Zero-Commission Individual Investors, High Frequency Traders, and Stock Market Quality

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Microstructure Exchange



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Motivation

- Retail trading has exploded
 - Recent estimates: 20% or more of US stock volume
- Important innovation: zero-commission trades
- Robinhood
 - No account minimums
 - User-friendly interface
 - 13 million or more Robinhood users
 - 12.7 million Schwab accounts; 5.5 million at E*Trade
 - Some estimates: Robinhood comprises a third of trading from major US retail brokers
- This paper: effects of zero-commission (Robinhood) traders on financial markets
 - Are they noise traders?
 - How do they impact market quality?

First: Are Robinhood investors noise traders?

- We first study whether Robinhood users are noise traders
- Descriptive statistics suggest they're:
 - Young and inexperienced
 - 78% under 35; half are first-time users
 - Unsophisticated
 - Most common FAQ: "What is the stock market?"
- We find: Robinhood ownership changes are unrelated to future returns
 - Consistent with noise trading
 - Contrasts to recent evidence that retail investors in general are informed (e.g., Boehmer et al. 2020)

Overview

What are effects of Robinhood trading on market quality?

- Theory mixed on noise trading's effect on liquidity
 - Reduced adverse selection (Glosten and Milgrom 1985) vs.
 - Increased volatility and inventory risk (Grossman and Miller 1988)
- Identification is challenging: retail trading activity is endogenous
 - Use Robinhood platform outages as exogenous shocks
- Diff-in-diffs type approach
 - Cross-section: High Robinhood interest stocks versus the rest
 - Time: Compare outage period to pre-outage period
- During outages, stocks favored by Robinhood traders have:
 - Lower trading activity
 - Improved liquidity
 - Reduced volatility
- Results robust

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What explains negative relation between Robinhood trading and market quality?

- Retail trading mediated by HFTs who pay for order flow
 - HFT's wholesale unit manages retail trades
 - Wholesale unit's inventory risk can impact overall firm risk
 - As response, HFT's market making unit may alter risk exposure
 - Robinhood-affiliated HFTs are leading market makers
- During outages: Robinhood-affiliated HFTs post improved spreads on lit markets (no change for other dealers)
- Inventory risk is key driver:
 - Uninformed trading pressure (inventory risk) can cause quote imbalances
 - Reduced depth imbalance during outages for Robinhood-affiliated market makers
 - Market quality effects strongest for stocks with high inventory risk
 - Inventory risk proxy: Autocorrelation of Robinhood order flow

Related literature on zero-commission investors

- Barber et al. (2020) document herding by Robinhood investors
 - Extreme herding associated with large price movements and reversals
- Welch (2020) studies aggregate Robinhood portfolios
 - Robinhood users bought after downturn in March, but also after later upswings
- Glossner et al. (2020) and Ozik et al. (2020): zero-commission investors provide liquidity during pandemic
 - Our findings robust to excluding March 2020
 - Ozik et al. results weaken if focus on high-attention stocks, actively traded by Robinhood
 - We focus on such stocks

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Measuring retail trading

- Robinhood (used to) publish the number of users holding a stock
 - Scrape these data from Robinhood website (Robintrack)
 - Discontinued in August 2020
 - Robinhood trading proxy: weekly change in ownership for each stock
- Also construct aggregate retail trading measure
 - Using algorithm from Boehmer, Jones, Zhang, and Zhang (2020)
 - Captures retail trading from all brokers

Fama-Macbeth regressions of returns on retail trading plus controls

	Retu	Return [1,3] Return [1		rn [1,5]] Return [
Robinhood Change	-0.042	-0.015	-0.07	-0.009	-0.075	0.253	
-	(-0.47)	(-0.19)	(-0.60)	(-0.08)	(-0.28)	(0.91)	
Aggregate Retail OIB		0.405***		0.374***		1.047*	
		(3.80)		(2.70)		(1.75)	
Ret[0]		-0.047**		-0.070**		-0.052	
		(-1.98)		(-1.98)		(-0.96)	
Ret[-1]		-0.027		-0.056**		-0.029	
		(-1.40)		(-2.10)	(-0.60)		
Ret[-5,-1]		-0.031*		-0.027		-0.043	
		(-1.71)		(-1.09)		(-1.00)	
Market Cap[t-1]		-0.108*		-0.171*		-0.683*	
		(-1.92)		(-1.96)	(-1.96)		
Book-to-Market		-0.203**		-0.288*		-0.731	
		(-1.98)	(-1.68)			(-1.17)	
Skewness		-0.021		0.004		-0.019	
		(-0.60)		(0.08)		(-0.17)	
Observations	299,974	243,879	299,789	243,724	298,442	242,644	
Average R ² (%)	0.39	7.13	0.36	7.51	0.29	6.27	

Panel A: Weekly Change in Robinhood Ownership

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Analysis of Robinhood's effects on financial markets

- Identification: Robinhood outages
 - Downdetector: tracks outage complaints every 15 minutes
 - We require at least 200 complaints
 - 25 unique outages; 30 minute median length
 - Sample period: Jan. to Aug. 2020 (few outages prior to 2020)



Stocks with high Robinhood interest

- Which stocks would Robinhood users trade if no outage?
- Alternative measures (week preceding outage)
 - WallStreetBets: Number of unique posters mentioning stock
 - Absolute change in Robinhood users
 - Absolute percentage change in Robinhood users
- Top quintile of each measure
- Presentation: mainly report WallStreetBets results

WSB mentions lead RH activity (follow aggregate retail volume)





Days Surrounding High WSB Mentions

Zero-Commission Trading

Estimating Robinhood's effects on financial markets

 $y_{i,t} = \alpha + \beta_1 RH_{i,d-1} + \beta_2 Outage_t + \beta_3 RH_{i,d-1} \times Outage_t + \gamma_i + \delta_d + \epsilon_{i,t}$

- Diff-in-diffs type approach
- Indicators for outages and high Robinhood (RH) stocks
- Outage windows and the same time of day over previous five days
 - Five-minute intervals
- Consider alternative y-variables:
 - Volume and trading intensity
 - Liquidity measures
 - Return volatility
- Include firm and day fixed effects
- Contrast with pseudo events one hour after outage ends

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Trading activity falls during outages for high Robinhood stocks

	Robin	hood Event Oi	Pseudo Outages			
	Trading Volume	Trading Intensity	Agg. Retail Volume	Trading Volume	Trading Intensity	Agg. Retail Volume
$RH_{i,d-1} \times Outage_t$	-0.084**	-0.062*	-0.024	0.010	0.024	0.078
	(-2.260)	(-1.944)	(-0.332)	(0.372)	(0.895)	(1.610)
RH _{i,d-1}	0.335***	0.221***	0.503***	0.371***	0.334***	0.521***
	(8.067)	(6.951)	(9.544)	(8.765)	(7.814)	(10.327)
Outage _t	0.158	0.047	0.188	-0.041	-0.036	-0.028
	(1.301)	(0.342)	(1.432)	(-0.485)	(-0.439)	(-0.467)
Fixed Effects	Firm, Day	Firm, Day	Firm, Day	Firm, Day	Firm, Day	Firm, Day
Observations	2,277,649	2,277,649	2,277,649	1,823,321	1,823,321	1,823,321
Firm Clusters	2,015	2,015	2,015	2,001	2,001	2,001
Δ R-squared (%)	0.6423	0.2613	0.4908	0.8600	0.2242	0.6015

Panel A: WallStreetBets Mentions as the Proxy for Expected Robinhood Trading

Liquidity improves during outages for high Robinhood stocks

	Robinhood Outages					Pseudo	Outages	
	Quoted Spread	Effective Spread	Realized Spread	Price Impact	Quoted Spread	Effective Spread	Realized Spread	Price Impact
Panel A: WallStreetE	Bets Activity as th	e Proxy for Exp	ected Robinhood	Trading				
$RH_{i,d-1} \times Outage_{t}$	-2.927**	-6.11*	-4.744*	-5.069**	-0.726	0.558	2.306	-2.524
	(-2.075)	(-1.862)	(-1.752)	(-2.04)	(-0.644)	(0.171)	(1.076)	(-1.211)
RH _{i,d-1}	-1.965***	-9.225	-12.297**	-2.156	-1.645***	-5.067	-4.837	-1.688
	(-2.906)	(-1.359)	(-2.03)	(-0.611)	(-2.824)	(-0.851)	(-1.371)	(-0.518)
Outage _t	4.546	6.601	0.331	4.211	0.704	-0.566	-0.778	0.758
	(0.864)	(0.934)	(0.072)	(1.083)	(0.984)	(-0.415)	(-0.509)	(0.852)
Firm Clusters	2,015	2,015	2,015	2,015	2,001	2,001	2,001	2,001
∆ R-Squared (%)	0.109	0.0077	0.0104	0.0023	0.0524	0.0018	0.0016	0.0009

Volatility drops during outages for high Robinhood stocks

	Robinhood Outage	Pseudo Event
$\mathrm{RH}_{i,d-1} \times \mathrm{Outage}_t$	-0.266**	-0.048
	(-2.461)	(-0.354)
RH _{i,d-1}	-0.162**	-0.153**
	(-1.962)	(-2.160)
Outage _t	0.575	-0.076
	(0.738)	(-0.826)
Firm Clusters	2,015	2,001
Δ R-Squared (%)	0.0452	0.0088

Panel A: WallStreetBets Activity as the Proxy for Expected Robinhood Trading

Robustness analysis

- Alternative proxies for expected Robinhood trading
- Exclude firm-outage events with a 20% spike in WallStreetBets mentions
- Exclude platform outages that begin before 9:45 AM
- Exclude all platform outages in March 2020 (8 out of 25)
- Match outage event windows more closely to pseudo windows
- Measure benchmark control period -10 to -6 days before platform outage (instead of -5 to -1)
- Alternative minimum number of Robinhood owners (500, 1000, etc.)

Event-time plots



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How do HFTs behave during Robinhood outages?

- Construct broad measures of HFT activity
 - Strategic Runs: Consecutive order submissions, cancellations, and executions with same size and side, within short window
 - Order Volume / Trade Volume
 - Cancel-to-Trade Ratio
- Examine Robinhood-affiliated quotes
 - Non-anonymous quotes by HFTs (market makers) with payment for order flow arrangements with Robinhood
 - Citadel, Virtu, G1 Execution, Two-Sigma, Wolverine

HFT activity lower during outages for high Robinhood stocks

	Robin	hood Event O	utages	Pseudo Outages			
	Strategic Runs	Order Vol / Trade Vol	Cancel-Trade Ratio	Strategic Runs	Order Vol / Trade Vol	Cancel-Trade Ratio	
$\mathrm{RH}_{i,d-1} \times \mathrm{Outage}_t$	-0.064**	-0.08***	-0.058***	-0.001	-0.025	-0.028	
	(-1.961)	(-2.884)	(-2.666)	(-0.047)	(-0.643)	(-1.251)	
RH _{i,d-1}	0.124***	0.084***	0.053***	0.185***	0.122***	0.052***	
	(5.834)	(4.283)	(3.609)	(7.686)	(4.341)	(3.355)	
Outage _t	-0.205	-0.001	-0.099	-0.031	0.045	0.043	
	(-1.109)	(-0.011)	(-1.242)	(-1.397)	(1.150)	(1.125)	
Firm Clusters	2,015	2,015	2,015	2,001	2,001	2,001	
Δ R-squared (%)	0.14505	0.0280	0.0838	0.1531	0.0221	0.0319	

Panel A: WallStreetBets Activity as the Proxy for Expected Robinhood Trading

Spreads quoted by Robinhood-affiliated market makers (HFTs) fall during outages

Panel A: WallStreetBets Activity as the Proxy for Expected Robinhood Trading

	Robinhoo	od Outages	Pseudo Outages				
	Robinhood Market Maker Spreads	Other Market Maker Spreads	Robinhood Market Maker Spreads	Other Market Maker Spreads			
$RH_{i,d-1} \times Outage_t$	-10.957***	7.025	1.872	4.456			
	(-2.809)	(1.06)	(0.425)	(0.204)			
RH _{i,d-1}	3.510*	2.209	3.287*	-1.160			
	(1.792)	(0.123)	(1.864)	(-1.091)			
Outage _t	-1.070	5.725	2.842	1.313			
	(-0.08)	(0.134)	(2.271)	(0.711)			
Firm Clusters	2,015	2,015	2,001	2,001			
Δ R-squared (%)	0.0289	0.0422	0.0572	0.0622			

Robinhood's negative effect on market quality: Exploring inventory risk channel

- Examine imbalances in trades and quotes
 - Uninformed trading pressure may create imbalances in trades/quotes
 - Do imbalances unwind during outages?
 - Trade imbalance (TAQ)
 - Absolute difference in buy and sell volume
 - Depth imbalance around inside quotes (ITCH)
 - Depth imbalance = $|(P_{t,DW,O} M_t) (M_t P_{t,DW,B})|/M_t$
 - Robinhood-affiliated depth imbalance
- Also examine autocorrelated trading as proxy for inventory risk
 - The measure: Quintile of stocks with highest autocorrelation in hourly Robinhood trading over previous five days
 - How does inventory risk interact with RH stocks and outages?

Imbalances drop during outages, consistent with reduced inventory risk

Panel A: WallStreetBets Activity as the Proxy for Expected Robinhood Trading

	Robinhood Outages					Pseudo Outages					
	Trade Imbalance	Depth Weighted Imbalance	Robinhood Market Maker Depth Imbal.	Other Market Maker Depth Imbalance	Trade Imbalance	Depth Weighted Imbalance	Robinhood Market Maker Depth Imbal.	Other Market Maker Depth Imbalance			
$RH_{t,d-1} \times Outage_t$	-10.151**	-58.307***	-10.135**	-13.228	-5.275	19.753	6.219	-18.808			
	(-2.54)	(-3.456)	(-2.523)	(-0.727)	(-1.333)	(1.111)	(1.186)	(-1.008)			
RH _{i,d-1}	13.437***	56.202***	5.275*	-1.463	13.391***	66.996***	-1.658	6.699			
	(2.801)	(4.267)	(1.712)	(-0.109)	(2.950)	(5.582)	(-0.51)	(0.398)			
Outage _t	-10.783	-8.242	-34.434	21.809	1.061	-13.559	-3.079	5.378			
	(-1.115)	(-0.500)	(-1.125)	(0.982)	(0.173)	(-1.31)	(-1.179)	(0.385)			
Firm Clusters	2,015	2,015	2,015	2,015	2,001	2,001	2,001	2,001			
∆ R-Squared (%)	0.0141	0.1637	0.0169	0.0014	0.0091	0.2292	0.0012	0.0011			

Market quality improvement strongest for stock with high inventory risk (autocorrelated trades)

Panel A: WallStreetBets Activity as the Proxy for Expected Robinhood Trading

	Quoted Spread	Effective Spread	Realized Spread	Price Impact	Trade Imbalance	Depth Weighted Imbalance	Robinhood MM Depth Imbalance	Robinhood MM Quoted Spread
$RH_{\textit{t,d-1}} \times InventoryRisk_{\textit{t,d-1}} \times Outage_{\textit{t}}$	-2.902**	-46.488*	-35.73**	-18.824**	-4.246**	-19.54**	-6.326**	-5.613*
	(-2.241)	(-1.947)	(-2.163)	(-2.009)	(2.486)	(-2.069)	(-2.149)	(-1.824)
$RH_{t,d-1} \times Outage_t$	-3.201**	-9.364	-5.681	3.113	-11.530***	-58.51***	-11.134**	-13.477***
	(-2.103)	(-1.058)	(-1.227)	(0.604)	(-2.641)	(-2.913)	(-2.339)	(-2.793)
Outaget × InventoryRisk _{t,d-1}	1.458*	8.515	4.844	4.123	-1.489	3.981	-6.286	1.438
	(1.658)	(1.364)	(0.678)	(0.8)	(-0.4)	(0.29)	(-1.319)	(0.28)
$RH_{i,d-l} \times InventoryRisk_{i,d-l}$	0.021	29.639	20.904	6.627	0.8381	-3.649	-2.527	3.823
	(0.026)	(1.46)	(1.314)	(1.087)	(0.216)	(-0.32)	(-0.51)	(1.367)
RH _{1,d-1}	-1.583**	-16.346**	-2.056	-12.699**	13.241***	57.036***	4.739	-4.171
	(-2.132)	(-2.162)	(-0.34)	(-2.014)	(2.796)	(4.387)	-1.413	(-1.513)
Outage,	5.347	2.177	6.623	-8.174	-10.493	-8.867	-33.441	-1.449
	(0.94)	(0.28)	(0.713)	(-1.043)	(-1.085)	(-0.51)	(-1.089)	(-0.102)
InventoryRisk _{i,d-1}	0.912**	0.879	-1.269	3.674	-0.590	4.345	0.594	-7.286***
	(2.422)	(0.331)	(-0.314)	(1.347)	(-0.281)	(0.613)	(0.194)	(-2.757)
Firm Clusters	2,015	2,015	2,015	2,015	2,015	2,015	2,015	2,015
Δ R-squared (%)	0.0588	0.0041	0.0005	0.0009	0.0143	0.1663	0.0174	0.0627

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Concluding Remarks

- Evidence that zero-commission investors are noise traders
 - In contrast to broader set of retail traders
- High Robinhood trading associated with lower market quality
 - Robinhood platform outages as exogenous shock
 - Robust
- Evidence consistent with Robinhood investors creating inventory risks for HFT market makers