From: [redacted]
To: [redacted]
Subject: Payment for Order Flow Paper
Date: Friday, December 16, 2022 1:12:13 PM
Attachments: Kieran Daly Thesis.pdf

Dear Commissioner Uyeda,

I realize that the Commission has just issued several proposals on market microstructure.

Coincidentally, I just submitted my undergraduate thesis that focused on payment for order flow. I have attached it to this email on the remote chance that there is something useful for your staff in evaluating the new proposals.

My conclusions are that PFOF:

- made investing in the stock market easier for all investors (positive);
- increased market efficiency for retail investors (positive);
- may have increased speculation in the market by retail investors (mixed).

Best regards,

Kieran Daly

[redacted]

Claremont McKenna College

Societal Impacts of Payment for Order Flow

Submitted to

Professor Ben Gillen

And

Professor Mike Izbicki

by

Kieran Daly

For Senior Thesis

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12/05/22

Abstract

Payment for order flow is a market microstructure that has come about from designated market makers taking advantage of advances in technology and relaxations of an old SEC rule. PFOF has provided multiple benefits to US investors such as zero commission trading and faster, more efficient order execution. These benefits have come at a cost because most of the savings from designated market makers (DMMs) is taken by the brokerage that sells the order flow to market makers. On top of that, zero commission trading's widespread adoption has been accompanied by a rise in more risky speculative activity.

To study the effects of PFOF on the financial markets, we examined the SEC rules that paved the way for its widespread implementation. Using SEC MIDAS data and CBOE options volume data we regress trend variables against market efficiency (cancels-to-trades ratio) and volume. We find that there is statistical and economic significance for the monthly average options volume (in number of contracts) for before the first SEC rule change, between the two rule changes, and after the second rule change. We also had similarly significant findings in ETF volume (number of trade messages) before the first rule change and between the two rule changes, and for stock market efficiency between the two rule changes and after the second rule change.

The change in ETF volume could come from commission free trading that is made possible by PFOF. More long-term investors are able to invest without being penalized with a fixed commission fee. The changes in options volume and stock market efficiency seem to be coming from market makers going through a transition period. The amendments to SEC Rule 98 changed the market making landscape and allowed for more consolidation in the market making business. It is likely that the market makers adjusted their firm architecture to adapt to these changes and were finished when a few made large acquisitions near the second amendment to Rule 98.

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Introduction

People have been saving money for centuries, and one of the most common places to invest is in the stock market. It used to be comparatively harder to enter the stock market, but thanks to recent market microstructure changes it is almost free. Robinhood is a brokerage that pioneered commission free trading, which means that when a user submits a trade, they do not pay any upfront commission for the privilege to trade. It used to be around $5 to trade any number of shares greater than one, but because of a trading framework called Payment for Order Flow (PFOF), commissions are nonexistent.

PFOF is a system where brokerages process stock market orders and then sell the orders to a firm that specializes in executing trades on exchanges who can profit off every transaction. A share of the profit is returned to the brokerage and that is how most brokerages generate revenue. The system leans on the algorithms and models of the high frequency market makers that can consistently profit off each trade. The system has been under scrutiny by the SEC since the Gamestop fiasco and there have been calls to outlaw the practice as a result of such an event transpiring. As of November 2022, the SEC has said they will not ban PFOF.

Rule 98 is a SEC and New York Stock Exchange (NYSE) rule introduced in 1986 that puts information barriers in place to guard against conflicts of interests at market makers and its affiliates. The conflicts of interest could potentially effect customer orders and the business activities of affiliates. This rule was put in place in a different time period from the modern day where almost all trades are now electronic. So, the NYSE and its designated market makers (DMMs) proposed changes to the rule that better serve the exchange and its users.

The amendment to Rule 98 in 2014 lowered some of the historical information barriers between DMMs and other parts of the firm. In the proposal, NYSE (or the Exchange) asserts that

"a member organization should be able to integrate its DMM unit operations with its customer-facing operations because the instant proposal, in tandem with existing NYSE conduct rules [and FINRA regulations] should provide a regulatory framework that guards customer interests and protects against the misuse of material non-public information, while increasing the operational flexibility of member organizations" (SEC Filing). DMMs used to have to be completely separate from other parts of firms, which is why most DMMs were specialists that only executed orders. Quantitative trading firms entered the space because after this amendment, DMM activity could be housed in the same place as trading algorithms. This potentially opened the door to increasing ROI from innovations in trading algorithms by being able to apply it to algo trading and market making simultaneously.

The 2017 amendment of Rule 98 allowed the DMMs to trade and market make for securities while on the trading floor that are not specifically assigned to them by the Exchange. This rule no longer limits the securities that a DMM is permitted to trade. Besides loosening DMM restrictions, this amendment was part of a broader change to shift the NYSE from a "Floor-based trading model to a fully automated trading model" (SEC Filing). Something of particular interest for low latency traders was the fact that DMMs could continue to support their electronic trading "in the same physical location where they are currently operating" (Sec Filing). Allowing algorithmic traders to be physically close to the exchange and enabling them to trade other securities seemed sufficient to increase competition between DMMs. The DMM with the fastest execution and most efficient algorithms could potentially trade other DMMs' securities.

This paper begins with a review of PFOF and the scholarly literature exploring its impact on the investment markets. It then explores the incentives faced by retail brokerages to shift their business models towards more lucrative revenue streams. My empirical analysis focuses on how

changes to Rule 98 shifted trends in market microstructure relating to order volume and execution efficiency.

Literature Review

The Payment for Order Flow (PFOF) framework has recently been brought to the fore by litigators and researchers because of market events such as the GameStop Fiasco. PFOF is a trading framework that allows brokerages to sell customer order flow to high frequency market makers who's trading algorithms and systems allow them to profit on each trade. To put this in layman's terms, a brokerage receives an order from their user and sends it to a market maker that is more well equipped to execute the order. A portion of the profit on each trade is returned to the brokerage and a portion is kept by the market maker as the cost of doing business. By shifting the revenue source for brokerages from fixed commissions to variable rebates, PFOF has brought the upfront cost of trading down to zero dollars for retail investors. This has been lauded as democratizing stock market trading because PFOF lowers the barrier to entry to zero. The market makers are also said to be making the financial markets more efficient by providing liquidity at a pace not seen in history.

The electronic market makers provide significant price improvements when compared to the National Best Bid and Offer (the metric that represents the best available bid and ask price in the market). Bradford Lynch, a PHD student at Wharton Business School, uses a randomized control trial in his paper *Price Improvement and Payment for Order Flow: Evidence from A Randomized Controlled Trial* and finds that PFOF can provide price improvements but that agency problems prevent these savings from being passed on to customers. This is consistent with the initial data coming from each brokerage firm's SEC Form 606. The market makers send rebates back to the firms, so the allocation of these rebates is at the firm's discretion. Some firms have been seen to pass 100% of the rebates back to customers as price improvement because their revenue comes from another source,

while the firms (such as RobinHood) that only have PFOF rebates as their revenue source will take most of the rebate.

PFOF can function because high frequency market makers (HFTs) generate alpha consistently for almost every trade they execute. In *Do high-frequency traders anticipate buying and selling pressure?*, Nicholas Hirschey from the Nova School of Business and Economics writes that HFTs can anticipate future order flow behavior. The HFTs have extensive historical trade data that few firms in the world have access to. When this rich data set is used to train models, it is very easy for HFTs to generate alpha off the expected move. The paper also highlights the fact that HFTs are not quite informed traders, but sophisticated traders that lean on their models and rich historical datasets to execute orders at such an efficient rate that they generate alpha from each transaction. This contrasts with the uninformed moniker many RobinHood traders fall under. It is not a fair race between the sophisticated market makers and the uninformed traders because the HFTs can effectively front run the trades their models are predicting.

Commission free trading has brought many more market participants into the fold, but these new retail investors and traders are uninformed. Gregory W. Eaton et al. finds that RobinHood traders behave as noise traders in their paper *Zero-Commission Individual Investors, High Frequency Traders, and Stock Market Quality*. Eaton et al. used alternative data in the form of times that RobinHood's website was reported as down on downdetector for a natural experiment. What Eaton et al. found was that when RobinHood was down, high frequency market makers more efficiently executed orders (narrower spreads) and there was less order imbalance. In liquidity markets, a narrower spread is ideal, because this means that the market is more efficient, and it is less risky to buy and sell a given security for the market maker. Market order imbalances arise when there are excessive buy or sell orders that makes it impossible to match buyers and sellers of a security, or in

the market makers case they run out of tradable securities. The market shifts when Robinhood traders were inactive, which suggests that the new traders are uninformed and cause the markets to be more inefficient.

The narrative of democratizing finance by fintech cloaks predatory practices that push users towards higher yield, for the fintech firm, asset classes. Gordon Kuo Siong Tan of the Singapore University of Technology and Design examines this in his paper *Democratizing finance with Robinhood: Financial infrastructure, interface design and platform capitalism.* Tan delves into the dark side of commission free trading and the effects of fintech brokerages like Robinhood pushing options as a viable asset class for its users. One particularly heartbreaking story that is mentioned is a Robinhood user taking their life after losing what they thought was close to $730,000 in options. Though later it was shown to be a UI error, the amount of leverage users are able to attain while supplying limited information for know your customer purposes is abhorrent. The gamification of trading by Robinhood has turned it into a form of gambling, and it is possible to now view this as a sort of online gambling website.

Ivo Welch of the Anderson School of Management argues that from mid-2018 to mid-2020 an aggregated portfolio of Robinhood user's holdings has both good timing and good alpha. Welch uses a, now deprecated, Robinhood API that provides holdings data for equities and ETFs traded on the platform. The model that uses this data found that the Robinhood users delivered positive alpha for the time period. Welch argues that the investors are not uninformed because their returns for the two-year time period displays that they are earning an abnormal positive rate of return. However, it is possible that this only holds for the time period because the market had a positive return. The definition of an informed trader from this paper may also contrast with the definition

used by the other literature but it is unlikely. Welch's experiment had an upper bound of mid-2020, so running the experiment across a longer period could provide insights into trader behavior.

What has not been examined yet, is the aggregate effect on society that PFOF brings. It has been shown that HFTs have been making money from trades, but traditional liquidity providers earn a profit from bid-ask spreads. The current available literature proves many facts about what PFOF causes, HFTs generating alpha on each trade, more market participants, and attempts to push retail trader behavior towards the options asset class. This paper seeks to lay out all available information to help readers understand the positives and negatives of the PFOF practice.

Data & Methods

The data surrounding Payment for Order Flow (PFOF) is very sparse, for market making and algorithmic trading are both highly proprietary areas. In recent years, in response to PFOF-linked market volatility, the SEC has required brokerage firms to release a quarterly report called a Rule 606. Required under SEC Rule 606, these disclosures containing aggregated order totals became required. While all broker-dealers are required to post these disclosures, it is worth pointing out that they are not easy to find on their websites. Besides rule 606 filings, another data source that comes from the SEC is the MIDAS data set. The MIDAS data set has market data for every traded ETF and equity in the United States. The most useful metrics to this analysis are the market efficiency measures present in the data set. The specific one we are using is the Cancel-to-trade ratio, which is cancels over lit trades. We also pull-out volume from MIDAS but the volume is not in terms of dollars, but trade messages.

Rule 606 Filings

Rule 606 data contains multiple columns about payment received from selling order flow, percentage of order types sold to market makers, and the market making venues that the orders are

routed to. As seen in Figure 1, this data does make the PFOF market more transparent from the broker-dealer side. Anyone can see the magnitude of market maker order flow revenue and aggregate it.

Robinhood Securities, LLC - Held NMS Stocks and Options Order Routing Public Report

Generated on Thu Jul 28 2022 14:38:08 GMT-0400 (Eastern Daylight Time)

2nd Quarter, 2022

April 2022

S&P 500 Stocks

Summary

Non-Directed Orders as % of All Orders	Market Orders as % of Non-Directed Orders	Marketable Limit Orders as % of Non-Directed Orders	Non-Marketable Limit Orders as % of Non-Directed Orders	Other Orders as % of Non-Directed Orders
100.00	29.73	18.81	8.57	42.89

Venues

Venue - Non-directed Order Flow	Non-Directed Orders (%)	Market Orders (%)	Marketable Limit Orders (%)	Non-Marketable Limit Orders (%)	Other Orders (%)	Net Payment Paid/Received for Market Orders(USD)	Net Payment Paid/ Received for Market Orders(cents per hundred shares)	Net Payment Paid/ Received for Marketable Limit Orders(USD)	Net Payment Paid/ Received for Marketable Limit Orders(cents per hundred shares)	Net Payment Paid/ Received for Non-Marketable Limit Orders(USD)	Net Payment Paid/ Received for Non-Marketable Limit Orders(cents per hundred shares)	Net Payment Paid/Received for Other Orders(USD)	Net Payment Paid/ Received for Other Orders(cents per hundred shares)
CITADEL SECURITIES LLC	53.20	39.00	39.14	40.30	71.80	157,017.03	37.9890	89,486.96	41.8638	15,322.02	35.6547	319,498.44	105.0488
Virtu Americas, LLC	17.57	11.64	10.63	11.07	26.02	65,174.17	74.3966	33,011.19	74.0281	7,274.54	71.8066	188,491.57	238.3128
G1X Execution Services, LLC	12.25	20.76	22.34	20.70	0.23	153,426.16	126.8537	82,732.83	133.2005	16,712.51	130.1491	4,100.93	123.5056
Jane Street Capital	9.60	16.65	16.76	16.47	0.19	179,871.64	128.1711	87,827.45	125.6024	18,168.33	121.8827	3,366.79	89.9425
Two Sigma Securities, LLC	6.86	10.96	10.33	10.54	1.76	55,474.57	102.0300	27,908.33	100.4537	4,969.11	83.8433	5,652.62	184.0747

Figure 1: Robinhood Q2 2022 Form 606

To investigate the size of the PFOF industry, the year-to-date Rule 606 filings have been aggregated from the largest 7 firms in the market (who are around 99.6% of the industry from daytradingz). Figure 2 displays this aggregation by asset class. The asset class with the largest volume is options, which also coincidentally (or not) has the highest average payment for exposure to 100 shares. Options are most often used as insurance by asset managers to soften large swings in their portfolio. The estimated figure is that around 80% of options are not exercised. It seems like now options have started to be framed as viable asset classes by the brokerages. This behavior of herding new investors to options could be a result of the large margins that brokerage firms make on selling option order flow.

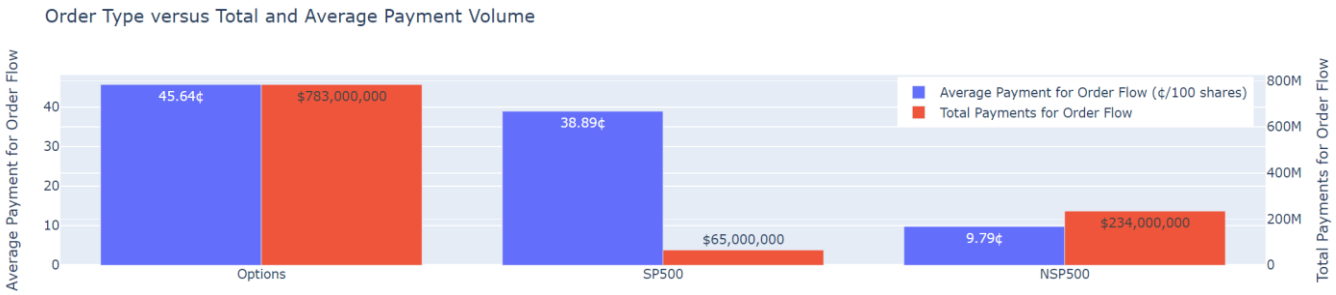

Figure 2: YTD PFOF Revenue by Asset Class

Brokerage Advertising

TD Ameritrade has recently been spending more and more on advertising to push their users to options trading. Figure 3 displays TDA's ad spending in recent years. The purchase of TDA by Charles Schwab complicates the data but the trend can still be seen in the approximately 20% increase in 2017. The content of TDA's advertisements mainly focuses on options trading. One of TDA's video adverts boasts of options specialists and personalized education tools that help the client to place their first options trades (Ad link). Most of the advertisements promote options and the company has been spending hundreds of millions of dollars trying to reach consumers with this message. A quote that is present in TDA's 5 most recent Form 10-Ks is: "We believe that we have a superior brand identity and that our advertising has established TD Ameritrade as a leading brand in the retail brokerage market" (TD Ameritrade Holding Corporation 2015-11-20 Form 10-K). TDA leverages advertising to grow their retail brokerage footprint and to promote the highest margin product they offer.

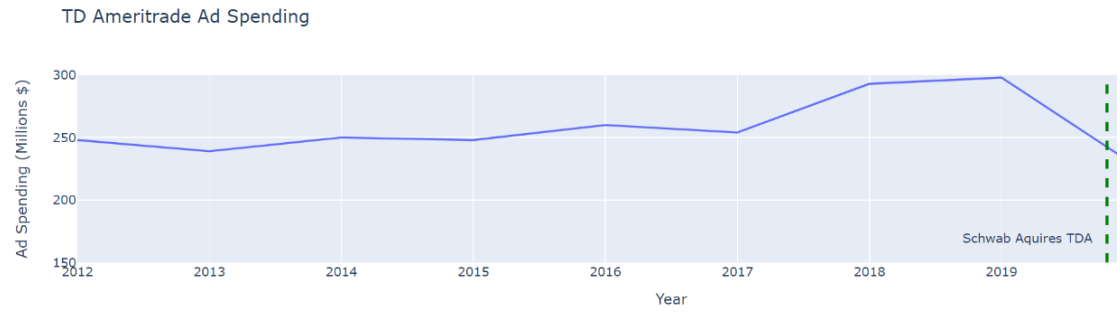

Figure 3: TDA Ad Spending

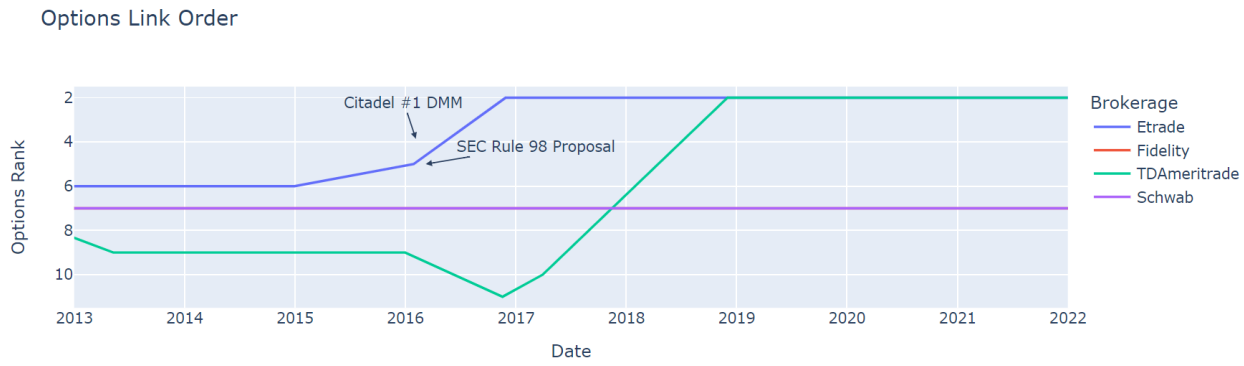

Figure 4: Options Link Ordering on Brokerage Websites

Using wayback machine to analyze link ordering of different asset classes provides support for the idea that brokerages shifted their priority to options when it became a relatively more lucrative order flow to sell. Figure four depicts the link ordering of some of the largest brokerage firms. Fidelity and Charles Schwab both kept their website link orderings constant while ETrade and TDAmeritrade had large changes in the ordering. Etrade saw a gradual increase in order of options on their website while TDAmeritrade decreased options in the order before a huge climb in 2018 and 2019.

Market Maker Acquisitions

In the PFOF space, Citadel securities is the largest name, they execute the largest amount of order flow and almost every brokerage routes orders through them. It is worth examining how Citadel rose to the number one spot. On February 5th, 2016, Citadel became the largest Designate Market Maker (DMM) on the New York Stock Exchange when it acquired KCG Holdings' DMM business. Citadel already had a strong market making business, but by acquiring KCG's DMM business they became the largest DMM on the NYSE. Figure 4 displays the approximate date that this acquisition took place and the link orderings for the options asset class of Etrade, Fidelity,

TDAmeritrade, and Charles Schwab. SEC Rule 98 that is referenced in Figure 4 is a law that, at the time, allowed for market making and proprietary trading to be housed under the same roof. This would make it easier for quant trading firms to trade based on their alpha research and market make with the same technology. Etrade's options link ordering also declines around this time, which means that when visiting the Etrade website in 2016, one would notice that options is higher on the list of assets available to invest in on the investing tab. This could be in response to Citadel expanding their reach and becoming the largest DMM, but only the correlation can be mentioned not causation. All three of these events, Citadel becoming the #1 DMM on the NYSE, SEC Rule 98, and Etrade prioritizing options more cannot be said to cause each other, but all three happening at the same time seems to be more than a coincidence.

Options Trading Increase

The recent irregular increase in options trading can partially be explained by broker-dealers allowing retail investors to gain access to leveraged products with limited know-your-customer protocols. Figure 5 displays the trend in options trading on the CBOE exchange. The trend is a steep positive line that displays increased consumer demand for options. There could be many contributing factors to this such as the rise of online discussion forums focused on risky trades, but the root of this increase is the access to these products on commission-free online brokerages. The online brokerages are the only venue that can be used to place these trades. There may be some confusion because options are "commission-free" because a fixed fee of around $10 is not charged to the user, but the fixed *per contract* fee is still charged of around 50 cents. These 50 cents make it even harder for the user to break even on an options contract. What is peculiar is how the behavior of the brokerage firms that receive PFOF has fundamentally changed the financial markets and made options trading popular.

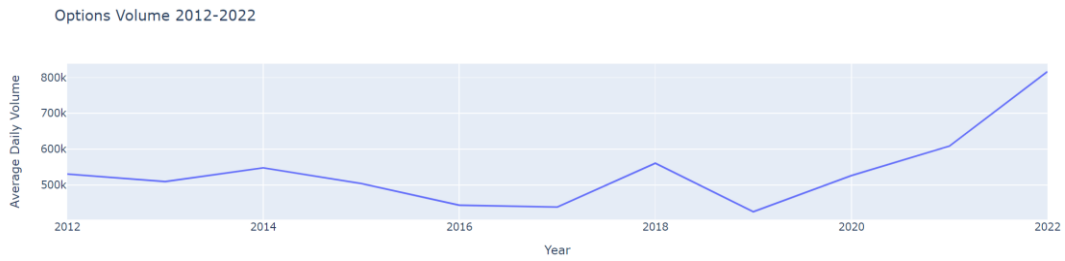

Figure 5: Options Volume on the CBOE Exchange

The increase in options volume could have two sources, the start of the coronavirus pandemic and the Gamestop incident. Google trends data highlights that the options craze has two local maximums, around March 2020 and January 2021. These two peaks of options search activity also coincide with two events that could motivate consumers to start investing in options: the CARES act and the Gamestop craze. On March 27, 2020, President Trump signed the CARES act which provided $2.2 Trillion of aid to Americans. Included in this $2.2 Trillion was payments of $1200 to each American adult. Suddenly, many Americans found they were stuck inside but with $1200 in cash on hand. It is not a leap to assume that many saw this money as something to occupy their boredom and googled something similar to "options trading" or "how to trade stocks". It is easy to see that the first spike in search activity for both options trading and how to trade stocks is right around the CARES act. This event could be the catalyst that put commission free stock trading on everyone's radars, and once they knew about it many were probably hooked. This would explain the elevated level of search activity for options trading that persisted. However, the GME fiasco really brought commission-free trading and options trading into the public eye. When retail traders coordinated a short squeeze that caused multiple hedge funds to lose billions of dollars, the media coverage of PFOF and retail traders was extensive. The brokerages would have been happy to cash in on this huge increase in volume from the Robinhood traders. PFOF has shown that liquidity can

be provided fast enough for events like GME to happen, but market efficiency also must be examined.

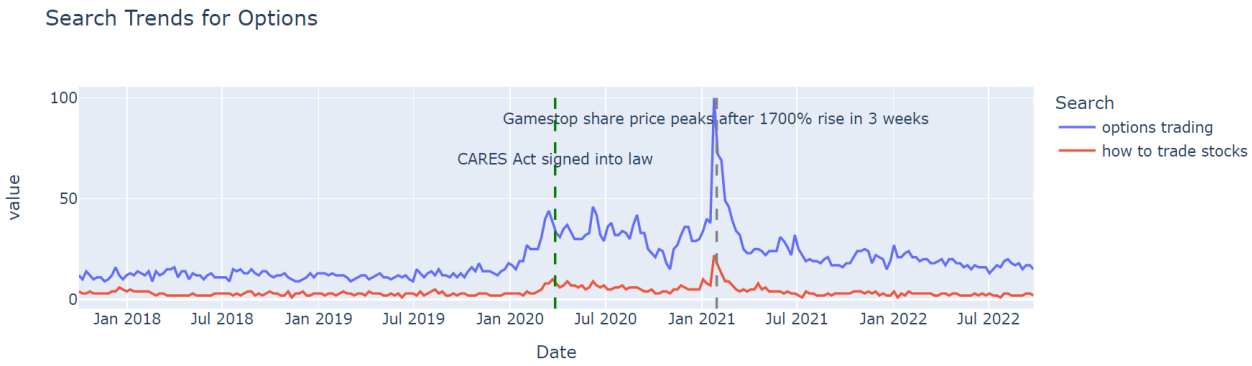

Figure 6: Google Trends Data

Stress Testing PFOF

To further examine the circumstances of the Gamestop case, we will examine options average daily volume and MIDAS data from the New York Stock Exchange (NYSE). CBOE has a historical data tab that allows one to download historical options data from their umbrella of exchanges (CBOE, BATS, C2, EDGX). The movement in GME's share price is an irregularity in the history of the market, so it is important to identify comparable listed equities that can control for the activity. Gamestop is in the retail industry, so one comparable that comes to mind is Walmart (WMT). The SPY ETF was also tested as a comparable to see if there was a difference between the whole market's activity and GME's.

Figure 7: Options Average Daily Volume

The average daily options volume on the CBOE exchange is displayed in Figure 7 for the SPY ETF, Gamestop, and Walmart. The volume of the SPY ETF is magnitudes higher than WMT and GME even during a time of volatility for the GME equity listed on the stock market. To create a more meaningful visualization, the log of each observation was taken, and the visualization of that change is visible in Figure 8. In Figure 8, the SPY is still at an elevated level, but GME and WMT are at more observable levels. An ETF being compared to a listed equity may not be compatible, so GME being compared to Walmart may be more correct.

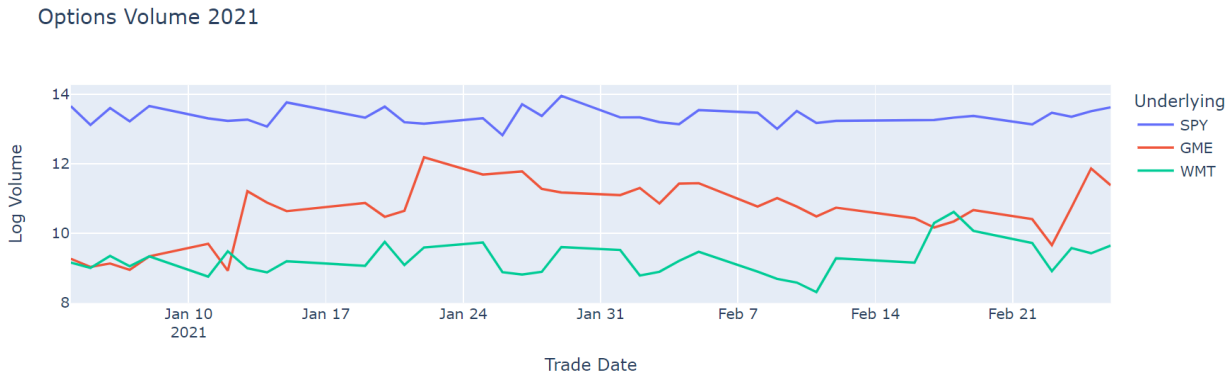

Figure 8: Log Average Options Daily Volume

PFOF has shown to increase market efficiency in times of market turbulence. A benefit of payment for order flow is increased market efficiency from not having to match orders in the CLOB every execution. The MIDAS dataset that the SEC provides monthly contains aggregated trade data for every equity that trades on a US exchange. Two columns of interest are *Cancels* and *LitTrades*. Cancels is defined as the count of all cancel messages, either full or partial, for all exchanges. LitTrades is the count of all trade messages for trades that are not against hidden orders and computed as the difference between Trades and Hidden. The SEC's README file defines the

Cancel-to-Trade ratio as Cancels/LitTrades. This Cancel-to-Trade ratio can be used as an approximation for market efficiency that is available daily. Market efficiency can be hard to measure, and granular measures are even harder to identify. The rationale for using Cancel-to-Trade ratio to measure market efficiency is that trade cancels make markets more inefficient because these orders are not completed. Cancel-to-Trade ratio was computed for the months of January and February 2021, the height of the Gamestop craze. The ratio was compared between GME, WMT, and SPY to find suitable comparables, but SPY was dropped because the ratio was still multiples above GME and WMT. Figure 9 displays the ratios and GME and WMT for this time period. The graph displays a surprising finding, the sharp increase in volatility in GME does not seem to cause a jump in market inefficiency in executing GME orders. This relationship is worth investigating further to find the reason.

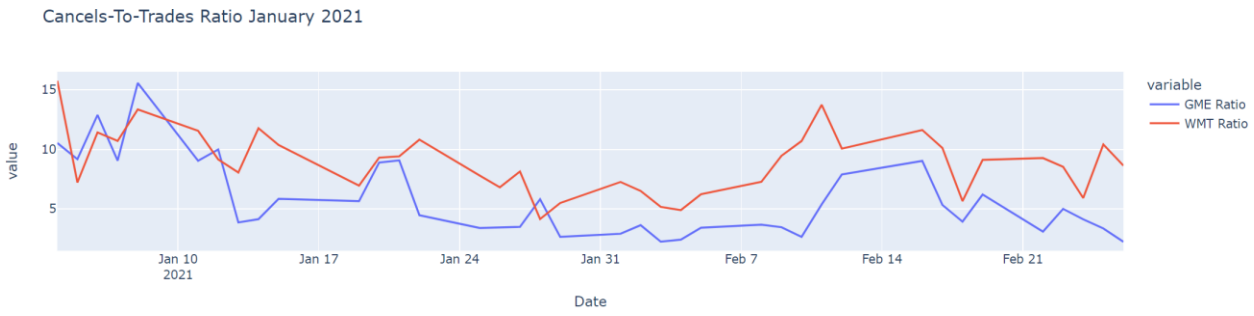

Figure 9: Cancels-To-Trades Ratio

In Ivo Welch's *The Wisdom of the Robinhood Crowd*, Welch used Robintrack to investigate if RH users were able to generate alpha with their trading and found that they generated abnormal positive rates of return compared to a benchmark. The website, Robintrack, is no longer available because Robinhood discontinued their API but Robinhood offers their customers the ability to invest in an index that tracks the most owned stocks on Robinhood. Figure 10 displays the performance of the index versus the Nasdaq. The results seem positive, so continuing Welch's investigation but using this index could provide insights into how informed RH investors are.

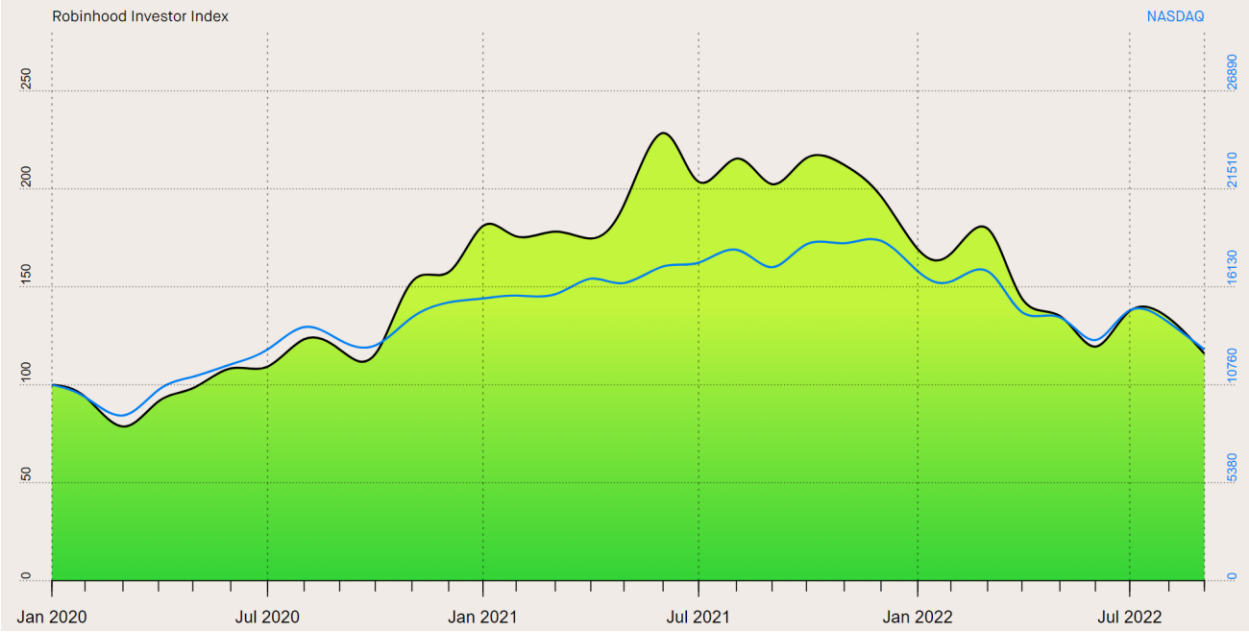

Figure 10: Robinhood Index versus Nasdaq

Market Trends and Rule 98

The introduction of payment for order flow was hastened by government rule changes. Rule 98 is a New York Stock Exchange (NYSE) rule that exists to create information barriers between a firm's market making unit and other functions. In the 2010s, this rule was updated twice that relaxed these barriers and, in the eyes of most, let firms use the same trading algorithms for proprietary purposes and designated market making (DMM) activity. After the rule changes, there was a flurry of market making units being purchased by proprietary quantitative trading firms. Figure 11 displays some of these acquisitions. The orange lines in order of least recent to most recent are IMC buying Goldman's DMM unit in 2014, GTS buying Barclays DMM in 2016, and Citadel buying KCG holdings DMM unit also in 2016. The multiple acquisitions of market making units consolidated market making within a few firms. The firms specialized even more which led to trading on the stock market becoming effectively free for the consumer. Robinhood had served as a proof of concept that this method of trading was viable and would catch on with consumers. The grey lines

are when proposed changes to Rule 98 were filed by the NYSE with the Securities and Exchange Commission (SEC).

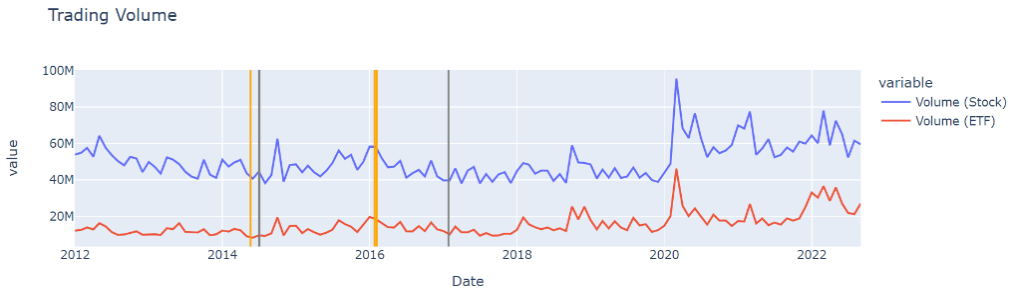

Figure 11: Trading Volume and Market Events

VARIABLES	(1) Cancels-to-Trades (ETF)	(2) Volume (ETF)	(3) Cancels-to-Trades (Stock)	(4) Volume (Stock)	(5) Monthly Avg Daily Volume (Options)
Pre-2014 Trend	9.667	220,065***	0.150	205,541	32,848**
	(7.788)	(73,898)	(0.371)	(154,380)	(12,854)
2014-2017 Trend	-1.901	-94,986*	-0.585**	-135,865	-23,889**
	(4.851)	(48,676)	(0.253)	(102,245)	(9,735)
Post-2017 Trend	1.786	-10,614	0.155*	32,115	7,641***
	(2.239)	(18,997)	(0.0827)	(41,455)	(2,914)
Constant	790.7***	7.730e+06***	80.42***	4.405e+07***	3.806e+06***
	(149.5)	(1.357e+06)	(6.455)	(2.876e+06)	(194,259)
Observations	129	129	129	129	130
R-squared	0.425	0.391	0.383	0.150	0.508

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The table has the monthly coefficient values from the regression. To interpret them, they are the monthly increases during that time period for the variable. For example, in the pre-2014 period, the Cancels-to-Trades (Stock) ratio increased by .150 every month. This increase is compared to the regression constant, which in this case is 80.42.

$$Cancels - Trades(Stocks) = \beta_1 Date1 - \beta_2 Date2 + \beta_3 Date3 + \beta_0$$

The advent of payment for order flow did not statistically significantly increase stock trading volume. To test if either of the two amendments were associated with stock trading volume, three different date columns were created. The first date column Pre-2014 Trend numbers all dates in the dataset from 1 to 129. 2014-2017 Trend uses the number from Pre-2014 Trend but every entry before March 18, 2014 (the date the NYSE proposed the rule change to the SEC) is a zero. This was done to try and measure the effect of the announcement of the change. A similar method was used to check the second amendment on January 26, 2017. All dates before January 26, 2017, are zero and all after kept their Pre-2014 Trend number. In the regression of stock volume, Pre-2014 Trend, 2014-2017 Trend, and Post-2017 Trend, none of the dates are statistically significant. This tells us that stock volume did not change a statistically significant amount over the investigation period. Also, none of the amendments to Rule 98 saw a change in stock volume. This makes economic sense, because when comparing the regression coefficients to the constant, the constant dwarfs all of them. Forty four million (44,000,000) is such a large number that it makes sense none of the coefficients were statistically significant.

Trend	ETF Cancels-Trades	ETF Volume	Stock Cancels-Trades	Stock Volume	Options Sum of ADV
Pre-2014 Trend Coefficient	9.667305	220065.3***	0.1498402	205541.4	32848.46**
Pre-2014-2017 Trend Coefficient	7.766266	125079.01°	-0.4355987°°	69676.6	8959.86°°
Pre-2014-Post-2017 Trend Coefficient	9.552493	114464.54	-0.280952^	101791.51	16601.223^^^

*** p<0.01, ** p<0.05, * p<0.1

Relative to zero (*) Relative to Trend Before March 18, 2014(°) Relative to Trend Before January 26, 2017(^)

There was a statistically significant change in stock market efficiency as a result of the first proposed amendment to Rule 98. An advertised benefit of payment for order flow was that market efficiency would increase. To prove that such a change occurred, a linear regression was fit on the equity cancel-to-trade ratio. Just like in part 1, we run a multi-regression with three date columns, one with no partitions, one with a partition before the first amendment (2014), and one with a partition after the second amendment (2017). We find that there is a statistically significant difference between the cancels to trades ratio before and after the first amendment (2014) to Rule 98 at the .05 significance level ($0.05 > 0.022$) and a statistically significant difference before and after the second amendment.

The economic significance of these coefficients becomes apparent when the number of observations in the period is multiplied by the coefficient. There are 27 months until the first amendment to Rule 98. This leads to an increase in the cancels-to-trades ratio for the stock market of 4.0 and when compared to the constant factor from the regression of 80.42, that's only a change of around 5% for the Pre-2014 period. During the 34 months between the first and second amendment to Rule 98, the cancels-to-trades ratio for the stock market decreased by, on average, -.585 every month. This is a more substantial difference than the Pre-2014 trend, for the -19.89 change in the cancels-to-trades ratio is around 25% of the constant. Hence, why it is statistically significant. The coefficient for the post-2017 period is .155, so if we multiply the 68 months by that we get 10.54. Summing all of the coefficients multiplied the number of months in each period yields a net negative number for the change in cancels-to-trades over the period (-5.35). As PFOF has been institutionalized, the stock market efficiency increased.

There was not a statistically significant change in cancels-to-trades for ETFs in the time period of study. All of the p values were greater than .05 and even larger than .1 if we increased our

significance level. This does not seem too surprising; the ETF market's size is a fraction of the stock market's and there should be more fluctuation in the price of stocks than equities. If more money can be made market making for the stock market, then more time and attention of the DMMs would go there over ETFs.

Even though the efficiency of the ETF market did not increase, the volume of the ETF market did change over the investigated time period. The results for the Pre-2014 trend regression are significant at the .05 significance level and the results of the 2014-2017 trend regression are significant at the .1 level. Taking into account the statistical significance of the 2014-2017 regression, 2014 was around the time that Robinhood was growing in popularity. Without Robinhood, it is likely that long term investors would make less moves in the market. But with Robinhood charging zero commission fees and other brokerages following suit soon after, they now had the flexibility to trade as much as they wanted and not have to pay $5 each time.

Every trend variable is statistically significant when regressed against the sum of monthly options average daily volume. Options average daily volume changes over the entire period, before and after the first amendment to Rule 98, and before and after the second amendment to Rule 98. At the same time as PFOF was catching on as a viable way for stock brokerages to make money, the options market experienced shifts. Over the entire investigation range, the monthly sum of average daily volume for the market increased before the 2014 amendment to rule 98, decreased between the 2014 and 2017 amendments and then jumped after the 2017 amendment. This is in-line with our thinking that market makers were experimenting and both DMMs and brokerages were getting used to the change in market micro-structure.

These findings are all in-line with what we believe to have happened in market micro-structure in recent years. It is likely that after the first amendment to Rule 98 in 2014, many firms

started to experiment with market making. Some firms made large moves (IMC buying Goldman's DMM unit) but no other notable events happened until almost simultaneously Citadel bought KCG Holding's DMM unit and GTS bought Barclay's DMM unit. The stock market efficiency graph, Figure 12, (using the Cancels-to-trades ratio as a proxy for efficiency) displays that for the two years between the IMC acquisition and the later two, the market efficiency for ETFs and Stocks fluctuated until Citadel and GTS expanded their scale.

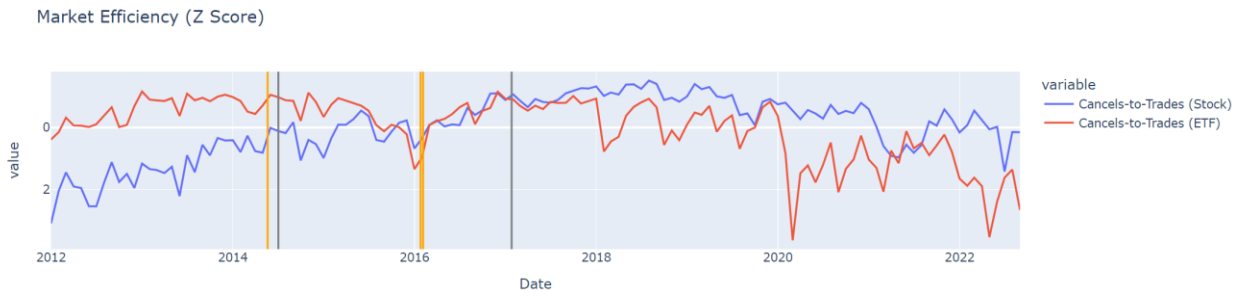

Figure 12: Market Efficiency Normalized

The statistically significant difference in the efficiency of the stock market from before and after the second amendment to Rule 98 indicates that something happened in that time period that caused the markets to behave differently than before. What is highly likely is that algorithmic traders tried their hand at generating alpha in the order execution market and once their models were trained on enough historical data and the hyperparameters were all tuned, these strategies were deployed at scale with help from large acquisitions.

Conclusion

PFOF has changed the structure of the United States' financial markets. It has made investing in the stock market easier for all investors and increased efficiency. These benefits were the result of the SEC relaxing strict restrictions that existed on DMMs before Rule 98 was amended. I have identified key manifestations from the shift in market structure, the date when Rule 98

changed, and the change in market volume and efficiency. These manifestations have not always been positive. Increased options volume in isolation is not a bad thing, but it is an indicator of increased speculation in the market from retail investors. The worry is that these traders are uninformed and by engaging in risky trades, they will lose their savings. These changes in market microstructure have been shown to be present in all three markets of stock, bonds, and ETFs. ETF volume, options volume, and stock market efficiency changed as a result of PFOF.

Bibliography

Adams, Samuel, Connor Kasten, and Eric K. Kelley. "Do Investors Save When Market Makers Pay? Retail Execution Costs Under Payment for Order Flow Models." *Retail Execution Costs Under Payment for Order Flow Models (December 1, 2021)* (2021).

Battalio, Robert, Robert Jennings, Jamie Selway, and L. L. C. Archipelago. "Payment for order flow, trading costs, and dealer revenue for market orders at knight securities." *P* (1998).

Battalio, Robert, and Craig W. Holden. "A simple model of payment for order flow, internalization, and total trading cost." *Journal of Financial Markets* 4, no. 1 (2001): 33-71.

Battalio, Robert H., and Tim Loughran. "Does payment for order flow to your broker help or hurt you?." *Journal of Business Ethics* 80, no. 1 (2008): 37-44.

Biais, Bruno, Thierry Foucault, and Sophie Moinas. "Equilibrium fast trading." *Journal of Financial economics* 116, no. 2 (2015): 292-313.

Chakrabarty, Bidisha, Terrence Hendershott, Samarpan Nawn, and Roberto Pascual. "Order exposure in high frequency markets." *Available at SSRN 3074049* (2022).

Chang, Briana, and Shengxing Zhang. "Endogenous market making and network formation." *Available at SSRN 2600242* (2021).

Chordia, Tarun, and Avanidhar Subrahmanyam. "Market making, the tick size, and payment-for-order flow: theory and evidence." *Journal of Business* (1995): 543-575.

Chung, Kee H., and Chairat Chuwonganant. "Regulation NMS and market quality." *Financial Management* 41, no. 2 (2012): 285-317.

Eaton, Gregory W., T. Clifton Green, Brian Roseman, and Yanbin Wu. "Zero-commission individual investors, high frequency traders, and stock market quality." *High Frequency Traders, and Stock Market Quality (January 2021)* (2021).

Ernst, Thomas, and Chester S. Spatt. *Payment for Order Flow and Asset Choice*. No. w29883. National Bureau of Economic Research, 2022.

Euch, Omar El, Thibaut Mastrolia, Mathieu Rosenbaum, and Nizar Touzi. "Optimal make–take fees for market making regulation." *Mathematical Finance* 31, no. 1 (2021): 109-148.

Ferrell, Allen. "A Proposal for Solving the Payment for Order Flow Problem." *S. Cal. L. Rev.* 74 (2000): 1027.

Ferreruela, Sandra, and Daniel Martín. "Market Quality and Short-Selling Ban during the COVID-19 Pandemic: A High-Frequency Data Approach." *Journal of Risk and Financial Management* 15, no. 7 (2022): 308.

Foley, Sean, and Tālis J. Putniņš. "Should we be afraid of the dark? Dark trading and market quality." *Journal of Financial Economics* 122, no. 3 (2016): 456-481.

Harris, Frederick H. deB, Thomas H. McInish, Frank J. Sensenbrenner, and Robert A. Wood. "Fragmentation and Price Discovery: A Comparison of Reg NMS and MiFID1." *The Journal of Trading* 9, no. 4 (2014): 6-36.

He, Xuezhong, Junqing Kang, and Xuan Zhou. "The fast and the furious: exchange latency and ever-fast trading." *Available at SSRN 3681157* (2022).

Hirschey, Nicholas. "Do high-frequency traders anticipate buying and selling pressure?." *Management Science* 67, no. 6 (2021): 3321-3345.

Hossain, Shahadat. "High-Frequency Trading (HFT) and Market Quality Research: An Evaluation of the Alternative HFT Proxies." *Journal of Risk and Financial Management* 15, no. 2 (2022): 54.

Jones, Charles M. "What do we know about high-frequency trading?." *Columbia Business School Research Paper* 13-11 (2013).

Kugele, Lynn Phillips, and Robert A. Wood. "Trade shredding: SRO-sponsored payment for order flow." *The Journal of Trading* 2, no. 1 (2006): 9-29.

Lynch, Bradford. "Price Improvement and Payment for Order Flow: Evidence from A Randomized Controlled Trial." *Available at SSRN 4189658* (2022).

Meyer, Steffen, Charline Uhr, and Lutz Johanning. "Private investors and the emergence of neo-brokers: Does payment for order flow harm private investors?." (2021).

Parlour, Christine A., and Uday Rajan. "Payment for order flow." *Journal of Financial Economics* 68, no. 3 (2003): 379-411.

Petrella, Giovanni. "MiFID, Reg NMS and competition across trading venues in Europe and the USA." *Journal of Financial Regulation and Compliance* 18, no. 3 (2010): 257-271.

Poutré, Cédric, Georges Dionne, and Gabriel Yergeau. "International High-Frequency Arbitrage for Cross-Listed Stocks." *Available at SSRN 3890433* (2022).

Roşu, Ioanid. "Fast and slow informed trading." *Journal of Financial Markets* 43 (2019): 1-30.

Son, Matthew. "High-Frequency Trading in the Options Market and Order Flow Toxicity." *Available at SSRN 4199462* (2022).

Welch, Ivo. "The wisdom of the Robinhood crowd." *The Journal of Finance* 77, no. 3 (2022): 1489-1527.

Zaharudin, Khairul Zharif, Martin R. Young, and Wei-Huei Hsu. "High-frequency trading: Definition, implications, and controversies." *Journal of Economic Surveys* 36, no. 1 (2022): 75-107.