



Evaluation of Quote Quality across Exchange-Provided Indicative Price Feeds

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1. Introduction

Nasdaq Basic, NYSE BQT and Cboe One are proprietary consolidated market data feeds that provide a unified view of comprehensive last sale and Best Bid and Offer (“BBO”) in all Tape A, B, and C securities that trade across each of those exchange groups. They are not intended to be used for purposes of making order-routing or trading decisions, but rather provide indicative prices for NMS stocks. The exchange-provided indicative data feeds distribute on a real-time basis the same BBO information that their respective exchanges provide to the CTA/UTP Securities Information Processors (“SIP”), which disseminates the BBOs and last trades for NMS Stocks from all U.S. equities markets and calculates the National Best Bid or Offer (“NBBO”).

The NYSE BQT data feed provides best bid and offer and last sale information using the combined data from the New York Stock Exchange LLC (“NYSE”) and its affiliates, NYSE Arca, Inc. (“NYSE Arca”), NYSE American LLC (“NYSE American”), NYSE National, Inc. (“NYSE National”) and NYSE Chicago, Inc. (“NYSE Chicago”). NYSE BQT also includes trades reported to the FINRA/NYSE Trade Reporting Facility (“TRF”). The Cboe One Feed provides best bid and offer and last sale information using the combined data of the four Cboe U.S. equities exchanges, Cboe BZX Exchange, Inc. (“BZX”), Cboe BYX Exchange, Inc. (“BYX”), Cboe EDGX Exchange, Inc. (“EDGX”), and Cboe EDGA Exchange, Inc. (“EDGA”). Nasdaq Basic provides best bid and offer and last sale information based on data from the Nasdaq Stock Market LLC (“Nasdaq”) and also trades reported to the FINRA/Nasdaq TRFs. (Nasdaq Basic does not include Nasdaq BX, Inc. (“Boston”) and Nasdaq PHLX LLC (“PSX”) as part of its base package. Quotes from those exchanges are not included in the composition of Nasdaq Basic in our analysis.)

Here we present the results of a comparative study which was conducted to assess the quality of the three exchange-provided indicative data feeds; where quality is expressed as a measure of the percentage of time in which quotes from an exchange-provided indicative data feed are the same as the NBBO or within various thresholds of the NBBO. The study was conducted using SIP data collected from June 2021.¹

¹ NYSE Group provided financial support for this study.

2. Data

The data used in our analysis was sourced from NYSE Daily TAQ for the month of June 2021. NYSE Daily TAQ provides trades and top-of-book quotes from all NMS Stocks for all equities markets timestamped to the nanosecond and is sourced from SIP data. As of June 2021, there were 16 national stock exchanges in operation. There were 22 days in June on which these markets were open.

The dataset includes roughly 10,712 securities. This count varies from day to day as additional securities are listed and some are delisted. For example, on June 1, 2021, the dataset consisted of 10,712 securities of which 2,458 were ETPs (including exchange traded funds, notes and vehicles) and 558 were preferred stock. Of the total number of securities, 3,585 have their trades printed to Tape A, 2,420 to Tape B and 4,707 to Tape C.

In addition to these categories, securities can be grouped according to their trading volumes. We use four groups: (1) “High Volume”, where greater than 1,000,000 shares are traded daily; (2) “Excluding High-Volume”, where less than 1,000,000 shares are traded daily; (3) “Low Volume”, where less than 50,000 shares are traded daily; and (4) “Very-Low Volume”, where less than 10,000 shares are traded daily. Note that group 1 and group 2 are mutually exclusive, while group 3 is a subset of group 2 and group 4 is a subset of group 3.

On June 1, 2021, there were 1,932 High-Volume securities, 8,783 securities not considered High-Volume, 4,391 Low-Volume securities and 2,670 Very-Low-Volume securities. Note that since a symbol’s trading volume changes from day to day, a symbol’s classification with respect to a volume range may also change. The following table illustrates how the number of securities in these categories changed from the first to the last trading day of June 2021. These counts do not include test symbols.

Category	June 1	June 30
All	10,712	10,821
Tape A	3,585	3,575
Tape B	2,420	2,454
Tape C	4,707	4,789
ETP	2,458	2,496
Preferred	558	550
(1) Vol > 1MM	1,932	2,138
(2) Vol <= 1MM	8,783	8,683
(3) Vol < 50K	4,391	4,156
(4) Vol < 10K	2,347	2,264

Table 1: *Number of Securities per Category.*

Quotes for the three exchange-provided indicative data feeds were derived from the quotes of their constituent exchanges by comparing the bid/ask prices after each quote event. Among these top-of-

book quotes, the quote with the best bid price was selected for the feed's bid price and size, and the quote with the best ask price was selected as the feed's ask price and size.

When comparing an exchange-provided indicative data feed to the NBBO, we considered all eligible securities, regardless of whether an exchange or indicative feed produced a quote on a given day for that security. If an exchange or indicative feed does not quote an eligible security, then its average time within various thresholds of the NBBO, including "at" the NBBO, will be 0 for that day.

3. Methodology

To compare exchange-provided indicative data feed products to one another, we assessed their quote quality with respect to the prevailing NBBO. Several metrics were calculated that express both the percentage of time and size of a feed's quote, within various thresholds of the NBBO.

We define the term "within a threshold of X percent of the NBBO" for a quote as the condition where the quote's bid price differs from the national best bid (NBB) by no more than X percent and, at the same time, its ask price differs from the national best offer (NBO) by no more than X percent. When the threshold is zero on both sides the quote is said to be "at" the NBBO.

Using this definition, time-weighted averages, representing the percentage of time one can expect any quote to be within the NBBO, were calculated for each of the three exchange-provided indicative data feed products. Similar time-weighted averages were calculated for each of the constituent exchanges of the data feed products.

The time-weighted averages for each covered security were calculated over the twenty-two consecutive trading days from Tuesday, June 1, 2021, through Wednesday, June 30, 2021. Quotes occurring from market open, 9:30 am, until market close, 4:00 pm, were considered in the analysis, with the most recent quote prior to the open given a timestamp of 9:30 am to set the prevailing quote at the open. In addition, time intervals in which no NBBO had been established by the SIP, as in the case where both NBB and NBO are zero, were not included.

NYSE Daily TAQ data, as previously described, was obtained for this period, and was used in the analysis. All timestamps from the TAQ data were represented in nanoseconds and were not rounded during the analysis. Thresholds of 0.1%, 0.25%, 0.5%, and 1.0% were used to calculate the averages. (In absolute terms, these thresholds are 5 cents, 12.5 cents, 25 cents, and 50 cents, respectively, for a stock trading at \$50 a share.) Averages were calculated for each <symbol, date, feed> combination for benchmarking to the NBBO.

Time-weighted average display sizes at the NBBO for each exchange-provided indicative data feed were calculated by taking the sum of the display sizes of each constituent exchange quote with a price at the NBBO. For example, at a given time if the bid price for a 300-share quote from EDGA and the bid price for a 200-share quote from EDGX both were equal to the NBB, and quotes from BYX and BZX had bid prices lower than NBB, then the display size at the NBB for the CBOE One indicative feed quote would be 500 shares.

Symbols were grouped by security type (Preferred or ETP), tape (A, B, or C)², and ranges of daily volume (greater than 1,000,000 shares, less than 50,000 shares and less than 10,000 shares). Separate results were obtained for each category by applying an equal weight to the calculated averages of the symbols within the specific group.

² Tape A represents all NYSE-listed securities, Tape B represents all stocks listed on NYSE American, NYSE Arca and CBOE BZX, and Tape C represents all stocks listed on Nasdaq.

4. NBBO Results Summary

To highlight the general differences between the exchange-provided indicative data feeds, the following chart is presented. It compares the average percent of time in which quotes from each of the three indicative feeds were at the NBBO for each of the security categories during market hours (9:30 am to 4:00 pm).

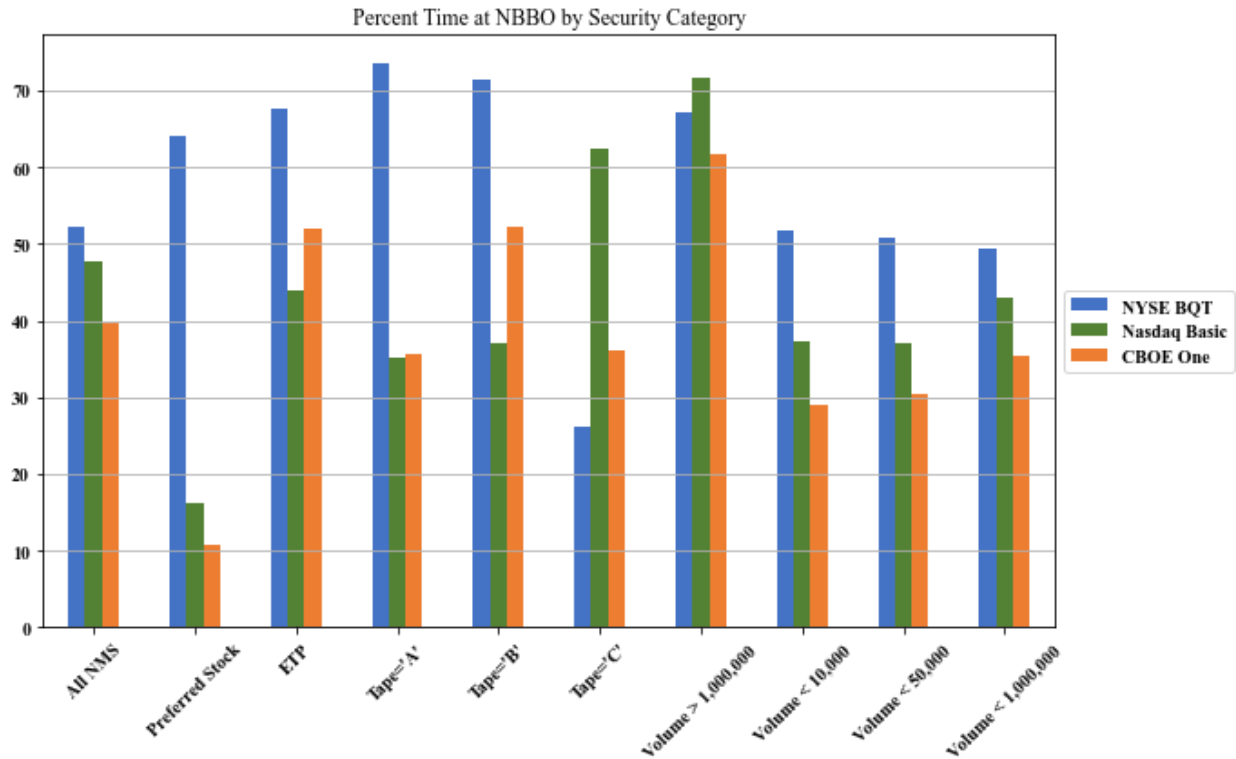


Figure 1: Percentage of time quotes are at the NBBO by security category.

The time-weighted average number of shares displayed when the quote is at the NBBO was also calculated.

Security Category	NYSE BQT	CBOE One	Nasdaq Basic
ALL	1,572	1,145	951
Tape A	1,594	805	574
Tape B	3,036	2,261	1,307
Tape C	804	829	1,052
ETP	3,217	2,448	1,569
Pref	513	200	158
(1) Vol > 1MM	4,992	3,212	2,768
(2) Vol <= 1MM	923	753	606
(3) Vol < 50K	839	695	591
(4) Vol < 10K	926	766	652

Table 2: Time-weighted average display size at the NBBO.³

³ A 99.5% winsorization was applied to shares displayed at the NBBO to reduce the effect of outliers, resulting in a more accurate picture of liquidity available on each market.

5. Pre-Market: 9:15 am to 9:30 am

In addition to the quote analysis performed on quotes during market hours, we also performed similar analysis for the fifteen minutes prior to the opening of the markets.⁴

The following chart presents the average percent of time in which quotes from each of the three exchange-provided indicative data feeds were at the NBBO for each of the security categories from 9:15 am until 9:30 am.

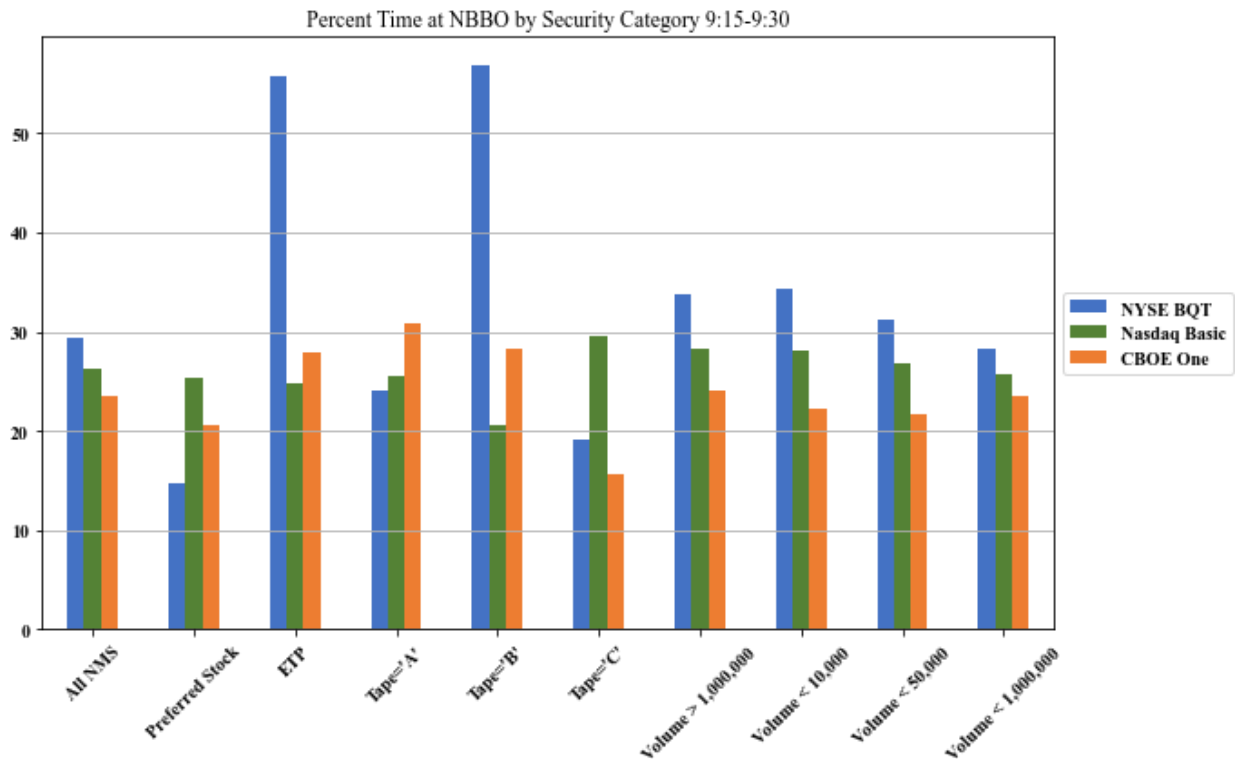


Figure 2: Pre-open percentage of time quotes are at the NBBO by security category.

When broken down by feed and exchange in the fifteen minutes before the open, we find that the NBBO is driven by only a small number of exchanges; in particular, NYSE Arca, BZX, EDGX, and Nasdaq. This is illustrated in figure 3 which follows.

⁴ NYSE does not quote Tape A securities prior to 9:30 am.

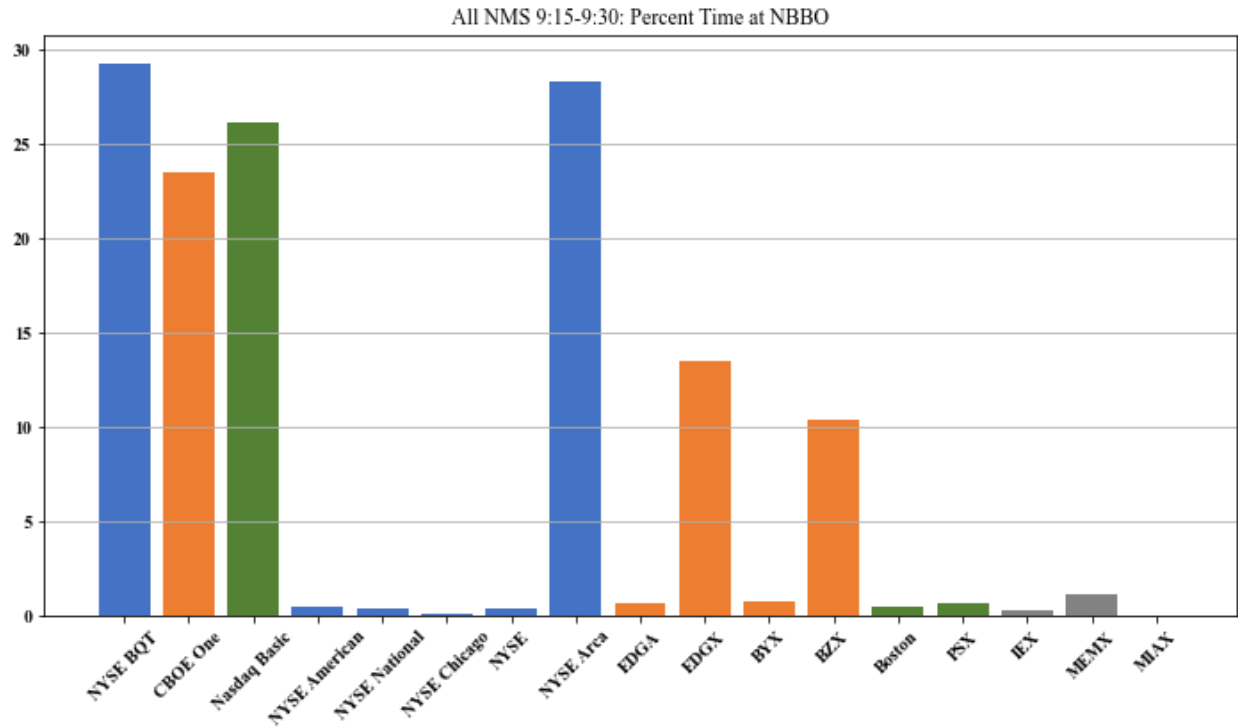


Figure 3: Pre-open percentage of time quotes are at the NBBO by feed/exchange.

6. Quote Analysis Results by Category

Results for the various groups of securities are presented in the sections that follow. Each will show (1) the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and individual exchanges (Long-Term Stock Exchange, Inc. is not shown), (2) changes in the time percentages as the threshold from the NBBO is increased from 0 to 1%, and (3) the count of securities in which their calculated average percent of time at the NBBO is above 90%, 80%, and down to 0%.

6.1 All NMS Securities

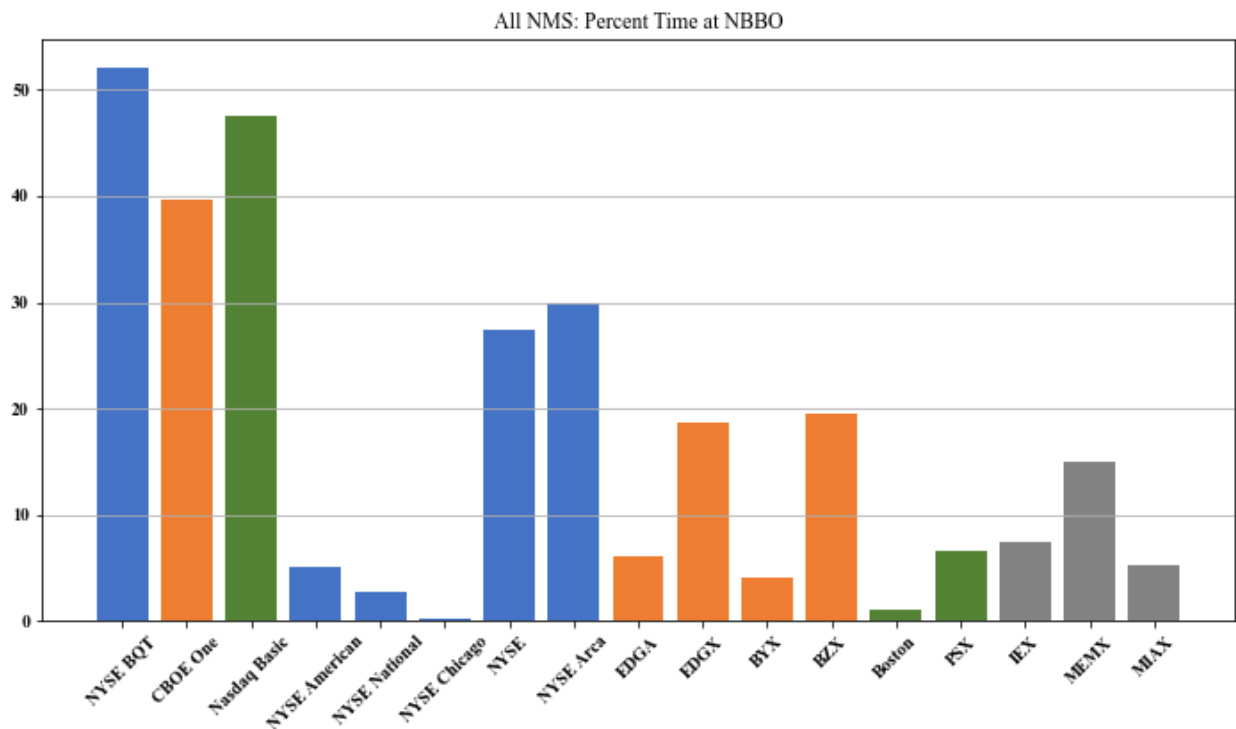
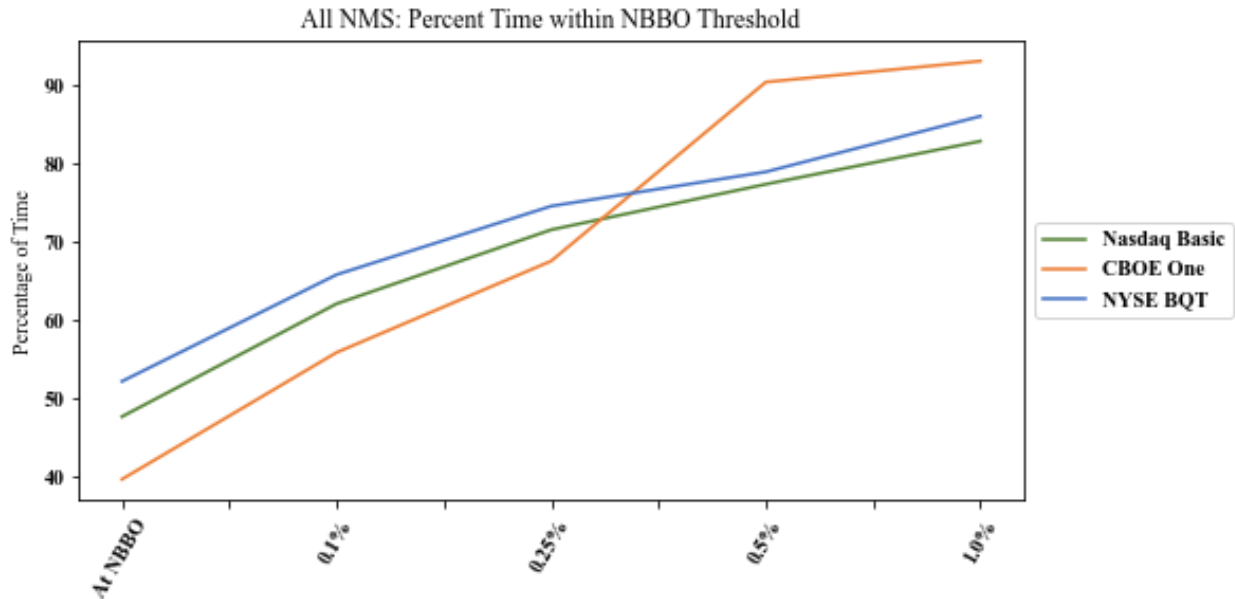


Figure 4: Percentage of time All NMS quotes are at the NBBO by feed/exchange.

The preceding chart presents the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and their constituent exchanges for all NMS stocks.



The preceding figure illustrates the average percentage of time the exchange-provided indicative data feeds for all NMS Stocks are at or within thresholds of 0.1%, 0.25%, 0.50%, and 1%. (In absolute terms, these thresholds are 5 cents, 12.5 cents, 25 cents, and 50 cents, respectively, for a stock trading at \$50 a share.) As the amount of the threshold increases so too does the average percentage of time the exchange-provided indicative data feeds are within the threshold.

The number of NMS securities meeting thresholds of 90% of the time at the NBBO, down to 10% of the time at the NBBO are provided in the following table.

Security count at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	2,498	1,221	1,669
>= 80% of time	3,525	1,762	2,528
>= 70% of time	4,368	2,334	3,430
>= 60% of time	5,100	2,996	4,352
>= 50% of time	5,780	3,769	5,260
>= 40% of time	6,395	4,707	6,117
>= 30% of time	6,948	5,876	6,906
>= 20% of time	7,569	7,093	7,635
>= 10% of time	8,505	8,097	8,382
>= 0% of time	10,749	10,749	10,749

Table 3: Number of NMS securities meeting percent of time thresholds.

6.2 Tape A

Looking at the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and their constituent exchanges for Tape A (NYSE listed) stocks as we would expect NYSE BQT and its constituent exchanges perform significantly better than the other exchange-provided indicative data feed products and their constituent exchanges.

Similarly, the average percentage of time NYSE BQT is within thresholds of 0.1%, 0.25%, 0.50%, and 1% of the NBBO in all cases is higher than the other exchange-provided indicative data feed products, with Nasdaq Basic having the lowest average percentage of time within the thresholds.

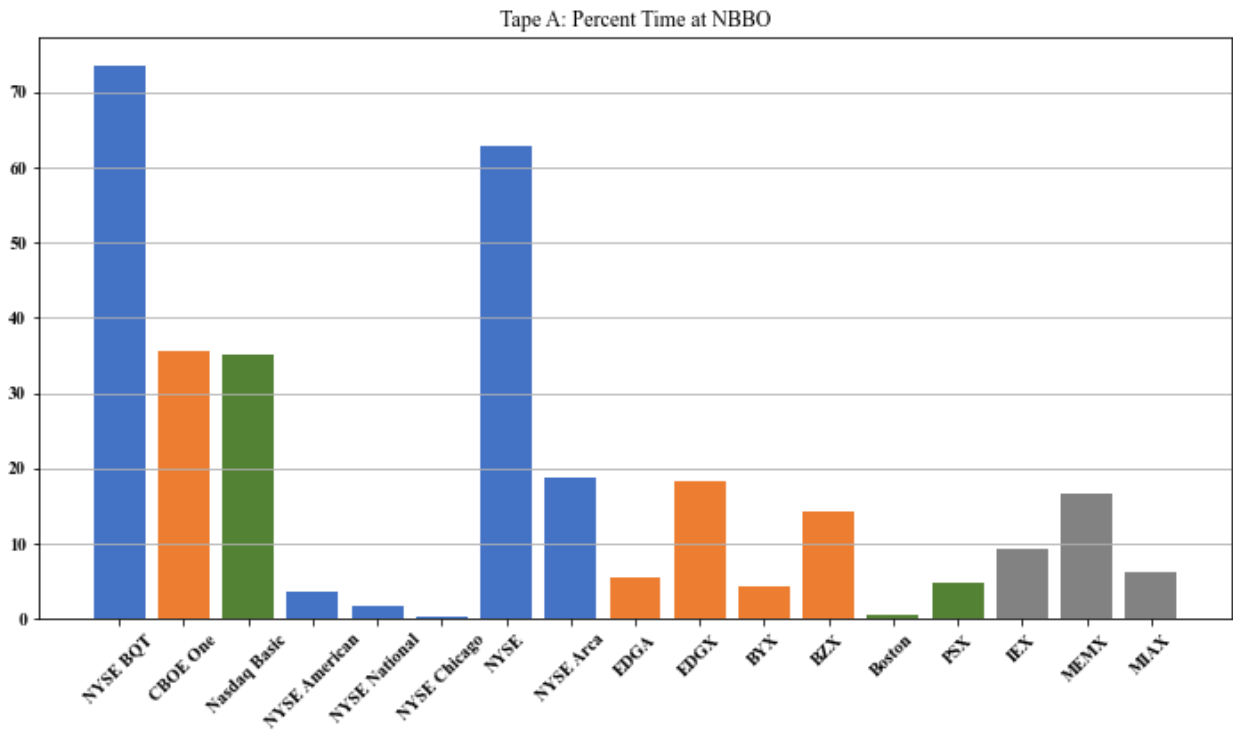
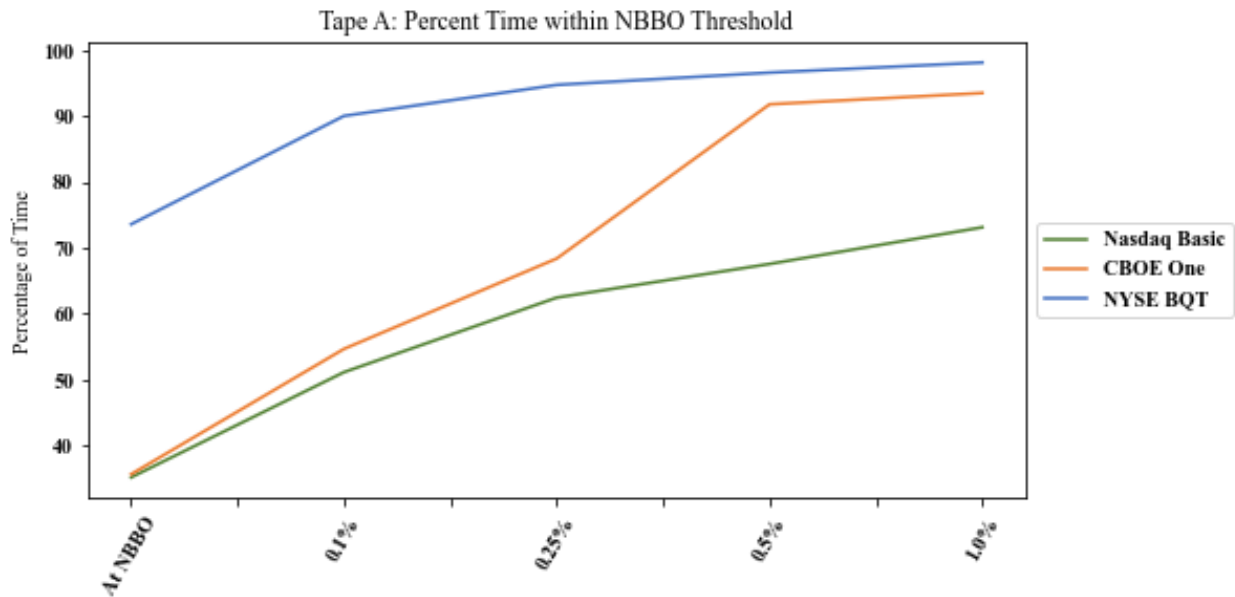


Figure 5: Percentage of time Tape A quotes are at the NBBO by feed/exchange.



Tape A securities at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	1,126	274	324
>= 80% of time	1,687	415	494
>= 70% of time	2,164	575	699
>= 60% of time	2,588	776	914
>= 50% of time	2,976	1,017	1,129
>= 40% of time	3,272	1,331	1,373
>= 30% of time	3,437	1,790	1,670
>= 20% of time	3,506	2,309	2,035
>= 10% of time	3,537	2,703	2,466
>= 0% of time	3,578	3,578	3,578

Table 4: Number of Tape A securities meeting percent of time thresholds.

6.3 Tape B

For Tape B (NYSE American, NYSE Arca, BZX listed) stocks, NYSE BQT continues to outperform the other exchange-provided indicative data feed products and their constituent exchanges in terms of the average percentage of time at the NBBO or within thresholds of 0.1%, 0.25%, 0.50%, and 1% of the NBBO.

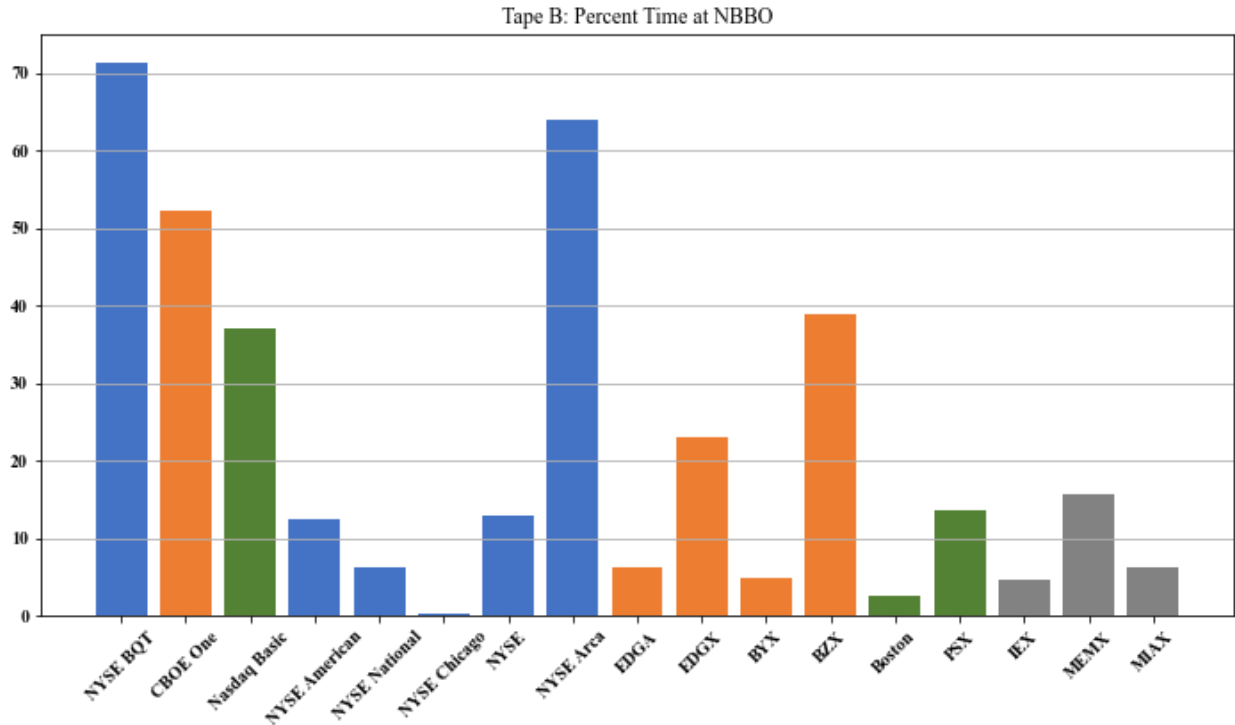
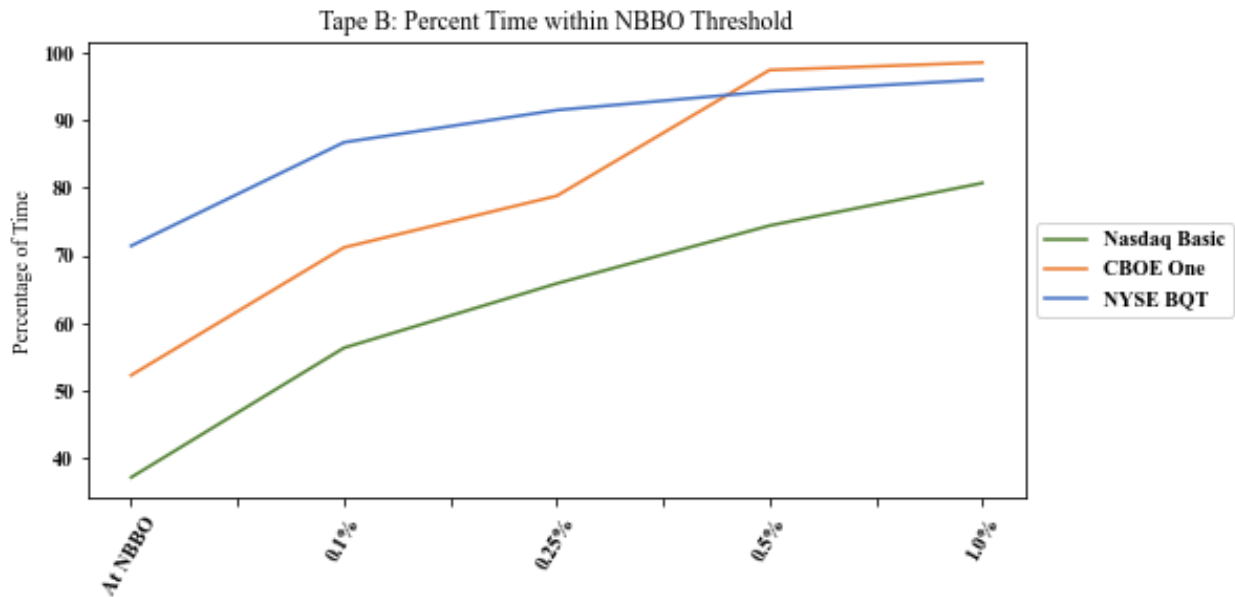


Figure 6: Percentage of time Tape B quotes are at the NBBO by feed/exchange.



Tape B securities at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	1,039	607	373
>= 80% of time	1,350	826	528
>= 70% of time	1,577	1,025	667
>= 60% of time	1,744	1,188	799
>= 50% of time	1,872	1,335	921
>= 40% of time	1,979	1,476	1,034
>= 30% of time	2,063	1,598	1,144
>= 20% of time	2,130	1,711	1,265
>= 10% of time	2,191	1,822	1,415
>= 0% of time	2,433	2,433	2,433

Table 5: Number of Tape B securities meeting percent of time thresholds.

6.4 Tape C

The following figure illustrates the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and their constituent exchanges for Tape C (Nasdaq listed) stocks and as we would expect Nasdaq Basic statistically outperforms the other exchange-provided indicative data feed products and their constituent exchanges.

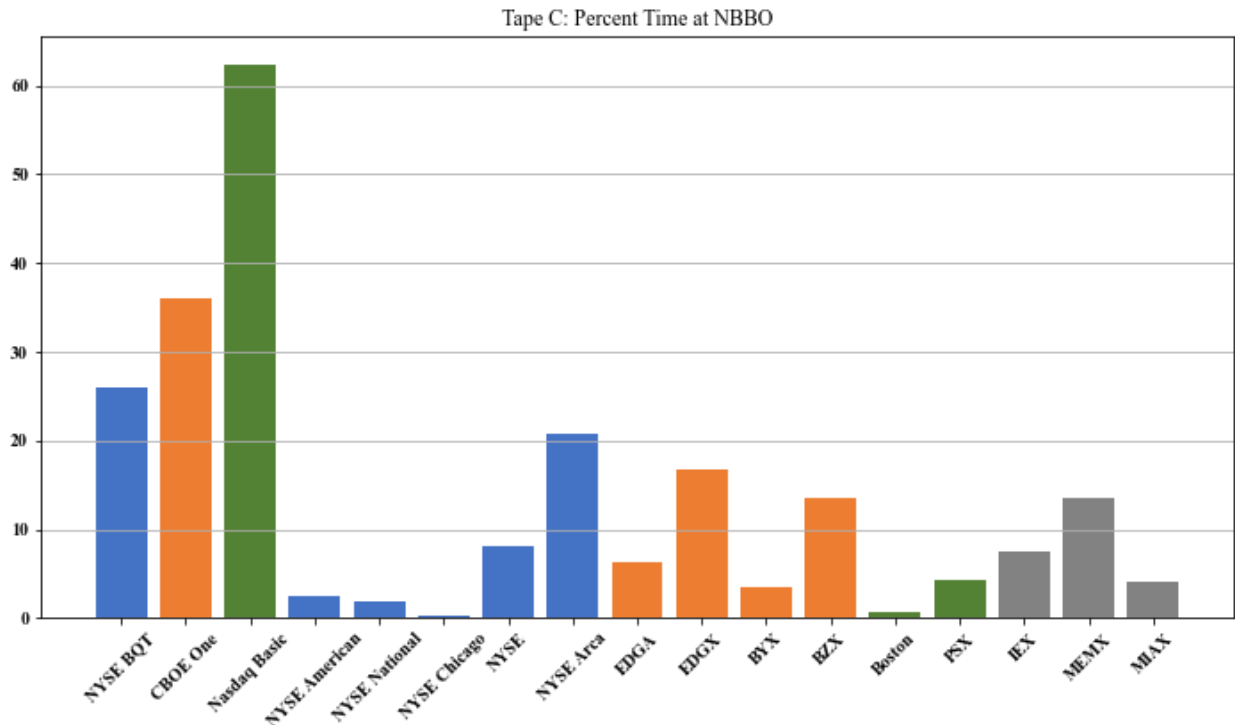
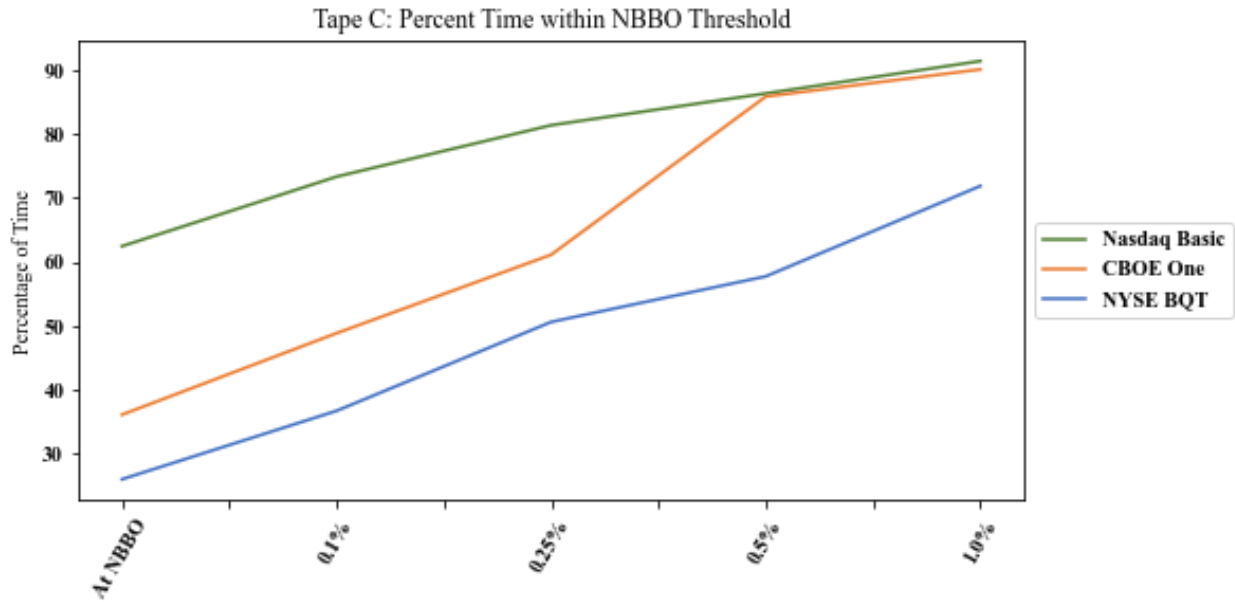


Figure 7: Percentage of time Tape C quotes are at the NBBO by feed/exchange.

The disparity in the average percentage of time Nasdaq Basic is within thresholds of the NBBO begins to converge with CBOE One at 0.50% threshold of the NBBO.



Tape C securities at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	332	339	971
>= 80% of time	486	520	1,505
>= 70% of time	626	734	2,064
>= 60% of time	767	1,032	2,638
>= 50% of time	931	1,416	3,208
>= 40% of time	1,143	1,899	3,710
>= 30% of time	1,447	2,488	4,092
>= 20% of time	1,932	3,072	4,334
>= 10% of time	2,776	3,571	4,500
>= 0% of time	4,737	4,737	4,737

Table 6: Number of Tape C securities meeting percent of time thresholds.

6.5 ETPs

For ETPs, NYSE BQT performs better than the other exchange-provided indicative data feed products largely due to quotes from NYSE Arca.

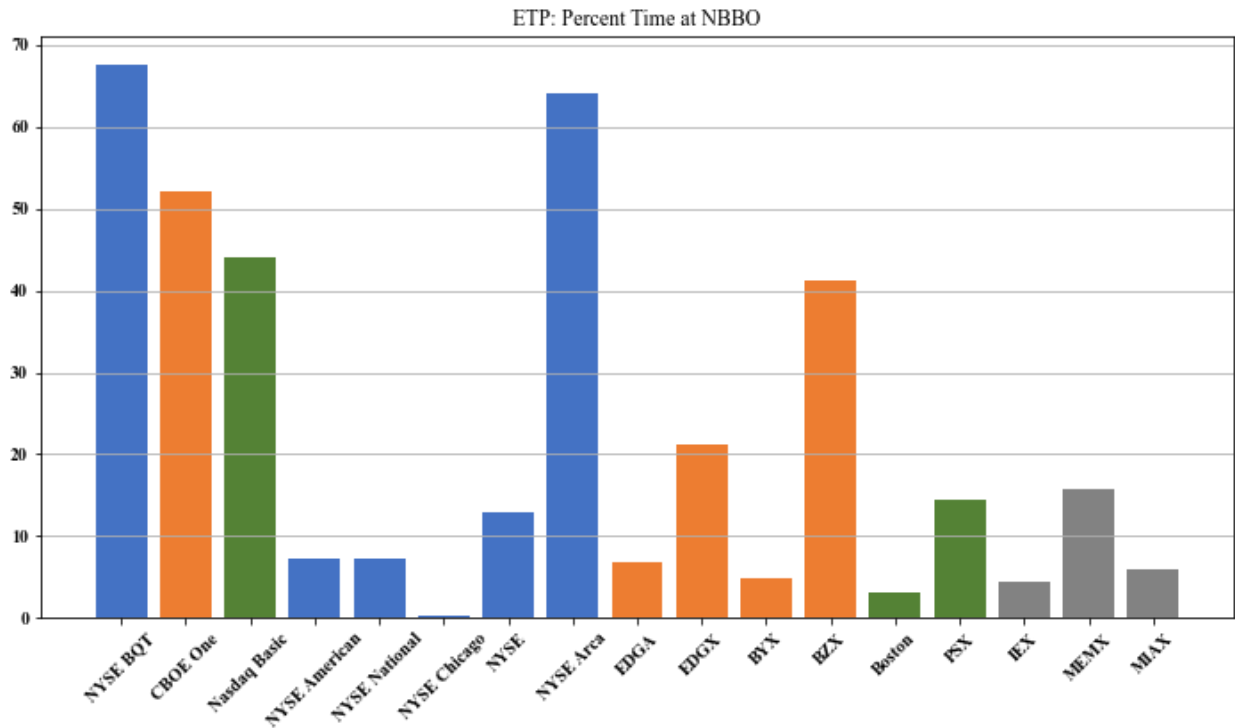
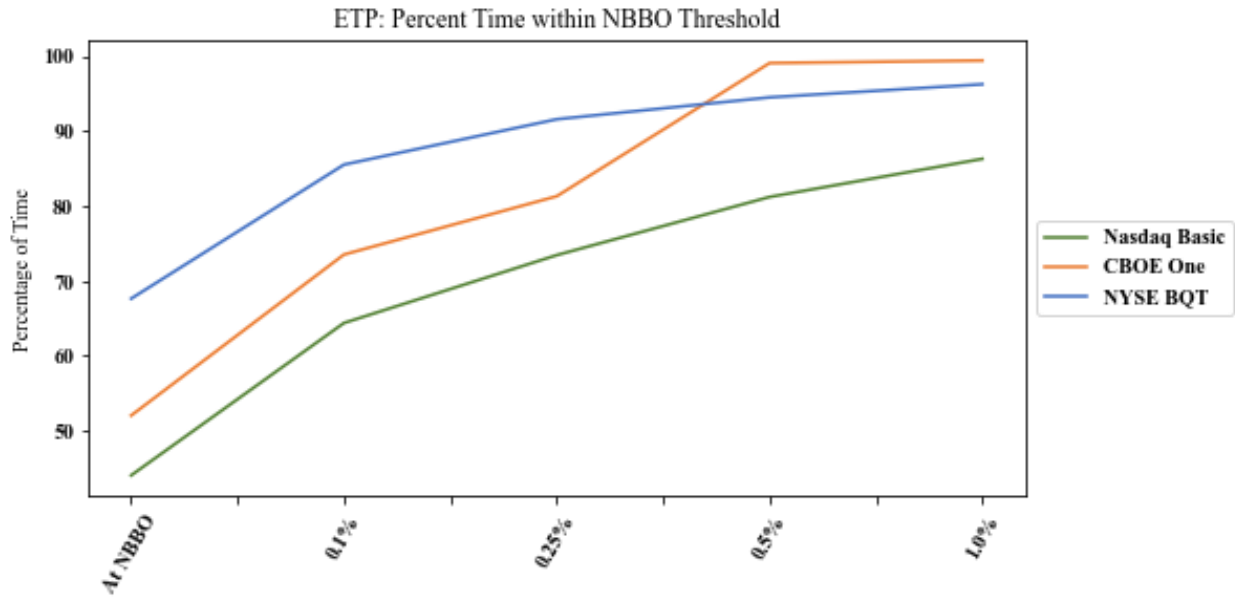


Figure 8: Percentage of time ETP quotes are at the NBBO by feed/exchange.

The disparity in the average percentage of time NYSE BQT is within thresholds of the NBBO begins to converge with CBOE One at 0.50% threshold of the NBBO.



ETPs at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	1,006	627	509
>= 80% of time	1,304	861	723
>= 70% of time	1,514	1,068	887
>= 60% of time	1,668	1,227	1,026
>= 50% of time	1,788	1,357	1,143
>= 40% of time	1,891	1,481	1,248
>= 30% of time	1,977	1,595	1,345
>= 20% of time	2,052	1,704	1,449
>= 10% of time	2,129	1,817	1,572
>= 0% of time	2,474	2,474	2,474

Table 7: Number of ETP securities meeting percent of time thresholds.

6.6 Preferred Stocks

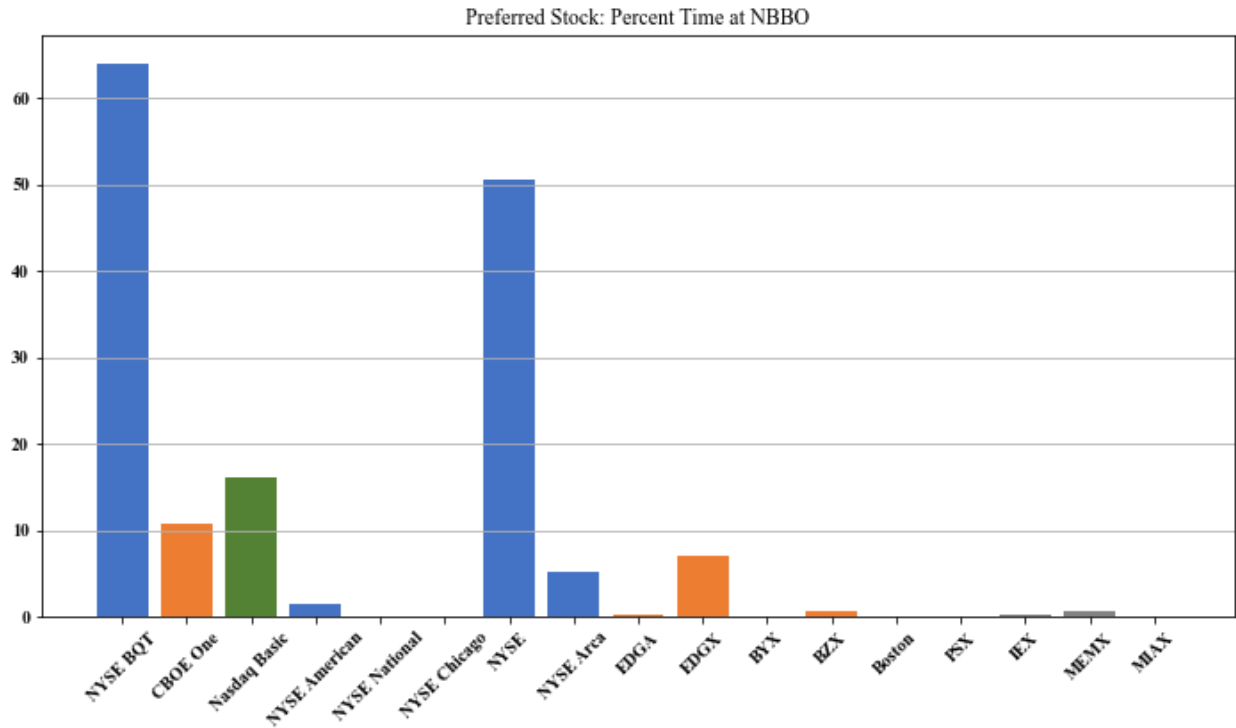
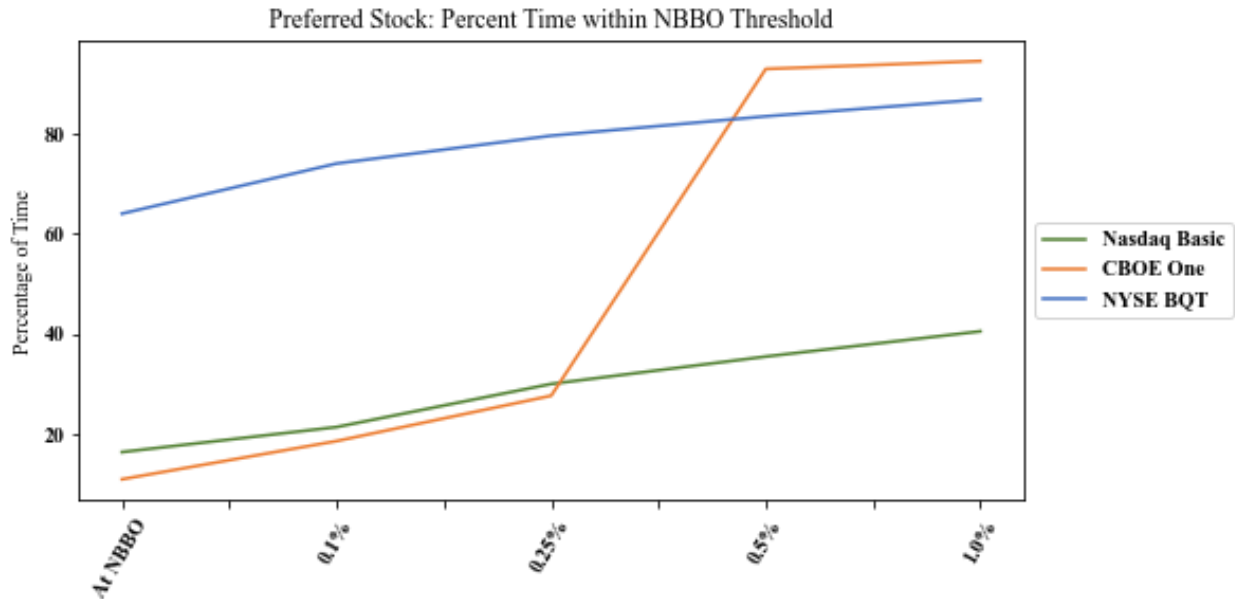


Figure 9: Percentage of time Preferred quotes are at the NBBO by feed/exchange.

The preceding figure illustrates the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and their constituent exchanges for Preferred shares and NYSE BQT statistically outperforms the other exchange-provided indicative data feed products and their constituent exchanges.



The disparity in the average percentage of time NYSE BQT is within thresholds of the NBBO in comparison to the other exchange-provided indicative data feed products begins to converge with CBOE One at 0.50 threshold of the NBBO. Note that there is a significant jump in CBOE One as the threshold is increased from 0.25% to 0.5%.

Preferred Stocks at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	171	4	24
>= 80% of time	268	8	37
>= 70% of time	328	13	49
>= 60% of time	365	20	62
>= 50% of time	394	30	74
>= 40% of time	414	45	90
>= 30% of time	432	69	111
>= 20% of time	448	106	136
>= 10% of time	464	165	182
>= 0% of time	556	556	556

Table 8: Number of Preferred securities meeting percent of time thresholds.

6.7 High Volume - Above 1MM Shares Traded Daily

For High Volume securities, where greater than 1,000,000 shares are traded daily, the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and their constituent exchanges increases in comparison to the data for all NMS stocks.

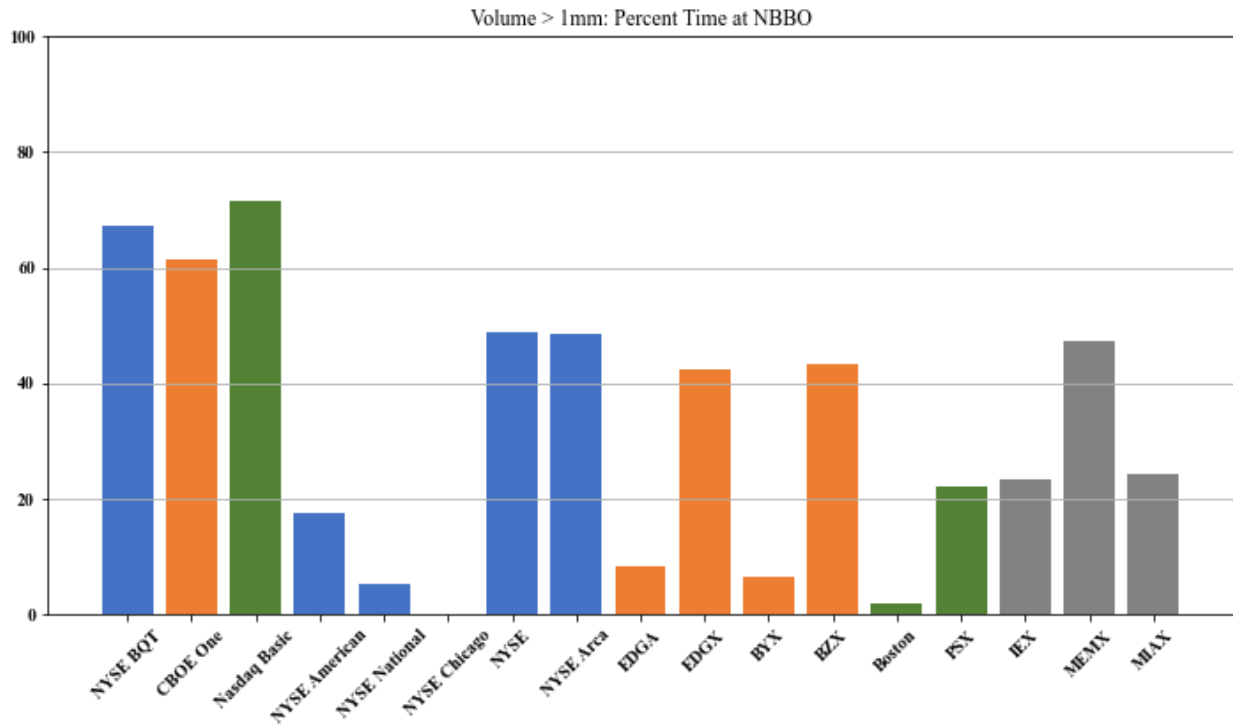
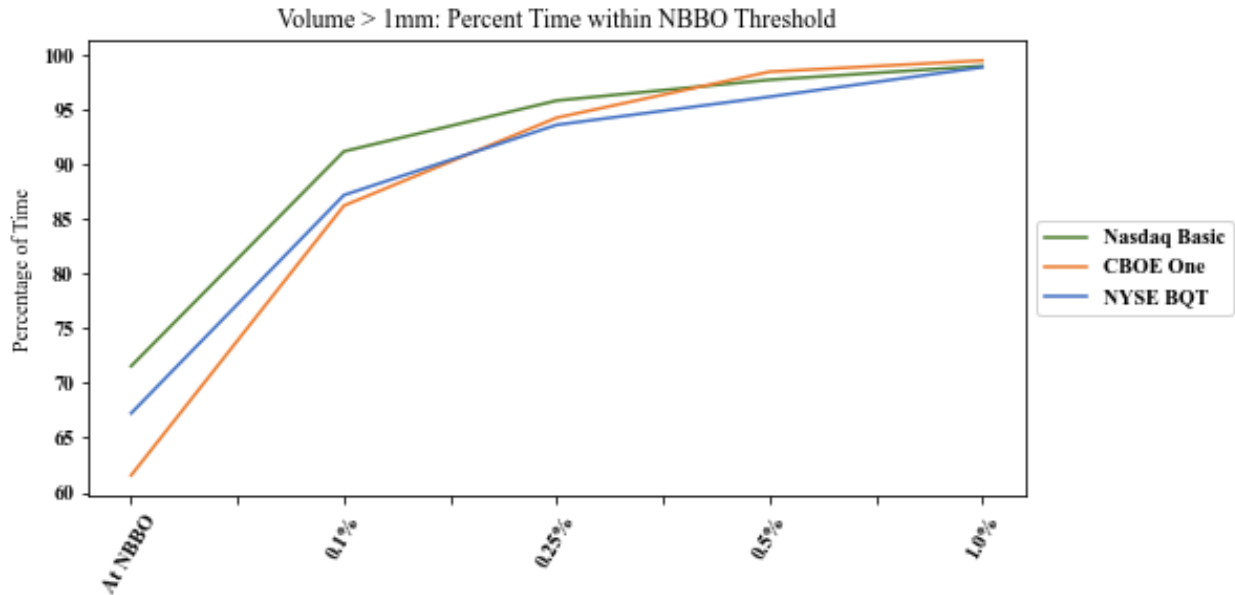


Figure 10: Percentage of time quotes for High-Volume securities are at the NBBO by feed/exchange.

Similarly, the average percentage of time the exchange-provided indicative data feeds for all High-Volume securities are at NBBO or within thresholds of 0.1%, 0.25%, 0.50%, and 1% all increases relative to the data for all NMS stocks.



High Vol Stocks at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	589	470	603
>= 80% of time	777	619	827
>= 70% of time	937	746	1,024
>= 60% of time	1,080	873	1,190
>= 50% of time	1,216	1,010	1,327
>= 40% of time	1,341	1,184	1,447
>= 30% of time	1,434	1,414	1,554
>= 20% of time	1,527	1,611	1,637
>= 10% of time	1,644	1,692	1,694
>= 0% of time	1,715	1,715	1,715

Table 9: Number of High-Volume securities meeting percent of time thresholds.

6.8 Excluding High Volume - Below < 1MM Shares Traded Daily

When the volumes decrease, we can see the quote quality begins to diminish. As can be seen in the following chart, average percentage of time at the NBBO is lower for each feed for stocks with volume less than 1MM daily shares than stocks with volumes greater than 1MM daily shares.

It can also be noticed that the improvement in quote quality for this group does not increase as fast as it did for the high-volume group.

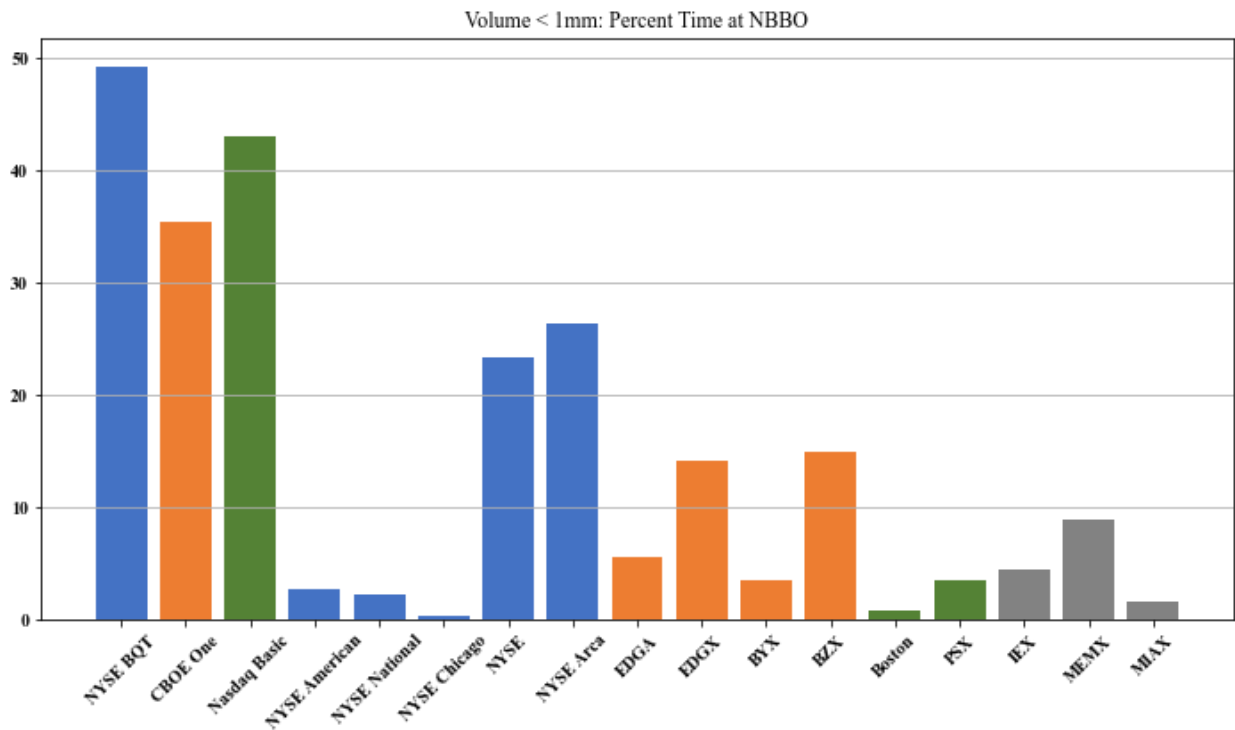
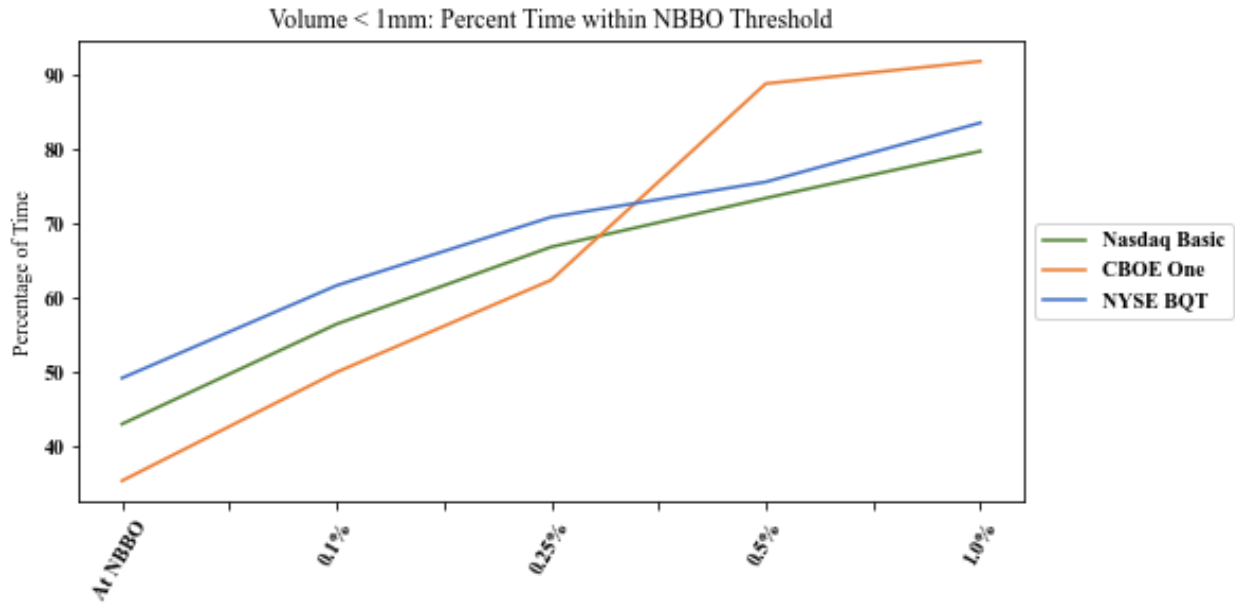


Figure 11: Percentage of time quotes for Non-High-Volume securities are at the NBBO by feed/exchange.



Vol < 1MM Stocks at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	1,909	751	1,065
>= 80% of time	2,747	1,142	1,701
>= 70% of time	3,431	1,587	2,405
>= 60% of time	4,020	2,122	3,161
>= 50% of time	4,563	2,759	3,933
>= 40% of time	5,054	3,523	4,670
>= 30% of time	5,513	4,462	5,351
>= 20% of time	6,042	5,481	5,998
>= 10% of time	6,860	6,404	6,688
>= 0% of time	9,034	9,034	9,034

Table 10: Number of securities with vol < 1MM meeting percent of time thresholds.

6.9 Low Volume - Below 50,000 Shares Traded Daily

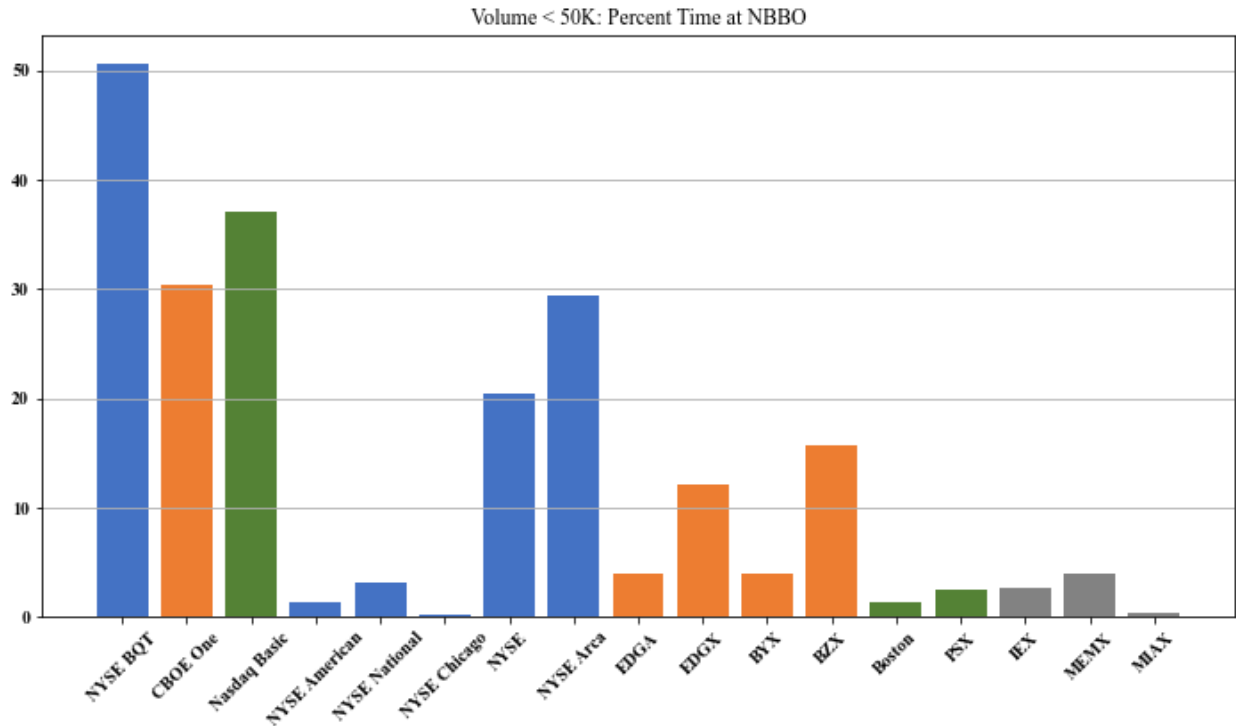
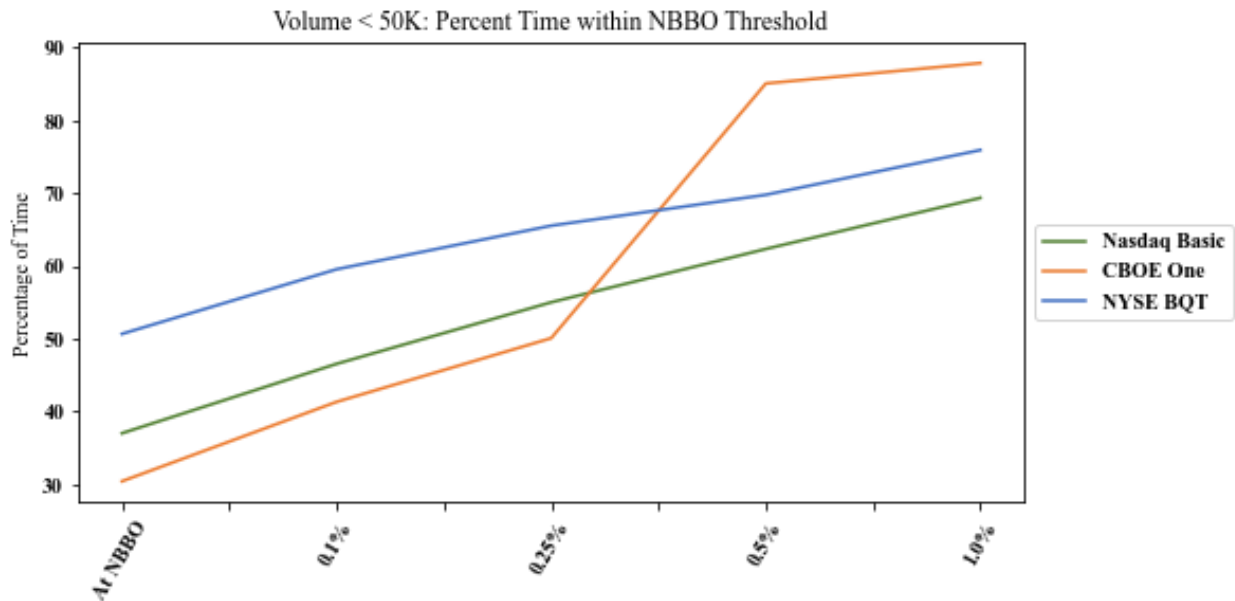


Figure 12: Percentage of time quotes for Low Volume securities are at the NBBO by feed/exchange.

NYSE BQT continues to outperform the other exchange-provided indicative data feed products and their constituent exchanges in the average percent of time quotes are at the NBBO for Low Volume stocks, where less than 50,000 shares are traded daily.



The average percentage of time Nasdaq Basic is within thresholds of 0.50% and 1% of the NBBO lags the other exchange-provided indicative data feed products. A steady increase is seen in NYSE BQT and an increase in CBOE One is seen again at 0.50%.

Vol < 50K count at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	1,341	519	699
>= 80% of time	1,755	728	969
>= 70% of time	2,055	929	1,219
>= 60% of time	2,284	1,128	1,470
>= 50% of time	2,476	1,336	1,721
>= 40% of time	2,643	1,561	1,966
>= 30% of time	2,800	1,808	2,209
>= 20% of time	2,956	2,103	2,461
>= 10% of time	3,169	2,465	2,770
>= 0% of time	4,662	4,662	4,662

Table 11: Number of Low Volume securities meeting percent of time thresholds.

6.10 Very Low Volume - Below 10,000 Shares Traded Daily

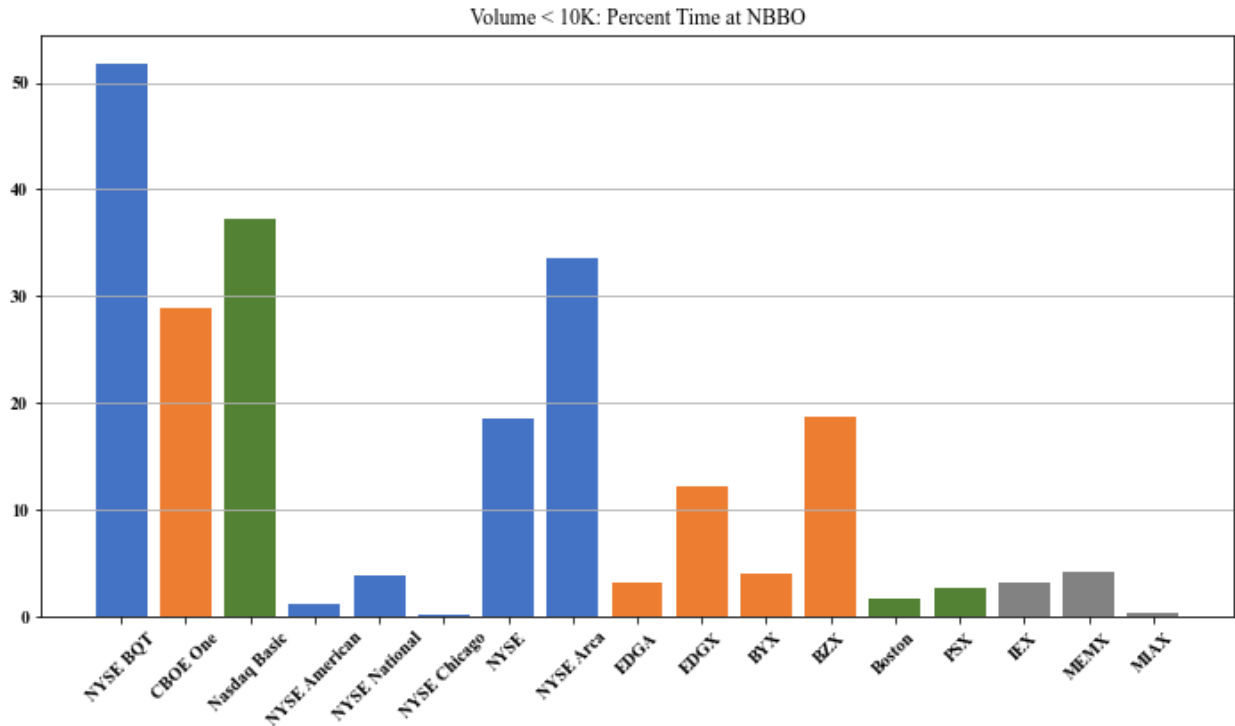
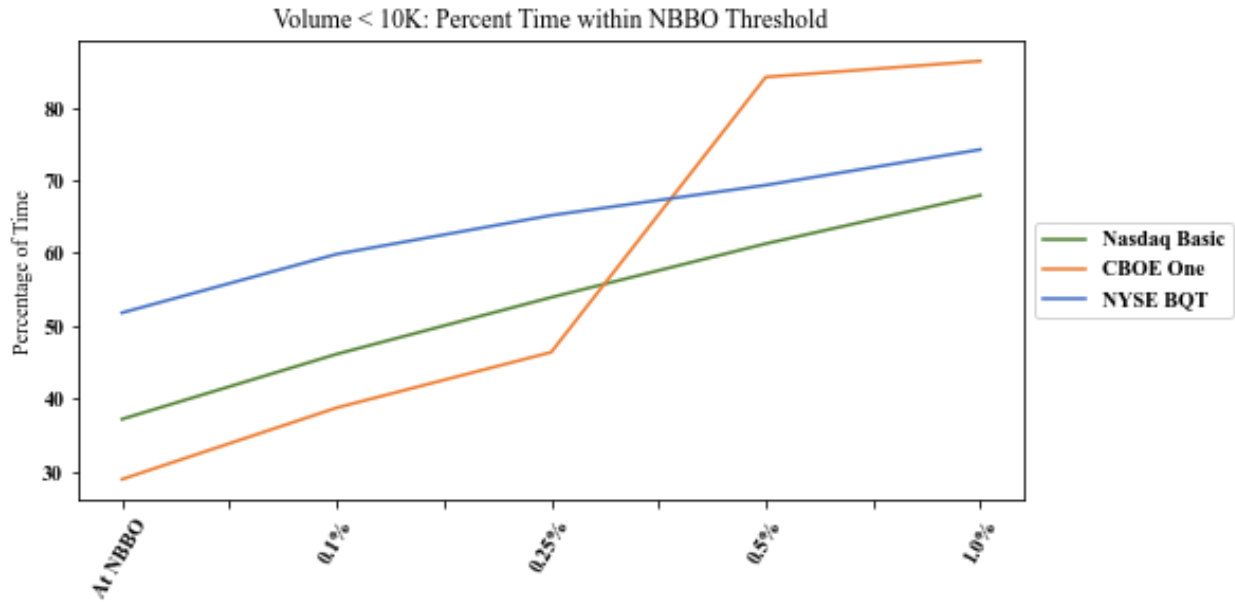


Figure 13: Percentage of time quotes for Very Low Volume securities are at the NBBO by feed/exchange.

In analyzing the average percent of time quotes are at the NBBO for each exchange-provided indicative data feed product and their constituent exchanges for Very Low Volume securities, NYSE BQT performs better than the other exchange-provided indicative data feed product and constituent exchanges. However, as the thresholds of NBBO increase to 1% CBOE One average percentage of time within the threshold of 1% is greater than NYSE BQT.



Vol < 10K count at NBBO	NYSE BQT	CBOE One	Nasdaq Basic
>= 90% of time	927	400	539
>= 80% of time	1,113	518	679
>= 70% of time	1,247	609	794
>= 60% of time	1,348	685	901
>= 50% of time	1,437	759	1,006
>= 40% of time	1,518	838	1,105
>= 30% of time	1,593	924	1,202
>= 20% of time	1,667	1,026	1,303
>= 10% of time	1,752	1,164	1,437
>= 0% of time	2,675	2,675	2,675

Table 12: Number of Very Low Volume securities meeting percent of time thresholds.

Appendix A: Time-weighted NBBO metrics

The following table shows the calculated average amount of time quotes are within threshold of 0 (“At”), 0.1, 0.25, 0.5 and 1% of NBBO for each security category and for each indicative feed and constituent exchange.

		NYSE BQT	CBOE ONE	Basic	A	C	M	N	P	J	K	Y	Z	Q	B	X	V	U	H	L
All	At	52.13	39.60	47.61	5.14	2.78	0.27	27.40	29.90	6.09	18.63	4.08	19.55	47.61	1.02	6.56	7.45	15.01	5.29	0.00
All	0.1	65.77	55.82	62.05	9.53	7.86	0.76	38.69	41.41	14.50	29.70	16.68	31.51	62.05	6.32	13.05	12.58	20.64	7.84	0.00
All	.25	74.54	67.51	71.51	16.14	15.69	7.54	49.99	51.35	26.86	40.86	31.26	41.96	71.51	18.23	26.00	14.78	23.78	12.05	0.00
All	0.5	78.92	90.40	77.34	19.23	17.90	8.57	54.90	60.84	40.20	54.50	44.93	83.87	77.34	32.35	38.83	16.43	26.47	12.69	0.00
All	1	86.04	93.09	82.84	23.59	19.21	8.94	59.88	74.74	51.09	69.85	54.87	89.07	82.84	42.99	47.43	17.68	28.53	13.05	0.01
A	At	73.57	35.61	35.14	3.54	1.66	0.21	62.84	18.69	5.62	18.27	4.30	14.29	35.14	0.50	4.88	9.27	16.58	6.17	0.00
A	0.1	90.02	54.64	51.10	8.65	6.85	0.31	84.40	30.35	13.58	30.06	17.97	25.08	51.10	2.89	12.22	13.96	22.35	8.98	0.00
A	.25	94.73	68.37	62.43	13.77	11.00	0.56	91.23	44.22	31.91	42.60	38.32	37.23	62.43	20.40	30.59	16.57	25.77	10.02	0.00
A	0.5	96.60	91.78	67.54	17.19	12.78	0.79	94.12	57.44	47.57	59.28	53.12	87.46	67.54	37.10	44.44	18.25	28.52	10.36	0.01
A	1	98.13	93.50	73.11	21.86	13.61	0.92	96.32	71.86	57.77	74.86	61.10	90.67	73.11	46.64	51.04	19.25	30.36	10.52	0.02
B	At	71.38	52.26	37.15	12.58	6.18	0.25	12.94	63.99	6.35	22.95	4.94	38.90	37.15	2.62	13.52	4.76	15.74	6.25	0.00
B	0.1	86.69	71.14	56.30	20.02	15.06	1.62	21.81	80.75	22.94	40.22	26.78	60.67	56.30	17.94	23.79	13.42	25.05	9.76	0.00
B	.25	91.46	78.78	65.82	33.45	34.61	25.11	29.36	85.94	32.32	52.88	38.19	69.75	65.82	29.72	34.04	15.29	28.41	21.96	0.00
B	0.5	94.22	97.38	74.38	35.97	37.86	28.32	34.87	89.26	42.86	62.73	48.60	94.76	74.38	42.35	45.44	16.29	30.11	23.06	0.00
B	1	95.95	98.49	80.67	37.73	39.29	29.25	38.90	92.24	50.55	68.86	56.05	96.64	80.67	50.91	52.43	17.01	31.18	23.49	0.00
C	At	26.03	36.11	62.41	2.53	1.88	0.32	8.05	20.86	6.30	16.68	3.48	13.59	62.41	0.59	4.26	7.44	13.45	4.12	0.00
C	0.1	36.72	48.83	73.27	4.80	4.93	0.65	12.82	29.56	10.85	24.02	10.52	21.40	73.27	2.94	8.17	11.10	17.09	5.99	0.00
C	.25	50.59	61.08	81.30	9.04	9.51	3.79	29.44	38.97	20.24	33.38	22.38	31.27	81.30	10.68	18.41	13.16	19.91	8.49	0.00
C	0.5	57.70	85.78	86.26	12.17	11.51	4.31	35.55	48.80	33.27	46.67	36.85	75.56	86.26	23.62	31.21	15.12	23.06	9.12	0.00
C	1	71.81	90.02	91.32	17.64	13.13	4.57	43.13	67.93	46.33	66.57	49.57	83.97	91.32	36.18	42.13	16.84	25.79	9.60	0.01
Low	At	50.68	30.45	37.04	1.29	3.13	0.20	20.38	29.50	3.93	12.09	3.89	15.68	37.04	1.34	2.43	2.70	3.93	0.44	0.00
Low	0.1	59.54	41.35	46.57	2.05	4.34	0.79	25.08	37.55	7.33	19.44	9.98	24.65	46.57	4.42	5.04	4.87	6.11	0.86	0.00
Low	.25	65.53	50.09	55.01	6.79	10.97	8.14	31.05	43.10	11.43	29.13	15.32	30.03	55.01	8.84	9.32	5.91	7.65	4.88	0.01
Low	0.5	69.76	85.04	62.33	7.65	12.21	9.35	35.22	48.40	18.04	38.51	21.95	79.58	62.33	15.17	15.81	7.01	8.99	5.25	0.01
Low	1	75.91	87.85	69.34	8.24	12.63	9.74	38.90	58.13	24.45	49.14	27.70	83.54	69.34	20.42	21.01	7.49	9.68	5.37	0.01
VL	At	51.81	28.91	37.18	1.26	3.96	0.16	18.60	33.51	3.17	12.24	4.06	18.77	37.18	1.74	2.66	3.26	4.29	0.45	0.00
VL	0.1	59.87	38.74	46.12	1.93	5.40	0.94	22.27	41.23	6.16	18.61	9.67	27.29	46.12	5.06	5.09	5.40	6.00	0.87	0.00
VL	.25	65.20	46.38	53.92	5.24	10.77	6.91	26.89	46.16	10.00	26.94	14.24	32.18	53.92	8.74	8.23	6.34	7.24	3.66	0.00
VL	0.5	69.35	84.22	61.30	5.86	12.10	8.19	30.35	50.86	15.53	35.56	19.27	80.28	61.30	13.23	12.79	7.40	8.35	3.98	0.00
VL	1	74.25	86.41	67.95	6.19	12.48	8.56	33.69	57.59	19.38	43.85	22.89	82.55	67.95	17.18	16.12	7.86	8.86	4.08	0.00
XHV	At	49.26	35.43	43.07	2.79	2.32	0.29	23.32	26.33	5.67	14.12	3.59	15.02	43.07	0.85	3.62	4.43	8.87	1.70	0.00

XHV	0.1	61.71	50.05	56.52	5.36	4.78	0.74	32.64	35.69	10.98	22.68	12.54	25.00	56.52	4.52	8.16	8.05	12.85	2.85	0.00
XHV	.25	70.92	62.44	66.90	11.57	12.15	7.76	43.71	45.10	20.78	33.42	25.08	34.83	66.90	14.13	19.47	9.77	15.68	7.17	0.00
XHV	0.5	75.65	88.88	73.47	14.16	13.88	8.79	48.69	54.87	33.82	47.48	38.53	81.82	73.47	27.52	32.21	11.16	18.32	7.69	0.01
XHV	1	83.61	91.89	79.79	18.12	14.73	9.14	53.83	70.36	44.99	64.62	48.63	87.46	79.79	37.75	41.24	12.04	20.31	7.92	0.01
HV	At	67.24	61.56	71.54	17.51	5.18	0.15	48.87	48.67	8.29	42.39	6.66	43.43	71.54	1.93	22.07	23.33	47.35	24.20	0.00
HV	0.1	87.16	86.20	91.16	31.49	24.08	0.87	70.56	71.50	33.04	66.66	38.52	65.80	91.16	15.82	38.84	36.43	61.70	34.12	0.00
HV	.25	93.58	94.23	95.79	40.20	34.34	6.39	83.10	84.29	58.92	80.10	63.84	79.51	95.79	39.83	60.45	41.17	66.46	37.75	0.00
HV	0.5	96.14	98.43	97.69	45.91	39.06	7.42	87.60	92.29	73.80	91.51	78.63	94.64	97.69	57.77	73.71	44.16	69.43	39.02	0.00
HV	1	98.84	99.45	98.95	52.42	42.83	7.91	91.74	97.82	83.20	97.38	87.77	97.55	98.95	70.59	80.00	47.38	71.83	40.09	0.00
ETP	At	67.77	52.27	44.39	7.67	7.05	0.25	13.51	64.29	6.88	21.96	5.09	41.39	44.39	3.11	14.97	4.81	16.34	6.47	0.00
ETP	0.1	85.70	73.76	64.76	15.47	17.59	2.12	23.67	84.10	26.21	41.35	29.56	66.65	64.76	20.85	27.39	15.50	26.99	10.74	0.00
ETP	.25	91.73	81.53	73.78	30.81	40.69	30.21	32.16	90.33	36.87	55.20	42.24	76.65	73.78	34.54	38.94	17.54	30.40	25.62	0.00
ETP	0.5	94.63	99.08	81.44	32.65	43.96	33.90	37.90	93.85	48.61	65.28	53.72	98.94	81.44	49.00	51.29	18.28	31.73	26.81	0.00
ETP	1	96.34	99.42	86.44	33.56	44.86	34.93	41.59	95.98	56.00	70.82	60.78	99.35	86.44	57.96	58.38	18.67	32.19	27.12	0.00
Pref	At	64.04	10.79	16.24	1.54	0.03	0.01	50.62	5.17	0.28	7.18	0.11	0.70	16.24	0.01	0.00	0.21	0.70	0.05	0.00
Pref	0.1	74.09	18.45	21.25	1.94	0.05	0.01	63.17	9.67	0.55	13.38	0.29	1.21	21.25	0.02	0.01	0.27	1.23	0.07	0.00
Pref	.25	79.67	27.54	29.90	2.28	0.08	0.01	69.92	15.21	1.04	21.47	0.57	1.71	29.90	0.05	0.04	0.37	1.68	0.07	0.00
Pref	0.5	83.55	93.05	35.39	2.60	0.12	0.01	74.29	21.67	1.52	30.69	1.00	90.18	35.39	0.09	0.09	0.50	1.93	0.07	0.00
Pref	1	86.93	94.63	40.45	2.92	0.16	0.02	76.95	36.77	1.85	43.21	1.78	91.36	40.45	0.11	0.15	0.56	2.08	0.07	0.00

Security Categories

All:	All NMS stocks	ETP:	Exchange traded products
HV:	High volume (> 1MM)	Pref:	Preferred stocks
A:	Tape A	Low:	Low volume (< 50K)
B:	Tape B	VL:	Very low volume (< 10K)
C:	Tape C	XHV:	X-High-Volume (< 1MM)

Exchanges

A:	NYSE American LLC	N:	New York Stock Exchange LLC
B:	NASDAQ BX, Inc.	P:	NYSE Arca, Inc.
C:	NYSE National, Inc.	Q:	The Nasdaq Stock Market LLC
H:	MIAX PEARL, LLC	U:	MEMX LLC
J:	Cboe EDGA Exchange, Inc.	V:	Investors Exchange LLC
K:	Cboe EDGX Exchange, Inc.	X:	NASDAQ PHLX LLC
L:	Long-Term Stock Exchange, Inc.	Y:	Cboe BYX Exchange, Inc.
M:	NYSE Chicago, Inc.	Z:	Cboe BZX Exchange, Inc.

Appendix B: Time-weighted display size metrics

The following table shows the calculated average one-sided display size for each exchange-provided indicative data feed and exchange when their quotes are at the NBBO price. A 99.5% winsorization was applied to shares at the NBBO to reduce the effect of outliers, resulting in a more accurate picture of liquidity available on each market.

	NYSE BQT	CBOE ONE	Basic	A	C	M	N	P	J	K	Y	Z	Q	B	X	V	U	H	L
ALL	1572	1145	951	57	44	3	592	830	74	547	96	427	951	46	133	93	305	29	0
A	1594	805	574	32	35	3	1010	459	44	431	56	266	574	17	69	97	223	23	0
B	3036	2261	1307	166	87	2	761	1956	152	880	224	1007	1307	131	340	115	606	58	0
C	804	829	1052	19	30	4	190	533	58	463	60	249	1052	25	75	80	211	18	0
Low	839	695	591	10	21	1	259	510	56	296	76	267	591	39	51	26	99	5	0
VL	926	766	652	9	24	1	253	587	64	292	93	318	652	47	56	27	107	3	0
XHV	923	753	606	25	24	3	323	521	61	354	70	268	606	34	75	48	153	12	0
HV	4992	3212	2768	224	152	3	2009	2460	146	1564	235	1261	2768	111	443	332	1102	116	0
ETP	3217	2448	1569	112	95	2	814	2105	181	917	253	1119	1569	153	403	130	679	61	0
Pref	513	200	158	8	2	0	364	122	7	162	4	25	158	1	2	5	37	0	0

Security Categories

All:	All NMS stocks	ETP:	Exchange traded products
HV:	High volume (> 1MM)	Pref:	Preferred stocks
A:	Tape A	Low:	Low volume (< 50K)
B:	Tape B	VL:	Very low volume (< 10K)
C:	Tape C	XHV:	X-High-Volume (< 1MM)

Exchanges

A:	NYSE American LLC	N:	New York Stock Exchange LLC
B:	NASDAQ BX, Inc.	P:	NYSE Arca, Inc.
C:	NYSE National, Inc.	Q:	The Nasdaq Stock Market LLC
H:	MIAX PEARL, LLC	U:	MEMX LLC
J:	Cboe EDGA Exchange, Inc.	V:	Investors Exchange LLC
K:	Cboe EDGX Exchange, Inc.	X:	NASDAQ PHLX LLC

L: Long-Term Stock Exchange, Inc.
M: NYSE Chicago, Inc.

Y: Cboe BYX Exchange, Inc.
Z: Cboe BZX Exchange, Inc.