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1 Dataset

The tick dataset provided had a total of 16 columns, 4 of which (columns 2, 10, 14 and 16) are not used in the analysis. The dataset was initially sorted by ticker, date and seconds past midnight in the respective order, which had a total of 13,260,277 rows. After filtering out for auction events (removing rows where bid > ask), there were 13,099,801 remaining. A further filtering by only including condition codes XT and 0 and removing every other condition code reduced the number of rows to 12,969,198, and finally the number of rows where update type = 1 (which indicates a trade) was at 1,516,299.

Table	No. of rows
df_sorted	13,260,277
df_remove_auc	13,099,801
df_conditions_filtered	12,969,198
df_trades	1,516,299

Table 1: Rows during data filtration

In the context of this dataset, a particular entry is defined as a 'trade' if and only if its update flag is 1. Rows with any other update flag (including 1) are defined as 'ticks', meaning that after applying the prior filters, there are a total of 12,969,198 ticks, and 1,516,299 of these are trade orders.

Additionally, after the filtration the total number of unique tickers decreased from 100 by 1 to 99. The ticker code 'BBHBEAT Index' was completely filtered out, and a google search revealed that it is a ticker used to check connectivity purposes, hence it was the only ticker with a anomalous condition code (@1).

2 Mean time

2.1 Between trades

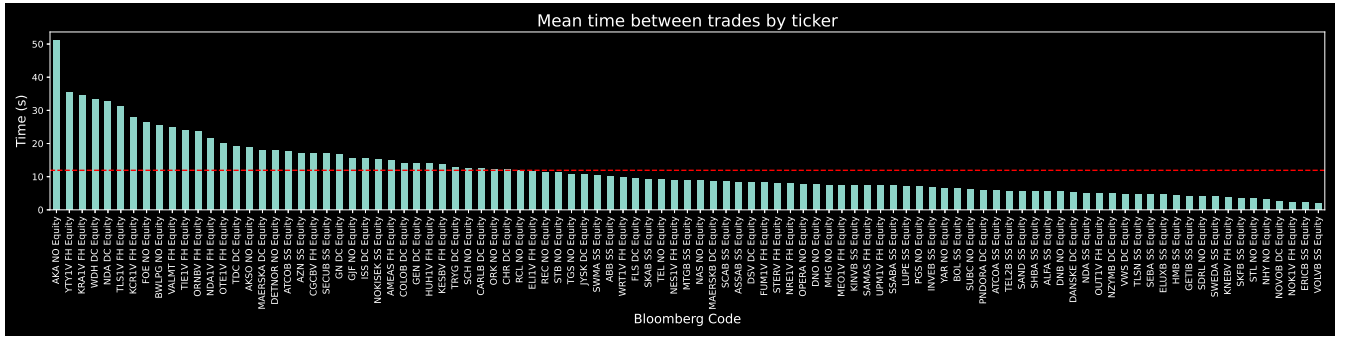


Figure 1: Bar plot of the mean time between each trade, sorted in descending order

The ticker AKA:NO had the highest mean time between trades at 51.089 seconds, and VOLVB:SS had the lowest mean time between trades at 2.0823 seconds. The mean level of the bar plot is 11.921 seconds, as indicated by the dashed red line.

2.2 Between tick changes

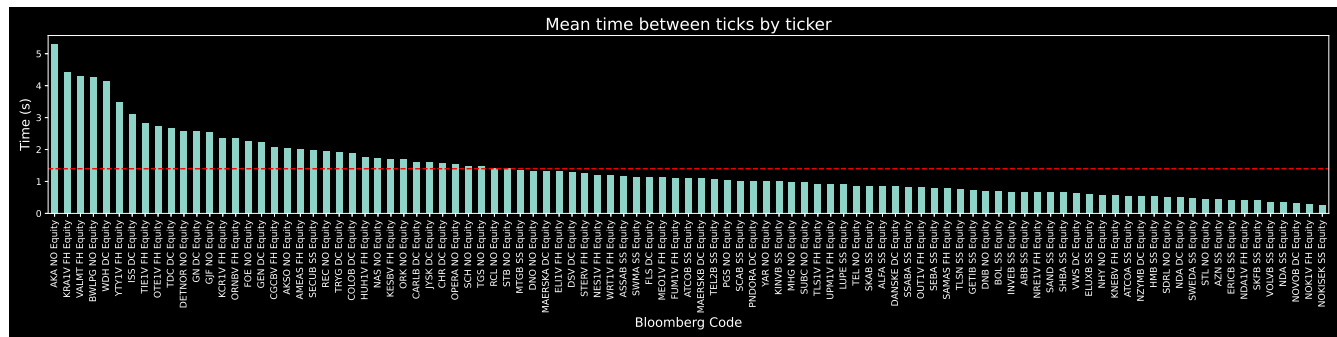


Figure 2: Bar plot of the mean time between each tick, sorted in descending order

Again, the ticker AKA:NO had the highest mean time between ticks at 5.3044 seconds, and NOKISEK:SS had the lowest mean time between ticks at 0.26255 seconds. The mean level of the bar plot is 1.3976 seconds. The descending order of tickers in figure 1 is similar to that of the ticker ordering in figure 2, but the magnitude is reduced by roughly a factor of 10. This is expected as from Table 1 we see that there is roughly 10 times more ticks than trades.

2.3 Scatter comparison

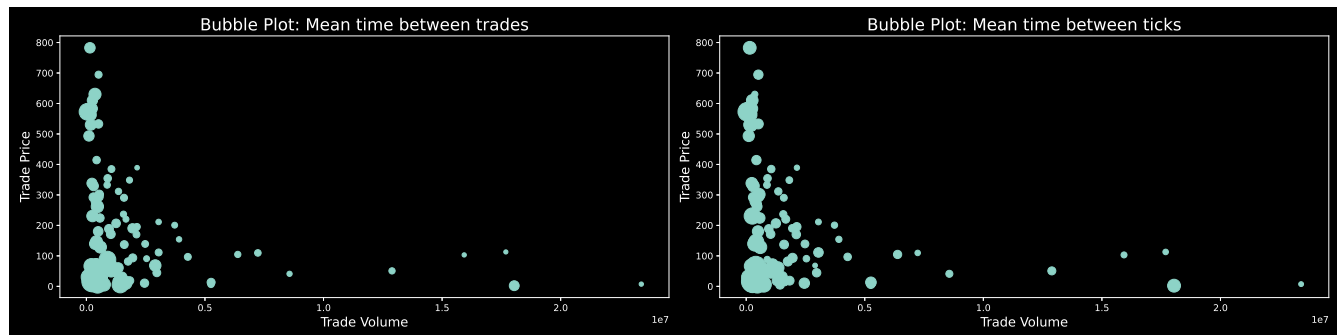


Figure 3: Bubble plot of the mean time between each trade/tick

A bubble plot is a scatter plot where a third dimension is added (mean time): the value of an additional numeric variable is represented through the size of the dots. For each ticker, the 'Trade Price' on the y-axis is an average level of the stock price over the 4 days of data, and the 'Trade Volume' on the x-axis is an averaged daily trade volume over the 4 days. Two tickers have been removed for the bubble plot (and are also removed for subsequent bubble plots), MAERSKA:DC and MAERSKB:DC trade at levels far too high for there to be any significant volume.

As we can see, tickers with a lower average trade volume and a trade price below 100 have the longest mean time between both trades and ticks. As trade price increases, the mean time between trades/ticks appears to decrease as well. The average trade volumes are clustered between 0 and 5M, and therefore there is no clear correlation between trade volume and mean time.

3 Median time between trades and tick changes

For both trades and tick changes, the median time is zero. This is expected because for the given dataset many of the trades/ticks occur at the same second, and since each trade/tick is unique, the time between many of these trades/ticks are zero. For instance, if a particular dataset had values $d = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 5, 8, 10, 12]$, the median of d is 0. These trade/tick times are likely to differ on the milli/microsecond level, and therefore the actual median should be in the milli/microsecond range, but however the granularity of this particular dataset is to the nearest second.

4 Longest time

4.1 Between trades

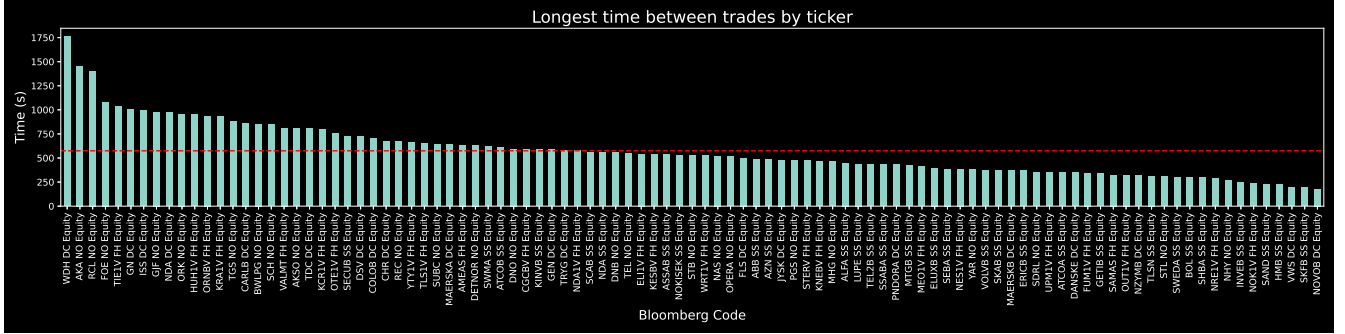


Figure 4: Bar plot of the longest time between each trade, sorted in descending order

The ticker WDH:DC had the longest time between trades at 1759 seconds, and NOVOB:DC had the shortest time between trades at 178 seconds. The mean level of the bar plot is 574.62 seconds.

4.2 Between tick changes

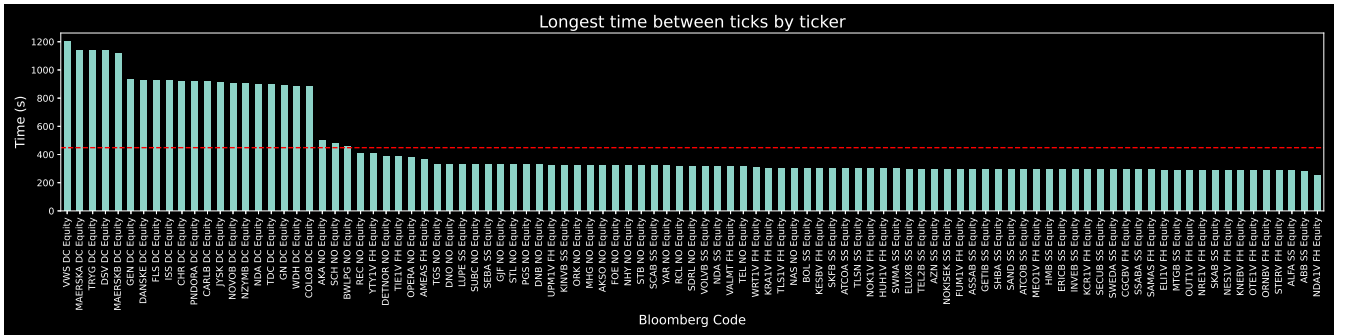


Figure 5: Bar plot of the longest time between each tick, sorted in descending order

The ticker VWS:DC had the longest time between trades at 1202 seconds, and NDA1V:FH had the shortest time between trades at 253 seconds. The mean level of the bar plot is 448.62 seconds.

One interesting observation to point out here is that the tickers with the longest time between ticks all have the 'DC' tag, the tickers with the shortest time between ticks are either 'FH' or 'SS', and the tickers in between are 'NO'. These tags specify which exchange the stock is listed on, where DC = Copenhagen, NO = Oslo, SS = Stockholm, FH = Helsinki.

All the Copenhagen listed stocks have a maximum time between ticks well above the mean of 448.62s, and the bars in this plot also appear to be more flat and saturated at a particular level (depending on which exchange).

4.3 Scatter comparison

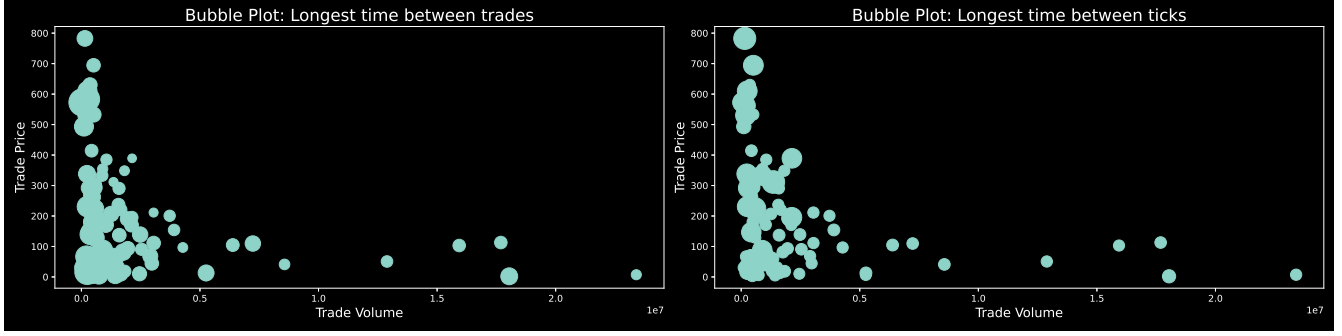


Figure 6: Bubble plot of the longest time between each trade/tick

If we look at the 'between ticks' bubble plot, the biggest bubbles are mainly of low trade volume, but for a variety of trade prices. This shows that the maximum time between ticks is unlikely to be correlated with trade price or volume, but instead related to some external factor, which in this case could be exchange location.

5 Bid-Ask Spread

5.1 Mean Bid-Ask Spread

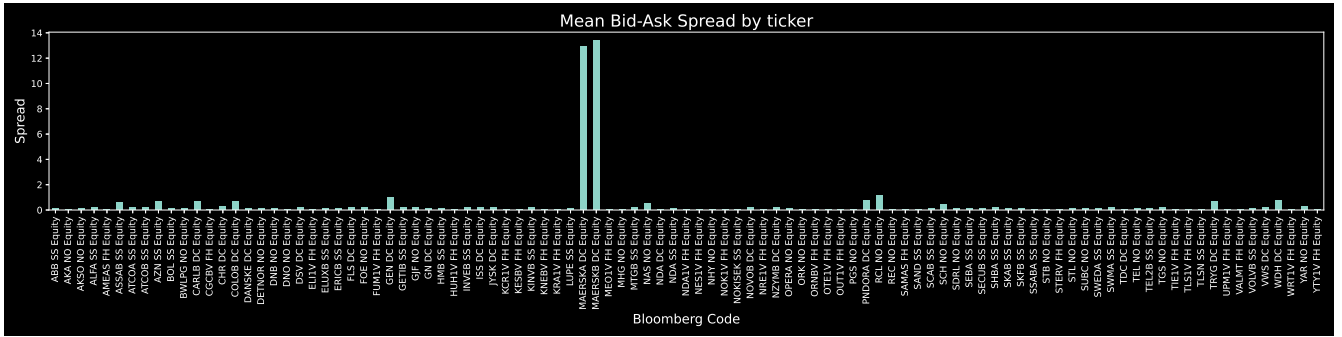


Figure 7: Bar plot of the mean spread between each trade

The ticker MAERSKB:DC had the largest mean bid-ask spread at 13.39, and REC:NO had the smallest mean bid-ask spread at 0.005493.

5.2 Median Bid-Ask Spread

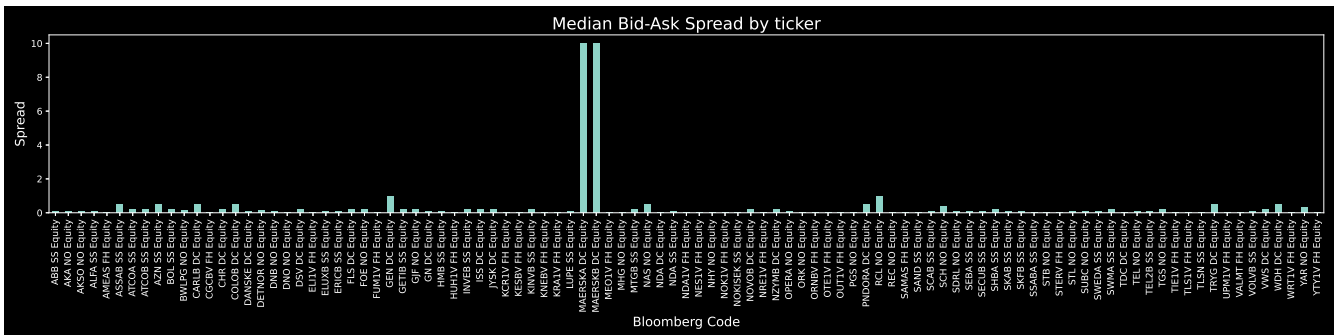


Figure 8: Bar plot of the median spread between each trade

The ticker MAERSKA:DC had the largest median bid-ask spread at 10.00, and NOK1V:FH had the smallest median bid-ask spread at 0.005.

Both the mean and median plots have extremely similar values, indicating that the bid-ask spread across all tickers should be close to a symmetric distribution. For MAERSKA:DC and MAERSKAB:DC, the two tickers with the largest mean and median bid-ask spread, we would expect the distribution to be positively skewed as mean > median, and this is verified by figure 9. It is however not symmetric at all.

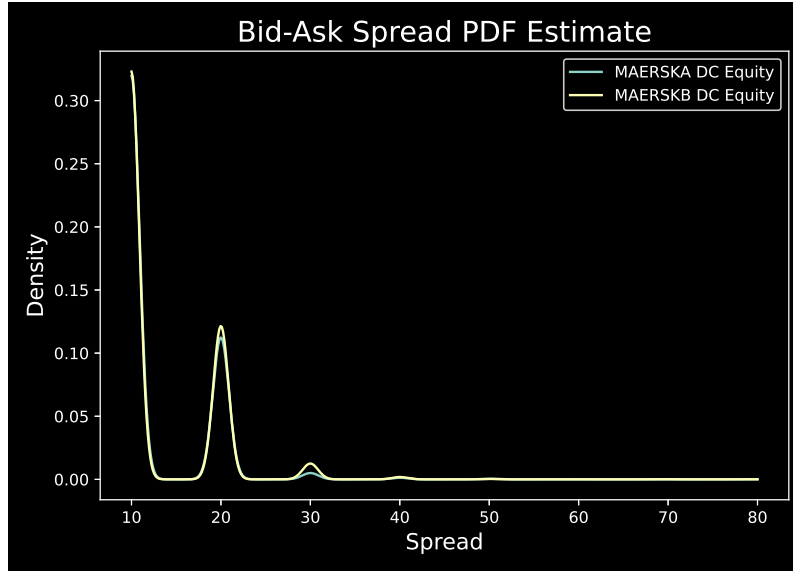


Figure 9: PDF Estimate of Bid-Ask Spread

5.3 Scatter comparison

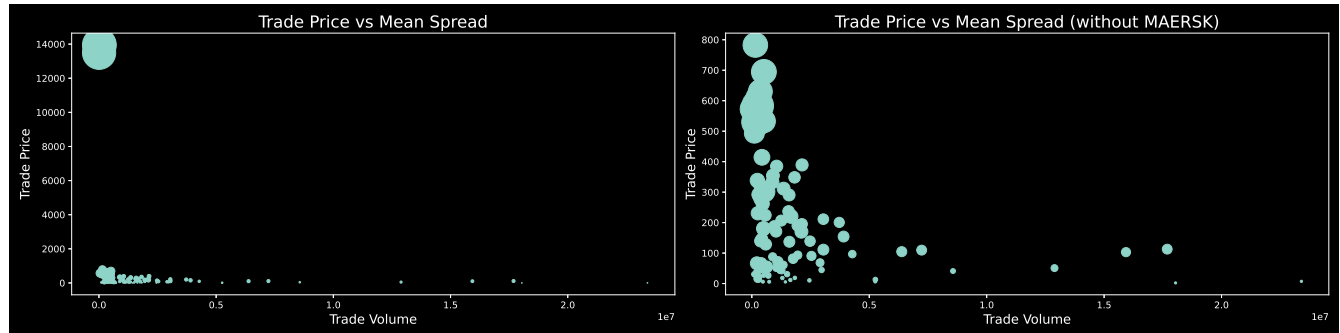


Figure 10: Scatter plot of the mean spread between each trade vs average price of stock

Removing the two expensive tickers leaves us with the plot on the right, and we see that the lower the average volume and the higher the trade price, the wider the bid-ask spread. For stocks trading at high volumes the spread is relatively narrow as these stocks are highly liquid and it is easy to match buyers and sellers. For an expensive stock like MAERSK, trading above 10000, there are few buyers and sellers, resulting in bid prices being pushed down and ask prices being elevated. This is a reason why financial instruments that are not as liquid have wide bid-ask spreads.

6 Examples of the round number effect

6.1 Trade Price

From data exploration, it was found that the trade prices are to a maximum of 5 significant figures. For instance, a ticker trading in the single digits could have 4 decimal places (e.g. 6.3245), a double digit ticker would have a maximum of 3 decimal places (e.g. 55.345) and so on.

I have defined the notion of a 'round number' to depend on the magnitude of the whole number concerned. If a ticker is trading below 10, then an appropriate rounding would be e.g. 6.35 or 9.40. It would be of 3 s.f. and must end in either a 0 or 5. In this case, a value such as 6.345 or 6.1255 would not be 'round enough'.

For tickers trading between 10 and 100, an appropriate rounding would be if the first decimal place is either a 0 or 5. For example, 61.0, 72.5, 10.5, 99.5 are all examples of round numbers in this category.

For tickers trading between 100 and 999, the rounding rule is further simplified. It is round if it is a whole number, e.g. 189.0, 242.0 etc.

Since there are no tickers with trade prices in the thousands, it is skipped and finally there are 2 tickers (MAER-SKA:DC/MAERSKB:DC) whose trade prices are above 10000. The rounding condition here is, if the trade price ends in '00', then it is round. 13700, 13800, and 14000 are all valid examples.

With these 'rounding conditions' in mind, we can calculate the percentage of trades that occurred at a 'round price' as a percentage of total trades for each ticker, to see if trades are more likely to occur at these prices, as trade entry/exit points may be influenced by round numbers.

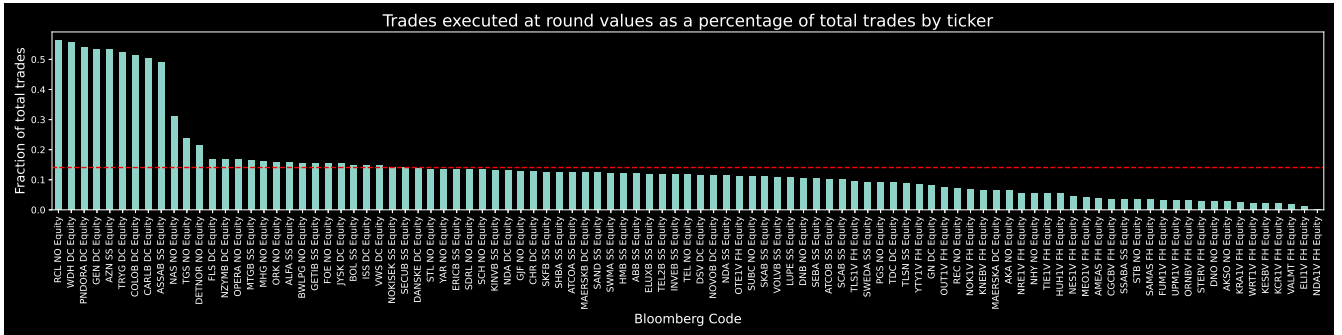


Figure 11: Bar plot of the percentage of round number trades made as a percentage of total trades for each ticker, sorted in descending order

The ticker RCL:NO had the largest proportion of trades executed at a round price at 56.31%, and NDA1V:FH had the smallest proportion of trades executed at a round price at 2.15%. The mean level of the bar plot is 14.23%.

The first ten tickers or so seem to have a rather high percentage, well above the dashed red mean line where most of the bars are located at or below. By looking at the bubble plot below (figure 12), these tickers with high percentages appear to all trade above 500, as the largest bubbles are all clustered together on the top left. Traders tend to focus on round numbers as cognitive reference points for value, and from this dataset it is evident this effect is magnified by expensive stocks.

On the other hand, Table 2 shows the tickers with the lowest percentages, in ascending order of percentage. The majority of these tickers have an average trade price close to 10, meaning that over the 4 days it is likely that these stocks may have crossed 10, and since our rounding conditions are different for stocks above and below 10, this discrepancy may be why these stocks have abnormally low percentages.

Bloomberg Code	percentage	Trade Price	Trade Volume
NDA1V FH Equity	0.002148	11.759417	1639715.00
ELI1V FH Equity	0.012987	26.795886	495322.50
VALMT FH Equity	0.017340	11.237908	317306.75
KCR1V FH Equity	0.020235	30.656792	105406.75
KESBV FH Equity	0.020869	38.971584	189212.00
WRT1V FH Equity	0.020900	42.652275	333875.25
KRA1V FH Equity	0.023620	11.206187	270849.25
AKSO NO Equity	0.027469	46.796205	561217.50
DNO NO Equity	0.028879	13.248355	5259845.50
STERV FH Equity	0.029699	10.440365	2451554.50

Table 2: Tickers with lowest percentages

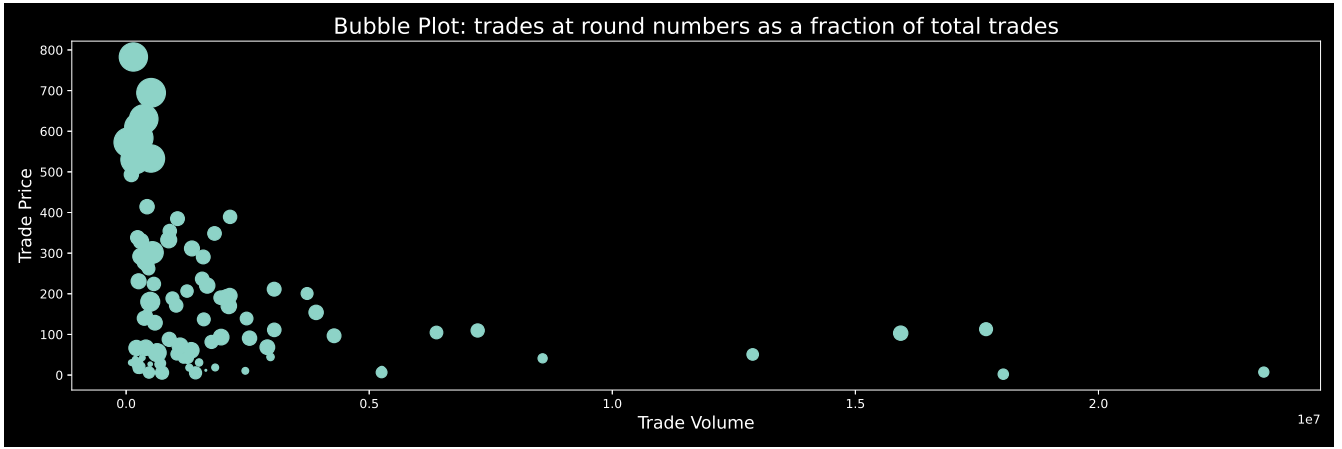


Figure 12: Bubble plot: round number trade percentages

6.2 Trade Volume

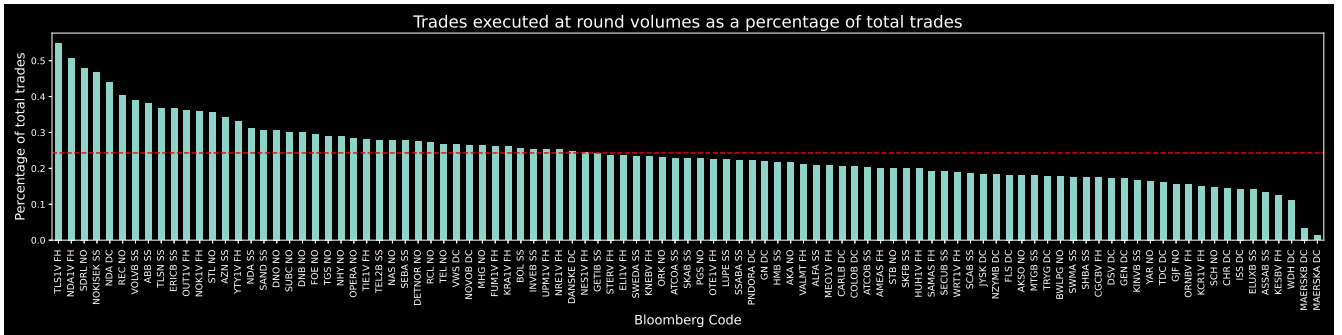


Figure 13: Bar plot of the percentage of trades executed at round volumes as a percentage of total trades for each ticker, sorted in descending order

Similar to trade prices, the percentage of trades executed at round volumes was also calculated to see traders or algorithms prefer to enter trades at round volumes. Here, a 'round volume' is arbitrarily defined as a whole number that ends with a '0', e.g. 10, 170, 5790. The ticker TLS1V:FH had the largest proportion of trades executed at a round price at 54.94%, and MAERSKA:DC had the smallest proportion of trades executed at a round price at 0.1340%. The mean level of the bar plot is 24.30%.

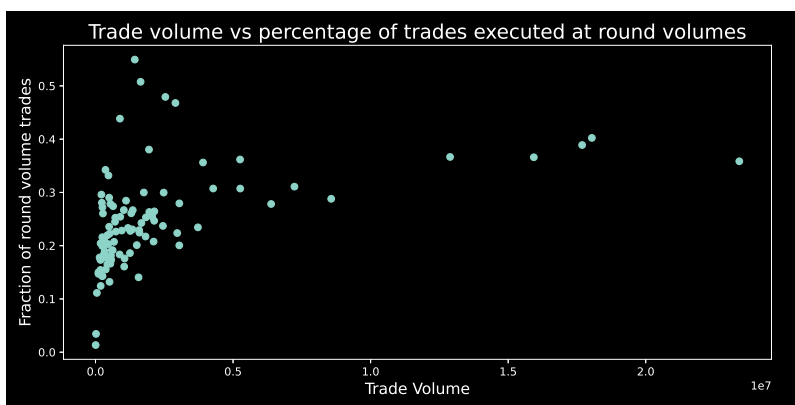


Figure 14: Scatter plot: trade volume vs round volumes trade percentages

In the scatter plot above, the trade volume is plotted against the round volume percentage. The majority of low volume stocks are clustered in the bottom left corner, below the $y=0.3$ threshold. As trade volume increases, the round volume percentage also increases, which could mean that for stocks that are more liquid (more popular/hot stocks), traders are more psychologically inclined to place trades at round volumes, and vice versa.

6.3 Trade Volume and Price

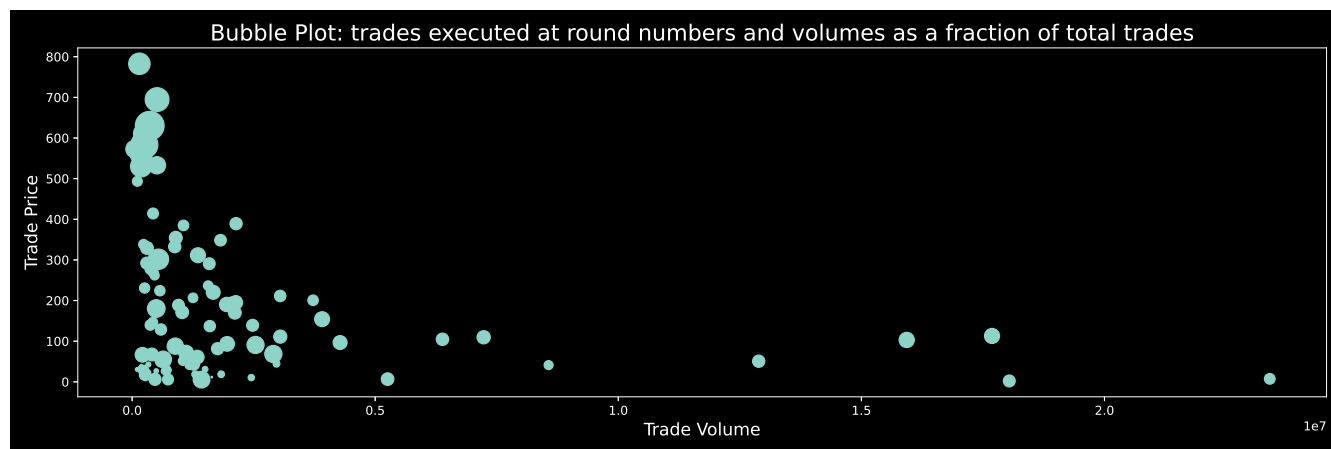


Figure 15: Bubble plot: round numbers and round volumes trade percentages

Figure 15 shows the percentage of trades executed at both round numbers and volumes, with the same conditions described in sections 6.1 and 6.2. The bubble plot is very similar to figure 12, further reinforcing the round number psychology (with volume as well) in trading stocks that are relatively more expensive.

Table 3 below shows the top 5 and bottom 5 percentages, ranked in descending order by 'both percentage'. Again, we see in tabular form that the top 5 tickers all trade above 500.

Bloomberg Code	round price percentage	round volume percentage	both percentage	Trade Price	Trade Volume
AZN SS Equity	0.533948	0.342310	0.181290	630.174734	362495.50
RCL NO Equity	0.563105	0.271993	0.159668	583.385854	252023.25
PNDORA DC Equity	0.541333	0.222548	0.123895	694.577486	513701.75
COLOB DC Equity	0.512131	0.204430	0.109867	562.213046	185987.50
CARLB DC Equity	0.503321	0.205770	0.106042	610.188922	254799.25
ELIIV FH Equity	0.012987	0.235498	0.004425	26.795886	495322.50
KCR1V FH Equity	0.020235	0.149920	0.003219	30.656792	105406.75
KESBV FH Equity	0.020869	0.124419	0.002155	38.971584	189212.00
MAERSKA DC Equity	0.064775	0.013396	0.000946	13491.695035	6626.25
NDA1V FH Equity	0.002148	0.507698	0.000537	11.759417	1639715.00

Table 3: Trades executed at round numbers and volumes, top 5 and bottom 5