contract order flow payment made on a round trip liquidity demanding trade. We then

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<sup>16</sup> Angel et al. (2010) note that "since brokers cannot obtain payments (order flow inducements) if they do not have retail orders, competition forces the brokers to return much, if not all of these payments to their clients in the form of lower commissions or better services, both of which attract retail clients and their orders."

divide this amount by the midpoint of the execution-time NBBO. We arrive at our ‘payment-adjusted’ relative effective spread by subtracting this amount from the trade’s relative effective spread. Equal-weighted payment-adjusted relative effective spreads are presented for the PFOF exchanges in column 2 of Table 5.

The results in Table 5 illustrate the importance that order flow inducements and taker fees (if passed onto investors) have on inferences as to which type of market, maker-taker or PFOF, offers the cheapest liquidity. When we make the assumption that 100% of taker fees and order flow inducements are passed onto liquidity demanders, the payment-adjusted relative spreads are lower than the fee-adjusted spreads for every trade size category, for equity and ETF options, for options that do and do not trade in pennies, and for the near-the-money options. Across all trades, the average payment-adjusted relative effective spread is 5.83% versus the average fee-adjusted spread of 8.32% on the maker-taker exchanges. Recall that when fees and order flow payments are ignored, the average spread is 7.58% on the PFOF exchanges versus 6.78% on the maker-taker venues. These results highlight the difficulty of using unadjusted effective spreads to evaluate best execution in markets with maker-taker fees and/or order flow inducements.

Consistent with these results, trades that execute on the PHLX under the maker-taker model on average pay significantly higher net liquidity costs than trades that execute via the PFOF model. Conversely, there is no statistical difference in the average payment-adjusted and the average fee-adjusted spreads on the NYSE Arca. It is difficult to reconcile these two results given that the PHLX pays \$0.05 more per contract for uninformed orders than does the NYSE Arca (Panel B of Table 4, column titled Non-penny) and given that the NYSE Arca charges taker fees that are often higher than those on the PHLX.

Taken at face value, the results in Table 5 do not imply that exchanges utilizing the maker-taker model offer non-competitive execution prices. Rather, these results likely reflect the fact that maker-taker exchanges receive only those orders that cannot be sold to the PFOF exchanges. Presumably, these orders are more informed and therefore costlier to execute. Thus, in a competitive market, one would expect trades that execute on the maker-taker exchanges to pay higher unadjusted effective spreads.

### 5.5 *Multivariate analysis of execution quality*

Options exchanges typically trade hundreds of different options on a given stock. Some of these options are liquid, while others are not. Some trade in pennies, while others trade in nickels and dimes. Thus, even though we require our sample option classes to average at least ten trades per day, there is no guarantee that the liquidity of options that execute on each exchange is comparable. For example, if certain exchanges specialize in providing executions for the most liquid options, simple univariate comparisons of execution quality may lead us to incorrectly conclude that these exchanges offer superior execution quality. For this reason, we next examine whether our univariate results survive when we more carefully control for differences in option and underlying stock characteristics.

To test our results in a multivariate setting, we estimate the following panel regression model:

$$\begin{aligned} \%EFFSP_{idt} = & \alpha + \beta_1 PFOF_{it} + \beta_2 PENNY_i + \beta_3 ETF_i + \beta_4 IVOL_{idt} + \beta_5 MONEY1_{idt} \quad (1) \\ & + \beta_6 MONEY2_{idt} + \beta_7 PRICE_{idt} + \beta_8 TSIZE_{idt} + \beta_9 MCAP_{id} \\ & + \beta_{10} EXPIRATION_d + \beta_{11} CRASH_d + \varepsilon_{idt}. \end{aligned}$$

Since trades represent only one side of a round-trip transaction, for each trade in option class  $i$  executed on day  $d$  at time  $t$  we measure the dependent variable,  $\%EFFSP_{idt}$ , as twice the absolute difference between the trade price and the midpoint of the execution-time NBBO normalized by the midpoint of the execution-time NBBO.

Given the well documented relationship between spreads and volatility, equation (1) includes  $IVOL$ , the trade's implied volatility as computed by LiveVol. Further, since liquidity is a function of an option's moneyness, we include a dummy variable  $MONEY1$  that equals to 1 if the option's stock-to-strike price is between 0.9 and 1.1 and equals to zero otherwise. We also include a dummy variable  $MONEY2$  that equals to 1 if the option's stock-to-strike price is either between 0.7 and 1.1 or is between 1.1 and 1.3 and equals to zero otherwise. Additionally, we include the execution-time NBBO midpoint,  $PRICE$ , since prior work (e.g., Harris, 1994) shows that spreads depend on price. Following Battalio et al. (2004), we include the natural log of the underlying asset's market capitalization,  $MCAP$ , calculated each day using CRSP data.  $MCAP$  is intended to capture the effect of informational asymmetries and liquidity in the equity market on option trades. Theoretical predictions by Easley and O'Hara (1987) suggest a positive relation between liquidity costs and trade size, therefore we include the natural log of the trade size,  $TSIZE$ , as a control.

Since the \$0.05 minimum variation creates a lower bound on effective spreads for options that do not trade in pennies, we include an indicator variable  $PENNY$  that is equal to one if the option trades in pennies and is equal to zero otherwise. To control for potential differences in cost of hedging positions in options on exchange traded funds and options on equities, we include an indicator variable  $ETF$  that is equal to one if the option is on an exchange traded fund and is equal to zero otherwise. To capture option expiration day effects, we include a binary

variable *EXPIRATION* that equals one for trades that execute on March 19, April 16, May 21, and June 18 and zero otherwise. We also include an indicator variable *CRASH* that equals to one for trades that execute on May 6 and zero otherwise, to account for the impact of the flash crash on liquidity costs. The variable of interest is *PFOF*, which equals one if the trade occurs under the PFOF model and zero if the trade occurs under the maker-taker model.

We expect trade *i*'s relative effective spread to be increasing in the option's implied volatility and in trade size and decreasing in the market capitalization of the underlying stock. We expect spreads to be higher on expiration days and on the day of the flash crash. To the extent that exchange traded funds are more liquid than stocks, we expect effective spreads to be smaller for options on ETFs. Finally, we expect spreads to be smaller for options that trade in pennies and for the near-the-money options.

Our data test positive for class-level fixed effects, therefore we estimate the model with an adjustment for fixed effects. In addition, we allow standard errors to cluster at the option class level. Fixed effect estimation does not allow us to directly estimate coefficients of the *PENNY* and *ETF* indicators because these indicators do not vary within option classes. Given our interest in the effect that these two variables may have on the trading costs, we estimate model (1) twice: with and without fixed effects. Finally, to gauge the effects of taker fees and order flow inducements, we estimate model (1) for the following three variants of the dependent variable: (i) without taker fees and without payments for order flow; (ii) with taker fees, but without payments; and (iii) with both fees and payments. Our results for the entire sample are presented in Table 6.

**[Insert Table 6 about here]**

The first and second columns of Table 6 contain simple OLS and OLS with fixed effects regression results when equation (1) is estimated using unadjusted relative effective spreads. Most of the results are remarkably similar between the two estimation approaches. Consistent with our expectations, relative effective spreads increase in implied volatility and trade size; are higher on expiration Fridays and are lower for options on stocks with larger market capitalizations. The cost of liquidity as measured by relative effective spreads is 280 basis points higher on the day of the flash crash. Finally, relative effective spreads are significantly lower for options that trade in pennies (around 450 basis points) and are significantly higher for options with stock-to-strike price ratios that are less than 0.7 or are greater than 1.3.

Our univariate analysis suggests the average relative effective spread for trades that execute in the PFOF model is 80 basis points higher than the average spread in the maker-taker model. The multivariate analysis presented in Table 6 implies that this difference was understated: the coefficient on the PFOF dummy is 0.010 (t-statistic = 11.61) in the simple OLS regression and is 0.010 (t-statistic = 15.60) in the fixed effects regression. These results imply that liquidity demanding trades that execute in the PFOF model pay relative effective spreads that are, on average, 100 basis points higher than similar trades that execute in the maker-taker model.

The third and the fourth columns of Panel A contain the OLS and fixed effects regression results obtained when we use the fee-adjusted relative effective spread as the dependent variable. Consistent with our univariate analysis, the inclusion of taker fees negates the cost advantage offered by the maker-taker exchanges. When we assume that investors pay 100% of the taker fees, our results suggest that liquidity demanding trades that execute in the PFOF model pay adjusted spreads that are 70 basis points lower than those that execute in the maker-taker model.

Finally, the fifth and the sixth columns of Panel A contain regression results obtained when we use the fee- and payment-adjusted relative effective spread as the dependent variable. Again, consistent with our univariate analysis, the assumption that 100% of both taker fees and marketing fees flows through to the liquidity demander reduces the relative cost of liquidity on the PFOF exchanges. Our estimates suggest that the relative trading costs are now between 200 and 210 basis points cheaper on the PFOF exchanges. We emphasize that this result does not, however, imply that brokers routing orders to the maker-taker exchanges are failing to fulfill their fiduciary responsibility to obtain best execution, since they may not be able to sell their orders to the PFOF venues.

There may be some concern that our results simply reflect differences across exchanges. We address this concern in two ways. First, we add exchange dummies to model (1) and estimate the model using unadjusted spreads. Consistent with our prior results, when we include exchange dummies we find that the fee-adjusted relative effective spreads are higher on each of the pure maker-taker exchanges than they are on each of the pure PFOF exchanges. This suggests that our results are not being driven by a single exchange. Next, we estimate model (1) separately for trades on the two exchanges that utilize both the PFOF model and the maker-taker model during our sample period. Unfortunately, the NYSE Arca uses the maker-taker model for options that trade in pennies and the PFOF model for options that do not trade in pennies. For this reason, we cannot distinguish the incremental impact of trading in pennies (not trading in pennies) from the incremental impact of trading in the maker-taker model (the PFOF model) for the NYSE Arca trades. We do not have this problem when analyzing trades on the PHLX. The results of these regressions are presented in Table 7.

**[Insert Table 7 about here]**

When significant, each of the control variables again has the predicted sign when we run each of the three variants of our fixed effects model using only the NYSE Arca trades and only the PHLX trades. While we recognize that we cannot identify the impact of the PFOF and maker-taker models on the NYSE Arca's trading costs, we present the NYSE Arca results for completeness. As is the case for the entire sample, the coefficient on the PFOF/Penny indicator variable declines as spreads are adjusted first for taker fees and then for both taker fees and order flow inducements.

Consistent with the overall results, trades that execute via the PFOF model on the PHLX have unadjusted relative effective spreads that are, on average, 90 basis points higher (t-statistic of 5.66) than comparable trades that execute via the maker-taker model (see column 2 of Table 7). After accounting for taker fees, there is no significant difference in fee-adjusted spreads on the PHLX. Finally, when both taker fees and order flow payments are considered, net trading costs are significantly lower for trades that execute via the PFOF model. To summarize, the results obtained using trades on a single exchange that utilizes both models to execute trades are consistent with those obtained from trades originating on exchanges that use a single model to execute all trades. This suggests that our results are not the product of unidentified exchange characteristics.

## 5.6 *Summary and discussion*

Our results highlight the fragility of best execution analyses. If best execution is narrowly defined as the relative effective spreads, our results suggest that the maker-taker model dominates the PFOF model. Moreover, since brokers routing uninformed orders to the PFOF

exchanges receive inducements, one might interpret our results as evidence that the agency problems associated with order flow inducements are severe.

Taker fees, however, must be paid to obtain the lower spreads offered by exchanges utilizing the maker-taker model. Who pays these fees? As noted by Angel et al. (2010), if the market for order flow is sufficiently competitive, these fees are passed onto liquidity demanders either explicitly or, more likely, implicitly via higher commissions and/or reduced services. Once effective spreads on maker-taker exchanges are adjusted to reflect taker fees, our results suggest that the PFOF exchanges have relative effective spreads that are, on average, around 70 basis points less than the spreads on maker-taker venues. This does not, however, necessarily imply that exchanges utilizing the maker-taker model offer inferior execution quality. Rather, it may reflect the fact that the PFOF exchanges get less informed order flow than the maker-taker exchanges. In a competitive world, uninformed investors should pay less for liquidity.<sup>17</sup>

Should order flow inducements also be included in an analysis of best execution? A cursory examination of the Rule 606 filings of 19 options brokers suggests that each of these brokers routes orders based at least in part on order flow inducements. This implies that competition for the scarce resource – uninformed customer orders – should force brokers to sell their orders in order to offer lower commissions and/or improved services. Angel et al. (2010) note that currently, most options brokers charge a single, fixed price commission to all of their customers and do not explicitly pass on the fees and/or order flow payments. They explain that while the SEC could require brokers to pass on all taker fees and order flow inducements to their

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<sup>17</sup> Unlike equity markets, in options markets the realized spread cannot be used to control for selection bias since option market makers hedge their positions by trading in the underlying stock. It may be argued that the movement in the underlying stock price following a trade in the option market could be used as a proxy for the information content of a liquidity demanding option trade. There are two problems, however, with this proxy. First, the proxy will not control for volatility trades which, by definition, are non-directional. Second, for directional trades, it is difficult if not impossible to distinguish between movements in the underlying stock that reflect information versus movements that reflect the hedging trades of options market makers.

customers, “the practice is complex and therefore confusing to most customers.” To the extent that brokers have a specific clientele (e.g., uninformed investors or day traders), it is reasonable to assume that most of the order flow inducement and/or taker fee reaches the investor via reduced/inflated commissions. In this scenario, execution quality can be evaluated by comparing the fee- and payment-adjusted effective spreads on the PFOF and the maker-taker exchanges. Our results suggest the PFOF exchanges charge uninformed investors the least for liquidity. If a broker’s clientele is mixed, fixed price commissions introduce a cross subsidy from uninformed investors to informed investors as order flow inducements are used to offset taker fees. In this situation, it may be more appropriate to evaluate execution quality at the broker level using commission data to adjust effective spreads.

Our results also highlight the importance of flash trading facilities. Angel et al. note that these facilities help the PFOF exchanges that are not currently offering the best posted price to find liquidity providers who are willing to match or improve the prices prevailing at the maker-taker exchanges. When an internal liquidity provider is found, the liquidity demander is able to avoid the taker fee. While taker fees sound small, ranging from \$0.0015 to \$0.0055 per option during our sample period, they are actually large relative to the price of the average option.

More generally, our results are consistent with what one would expect to find in a transparent market with competition. Taker fees inflate net trading costs and order flow inducements lower net trading costs. The omission of taker fees will cause effective spreads to understate the cost of liquidity on the maker-taker venues, while the omission of order flow inducements will cause effective spreads to overstate the cost of liquidity on the PFOF markets. This is exactly what we find: all else equal, the PFOF markets have higher unadjusted relative effective spreads than the maker-taker markets.

In a competitive equilibrium, one would expect uninformed orders (the scarce resource) to pay less for liquidity than more informed orders. We find a confirmation to this premise once we assume that 100% of the taker fee is passed onto investors. When we also assume that 100% of the inducement is passed on, the difference in net liquidity costs becomes substantial (around 200 basis points). These may be extreme assumptions, as fixed brokerage commissions almost certainly force some cross subsidization across uninformed and informed investors. Nevertheless, given the economic incentives that brokers have to attract uninformed orders, it is difficult to imagine that this cross subsidy is too large.

## **6. Conclusion**

U.S. option markets are unique in that, on each exchange, individual options trade either under the maker-taker system, where liquidity demanders pay liquidity suppliers a fee for liquidity, or via the PFOF model, where liquidity suppliers pay uninformed liquidity demanders for their orders. While the PFOF model has existed in the options markets since the listings war of 1999 (see De Fontnouvelle, et al., 2003), the maker-taker model entered option markets in 2007. The agency problems associated with order flow inducements are potentially enormous, given the dominant market share of the PFOF exchanges. In equity markets, venues utilizing the maker-taker model are generally associated with tighter quoted spreads. It is not clear whether economics or the potential agency problems associated with order flow inducements have limited the growth of the maker-taker model in the U.S. options marketplace.

Despite the fact that the options exchanges have voluntarily been producing monthly execution quality reports since 2008, we first show that the quality of these reports is not sufficient to allow liquidity demanding investors to evaluate whether brokers routing to the

PFOF exchanges are maximizing execution quality. This finding implies that voluntary disclosures of execution quality are not suitable replacements for federally mandated disclosures.

We next provide the first analysis of which we are aware that explicitly considers the impact of order flow inducements and taker fees on execution costs in the U.S. options markets. Our univariate analysis suggests that, on average, relative spreads are 80 basis points lower on maker-taker exchanges versus PFOF exchanges. In particular, the average spread for a \$3.00 option is around \$0.20 on a maker-taker exchange versus \$0.23 on a PFOF exchange. Except for options that do not trade in pennies, this relation obtains for every option sub-group and for every trade size.

We further show that assuming that the liquidity demander pays 100% of the taker fees increases the adjusted relative spread on maker-taker exchanges from 6.78% to 8.32%. This increase is enough to negate the maker-taker's cost advantage in every trade category except in trades for 1 contract. With few exceptions, the average unadjusted effective spread on the PFOF markets is lower than the fee-adjusted effective spread on the maker-taker markets. This differential explains the popularity of flash trading mechanisms on the PFOF exchanges, which attempt to avoid taker fees by encouraging liquidity providers to match the prices posted on maker-taker exchanges. Perhaps not surprisingly, when we further assume that 100% of the order flow inducements are passed onto investors, the PFOF markets uniformly offer the lowest adjusted spreads. On average, adjusted spreads are 200 basis points lower on the PFOF exchanges as confirmed by our multivariate analysis. We find similar results for trades on the PHLX, which uses the PFOF model to trade some option classes and the maker-taker model to trade others.

Consistent with the arguments of Angel et al. (2010), our results suggest that one cannot evaluate execution quality in a market with competing exchange models by simply comparing unadjusted effective spreads. Doing so would suggest that the PFOF exchanges are overcharging uninformed investors for liquidity, perhaps to maximize the dealer revenue associated with executing captive order flow. While seemingly small, the taker fees explain a large part of the discrepancy in unadjusted relative spreads across the PFOF and the maker-taker exchanges. The large cost advantage possessed by the PFOF exchanges after spreads are adjusted for both fees and order flow inducements is an indication that the market for options order flow is competitive.

Ultimately, whether or not the PFOF exchanges offer uninformed investors superior execution quality depends on the percentage of taker fees and order flow inducements that pass through to customers. Currently, the SEC relies on competition and transparency to return these fees/payments back to retail investors. As noted earlier, this mechanism may begin to fail when brokers have a mixed clientele of informed and uninformed investors. Given the economics of order flow, it seems quite unlikely that competition would allow a cross-subsidy this large to persist. This suggests regulation requiring brokers to explicitly pass taker fees and order flow inducements back to investors on a trade-by-trade basis is a potentially costly cure for an ailment that may not exist.

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**Table 1**  
**Sample selection and option class distribution**

Panel A. Sample filters	
	# of remaining option classes
Initial Sample	3,233
Exclude option classes that do not trade on each exchange (excluding BATS)	550
Exclude option classes that have fewer than 10 trades per day	314
Only keep option classes on common stocks or on ETFs	265
Exclude option classes that begin trading in pennies during our sample period	239
Final Sample	239
Panel B. Distribution of option classes	
	# of option classes
Option class on common stock that trades in pennies	95
Option class on common stock that does not trade in pennies	112
Option class on ETF that trades in pennies	27
Option class on ETF that does not trade in pennies	5
Final Sample	239

**Table 1 (continued)**

## Panel C. Trade filters

	All	NASDAQ	AMEX	CBOE	ISE	NYSE Arca	PHLX	BOX	BATS
# of trades in initial sample	21,165,901	974,460	3,175,565	4,813,400	3,960,191	4,717,716	2,664,075	788,295	72,199
Trades before 9:45am or after 3:55pm	11.27%	8.39%	11.44%	11.59%	11.83%	10.45%	12.57%	10.20%	6.71%
Spreads and straddles	10.48%	0.00%	0.43%	15.28%	35.25%	0.17%	2.42%	0.00%	0.00%
Trades executed in crossed markets	0.09%	0.12%	0.07%	0.14%	0.06%	0.09%	0.05%	0.07%	0.20%
Trades executed with a benchmark NBB of zero	0.36%	0.35%	0.65%	0.30%	0.29%	0.31%	0.38%	0.24%	0.08%
Bunch trades	16.61%	15.23%	42.86%	7.33%	4.29%	23.81%	8.68%	15.57%	10.28%
Final sample as a % of initial sample	61.19%	75.92%	44.54%	65.36%	48.28%	65.17%	75.90%	73.92%	82.72%
# of trades in final sample	12,951,298	739,778	1,414,547	3,145,905	1,912,053	3,074,657	2,021,952	582,685	59,721

Notes: Our sample period begins on March 1, 2010 and ends on June 30, 2010. We are missing two days of trading data because the data files for March 22 and March 25 are corrupt. In Panel C, trades are bunched by combining (into a single trade) multiple executions in the same option series, executing on the same exchange at the same price at the same time with the same trade message.

**Table 2**  
**Distribution of Trading Activity**

Panel A: Distribution of trades and volume across venues

	All classes		Stock		ETF		Penny		Not penny	
	% trades	% vol	% trades	% vol	% trades	% vol	% trades	% vol	% trades	% vol
CBOE	25.77%	25.07%	26.09%	25.10%	23.61%	23.72%	24.59%	24.62%	27.00%	25.36%
ISE	16.55%	20.58%	16.68%	20.79%	16.03%	19.72%	14.75%	18.82%	18.50%	22.52%
AMEX	13.90%	12.89%	14.37%	13.22%	11.67%	11.50%	10.44%	10.66%	17.68%	15.36%
NYSE Arca	18.49%	15.16%	17.53%	14.60%	23.31%	17.94%	26.86%	20.91%	9.45%	8.97%
PHLX	14.08%	17.52%	13.91%	17.18%	15.51%	20.38%	13.44%	18.04%	14.80%	17.08%
NASDAQ	5.45%	3.83%	5.50%	3.94%	5.03%	3.05%	4.93%	3.15%	5.98%	4.53%
BOX	5.62%	4.88%	5.83%	5.12%	4.41%	3.51%	4.72%	3.67%	6.59%	6.18%
BATS	0.14%	0.07%	0.10%	0.06%	0.44%	0.18%	0.27%	0.14%	0.00%	0.00%

**Table 2 (continued)**

## Panel B: Extreme trading activity

	Volume leader, % of class-days	Not active, % of class-days
CBOE	38.41%	0.04%
ISE	22.89%	0.27%
AMEX	7.04%	0.29%
NYSE Arca	13.35%	2.51%
PHLX	16.59%	0.46%
NASDAQ	0.63%	7.16%
BOX	1.09%	3.66%
BATS	0.00%	88.89%

## Panel C: Market share across different trade sizes

	1 contract		2 to 50 contracts		> 50 contracts	
	% trades	% volume	% trades	% volume	% trades	% volume
CBOE	28.04%	28.04%	25.32%	24.81%	26.84%	26.24%
ISE	15.27%	15.27%	16.29%	17.39%	23.90%	25.49%
AMEX	14.98%	14.98%	13.71%	13.46%	12.24%	11.75%
NYSE Arca	20.97%	20.97%	18.40%	17.71%	14.70%	12.81%
PHLX	12.49%	12.49%	14.02%	14.47%	17.06%	19.40%
NASDAQ	4.27%	4.27%	5.95%	5.44%	2.07%	1.70%
BOX	3.90%	3.90%	6.15%	6.60%	3.15%	2.60%
BATS	0.09%	0.09%	0.16%	0.14%	0.03%	0.02%

Notes: Market share statistics are computed for the 239 sample option classes during the March-June 2010 sample period. Due to corrupt data files, we do not have trading data for March 22 and March 25. To compute the summary statistics in Panels A and C, we first compute cross-sectional averages of market shares for each sample date and then compute time-series averages across sample dates. A class-day represents trades in all option series on a given stock that take place on a specific day. One option contract contains 100 options.

**Table 3**  
**Trade Volume and Effective Spreads Computed using**  
**Exchange-Generated Data and LiveVol Data**

Panel A: Volumes used to compute exchange-generated and LiveVol effective spreads

		March 2010	April 2010	May 2010	June 2010
CBOE	Exchange	7,106,031	9,713,081	8,593,211	5,783,989
	LiveVol	19,455,090	26,957,225	25,981,291	15,895,472
ISE	Exchange	23,412,831	22,570,197	23,063,145	15,604,127
	LiveVol	15,386,322	18,728,560	18,843,588	14,285,054
AMEX	Exchange	3,034,553	4,499,903	2,952,357	2,386,037
	LiveVol	9,823,393	12,567,815	10,775,495	8,484,765
NYSE Arca	Exchange	1,326,122	1,527,901	1,151,784	875,417
	LiveVol	14,613,574	18,152,267	18,271,374	13,136,541
PHLX	Exchange	3,843,741	3,555,859	2,593,842	1,678,475
	LiveVol	32,889,140	30,998,389	28,263,312	22,144,595
NASDAQ	Exchange	890,746	1,447,685	1,551,927	1,233,103
	LiveVol	2,339,280	3,288,508	3,366,837	2,536,307
BOX	Exchange	1,539,567	2,191,631	1,313,718	1,126,442
	LiveVol	2,590,773	3,879,173	3,114,996	3,352,627
BATS	Exchange	n.a.	n.a.	n.a.	n.a.
	LiveVol	30,427	233,033	216,905	455,027

**Table 3 (continued)**

Panel B: Volume-weighted effective spreads computed using exchange-generated and LiveVol data

		March 2010	April 2010	May 2010	June 2010
CBOE	Exchange	\$0.025	\$0.027	\$0.340	\$0.031
	LiveVol	\$0.026	\$0.027	\$0.045	\$0.035
ISE	Exchange	\$0.077	\$0.095	\$0.122	\$0.104
	LiveVol	\$0.026	\$0.028	\$0.041	\$0.031
AMEX	Exchange	\$0.032	\$0.032	\$0.053	\$0.038
	LiveVol	\$0.031	\$0.028	\$0.048	\$0.036
NYSE Arca	Exchange	\$0.019	\$0.019	\$0.029	\$0.022
	LiveVol	\$0.019	\$0.020	\$0.028	\$0.023
PHLX	Exchange	\$0.022	\$0.023	\$0.033	\$0.028
	LiveVol	\$0.043	\$0.058	\$0.065	\$0.051
NASDAQ	Exchange	\$0.020	\$0.036	\$1.078	\$0.232
	LiveVol	\$0.022	\$0.025	\$0.034	\$0.024
BOX	Exchange	\$0.024	\$0.026	\$0.497	\$0.200
	LiveVol	\$0.028	\$0.029	\$0.047	\$0.031
BATS	Exchange	n.a.	n.a.	n.a.	n.a.
	LiveVol	\$0.012	\$0.021	\$0.016	\$0.015

Notes: Most of the options exchanges produce monthly execution quality reports. We obtain these reports from the respective exchanges and use them to compute each exchange's trading volume and volume-weighted dollar effective spread for each of our four sample months. Next, using trade and quote data obtained from LiveVol, we compute each exchange's volume and volume-weighted effective spreads for each sample month. The Exchange volume-weighted effective spreads for NASDAQ do not include data for options on UYG and WM as these data are missing from NASDAQ's execution quality reports. Due to corrupt data files, we do not have trading data for March 22 and March 25, 2010.

**Table 4**  
**Maker-Taker and Marketing Fees**

Panel A. Maker-taker fees (per contract)				
	Penny		Non-penny	
	Maker	Taker	Maker	Taker
AMEX	\$0.00	\$0.00	\$0.00	\$0.00
CBOE	\$0.00	\$0.00	\$0.00	\$0.00
ISE	\$0.00	\$0.00	\$0.00	\$0.00
NYSE Arca	-\$0.25 / -\$0.30	\$0.45	\$0.00	\$0.00
PHLX	\$0.00 / -\$0.20	\$0.00 / \$0.25	\$0.00 / -\$0.20	\$0.00 / \$0.25
NASDAQ	-\$0.25	\$0.35	\$0.00	\$0.20
BOX	-\$0.15	\$0.15	-\$0.55	\$0.55

Panel B: Marketing fees (per contract)		
	Penny	Non-penny
AMEX	\$0.25	\$0.65
CBOE	\$0.25	\$0.65
ISE	\$0.25	\$0.65
NYSE Arca	\$0.00	\$0.65
PHLX	\$0.00 / \$0.25	\$0.00 / \$0.70
NASDAQ	\$0.00	\$0.00
BOX	\$0.00	\$0.00

Notes: A maker fee is the rebate paid to standing limit orders when they provide liquidity to a marketable order. A taker fee is the fee paid by marketable orders when they access liquidity. Marketing fees are collected from market makers on PFOF exchanges when they interact with purchased, retail marketable order flow. These marketing fees are used to fund the PFOF exchanges' payment for order flow programs. NASDAQ introduced maker rebates of \$0.30 per contract and taker fees of \$0.35 per contract for IWM, SPY, and QQQQ on May 3, 2010. The PHLX began using the maker-taker model to trade 27 actively-traded option classes on March 1, 2010, an additional 24 actively-traded option classes on April 13, 2010, 4 option classes on May 6, 2010, and an additional 23 actively traded option classes on June 4, 2010. Otherwise, PHXL charged no maker-taker fees. We incorporate all of these changes into our calculations. The NYSE Arca offers an additional rebate of \$0.05 per contract to makers in the following option classes as of April 1, 2010: SPY, C, BAC, QQQQ, AAPL, IWM, XLF, GLD, EEM, GE, UNG, FAZ, DIA, GDX, and USO. As of March 1, 2010, public customers removing liquidity in a price improvement period (PIP) pay a fee of \$0.15, and public customers adding liquidity in a PIP receive a rebate of \$0.30. The CBOE charged marketing fees of \$0.10 per contract for DIA and SPY and no marketing fees for trades in QQQQ and IWM. The PHLX charges marketing fees in those option classes that do not have maker-taker pricing during our sample period.

**Table 5**  
**Relative Effective Spreads**

	PFOF		Maker-Taker		Differences		
	Unadjusted (1)	Payment-Adjusted (2)	Unadjusted (3)	Fee-Adjusted (4)	(1) - (3)	(1) - (4)	(2) - (4)
1 contract trades	6.82%	5.19%	4.78%	6.13%	2.04% <sup>***</sup>	0.69% <sup>***</sup>	-0.94% <sup>***</sup>
2 to 50 contract trades	7.48%	5.76%	6.84%	8.37%	0.64% <sup>***</sup>	-0.89% <sup>***</sup>	-2.61% <sup>***</sup>
51 contract & larger trades	8.78%	6.61%	6.61%	9.16%	2.17% <sup>***</sup>	-0.38%	-2.55% <sup>***</sup>
Equity options	7.64%	5.85%	6.90%	8.38%	0.74% <sup>***</sup>	-0.74% <sup>***</sup>	-2.53% <sup>***</sup>
ETF options	7.34%	5.76%	6.12%	8.11%	1.22% <sup>***</sup>	-0.77% <sup>***</sup>	-2.35% <sup>***</sup>
Trades in pennies	6.11%	4.58%	4.23%	6.27%	1.88% <sup>***</sup>	-0.16%	-1.69% <sup>***</sup>
Does not trade in pennies	9.15%	7.16%	9.53%	10.55%	-0.38% <sup>*</sup>	-1.40% <sup>***</sup>	-3.39% <sup>***</sup>
0.9 ≤ S/X ≤ 1.1	5.53%	4.26%	5.24%	6.28%	0.29%	-0.75% <sup>***</sup>	-2.02% <sup>***</sup>
All	7.58%	5.83%	6.78%	8.32%	0.80% <sup>***</sup>	-0.74% <sup>***</sup>	-2.49% <sup>***</sup>
All minus NYSE Arca	7.71%	5.95%	7.24%	8.43%	0.47% <sup>***</sup>	-0.72% <sup>***</sup>	-2.48% <sup>***</sup>
NYSE Arca	7.81%	5.90%	3.70%	6.10%	4.11% <sup>***</sup>	1.71% <sup>***</sup>	-0.20%
All minus PHLX	7.43%	5.70%	6.73%	8.30%	0.70% <sup>***</sup>	-0.87% <sup>***</sup>	-2.60% <sup>***</sup>
PHLX	8.57%	6.73%	5.82%	7.60%	2.75% <sup>***</sup>	0.97% <sup>***</sup>	-0.87% <sup>***</sup>

Notes: Our sample consists of trades in 239 equity and ETF option classes that average at least ten trades per day between March 1, 2010 and June 30, 2010. Due to corrupt data files, we do not have trading data for March 22 and March 25, 2010. PFOF refers to trades executed by exchanges using the PFOF model. Maker-Taker refers to trades executed by exchanges using the maker-taker model. Unadjusted refers to the average relative effective spread for trades in the specified category. To compute average spreads, each trading day we compute an option class's average spread as the average of the underlying option series' spreads. We then compute the across-class average spread each day. Finally, we obtain an equal-weighted average by taking the time series average of the across-class average spreads. Payment-Adjusted refers to the average relative effective spread minus twice the exchange's marketing fee normalized by the trade's execution-time NBBO midpoint. Fee-Adjusted refers to the average relative effective spread plus twice the exchange's taker fee normalized by the trade's execution-time NBBO midpoint. S/X is the stock-to-strike price ratio. \*\*\* (\*) indicates significance at the 0.01 (0.10) level.

**Table 6**  
**Multivariate Analysis of Relative Effective Spreads**

	Unadjusted % Effective Spreads		Fee-Adjusted % Effective Spreads		Fee- & Paymt.-Adjusted % Effective Spreads	
Intercept	0.145 (10.23)	0.000 (-0.48)	0.163 (10.56)	0.000 (-0.54)	0.157 (10.82)	0.000 (-0.53)
PFOF Model	0.010 (11.61)	0.010 (15.60)	-0.007 (-5.52)	-0.007 (-6.08)	-0.020 (-10.00)	-0.021 (-10.01)
Penny	-0.045 (-16.08)		-0.046 (-15.11)		-0.039 (-12.28)	
ETF	0.002 (0.61)		0.002 (0.79)		0.002 (0.53)	
IVOL	0.010 (7.91)	0.011 (8.09)	0.011 (8.12)	0.012 (8.06)	0.010 (7.38)	0.011 (7.72)
Money 1	-0.062 (-12.14)	-0.064 (-12.64)	-0.071 (-13.34)	-0.072 (-13.44)	-0.061 (-11.22)	-0.063 (-12.37)
Money 2	-0.032 (-7.19)	-0.033 (-7.52)	-0.036 (-7.87)	-0.037 (-8.05)	-0.032 (-6.91)	-0.033 (-7.54)
Option Price	-0.005 (-5.36)	-0.006 (-5.43)	-0.006 (-5.69)	-0.007 (-5.54)	-0.005 (-6.05)	-0.005 (-5.97)
ln (Trade Size)	0.002 (9.84)	0.003 (13.38)	0.003 (10.99)	0.003 (13.53)	0.003 (12.88)	0.003 (15.10)
ln (Market Cap.)	-0.001 (-0.98)	-0.017 (-3.16)	0.000 (-0.52)	-0.017 (-2.76)	-0.001 (-1.28)	-0.014 (-2.72)
Expiration Friday	0.026 (8.54)	0.025 (9.06)	0.030 (9.81)	0.029 (10.24)	0.027 (8.56)	0.026 (8.97)
Flash Crash	0.028 (10.99)	0.028 (11.30)	0.026 (10.07)	0.026 (10.26)	0.028 (11.01)	0.028 (11.25)
R <sup>2</sup>	8.63%	6.55%	8.48%	6.93%	7.50%	6.67%
Class Fixed Effects	No	Yes	No	Yes	No	Yes

Note: Our sample consists of trades in 239 equity and ETF option classes that average at least ten trades per day between March 1, 2010 and June 30, 2010. Due to corrupt data files, we do not have trading data for March 22 and March 25, 2010. PFOF refers to trades executed by exchanges using the PFOF model. Trades not executed under this model are executed via the maker-taker model. Unadjusted % Effective Spread refers to a trade's unadjusted relative effective spread. Fee-Adjusted % Effective Spread refers to a trade's relative effective spread plus (if the trade is executed on a maker-taker exchange) an amount equal to twice the exchange's taker fee normalized by the trade's execution-time NBBO midpoint. Payment- & Fee-Adjusted % Effective Spread refers to a trade's relative effective spread plus (if the trade is executed on a maker-taker exchange) an amount equal to twice the exchange's taker fee normalized by the trade's execution-time NBBO midpoint minus (if the trade is executed on a PFOF exchange) an amount equal to twice the exchange's marketing fee normalized by the trade's execution time NBBO midpoint. PFOF is a dummy variable that equals one if the trade is in an option class that trades via the PFOF model and zero otherwise. Penny Pilot is a dummy variable that equals one if the trade is in an

### **Table 6 (continued)**

option that trades in pennies and is equal to zero otherwise. ETF is a dummy variable that equals one if the option is on an exchange-traded fund and zero otherwise. IVOL is option's implied volatility at the time of the trade. Money 1 is a dummy that equals one if the stock-to-strike price ratio of the option is between 0.9 and 1.1 and zero otherwise. Money 2 is a dummy that equals one if the stock-to-strike price is either between 0.7 and 0.9 or is between 1.1 and 1.3 and equals zero otherwise. Option price is the midpoint of the execution-time NBBO. Trade size is the size of the option trade. Market Cap. is the market capitalization of the underlying stock. Expiration Friday is a dummy variable that equals one if the trade occurs on an expiration date and equals zero otherwise. Flash Crash is a dummy variable that equals one if the trade occurs on May 6 (the day of the flash crash) and zero otherwise. t-statistics are in parentheses.

**Table 7**  
**Multivariate Analysis of Relative Effective Spreads on NYSE Arca and on PHLX**

	Unadjusted % Effective Spread		Fee-Adjusted % Effective Spread		Fee- & Paymt.-Adjusted % Effective Spread	
	NYSE Arca	PHLX	NYSE Arca	PHLX	NYSE Arca	PHLX
Intercept	-0.009 (-3.98)	0.004 (8.39)	-0.009 (-4.85)	0.003 (3.79)	-0.009 (-7.32)	0.003 (2.56)
PFOF/Penny Pilot	0.004 (0.99)		-0.019 (-6.27)		-0.033 (-14.61)	
PFOF		0.009 (5.66)		-0.004 (-1.86)		-0.019 (-5.58)
IVOL	0.008 (3.71)	0.020 (6.28)	0.012 (3.91)	0.023 (8.14)	0.012 (3.91)	0.021 (8.27)
Money 1	-0.054 (-12.31)	-0.063 (-9.41)	-0.079 (-14.91)	-0.070 (-10.51)	-0.078 (-14.92)	-0.063 (-10.72)
Money 2	-0.033 (-8.43)	-0.033 (-5.65)	-0.044 (-10.01)	-0.036 (-6.25)	-0.044 (-10.06)	-0.034 (-6.40)
Option Price	-0.004 (-6.33)	-0.005 (-3.75)	-0.007 (-5.95)	-0.006 (-3.88)	-0.007 (-6.00)	-0.005 (-4.22)
ln (Trade Size)	0.003 (15.57)	0.002 (6.28)	0.006 (16.08)	0.003 (6.43)	0.006 (15.74)	0.003 (7.28)
ln (Market Cap.)	-0.008 (-2.25)	-0.009 (-1.24)	-0.009 (-1.83)	-0.010 (-0.99)	-0.009 (-1.89)	-0.009 (-0.94)
Expiration Friday	0.023 (5.90)	0.027 (9.27)	0.035 (8.33)	0.030 (10.76)	0.035 (8.30)	0.028 (9.56)
Flash Crash	0.017 (7.78)	0.029 (10.36)	0.013 (5.71)	0.027 (9.07)	0.013 (5.81)	0.029 (9.20)
R <sup>2</sup>	8.12%	2.98%	9.18%	3.42%	9.18%	3.15%
Class Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: Our sample consists of trades in 239 equity and ETF option classes that average at least ten trades per day between March 1, 2010 and June 30, 2010. Due to corrupt data files, we do not have trading data for March 22 and March 25, 2010. NYSE Arca regressions only use trades executed on NYSE Arca. PHLX regressions only use trades executed on the PHLX. PFOF refers to trades executed by exchanges using the PFOF model. Trades not executed under this model are executed via the maker-taker model. Unadjusted % Effective Spread refers to a trade's unadjusted relative effective spread. Fee-Adjusted % Effective Spread refers to a trade's relative effective spread plus (if the trade is executed on a maker-taker exchange) an amount equal to twice the exchange's taker fee normalized by the trade's execution-time NBBO midpoint. Payment- & Fee-Adjusted % Effective Spread refers to a trade's relative effective spread plus (if the trade is executed on a maker-taker exchange) an amount equal to twice the exchange's taker fee normalized by the trade's execution-time NBBO midpoint minus (if the trade is executed on a PFOF exchange) an amount equal to twice the exchange's marketing fee normalized by the trade's execution-time NBBO midpoint. PFOF/Penny Pilot is a dummy variable that equals one if the trade is in

### **Table 7 (continued)**

an option class that trades in pennies, and thus, trades via the maker-taker model on NYSE Arca and zero otherwise. PFOF is a dummy variable that equals one if the trade is in an option class that trades via the PFOF model on the PHLX and zero otherwise. IVOL is option's implied volatility at the time of the trade. Money 1 is a dummy that equals one if the stock-to-strike price ratio of the option is between 0.9 and 1.1 and zero otherwise. Money 2 is a dummy that equals one if the stock-to-strike price is either between 0.7 and 0.9 or is between 1.1 and 1.3 and equals zero otherwise. Option price is the midpoint of the execution-time NBBO. Trade size is the size of the option trade. Market Cap. is the market capitalization of the underlying stock. Expiration Friday is a dummy variable that equals one if the trade occurs on an expiration date and equals zero otherwise. Flash Crash is a dummy variable that equals one if the trade occurs on May 6 (the day of the flash crash) and zero otherwise. t-statistics are in parentheses.

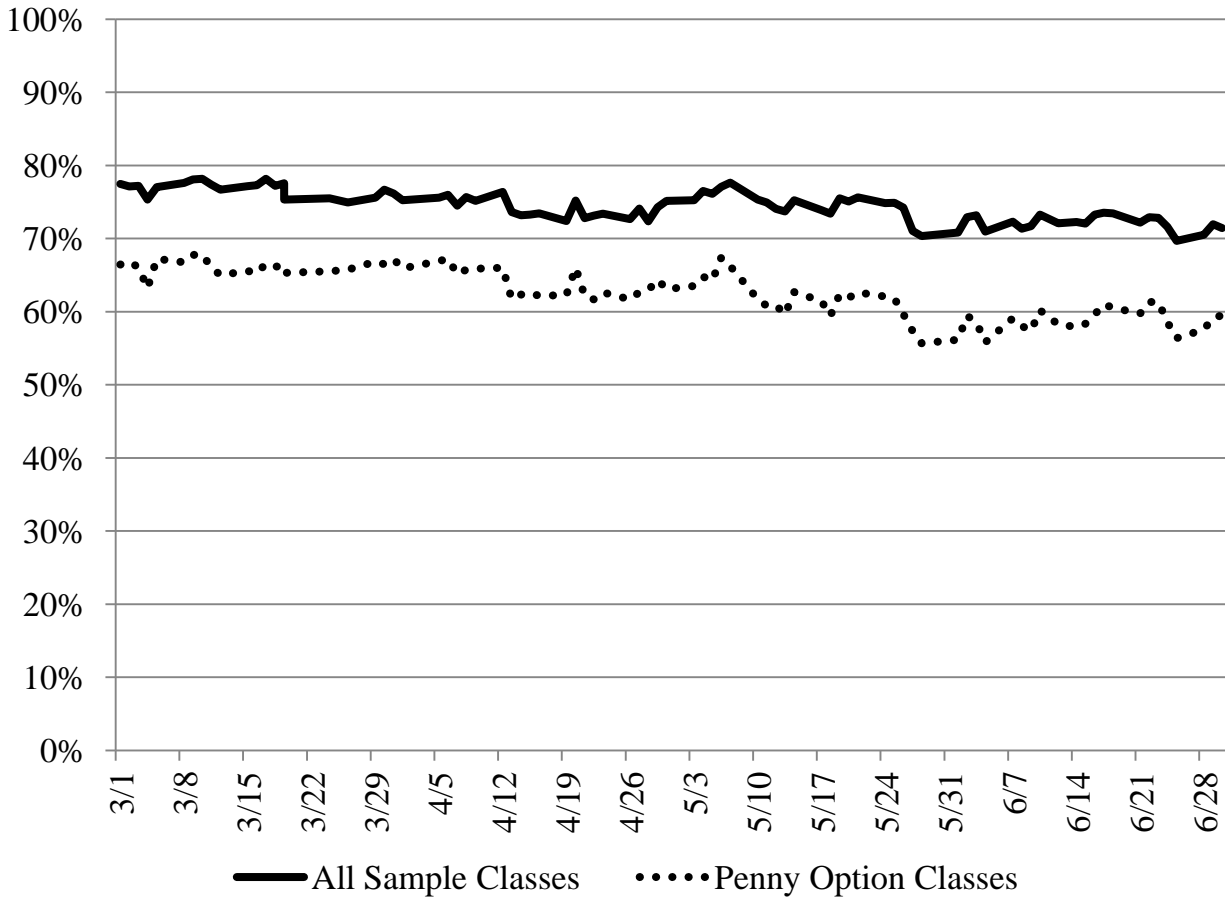


Figure 1. Percentage of contract volume executed on the PFOF exchanges.

PFOF volume is derived from the trades executed on the AMEX, the CBOE, and the ISE as well as trades in the non-penny option classes executed on NYSE Arca and trades in select (PFOF) classes on the PHLX. Maker-taker volume is derived from the trades executed on NASDAQ, the BOX, and BATS as well as trades in penny option classes that execute on NYSE Arca and trades in select (maker-taker) classes on the PHLX. We examine trading volume in the 239 options classes on stocks and ETFs that average at least 10 traders per day and trade on every exchange (other than BATS) during the sample period. Due to incomplete data, we exclude March 22 and March 25, 2010 trading days.