

VESTIGIAL TAILS? FLOOR BROKERS AT THE CLOSE IN MODERN ELECTRONIC MARKETS

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Floor Brokers on NYSE

- Floor brokers have played a central role in trading on NYSE since its inception in 1792.
- Globally, most exchanges have discontinued floor trading in favor of electronic trading.
- NYSE maintains a “hybrid” model with floor brokers and electronic trading.
- Discussing floor brokers, The Economist described NYSE as “still living in the horse-and-buggy era.”



Peter Michael Tuchman, the “most photographed NYSE trader”
Photo: Richard Drew/Associated Press

...in 1978

Floor Brokers in NYSE Closing Auctions

- Floor brokers have been largely supplanted by electronic trading (e.g., GTS, Citadel, Virtu).
- However, floor brokers retain significant advantages in NYSE closing auctions:
 - Floor brokers have near-exclusive access to the auction from 3:50pm to 4pm.
 - Floor brokers' orders (D-Orders) are excluded from auction info until 3:55pm.



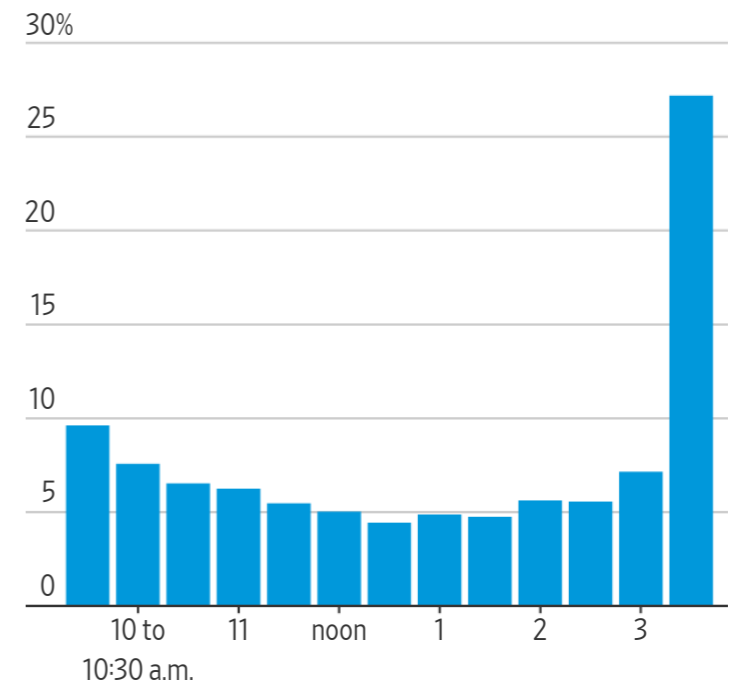
Photo: Spencer Platt/Getty Images

Closing auctions are increasingly important liquidity events

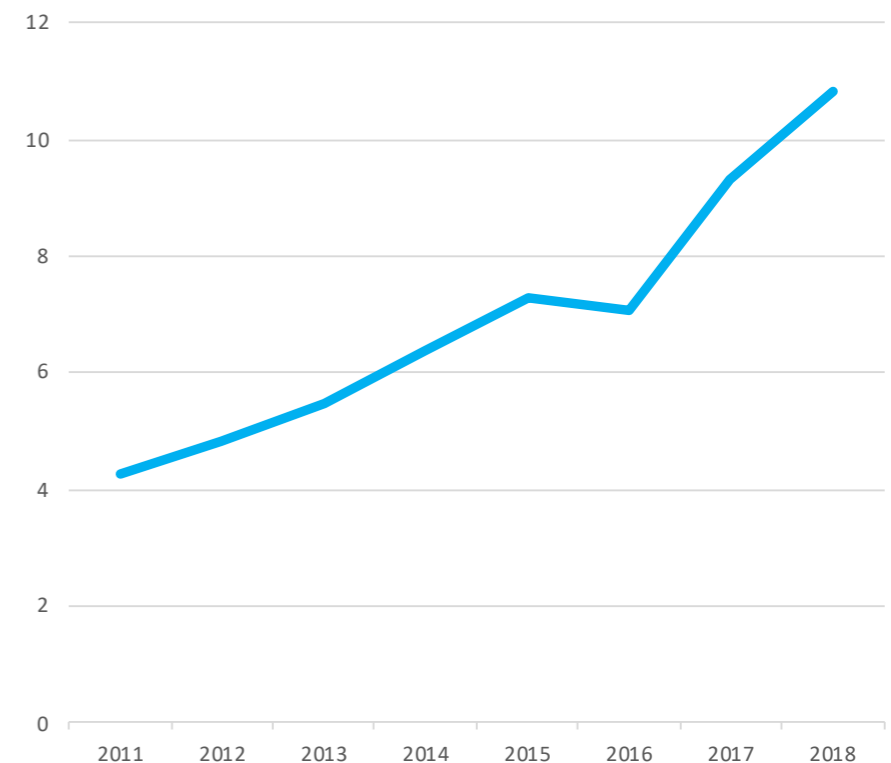
- Closing auctions determine end of day prices and thus trillions of dollars of fund NAVs.
- Closing volume has grown by 150% since 2012, now represents 10% of all volume.
- Unlike intraday trading, closing auction volume is almost completely exclusive to the listing venue (NYSE or Nasdaq).
- Floor brokers on NYSE handle around a third of this volume (~\$4T across our sample).

Late Surge

Percentage of daily volume in S&P 500 stocks by half-hour interval



Average % Closing Volume in S&P 500 Stocks



Our central question

Do floor brokers impair closing auction quality?

- We measure "quality" as the accuracy of indicative auction prices, volume, size of order imbalances, and efficiency of closing prices.
- Traders rely on accurate closing auction information to determine whether or not to participate.
- The market structure of the NYSE closing auction suggests that supply/demand information is incomplete for most investors.



Photo: CNBC

First period: all regular traders
Second period: floor brokers only

What does NYSE think?

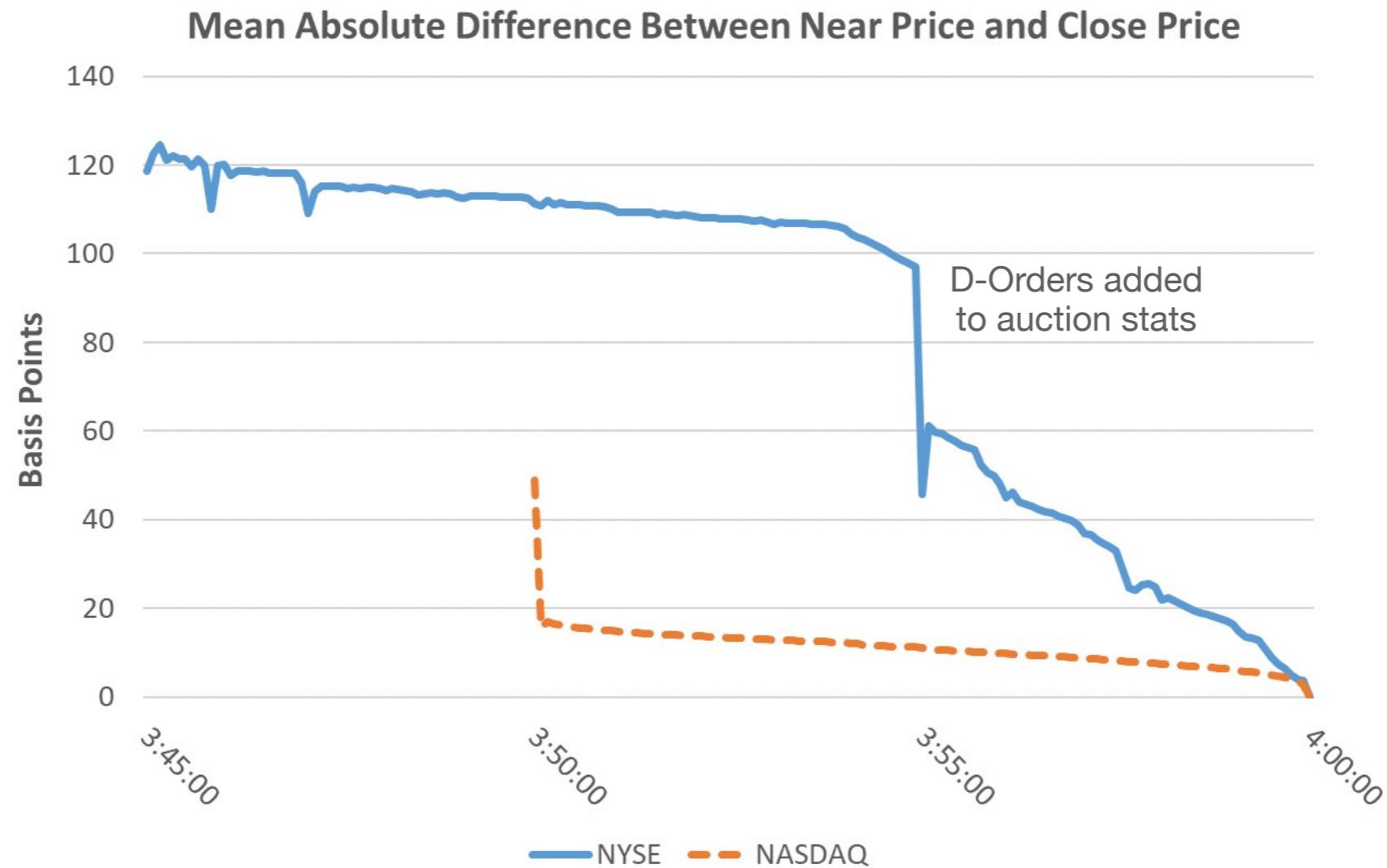
- “The NYSE trading floor... helps investors maximize the benefits of the NYSE closing auction.”
- “The NYSE's unique hybrid market model, [...] offers unmatched stability relative to other global markets, especially during times of market turbulence.”
- NYSE COO: “The **only credible conclusion...** is that the NYSE closing auction, in conjunction with its trading floor, leads to the fairest prices for investors.”



Photo: Allison Joyce/Getty Images

Main results

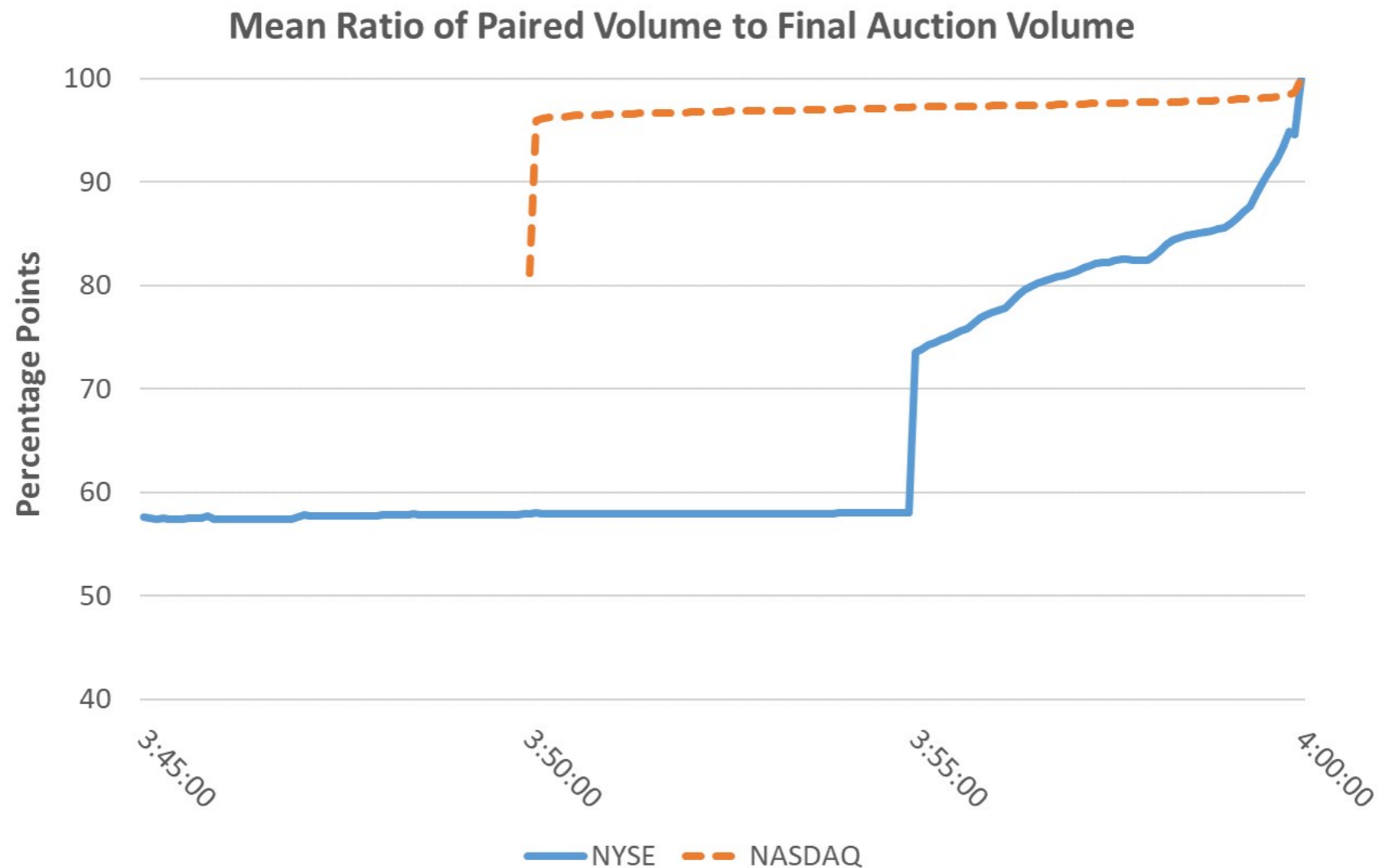
Indicative price on NYSE is significantly off from the closing price compared to Nasdaq



- At 3:55, indicative price accuracy converges by 40 bps due to incorporation of floor broker orders.

Main results

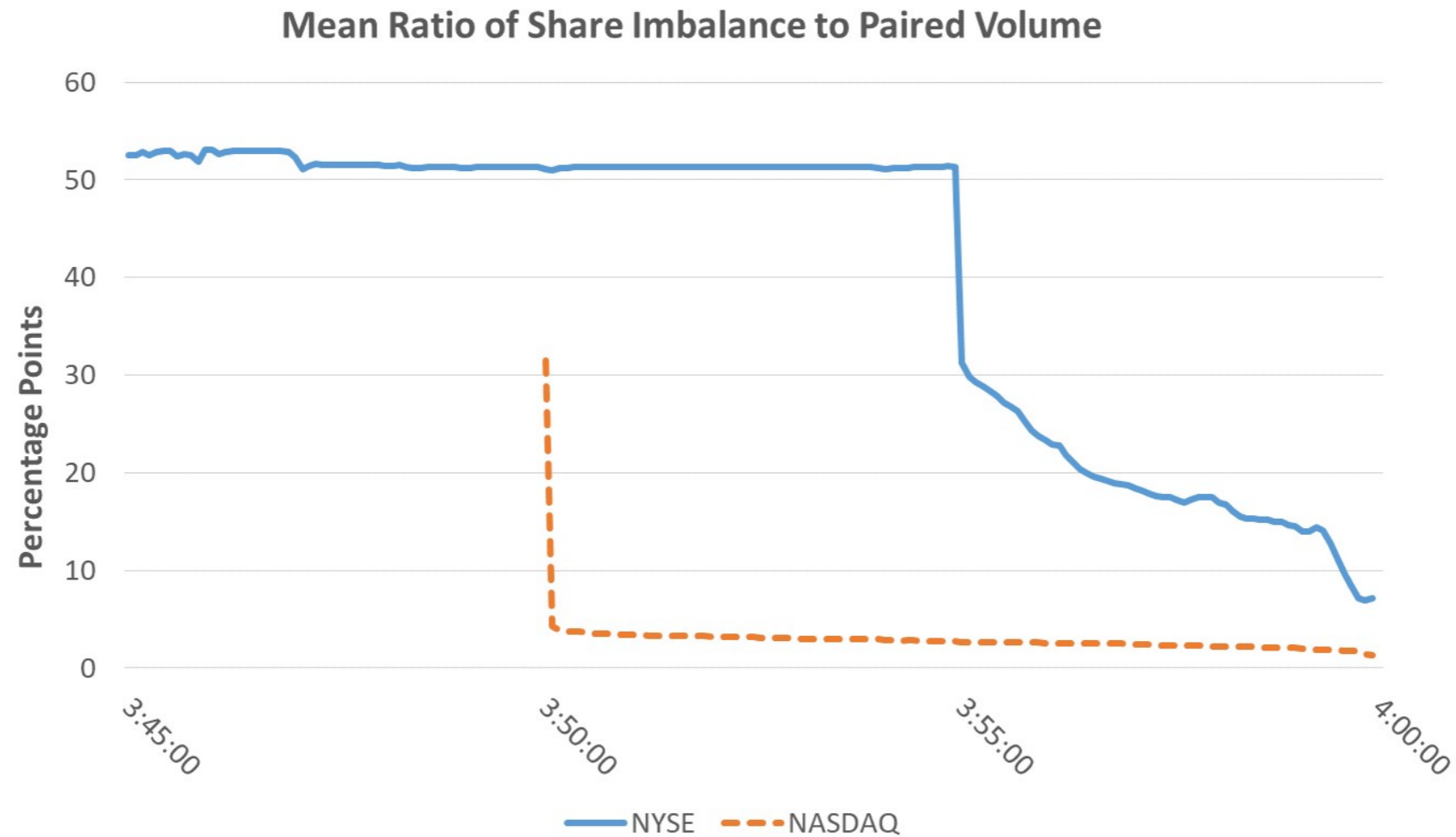
Indicative volume is lower than closing volume on NYSE compared to Nasdaq



- At 3:55, indicative matched volume increases by 15 pp (\$2.2MM).

Main results

Indicative imbalances are larger on NYSE compared to Nasdaq



- At 3:55, indicative absolute order imbalance decreases by 21 pp.

Main results

NYSE closing prices are also less efficient

- At 4pm, auction dislocations are slightly higher on NYSE than on Nasdaq.
- (Auction dislocation is the absolute change from last continuous market price to official closing price.)
- Overnight price reversals are **2X** larger on NYSE.
- NYSE closing auction dislocations are corrected overnight.

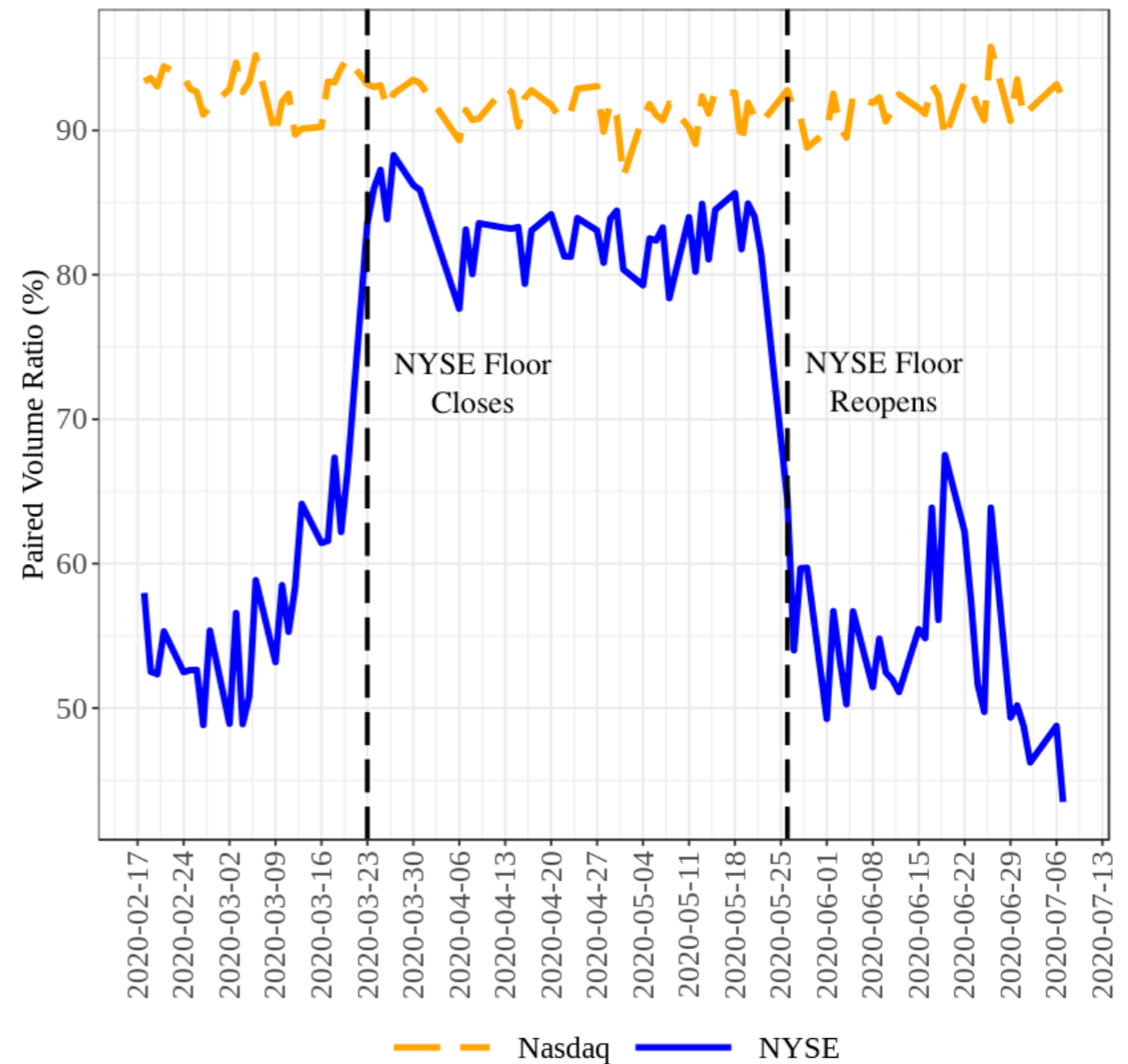


Photo: Timothy A. Clary / Getty Images

Main results

Closing auction quality improves during COVID-19 floor closure

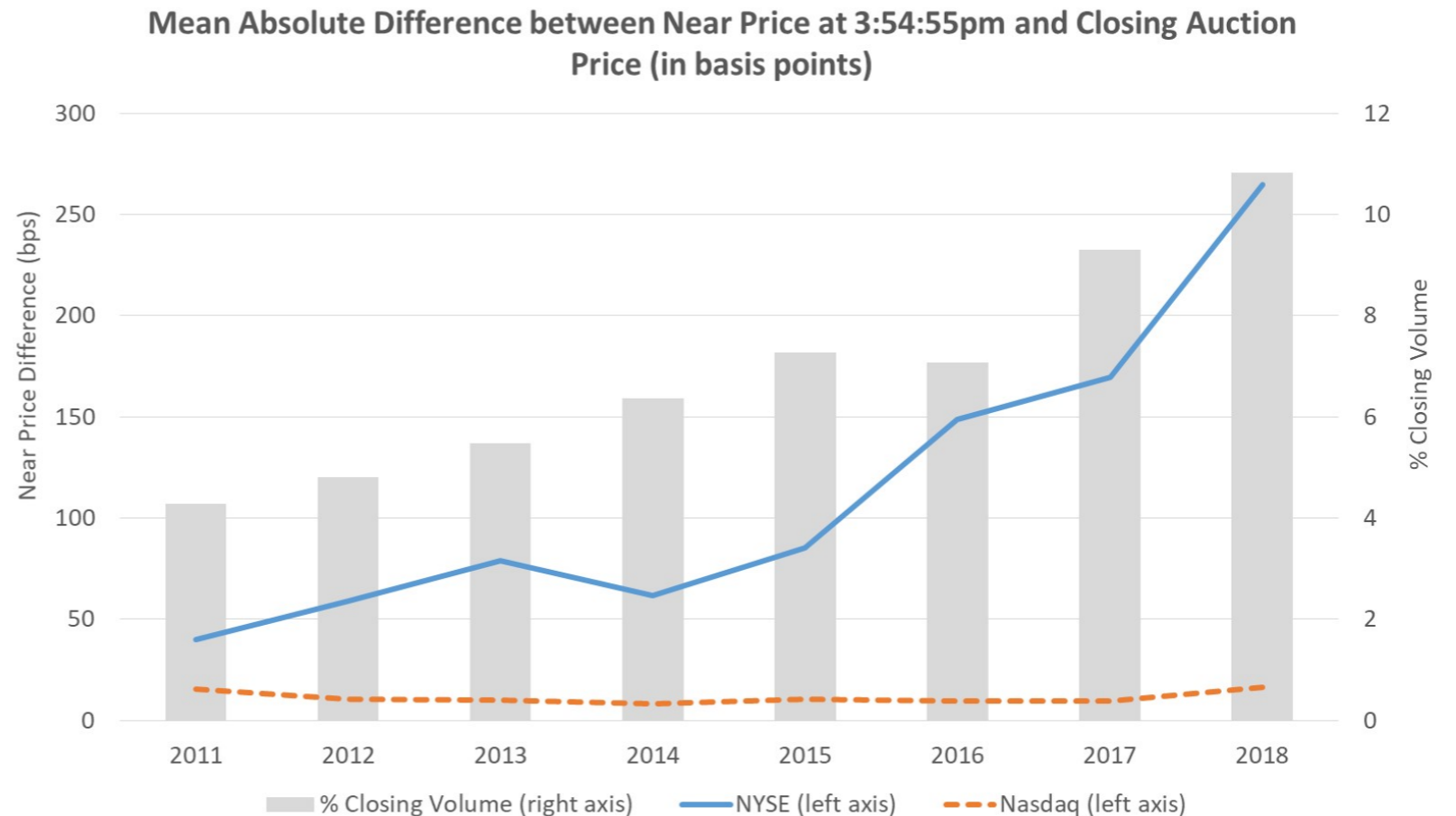
- Following the floor closure:
 - Pre-3:55pm indicative volume increases from 55% to 85%.
 - Pre-3:55pm indicative prices improve by 100 bps.
 - Pre-3:55pm indicative order imbalances decrease by 6 pp.
- All of these changes reverted once the floor reopened.



Main results

NYSE closing auction is less resilient to liquidity demand shocks compared to Nasdaq

- Closing auction quality has gotten worse over time as closing auction interest has grown.
- On days with high liquidity demand, auction quality is especially worse on NYSE.
- We use “triple witching days” and end-of-month portfolio rebalancing days as exogenous shocks to liquidity demand.

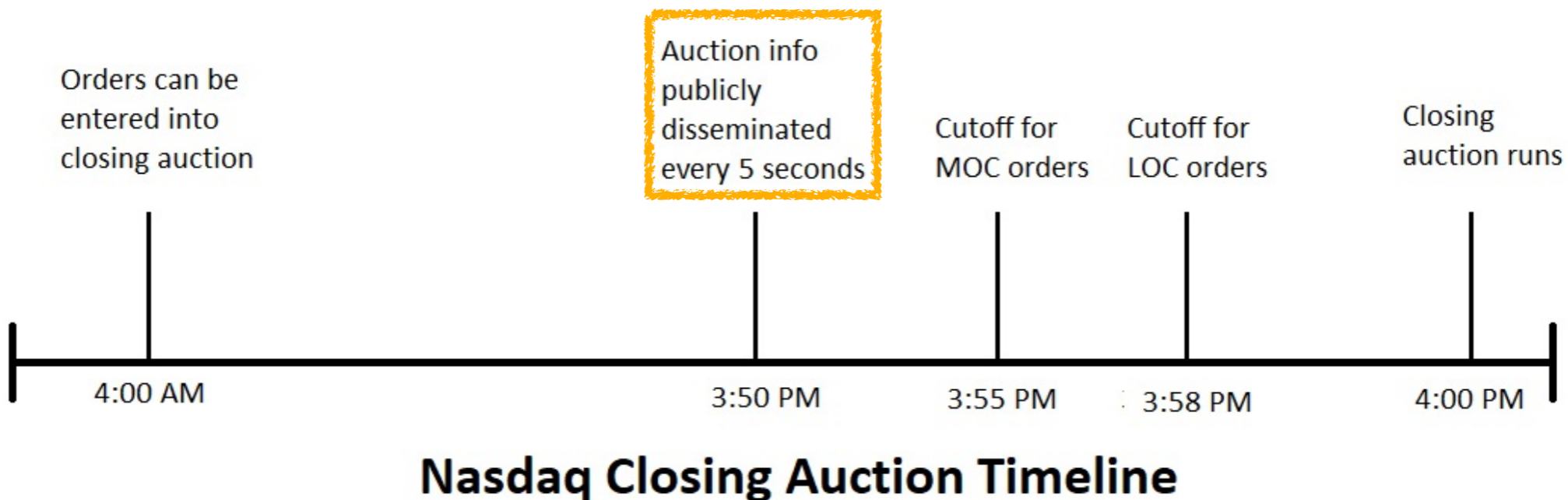
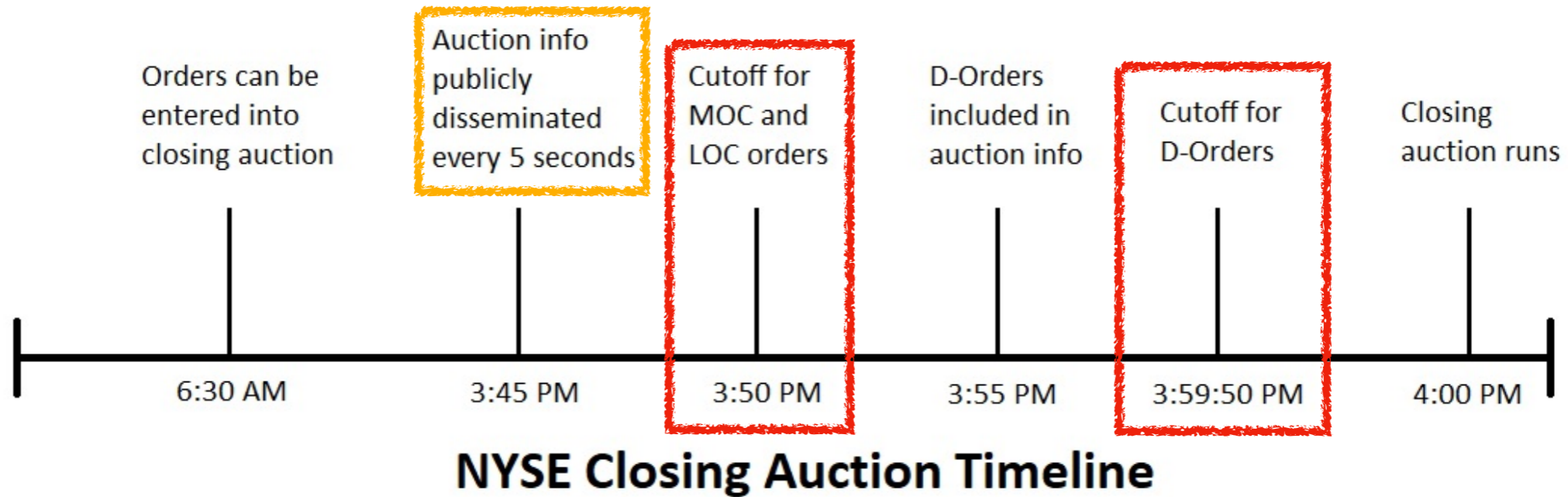


Related literature

- Battalio, Jennings, and McDonald (2018): analysis of the NYSE parity rule, which allows floor brokers to trade ahead of same-priced orders that arrived earlier.
- Mayhew, McCormick, and Spatt (2009): NYSE specialists trade in the direction of closing auction order imbalances before they are publicly reported.
- Bogouslavsky and Muravyev (2020): strong reversion in closing prices due to institutional price pressure.
- Brogaard, Ringgenberg, and Roesch (2020): NYSE intraday spreads increased after the COVID-19 floor closure.

Closing auction timeline

NYSE floor brokers have more information and more time to trade



Closing auction information

Prices, volume, order imbalances

- NYSE and Nasdaq disseminate real-time auction statistics to subscribers, which include the following:
 - **Near price:** price at which supply meets demand based on orders in the closing auction + the orders in the limit order book.
 - **Matched volume:** number of shares that would clear at the current market price.
 - **Order imbalance:** difference between supply and demand based on the current market price.
- D-Orders are not included in any of these statistics until 3:55pm.

The cost to trade in the close

Closing auction trades are lucrative for exchanges

- NYSE and Nasdaq charge about \$0.04 to \$0.11 per 100 shares traded on **each side** of the closing auction.
- For trading in the continuous market, exchanges typically pay a rebate to liquidity providers, and charge a fee to liquidity takers.
- D-Orders can be more than twice as expensive as regular auction orders:
 - \$0.05 to \$0.15 per 100 shares to enter a D-Order.
 - Additional \$0.03 to \$0.10 per 100 shares to modify a D-Order in the last 25 minutes of the trading day.

Hypothesis development

- Consider a closing call auction with two types of traders:
 - **Benchmark investors:** required to trade at the close or face large non-execution penalty. Will submit aggressively-priced limit orders to maximize execution probability.
 - **Flexible investors:** only want to trade in the closing auction if they can buy/sell at the efficient price or better. Will submit less aggressive orders to minimize implementation (price) shortfall.
- Analogous to impatient and patient traders in Foucault, Kadan, and Kandel (2005) and Roşu (2009).
- **NYSE:** before 3:50pm, auction only consists of aggressive orders from benchmark investors, when submission fees are lower. Post-3:50pm participation constraints reduce competition and auction efficiency.
- **Nasdaq:** no participation constraints. No cancellations allowed after 3:50pm so benchmark and flexible investors pool their orders by 3:50.

Empirical Predictions

1. Indicative prices on NYSE will be further off compared to Nasdaq throughout the closing auction process.
2. Indicative matched volume will be significantly lower than realized volume on NYSE versus Nasdaq throughout the closing auction process.
3. Indicative absolute order imbalances on NYSE will be significantly higher than Nasdaq throughout the closing auction process.
4. The realized closing auction price on NYSE will be less efficient than Nasdaq.

Data

- Indicative auction information obtained for S&P 500 stocks from 2011 to 2018 using the SEC's MIDAS system.
 - Less liquid stocks do not regularly hold auctions.
- Auction data obtained from MayStreet (provider of MIDAS) for 2/19/20 to 4/17/20 covering the floor closure.
- Daily liquidity control variables from WRDS TAQ IID.
 - Effective spreads, Kyle's Lambda, intraday volume and volatility.

Empirical Framework

Comparing auction statistics for NYSE-listed and Nasdaq-listed stocks

- We focus on auction statistics at: 3:54, 3:55, and 3:59.
- Dependent variables (y):
 - Near price difference: abs. difference between near price and final closing price.
 - Paired volume ratio: ratio of paired volume to final closing volume.
 - Order imbalance ratio: ratio of order imbalance to final closing volume.

- Model:

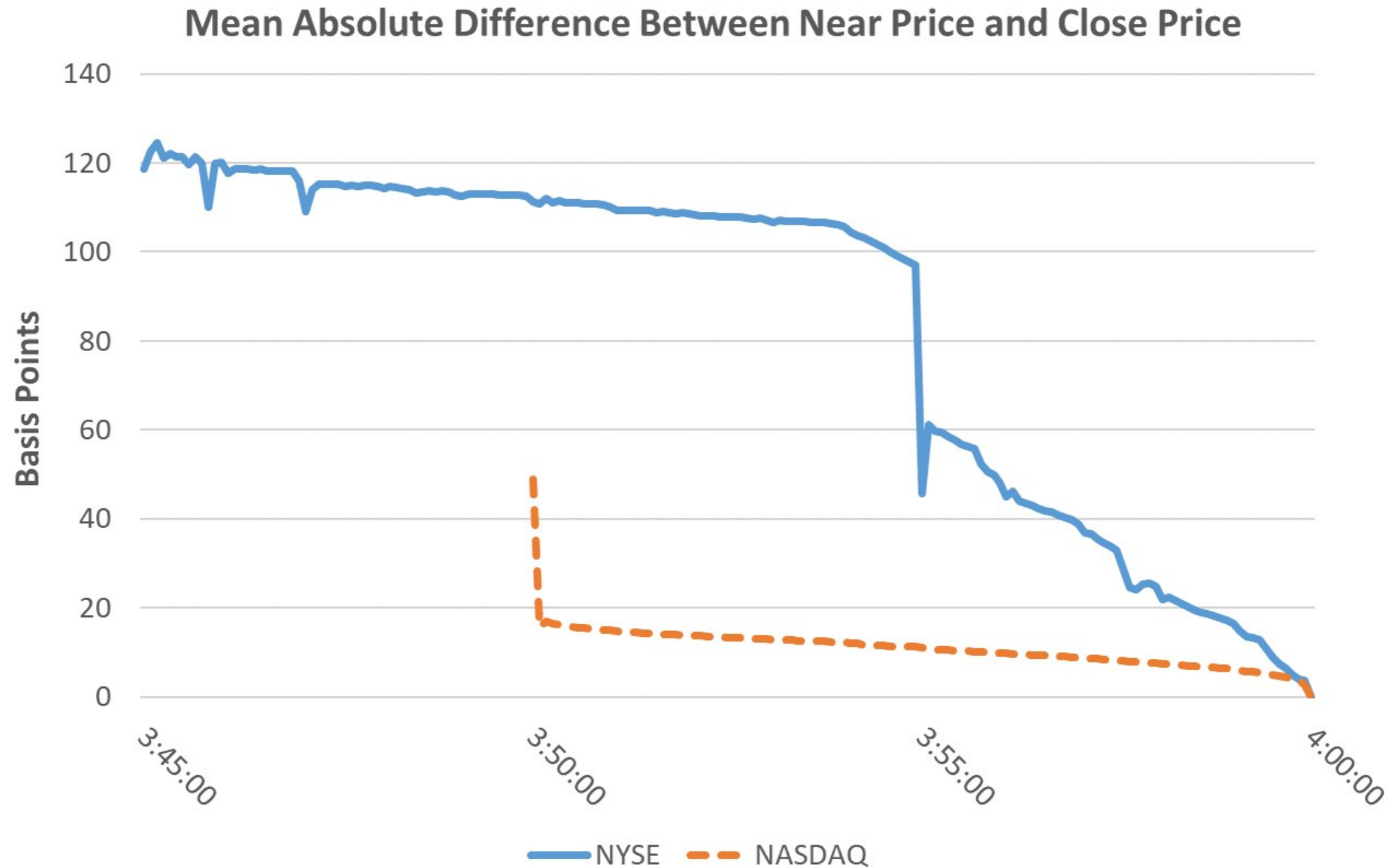
$$y_{i,t,d} = \beta_1 \cdot NYSE_i \times \mathbb{1}^{3:54} + \beta_2 \cdot NYSE_i \times \mathbb{1}^{3:55} + \beta_3 \cdot NYSE_i \times \mathbb{1}^{3:59} \\ + \beta_4 \cdot \mathbb{1}^{3:54} + \beta_5 \cdot \mathbb{1}^{3:55} + \alpha + \gamma X_{i,d-1} + \varepsilon_{i,t,d}$$

Near prices are less accurate on NYSE

Dep. Variable: Abs. Near Price Difference (bps)

	(1)	(2)	(3)
$NYSE \times \mathbb{1}^{3:54}$	107.9*** (40.34)	108.9*** (40.15)	108.0*** (40.37)
$NYSE \times \mathbb{1}^{3:55}$	62.74*** (40.91)	63.71*** (40.96)	63.01*** (41.39)
$NYSE \times \mathbb{1}^{3:59}$	1.131*** (11.98)	2.043*** (3.40)	
$\mathbb{1}^{3:54}$	9.362*** (40.84)	9.405*** (40.92)	10.40*** (34.96)
$\mathbb{1}^{3:55}$	9.091*** (35.03)	9.088*** (35.02)	9.080*** (35.04)
Constant	2.769*** (57.18)		
$NYSE \times (\mathbb{1}^{3:55} - \mathbb{1}^{3:54})$	-45.21*** (-25.53)	-45.15*** (-25.55)	-44.99*** (-25.61)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	None	None	Symbol, Date
N	1,931,645	1,931,455	1,931,455
Adj. R^2	0.118	0.120	0.172

Near prices on NYSE vs Nasdaq

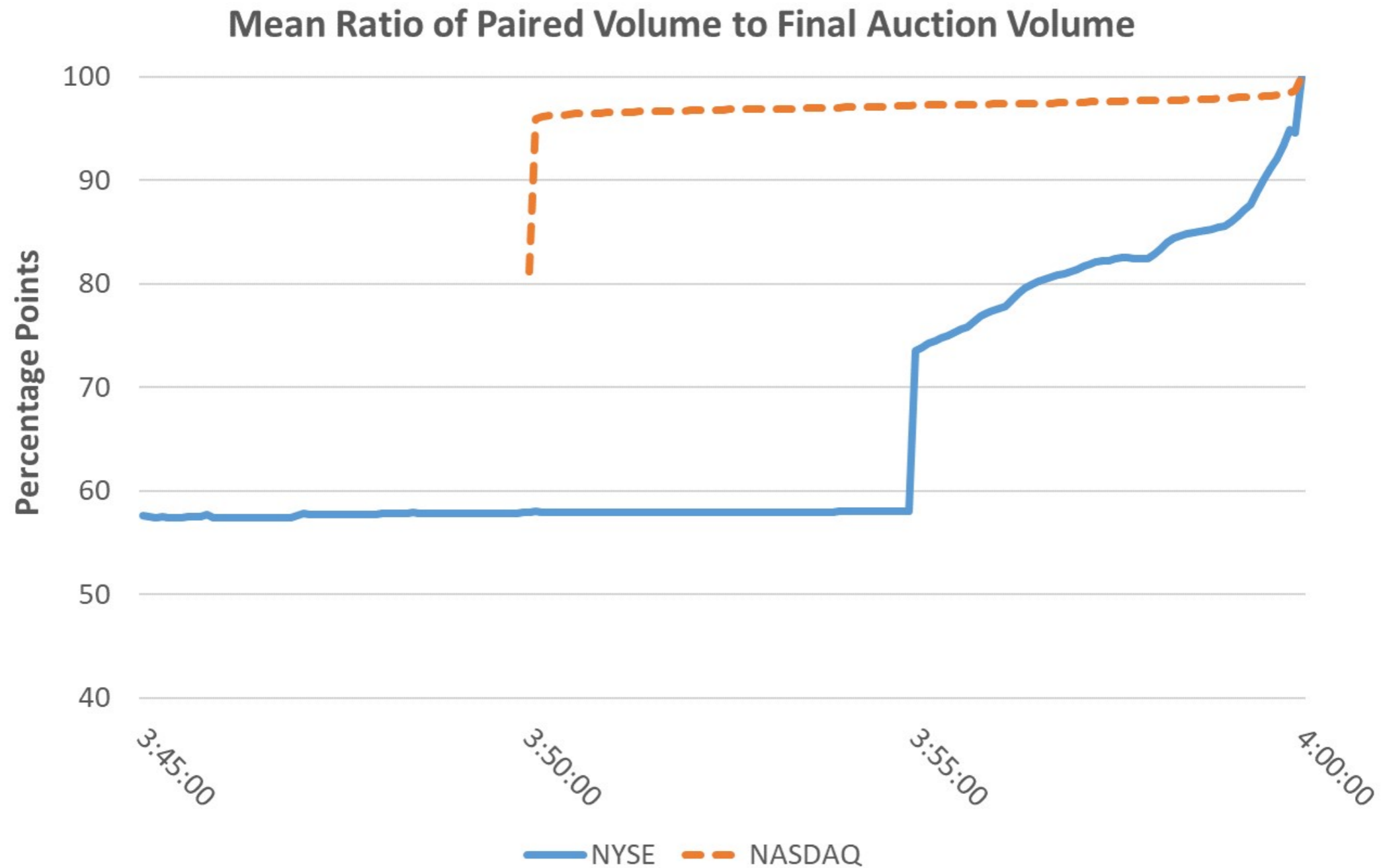


Paired volume is lower on NYSE

Panel A: Paired Volume Ratio (%)

	(1)	(2)	(3)
$NYSE \times \mathbb{1}^{3:54}$	-39.98*** (-152.53)	-39.92*** (-156.08)	-37.42*** (-138.46)
$NYSE \times \mathbb{1}^{3:55}$	-24.54*** (-113.52)	-24.48*** (-116.75)	-21.96*** (-99.21)
$NYSE \times \mathbb{1}^{3:59}$	-2.602*** (-18.35)	-2.542*** (-17.86)	
$\mathbb{1}^{3:54}$	-1.389*** (-33.23)	-1.384*** (-33.29)	-1.398*** (-33.49)
$\mathbb{1}^{3:55}$	-1.249*** (-31.96)	-1.248*** (-31.97)	-1.248*** (-31.96)
Constant	98.91*** (1038.5)		
$NYSE \times (\mathbb{1}^{3:55} - \mathbb{1}^{3:54})$	15.44*** (81.85)	15.45*** (81.82)	15.46*** (81.95)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	None	None	Symbol, Date
N	1,931,645	1,931,455	1,931,455
Adj. R ²	0.669	0.670	0.692

Paired volume on NYSE vs Nasdaq

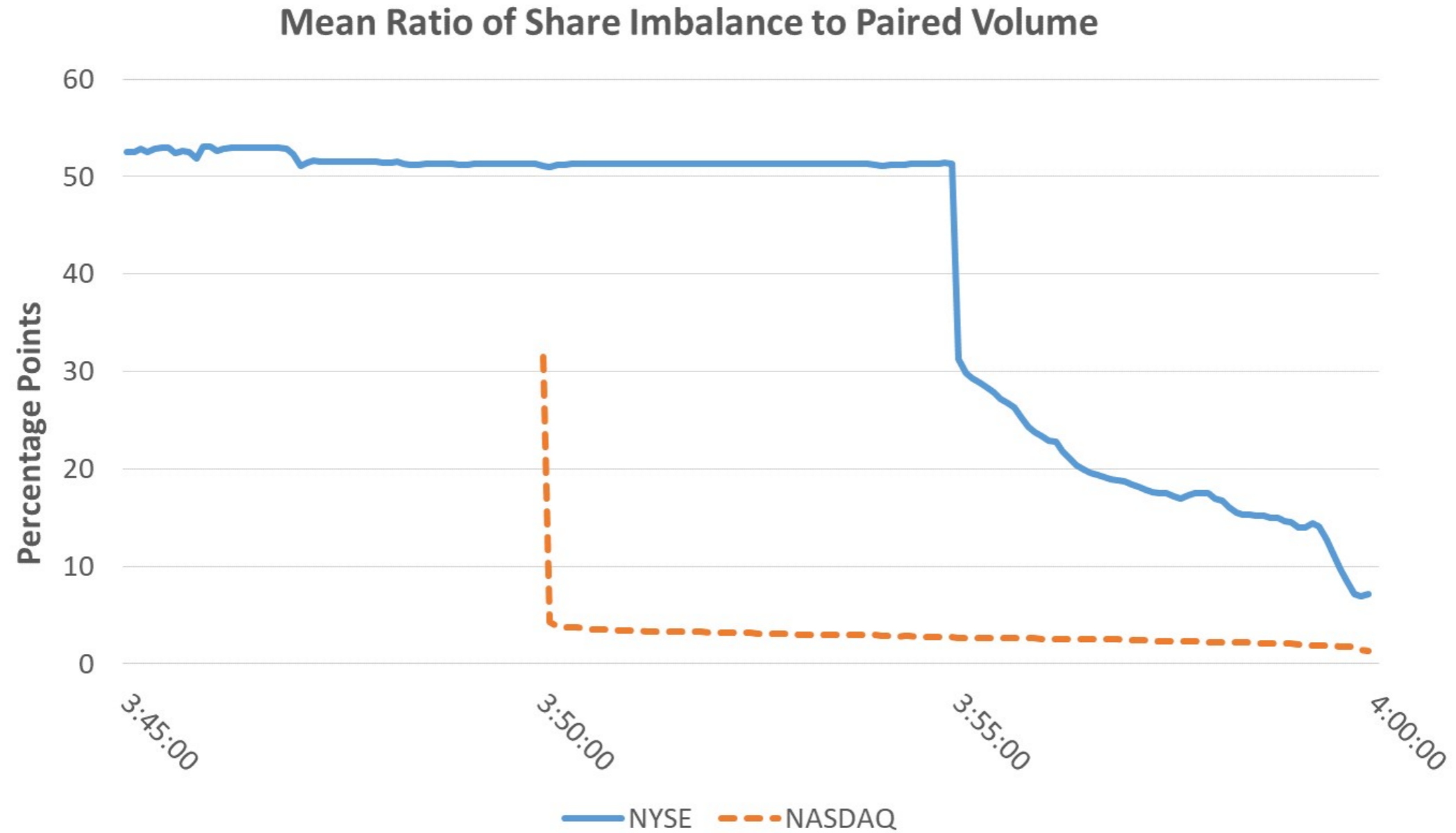


NYSE order imbalances are larger

Panel A: Abs. Imbalance Ratio (%)

	(1)	(2)	(3)
$NYSE \times \mathbb{1}^{3:54}$	49.92*** (83.88)	49.67*** (88.13)	44.64*** (82.84)
$NYSE \times \mathbb{1}^{3:55}$	29.00*** (69.35)	28.73*** (66.53)	23.63*** (65.86)
$NYSE \times \mathbb{1}^{3:59}$	5.238*** (35.81)	4.985*** (20.74)	
$\mathbb{1}^{3:54}$	1.413*** (27.46)	1.396*** (27.42)	1.282*** (23.20)
$\mathbb{1}^{3:55}$	1.260*** (26.66)	1.260*** (26.66)	1.261*** (26.63)
Constant	1.229*** (11.78)		
$NYSE \times (\mathbb{1}^{3:55} - \mathbb{1}^{3:54})$	-20.92*** (-50.30)	-20.94*** (-50.31)	-21.01*** (-50.38)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	None	None	Symbol, Date
N	1,931,645	1,931,455	1,931,455
Adj. R ²	0.289	0.293	0.321

Order imbalance on NYSE vs Nasdaq



Order imbalances flip more often

Panel C: Imbalance Sign Change

	(1)	(2)	(3)
<i>NYSE</i> × $\mathbb{1}^{3:54}$	0.0020*** (17.76)	0.0029*** (2.98)	-0.178*** (-53.55)
<i>NYSE</i> × $\mathbb{1}^{3:55}$	0.157*** (59.85)	0.158*** (59.61)	-0.0226*** (-7.35)
<i>NYSE</i> × $\mathbb{1}^{3:59}$	0.181*** (53.98)	0.182*** (54.36)	
$\mathbb{1}^{3:54}$	-0.0001*** (-2.64)	-0.0001 (-1.28)	0.0015*** (5.03)
$\mathbb{1}^{3:55}$	0.0070*** (5.70)	0.0070*** (5.70)	0.0070*** (5.69)
Constant	0.0002*** (5.33)		
Fixed Effects	None	None	Symbol, Date
Controls	No	Yes	Yes
N	1,931,645	1,931,455	1,931,455
Adj. R^2	0.100	0.102	0.123

Realized prices are inefficient

Larger dislocations, reversals 2X larger

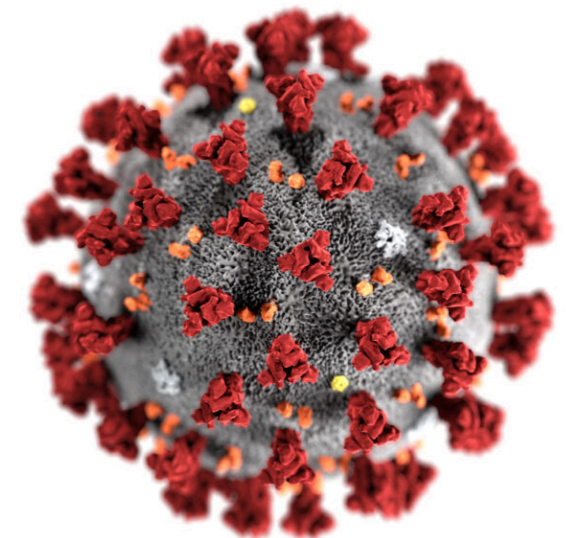
	$y = r^{lc} $	$y = r^{mc} $	$y = r^{co}$
	(1)	(2)	(3)
<i>NYSE</i>	0.297*** (6.70)	0.627*** (11.49)	
<i>NYSE</i> × r^{mc}			-0.385*** (-3.35)
r^{mc}			-0.274*** (-2.75)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	Date	Date	Symbol, Date
N	638,989	638,989	638,536
Adj. R^2	0.133	0.312	0.376

$$|r_{i,d}^{lc}| = \beta_1 \cdot NYSE_i + \gamma X_{i,d-1} + \delta_d + \varepsilon_{i,d}$$

$$r_{i,d}^{co} = \beta_1 \cdot r_{i,d}^{mc} \times NYSE + \beta_2 \cdot r_{i,d}^{mc} + \gamma X_{i,d-1} + \delta_{i,d} + \varepsilon_{i,d}$$

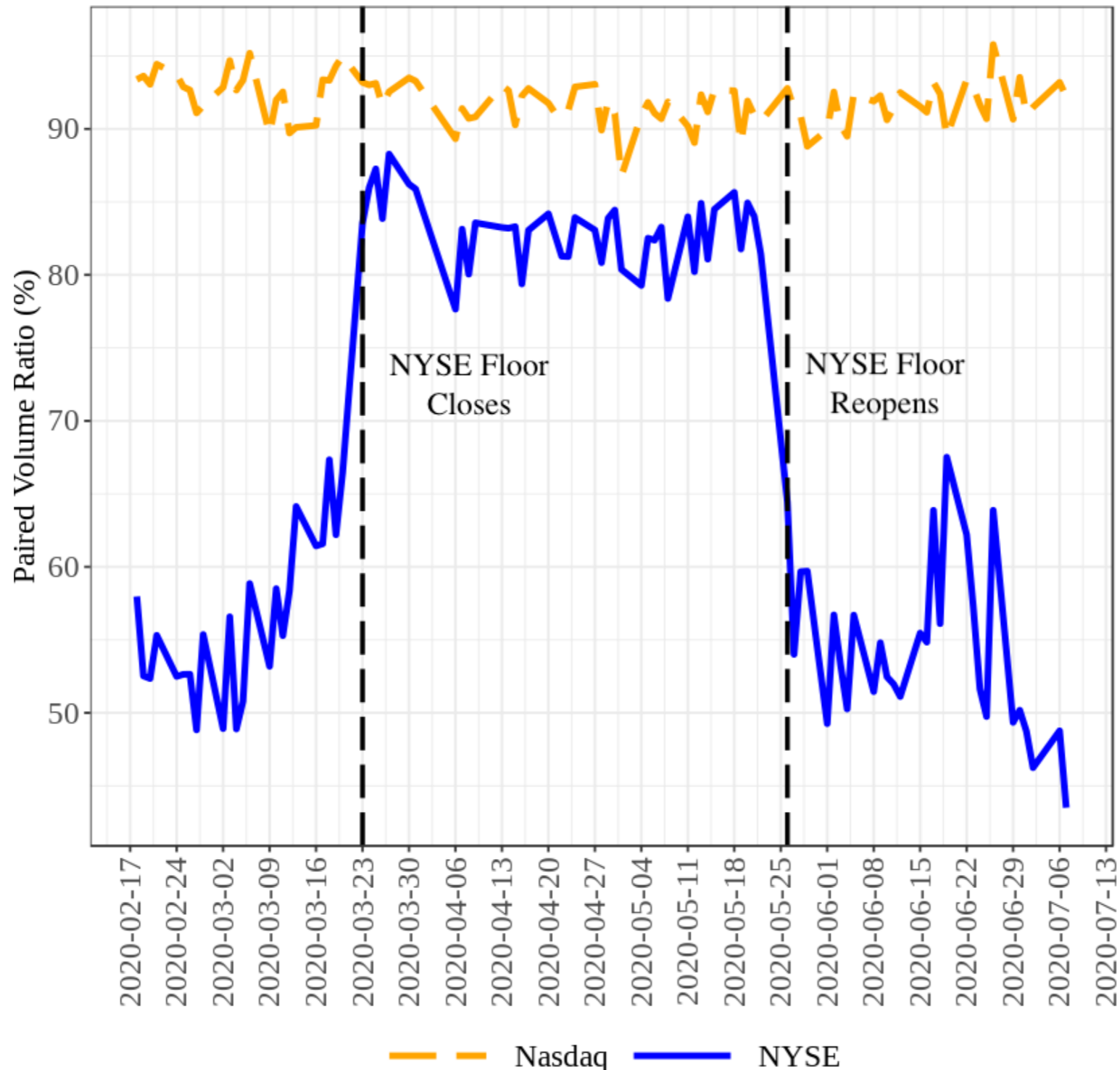
NYSE COVID-19 Floor Closure

- We further identify the effect of floor brokers on the NYSE closing auction using the COVID-19 floor closure.
- NYSE has always had floor brokers since 1792.
- During 9/11 and Hurricane Sandy NYSE halted all trading.
- NYSE closed the floor and maintained electronic trading **for the first in its history** because two people at the exchange tested positive for COVID-19.
- Precludes entry of D-Orders.



Matched volume around floor closure

Just before 3:55pm increased from 55% to 85%



Floor closure and auction statistics

Auction statistics become more accurate during the closure, and revert after re-opening.

	Paired Volume Ratio (%)	Abs. Near Price Diff. (bps)	Abs. Order Imb. Ratio (%)
	(1)	(2)	(3)
<i>NYSE</i> × <i>Closure</i>	28.09*** (25.32)	-123.8*** (-6.33)	-5.896*** (-4.00)
<i>NYSE</i> × <i>Reopen</i>	-29.04*** (-23.71)	104.3*** (5.78)	16.89*** (11.17)
<i>NYSE</i>	-36.63*** (-33.96)	343.4*** (18.44)	21.35*** (15.32)
<i>Closure</i>	-1.230*** (-2.96)	5.081 (0.40)	1.315** (2.45)
<i>Reopen</i>	0.471 (1.27)	-4.934 (-0.56)	0.246 (0.46)
Constant	85.63*** (58.96)	227.4*** (5.53)	15.15*** (5.67)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Controls	Yes	Yes	Yes
N	42,380	42,380	42,380
Adj. R^2	0.671	0.168	0.186

Floor closure and auction prices

Larger dislocations but weaker reversals

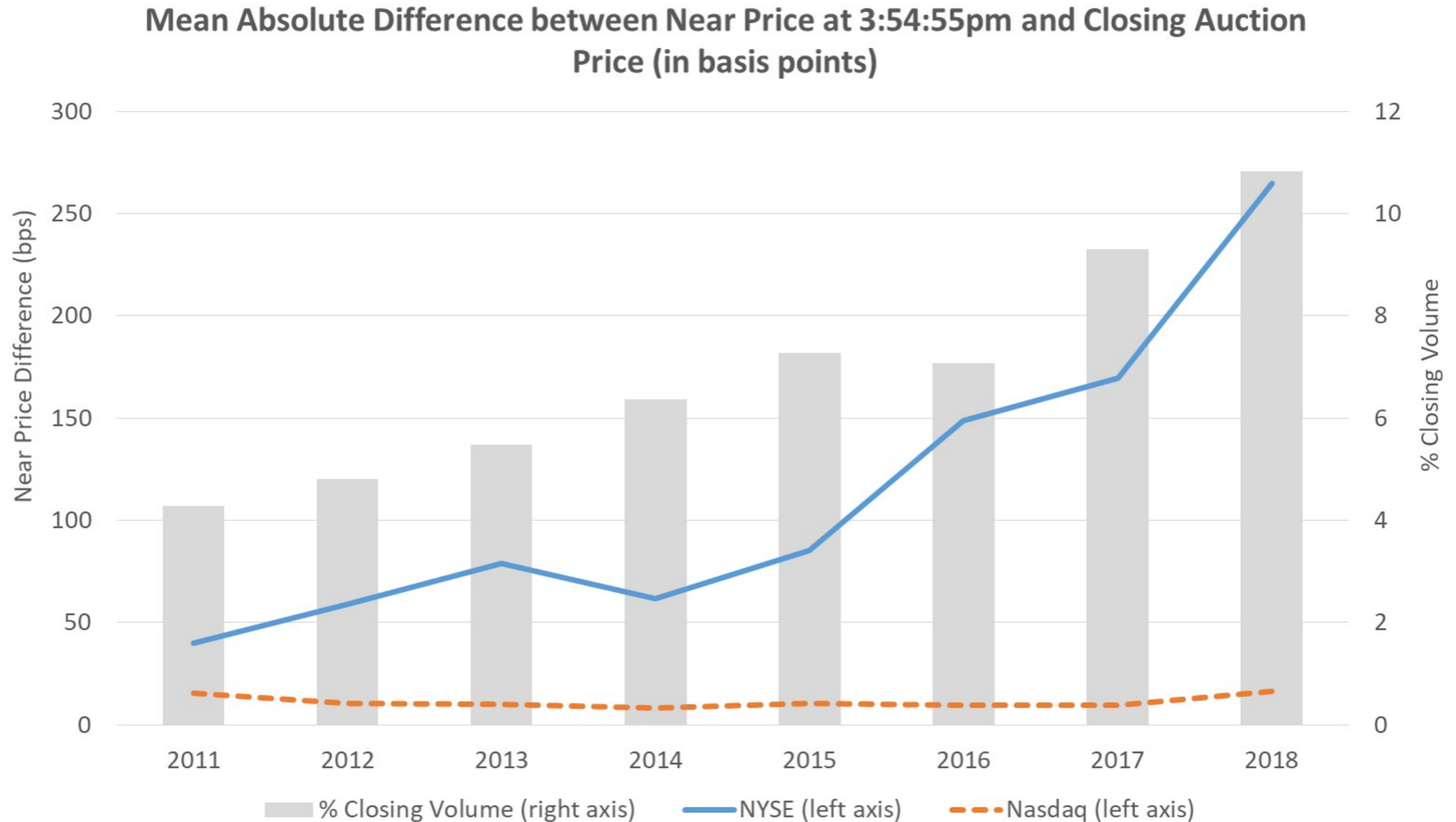
	$y = r^{lc} $	$y = r^{mc} $	$y = r^{co}$
	(1)	(2)	(3)
$NYSE \times Closure$	4.039*** (4.70)	3.672*** (3.80)	24.62 (1.52)
$NYSE \times Reopen$	-1.894*** (-6.71)	-2.169*** (-8.46)	2.641 (0.16)
$NYSE \times Closure \times r^{mc}$			1.023 (1.10)
$NYSE \times Reopen \times r^{mc}$			-0.604 (-0.68)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	Symbol, Date	Symbol, Date	Symbol, Date
Controls	Yes	Yes	Yes
N	44,579	44,562	44,557
Adj. R^2	0.165	0.182	0.707

Closing auction resiliency

How resilient are NYSE and Nasdaq closing auctions to liquidity demand shocks?

- We find that NYSE closing auction quality has gotten worse over time, as closing auctions have grown in importance.
- Auction quality is worse on days with high auction volume generally.
- Auction quality is worse on “triple witching days” and end of month portfolio rebalancing days specifically.

NYSE indicative prices less accurate over time



Abnormal matched volume

1 σ increase in abnormal volume leads to 15bps less accurate prices on NYSE

Abs. Near Price Difference, 3:54:55pm to 4:00pm (bps)

	(1)	(2)	(3)
NYSE \times Z(Volume)	14.99*** (11.94)	15.00*** (12.17)	13.12*** (13.05)
Z(Volume)	1.993*** (9.20)	1.102*** (4.25)	-5.830*** (-7.42)
NYSE	100.7*** (38.84)	102.0*** (38.26)	
$\log(\text{Volume})_{d-1}$		8.459*** (7.50)	4.569*** (2.77)
Volatility $_{d-1}$		-0.000984 (-0.81)	-0.00281 (-1.38)
Eff. Spread $_{d-1}$		0.114 (0.75)	0.559 (1.22)
Lambda $_{d-1}$		-17.46*** (-11.93)	1.075 (1.53)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	None	None	Symbol, Date
N	655,635	655,608	655,608
Adj. R^2	0.0754	0.0810	0.193

Triple Witching Day IV

Indicative prices less accurate on NYSE

Panel A: IV Regression with Triple Witching Day as Instrument

	First Stage (1)	First Stage (2)	Second Stage
	$x = \text{NYSE} \times Z(\text{Vol.})$	$x = Z(\text{Volume})$	$y = \text{Near Price Diff.}$
NYSE \times Witch	2.822*** (22.36)	0.193** (2.12)	
Witch	0.00189 (0.73)	2.627*** (28.30)	
Pred. NYSE \times Z(Volume)			13.73*** (4.38)
Pred. Z(Volume)			2.607*** (4.56)

- Index futures, index options, individual options all expire on the same day (third Friday of Mar, Jun, Sept, Dec).
- Triple witching days are the biggest closing auction days of the year (>2 standard deviation increase in matched volume) on both NYSE and Nasdaq.
- NYSE indicative prices are far less accurate.

End of month portfolio rebalancing

Indicative prices again less accurate on NYSE

Panel B: IV Regression with Last Day of Month as Instrument

	First Stage (1)	First Stage (2)	Second Stage
	$x = \text{NYSE} \times Z(\text{Volume})$	$x = Z(\text{Volume})$	$y = \text{Near Price Diff.}$
NYSE \times Last Day	1.145*** (14.59)	0.163*** (2.60)	
Last Day	0.00682** (2.07)	0.992*** (15.44)	
Pred. NYSE \times Z(Volume)			32.95*** (3.79)
Pred. Z(Volume)			5.630*** (4.31)

- Etula et al (2020): institutional investors sell securities to meet cash obligations at the end of each month, generating large price pressures on the last trading day of the month.
- We find a 1σ increase in volume on these days.
- NYSE indicative prices are far less accurate.

Conclusion

NYSE's auction is less efficient due to its unique market structure that advantages floor traders

- NYSE auction quality is much worse than Nasdaq on average.
- NYSE auction quality has been getting worse over time, as closing auctions have grown in importance.
- Quality improved when the floor closed due to COVID-19.
- Our results highlight the importance of leveling the playing field in the closing auctions.

Policy considerations

- Some traders like the flexibility that D-Orders provide, but we show there are negative externalities for other traders.
- Exchanges have near-monopoly on auction trading and auction data feeds. They have little incentive to change.
- SEC is considering adding auction feeds to the public feeds (SIP), but NYSE feeds are incomplete until 3:55pm.
- Possible solutions:
 - Allow non-listing exchanges to compete for closing business? (e.g., CBOE Market Close)
 - Require NYSE to immediately incorporate D-Orders into auction feeds?
 - Ban D-Orders altogether?

Stock summary stats

Panel A: NYSE Stocks

	Mean	Median	P5	P25	P75	P95	SD
Daily Volume (\$M)	188.6	118.0	29.3	66.7	217.7	587.4	234.9
Daily Close Volume (\$M)	15.9	7.4	1.3	3.6	16.6	57.6	33.0
% Close Volume	8.9	6.3	1.8	3.8	10.6	24.3	9.6
Close Price	75.62	58.62	16.88	36.43	91.21	186.22	69.21
Eff. Spread (\$)	0.025	0.013	0.009	0.010	0.022	0.072	0.057
Eff. Spread (bps)	3.24	2.74	1.40	2.07	3.75	6.49	2.14
Lambda ($\times 10^6$)	0.418	0.309	-0.125	0.120	0.589	1.320	0.518
Intraday Volatility ($\times 10^6$)	0.177	0.031	0.008	0.018	0.056	0.166	37.0
Abs. Open-Close Return (bps)	101.5	71.5	6.2	32.1	134.7	298.0	115.3

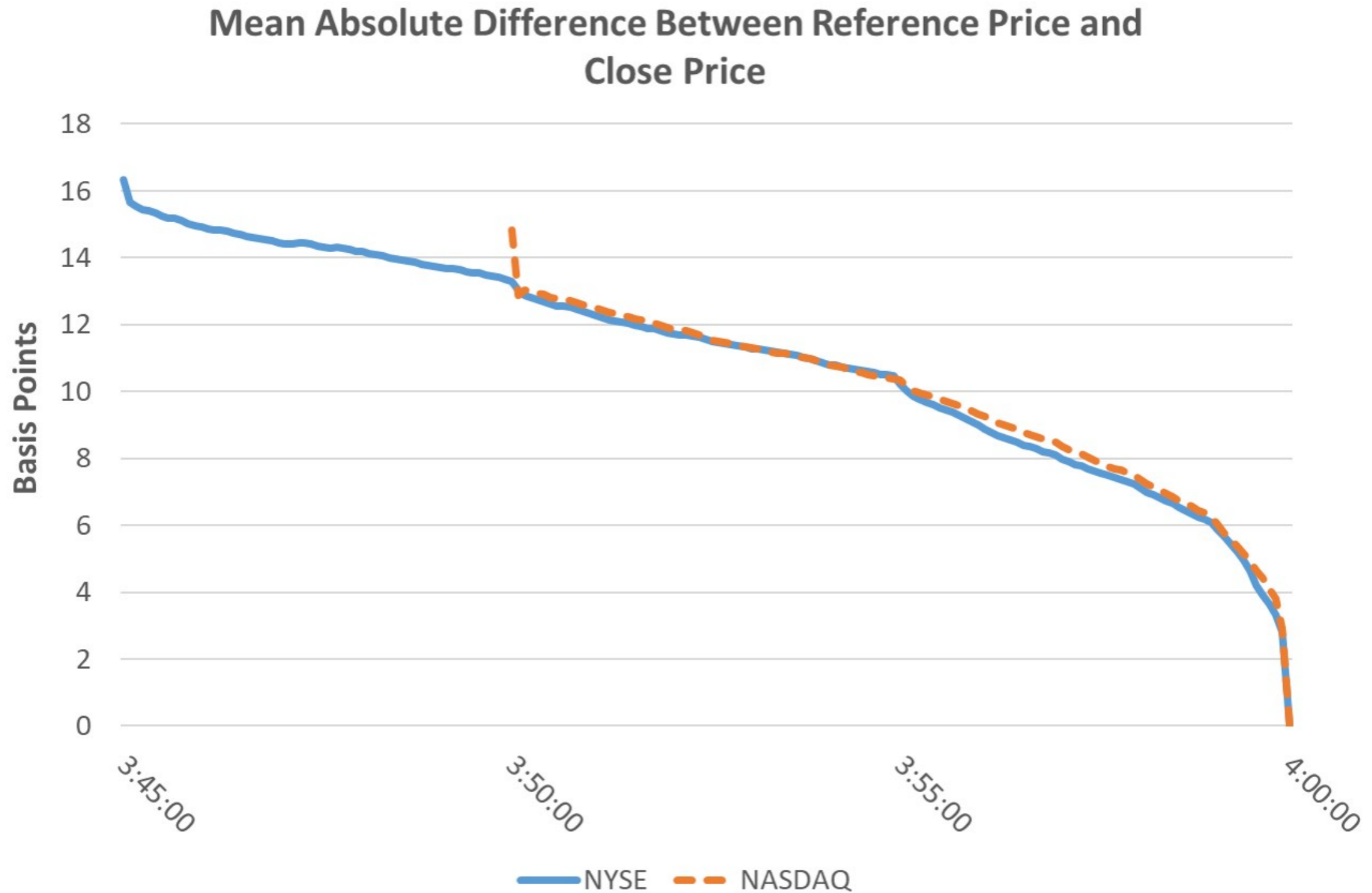
Panel B: Nasdaq Stocks

	Mean	Median	P5	P25	P75	P95	SD
Daily Volume (\$M)	322.6	126.2	28.2	68.2	264.5	1109.3	821.0
Daily Close Volume (\$M)	17.6	6.2	1.1	3.0	15.2	66.5	50.1
% Close Volume	7.1	4.8	1.3	2.8	8.4	19.7	8.2
Close Price	92.34	53.31	12.09	31.45	85.02	305.93	163.42
Eff. Spread (\$)	0.037	0.012	0.009	0.010	0.022	0.148	0.192
Eff. Spread (bps)	3.91	3.04	1.60	2.32	4.32	8.36	7.27
Lambda ($\times 10^6$)	0.427	0.325	-0.131	0.127	0.618	1.325	0.499
Intraday Volatility ($\times 10^6$)	0.571	0.036	0.010	0.021	0.069	0.214	110.1
Abs. Open-Close Return (bps)	107.9	78.0	6.5	35.0	145.6	309.8	108.3

D-Order Advantages

- Can enter orders after the regular cutoff time of 3:50pm.
- Orders are hidden until 3:55pm.
- Can modify/cancel up until 3:59:50pm.
- D-Orders are allowed to add to the imbalances, and can “flip” the sign of the imbalance.
- Floor brokers get to see the complete auction feed starting at 2pm, well before the rest of the market.
- D-Orders also have execution priority.
- Mayhew, McCormick, and Spatt (2009): NYSE specialists trade in the direction of closing auction order imbalances before they are publicly reported.

Reference price difference



Transmission latency

MIDAS datacenter co-located at Nasdaq (Secaucus)

Dep. Variable: Transmission Latency (μs)

	(1)	(2)	(3)
$NYSE \times \mathbb{1}^{3:54}$	860.8*** (31.84)	864.3*** (31.66)	-87.90*** (-13.34)
$NYSE \times \mathbb{1}^{3:55}$	1007.0*** (34.27)	1003.9*** (33.88)	67.89*** (13.22)
$NYSE \times \mathbb{1}^{3:59}$	910.9*** (31.68)	911.5*** (31.28)	
$\mathbb{1}^{3:54}$	1.613 (0.54)	1.215 (0.41)	-17.01*** (-6.49)
$\mathbb{1}^{3:55}$	-2.719 (-0.98)	-2.733 (-0.99)	-4.920** (-2.51)
Constant	282.0*** (13.76)	624.6*** (7.89)	
$NYSE \times (\mathbb{1}^{3:55} - \mathbb{1}^{3:54})$	146.22*** (16.17)	139.67*** (15.68)	155.80*** (23.45)
SE Clustering	Symbol-Date	Symbol-Date	Symbol-Date
Fixed Effects	None	None	Symbol, Date
N	1,480,199	1,480,055	1,480,055
Adj. R^2	0.241	0.247	0.723