AFM

Assessing the quality of executions on trading venues

The “Comparative Pricing Model”

January 2022

AFM

Contents

Summary

Following the emerging worldwide public debate on the risks and presumed benefits of the practice of payment for order flow (**PFOF**) [1], ESMA published a warning on the risks arising from PFOF. PFOF causes a conflict of interests between the firm and its clients as it incentivizes the firm to choose the third party offering the highest payment, rather than the best possible outcome for its clients when executing or routing their orders for execution. Therefore, ESMA called on national supervisory authorities to delve deeper into the issue.

Subsequently, the Dutch Authority for the Financial Markets (**AFM**) looked into the execution quality of two PFOF trading venues and one non-PFOF trading venues, all three used by pan-European operating low-cost neo-brokers, as well as one low-cost investment firm. The AFM has selected the trading venues and low-cost investment firm based on criteria such as data availability and a substantial presence of activities in multiple European countries. The initial results of our analysis show that these PFOF trading venues structurally offered worse execution prices based on a comparison of real transactions with multiple other trading venues.

In order to assess execution quality, the AFM developed an assessment methodology which provides a robust indicator of a trading venue's execution quality based on post-trade data: the *Comparative Pricing Model.* The methodology is easy to replicate by other NCAs using their own available datasets. The AFM applied this *Comparative Pricing Model* to review how execution prices of shares on one trading venue compare to prices of execution on multiple other trading venues. The use of multiple trading venues establishes an appropriate benchmark.

In its analysis, the AFM considers the price of a transaction to be *better* when the client is selling at a higher price (or buying at a lower price) than the price of any transaction on any reference trading venue in the same instrument in the same second. Vice versa, the AFM considers a trade to be *worse* priced when the client is selling at a lower price (or buying at a higher price) than the price of any transaction on any of the reference trading venues in the same instrument in the same second. If neither is the case, the execution price is considered of *similar* quality.

The results show that for the two PFOF trading venues, most retail client transactions are executed at a worse price in comparison to the most liquid reference markets. For most of the transactions (68-72% for PFOF trading venue X and 81-83% for PFOF trading venue Y) the execution price was worse. On PFOF trading venue X the average price deterioration for a transaction of € 3,000 is € 1.44, on PFOF trading venue Y this was € 3.46.

For the third trading venue (Z), a non-PFOF trading venue, most of the retail client transactions are executed at a similar price (74-77%) compared to the reference markets, with the average price deterioration for a trade of € 3,000 being € 0.24. For the investment firm that was examined, the percentage worse, better or similar executions are almost evenly divided, with the average price deterioration for a transaction of € 3,000 being € 0.42.

Additional analyses and refinement of the methodology would provide broader insights into order execution quality within the EU, for example by looking at other key indicators such as the costs of execution in combination with prices.

[1] Payment for order flow is the practice of a third party such as a regulated market, market maker or liquidity provider paying any monetary or non-monetary benefits to an investment firm for routing their clients' orders to that third party for execution.

1 Introduction

After the GameStop debacle, a public debate emerged on the practice of PFOF which causes a conflict of interest between the firm and its clients as it incentivizes the firm to choose the third party offering the highest payment, rather than the best possible outcome for its clients when executing or routing their orders for execution. In July 2021, ESMA warned investors for the risks arising from PFOF and called on NCAs to delve deeper into the issue.[2] The AFM has selected two PFOF trading venues, one non-PFOF trading venue and one low-cost investment firm based on criteria such as data availability and a substantial presence of activities in multiple European countries.

The public attention also put a spotlight on difficulties with the establishment of a proper reference price, whilst a reliable reference price is critical to the assessment of the quality of order execution. A reference price is not the only component that is required for the assessment of execution quality for retail orders, as fees for clearing and settlement, connectivity and financial infrastructure should also be included in such assessments.

Most retail investors are laypersons when it comes to order execution, let alone capable to influence the execution quality of their orders. In the current MiFID II best execution framework, the responsibility to substantiate the decision for (a) particular execution venue(s) lies primarily with the investment firm.[3] The approach to assess and achieve best execution varies per type of financial instrument.[4]

In this paper we focused on a method to create a reliable reference price to allow for an accurate assessment of the *price* of execution, a key component in the assessment of any broker's compliance with best execution requirements for retail client orders. The other key component is the costs of execution.

To assess the price of execution of shares, the AFM developed a method that:
- makes use of data that is readily available for NCAs
- can be applied to different kinds of trading venues (for instance single market maker vs. multiple market maker venues)
- is easy to understand and
- is easy to replicate by other NCAs.

This resulted in a method that uses post-trade data to compare the execution prices of shares on one trading venue to the prices of execution on multiple *other* trading venues. In particular, the method shows whether a client's order would have been better off when executed on another European trading venue, assuming these prices would have been available on aggregate over multiple timestamps. We elaborate on the methodology in chapter 2. In chapter 3 we show the individual results of the three trading venues and investment firm. In Annex I the code of the methodology is included. Annex II provides Q&As about the background, the limitations and opportunities of the *Comparative Pricing Model*.

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[2] https://www.esma.europa.eu/press-news/esma-news/esma-warns-firms-and-investors-about-risks-arising-payment-order-flow
[3] Article 66 (2) Delegated Regulation (EU) 2017/565.
[4] Recital 104 Delegated Regulation (EU) 2017/565: "*(…) given the differences in market structures or the structure of financial instruments, it may be difficult to identify and apply a uniform standard of and procedure for best execution that would be valid and effective for all classes of instrument. Best execution obligations should therefore be applied in a manner that takes into account the different circumstances associated with the execution of orders related to particular types of financial instruments*."

2 Methodology

Most existing standards for evaluating the quality of execution are based on analyses in which the reference price is based on the 'Best Bid Best Offer' (BBBO). However, comparing post-trade transaction prices with pre-trade quotes is problematic for various reasons, one being that pre-trade quotes do not necessarily take into account any hidden liquidity. When the best bid in a lit market is EUR 10.- and the best offer is EUR 11, there is often still liquidity to be found at, for instance, EUR 10.20 (think *sniping* orders, that only appear once the order to be traded with appears in the order book[5]). Hence, comparing the transaction price to the BBBO in the lit orderbook is theoretically unsound. A more accurate methodological basis to analyze quality of executions would be to use a benchmark based on *actual* transactions: the reference price.

Such a reference price based on actual prices could be constructed either through the concept of

(I) an average price of the ten[6] reference trading venues or

(II) by establishing a 'range' of prices consisting of the "minimum" and "maximum" price on the ten reference trading venues.

In this research the AFM used reference price II, which allows one to determine whether the price of a specific trade was worse, better or similar than the price on the reference trading venues.

In the MiFID II-dataset we identified the "client-side" by either taking (1) the opposite side in a transaction with a market maker (if there is only *one* market maker active on the relevant market) or (2) taking the side of the "Natural Person" (where available). The method for identification of the client-side depends on the particular trading venue to which the model is applied. This step is crucial, since it allows us to qualify the difference with the reference price as being worse, better or similar for the client.

Basically, the *Comparative Pricing Model* works as follows:

- For every transaction on the relevant trading venue, we take the price of execution and whether the client-side is buyer or seller.
- We compare this price with the execution prices in the same instrument in the same second on ten other venues.
- Each execution on the relevant trading venue is labeled as better, similar, or worse. Assuming the client-side is the buyer in the transaction, the execution is considered better if the price is lower than the prices of all transactions in the same instrument in the same second on all other trading venues, similar if the price is between the lowest and highest price, and worse otherwise (vice versa for transactions where the client-side is a seller).

The AFM included only transactions in Dutch shares in its analyses. The reason being that the AFM – in principle – receives all transactions in all Dutch shares within the EEA – irrespective of the trading venue being traded on. Hence, we can be sure that for any Dutch share we do have plenty of transactions on reference trading venues to compare our transactions with. For this reason, we recommend any other NCA to apply the method on local shares or on order flow with sufficient data points to compare.

Besides labeling a transaction as being "Worse", "Better" or "Similar" in execution, one can quantify *how much* worse or better a particular execution is when solely looked at the price component. For this – and our complete methodology – we refer the reader to Annex I.

[5] Another issue has to do with iceberg-orders, which might show only a particular number of shares on offer, while *in reality* there are many more shares on offer.
[6] The AFM used 10 trading venues, yet this number can be modified.

3 Research outcomes

The AFM has applied the methodology to the transactions in Dutch shares as reported by three trading venues (two PFOF trading venues and one non-PFOF trading venue) and one low-cost investment firm. These venues and investment firm were selected for the research because the availability of sufficient data points and because their activities and services are provided to retail clients across multiple EU member states.

The analyses found that the majority of retail client transactions on the two PFOF trading venues were executed at worse prices when compared to the transactions on the reference trading venues. On the non-PFOF trading venue, most of the retail client transactions have similar execution prices when compared to the reference trading venues. For the investment firm, the transaction prices are almost equally divided among the labels worse, better and similar.

In the remainder of this chapter, we will present the results for the three trading venues and the low-cost investment firm in more detail.

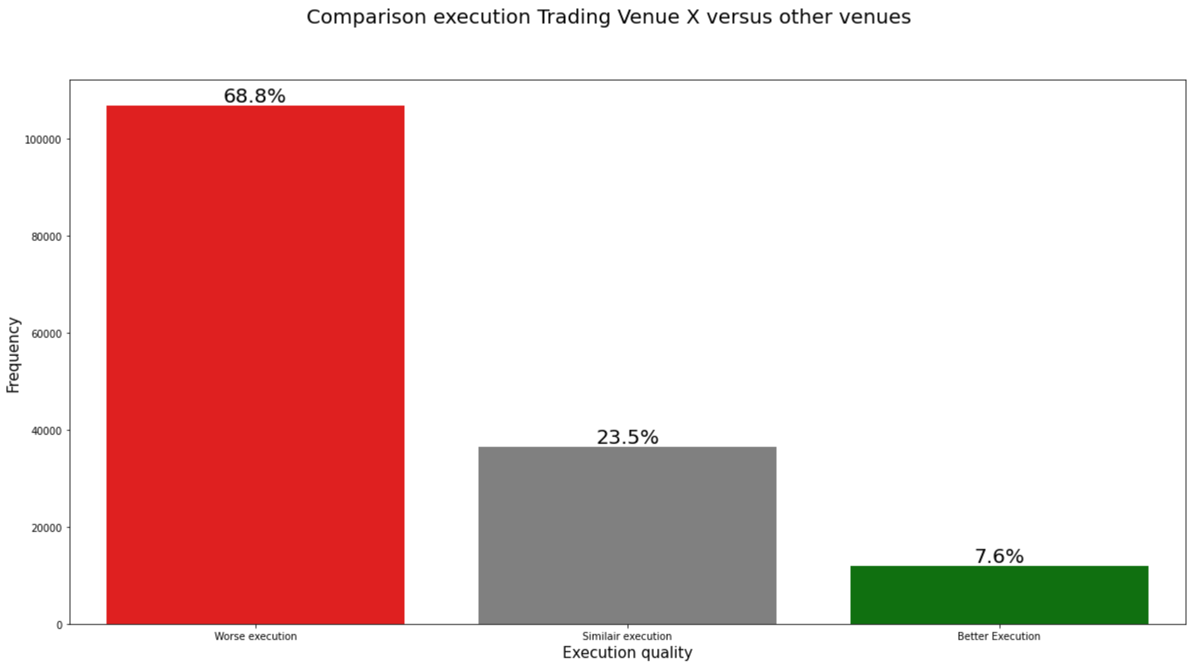
PFOF trading venue X

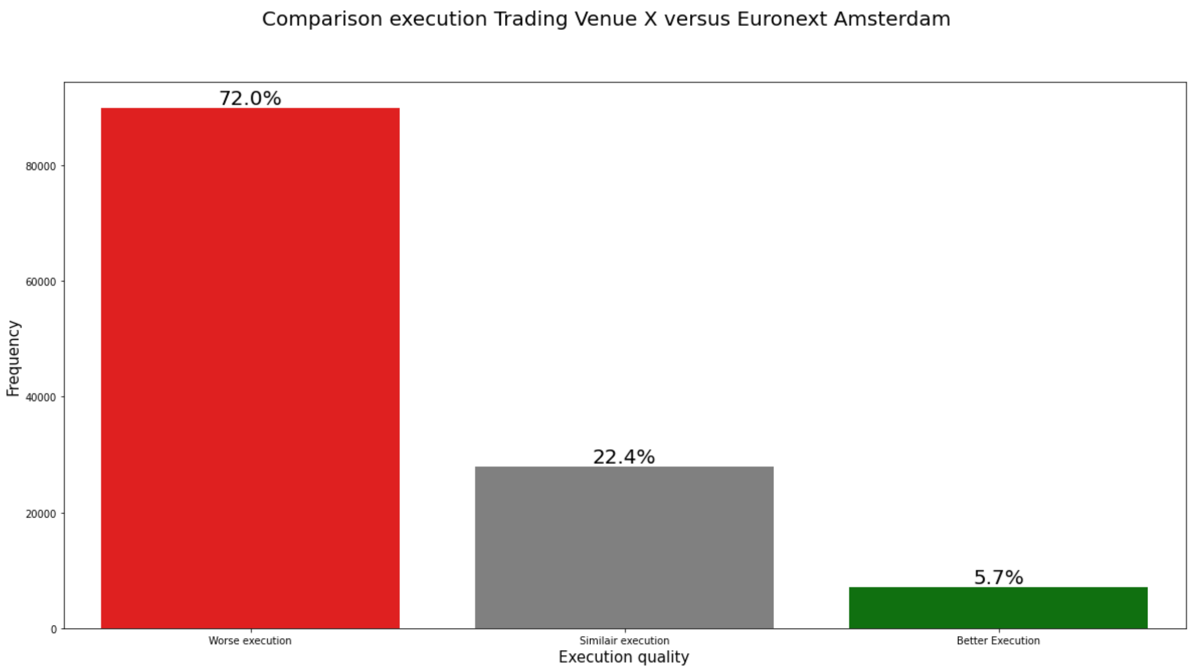
The outcome below shows that retail clients got a worse price in 68-72% of the cases and a better price in 5-8% of the transactions when compared to prices in the reference market(s). That is: 68.8% was worse when we compare the executions to executions on ten other trading venues and 72.0% was worse if we compare the trades with transactions on Euronext Amsterdam (which is the most liquid trading venue available in our dataset).

We found that – on average, when compared to executions on Euronext Amsterdam – clients trading on trading venue X are paying 4.80 basis points extra per transaction. For a transaction of € 3,000 this means the price is worse by € 1.44.

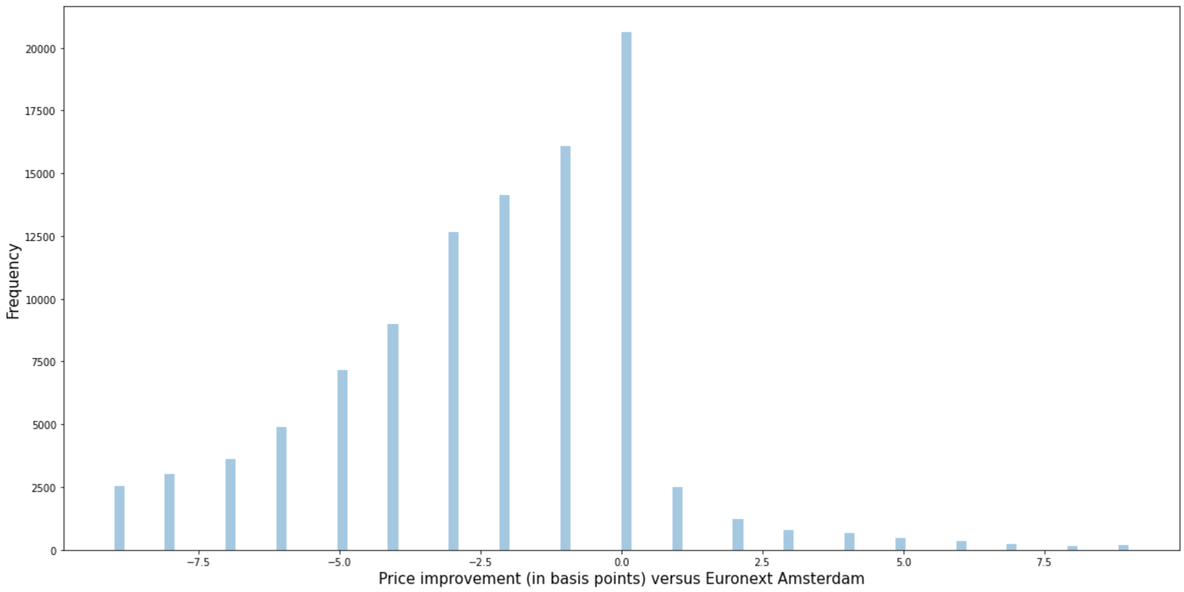
Trading venue X is a PFOF trading venue operating with a regulated market license. Trading venue X has one market maker acting as the counterparty for nearly all retail client orders in shares.

PFOF trading venue X				
	Execution prices vs other trading venues			
	Worse	Similar	Better	
Execution price vs other venues	68.8%	23.5%	7.6%	Based on > 140,000 transactions
Execution price vs Euronext Amsterdam	72.0%	22.4%	5.7%	Based on 124,904 transactions
	Price improvement or deterioration			
Average price **deterioration** vs Euronext Amsterdam	4.8 bps	Based on 124,904 transactions		
Average price **deterioration** for a trade of € 1,000	€ 0.48	Based on 124,904 transactions		
Average price **deterioration** for a trade of € 3,000	€ 1.44	Based on 124,904 transactions		


Comparison execution Trading Venue X versus other venues
68.8%
23.5%
7.6%
Frequency
0
20000
40000
60000
80000
100000
Worse execution
Similair execution
Better Execution
Execution quality


Comparison execution Trading Venue X versus Euronext Amsterdam
72.0%
22.4%
5.7%
Frequency
0
20000
40000
60000
80000
Worse execution
Similair execution
Better Execution
Execution quality

Execution on Trading Venue X is on average 4.8 basispoints worse than on Euronext Amsterdam



count	124904,00
mean	-4,80
std	15,22
min	-703,00
25%	-7,00
50%	-3,00
75%	-1,00
max	1465,00

PFOF trading venue Y

The outcome below shows that clients got a worse price in 81-83% of the cases and a better price in 6-7% of the transactions when compared to prices in the reference market(s). That is: 81.5% was worse when compared to transactions on ten other trading venues and 83.3% was worse when compared to transactions executed on Euronext Amsterdam (which is the most liquid trading venue available in our dataset).

We found that – on average, when compared to executions on Euronext Amsterdam – clients trading on Trading venue Y are paying 11.5 basis points extra per transaction, or € 3.46 worse for a transaction of € 3,000.

Trading venue Y is a PFOF trading venue operating with a regulated market license. Our data shows the trading venue seems to handle retail client orders from primarily one low-cost broker and in smaller number of trades some more traditional brokers. Trading venue Y has one market maker acting as the counterparty for nearly all retail client orders in shares.

PFOF trading venue Y

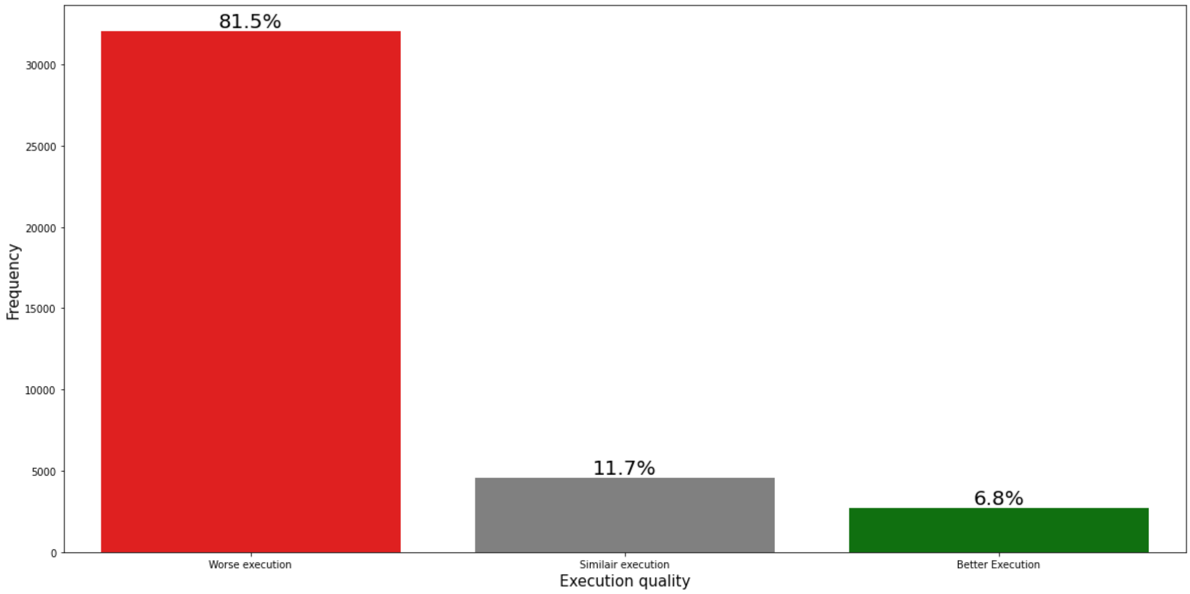
Execution prices vs other trading venues

	Worse	Similar	Better	
Execution price vs other venues	81.5%	11.7%	6.8%	Based on > 35,000 transactions
Execution price vs Euronext Amsterdam	83.3%	9.8%	6.9%	Based on 29,940 transactions

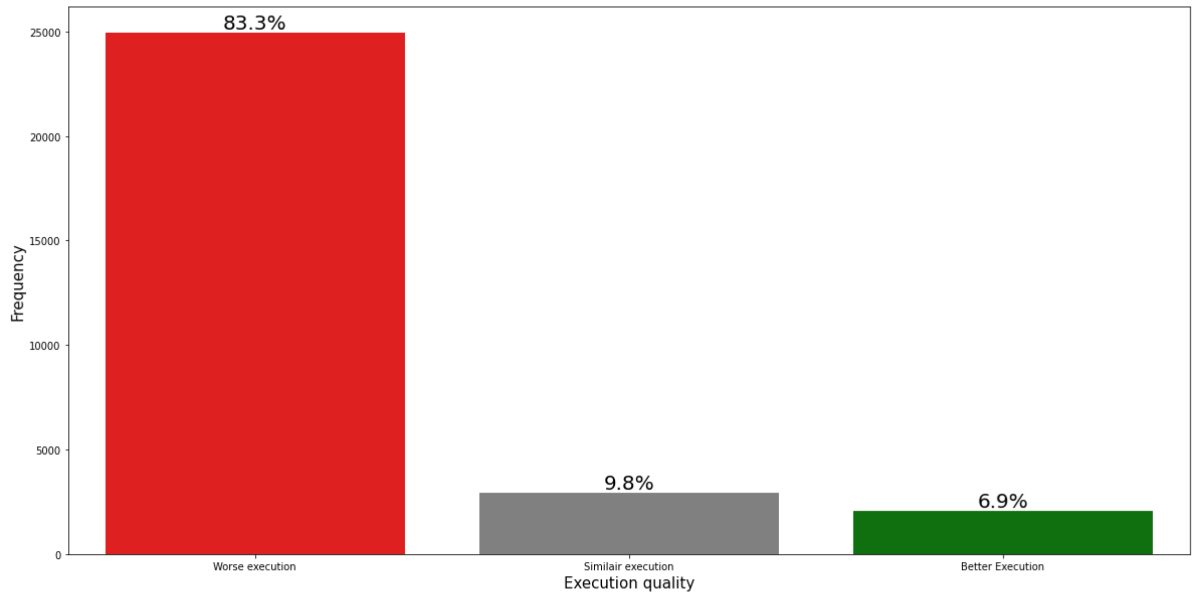
Price improvement or deterioration

Average price **deterioration** vs Euronext Amsterdam	11.5 bps	Based on 29,940 transactions
Average price **deterioration** for a trade of € 1,000	€ 1.15	Based on 29,940 transactions
Average price **deterioration** for a trade of € 3,000	€ 3.46	Based on 29,940 transactions

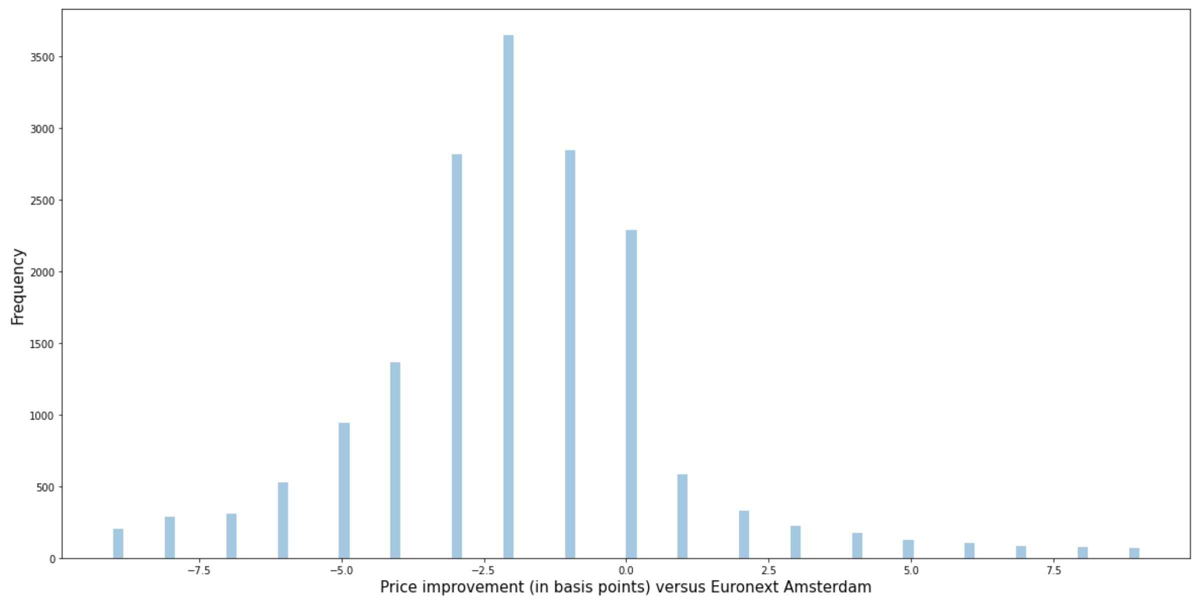
Comparison execution Trading Venue Y versus other venues



Comparison execution Trading Venue Y versus Euronext Amsterdam



Execution on Trading Venue Y is on average 11.544 basispoints worse than on Euronext Amsterdam



count	29940,00
mean	-11,54
std	17,95
min	-609,00
25%	-23,00
50%	-4,00
75%	-2,00
max	530,00

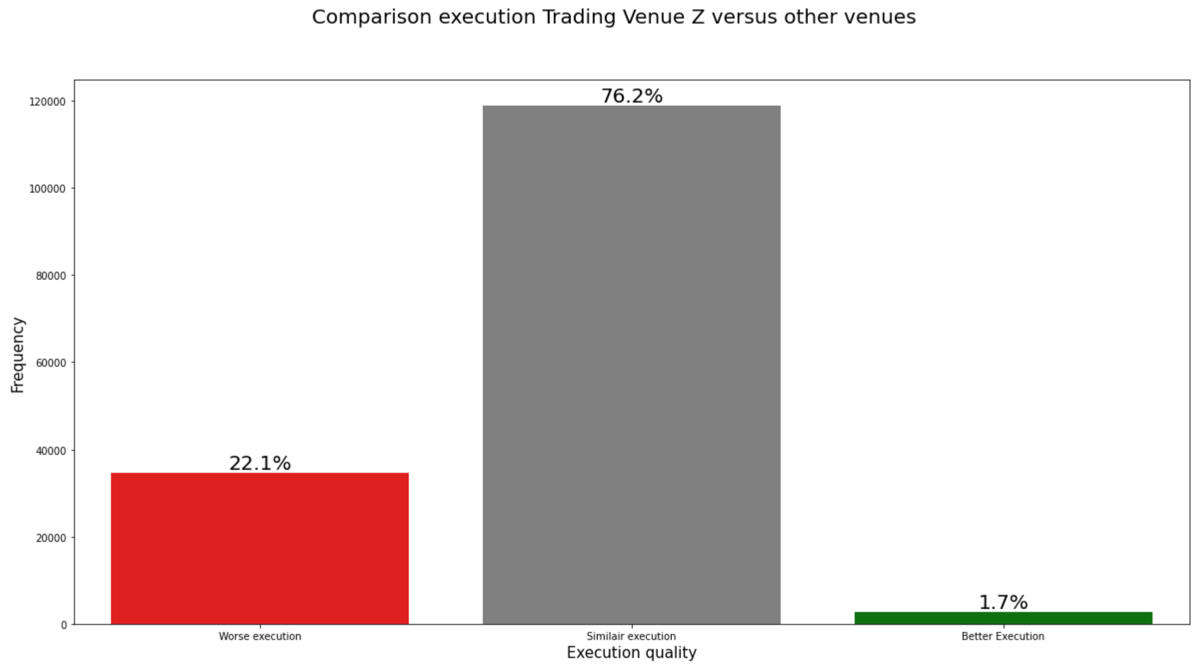
Trading venue Z

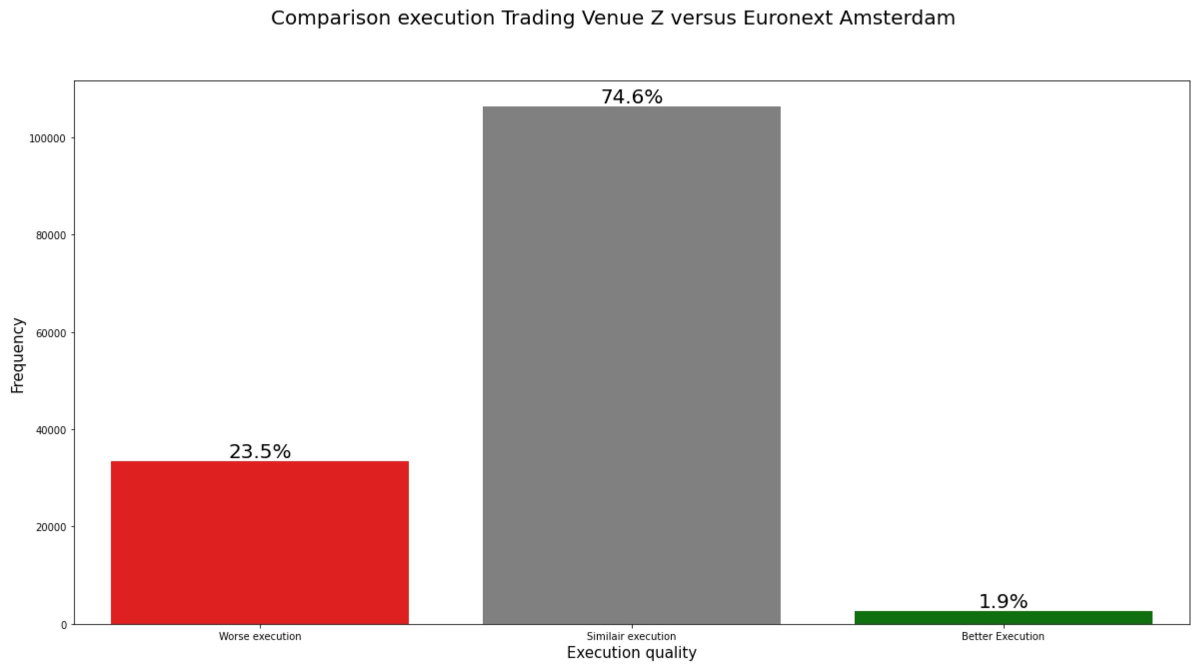
The outcome below shows that clients got a worse price in 22-24% of the cases and a better price in 1-2% of the transactions when compared to prices in the reference market(s). That is: 22.1% was worse when compared to transactions on ten other trading venues and 23.5% was worse when compared to transactions executed orders Euronext Amsterdam (which is the most liquid trading venue available in our dataset).

We found that – on average, when compared to executions on Euronext Amsterdam – clients trading on Trading venue Z are paying 0.8 basis points extra per transaction, or € 0.24 worse on a transaction of € 3,000.

Trading venue Z is operating with a regulated market license. The trading venue is used by all kinds of firms, ranging from low cost neobrokers to more traditional banks and investment firms. Low cost neobrokers with and without an inducement business model use Trading venue Z for execution of their retail client orders. The trading venue allows multiple market makers to provide liquidity and act as counterparty for client orders.

trading venue Z				
	Execution prices vs other trading venues			
	Worse	Similar	Better	
Execution price vs other venues	22.1%	76.2%	1.7%	Based on > 160,000 transactions
Execution price vs Euronext Amsterdam	23.5%	74.6%	1.9%	Based on 141,461 transactions
	Price improvement or deterioration			
Average price **deterioration** vs Euronext Amsterdam	0.8 bps	Based on 142,461 transactions		
Average price **deterioration** for a trade of € 1,000	€ 0.08	Based on 142,461 transactions		
Average price **deterioration** for a trade of € 3,000	€ 0.24	Based on 142,461 transactions		


Comparison execution Trading Venue Z versus other venues
Frequency
120000
100000
80000
60000
40000
20000
0
76.2%
22.1%
1.7%
Worse execution
Similair execution
Better Execution
Execution quality


Comparison execution Trading Venue Z versus Euronext Amsterdam
Frequency
100000
80000
60000
40000
20000
0
74.6%
23.5%
1.9%
Worse execution
Similair execution
Better Execution
Execution quality

count	142461,00
mean	-0,77
std	5,61
min	-240,00
25%	-1,00
50%	0,00
75%	0,00
max	456,00

Investment firm A

For the investment firm, we slightly modified the methodology. Since the investment firm is not a trading venue, we compare transactions via the investment firm to transactions occurring via other investment firms. The other steps remain the same.

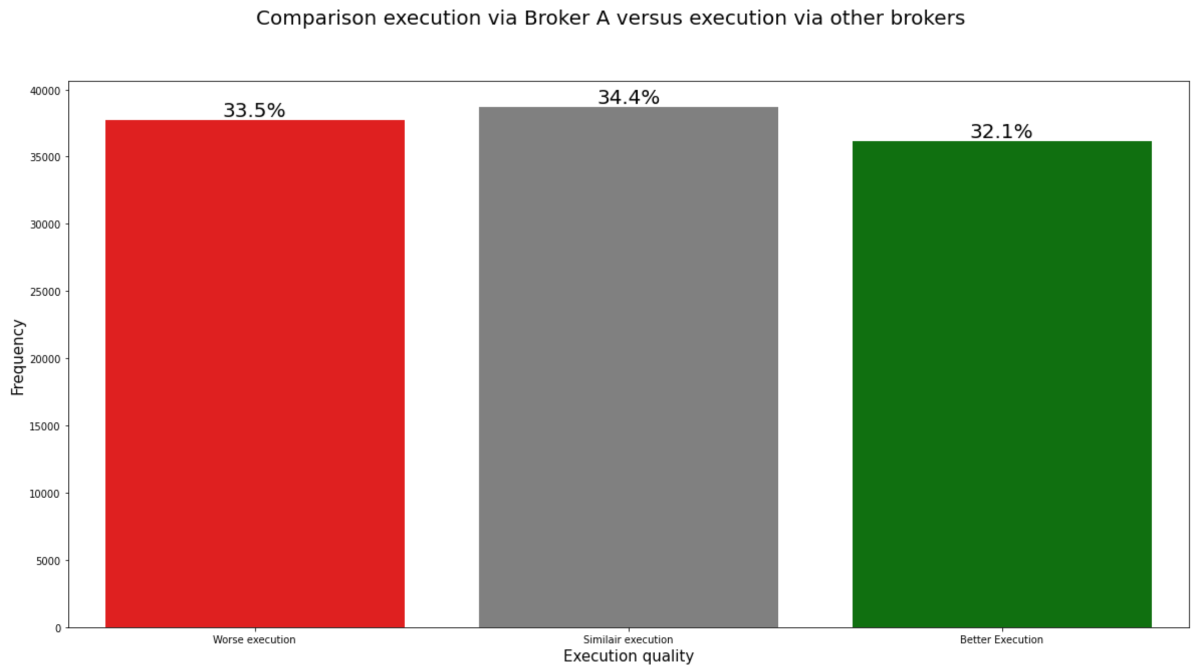
The outcome below shows that clients got a worse price in 30-35% of the cases and a better price in 32-36% of the transactions when compared to prices in the reference firms and Euronext. That is: 33.5% was worse when compared to transactions from other investment firms and 30.8% was worse when compared to transactions executed on Euronext Amsterdam (which is the most liquid trading venue available in our dataset).

We found that – on average, when compared to executions on Euronext Amsterdam – clients trading on Investment firm A are paying 1.38 basis points extra per transaction (or € 0.42 worse for transaction of € 3,000).

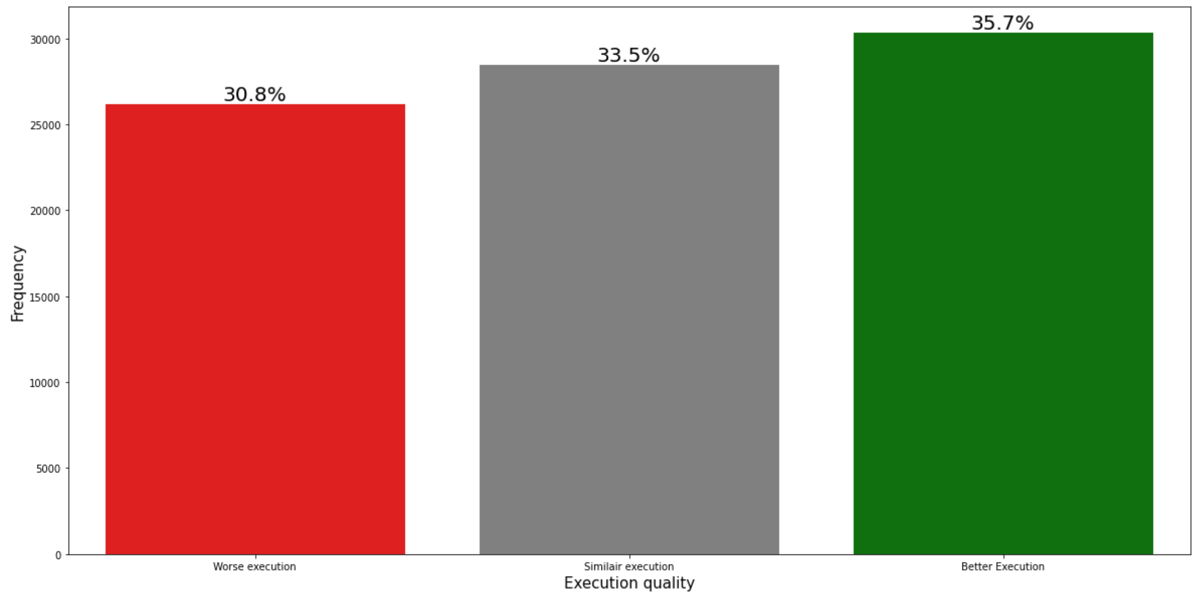
Investment firm A

Execution prices vs other investment firms and Euronext Amsterdam

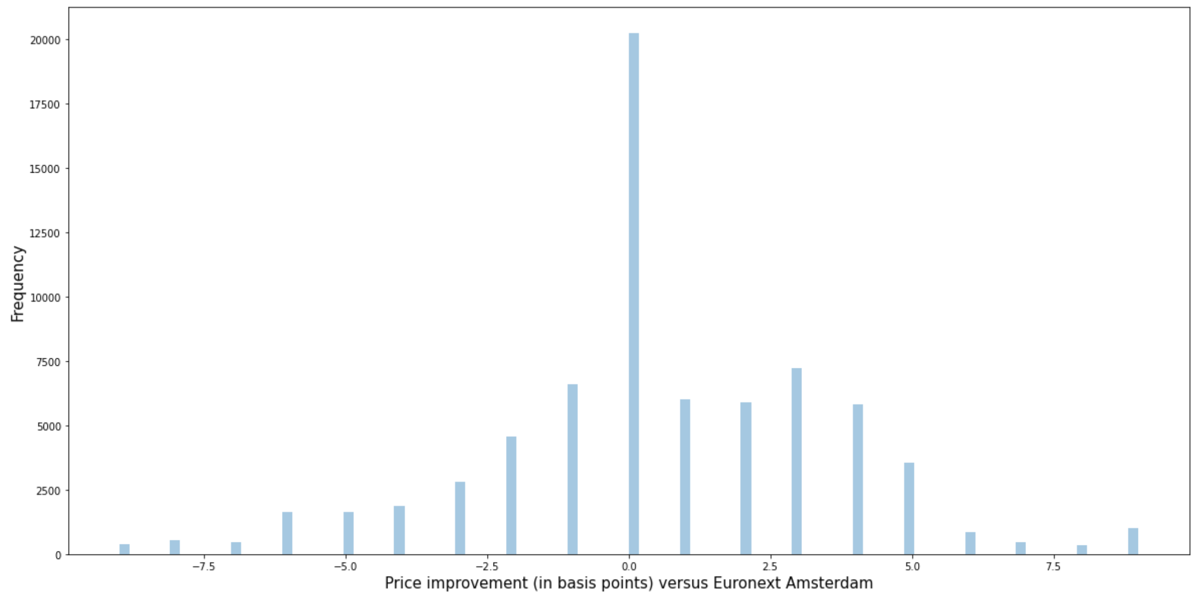
	Worse	Similar	Better	
Execution price vs other investment firms	33.5%	34.4%	32.1%	Based on > 100,000 transactions
Execution price vs Euronext Amsterdam	30.8%	33.5%	35.7%	Based on 84,977 transactions
	Price improvement or deterioration			
Average price **deterioration** vs Euronext Amsterdam	1.4 bps	Based on 84,977 transactions		
Average price **deterioration** for a trade of € 1,000	€ 0.14	Based on 84,977 transactions		
Average price **deterioration** for a trade of € 3,000	€ 0.42	Based on 84,977 transactions		



Comparison execution via Broker A versus execution on Euronext Amsterdam



Execution via Broker A is on average 1.375 basispoints worse than on Euronext Amsterdam



count	84977,00
mean	-1,38
std	18,03
min	-394,00
25%	-2,00
50%	0,00
75%	3,00
max	270,00

Annex I Specifications of the Comparative Pricing Model

1) Construct target dataset **"A"** by selecting from the consolidated TRS/MIFID II tape only actual transactions;

a) on the MIC of the trading venue of which the quality of execution is to be assessed (the "relevant market")

b) within a specific subset of time[7]

c) in a specific subset financial instruments[8] for which the Supervisor is Relevant Competent Authority[9]

2) Construct reference dataset **"R"** by selecting from the consolidated TRS/MIFID II tape only actual transactions;

a) within the specific subset of time as defined under 1b

b) in the specific subset of financial instruments as defined under 1c

c) on the MICs of the most liquid trading venues in that instrument[10]

3) Add a column/field to A that identifies the side of the client in each transaction[11].

4) Make a combined data table **"C"** where – for each transaction in A – we take (when available) the minimum- and maximum price as traded in the relevant instrument in the relevant second in dataset R[12]. For example: 10-11 would mean that trades in that instrument in that second on all MICs in dataset R, were executed between prices 10 and 11.

N.B. Depending on the liquidity and the volatility of the instrument the timeframe could be made shorter/longer. E.a. when it concerns trading in short term government bonds, prices are relatively stable, hence even a day could still provide significant insights in execution costs.

5) Add a column/field to C that identifies deviations between the price paid on the relevant market (A) and prices paid on other trading venues (R) in the same instrument in the same second. In case the transaction is a buy-transaction for the client (as identified in step 3), then:

(1) assign the transaction a "Better execution" if the price of the transaction is lower than the *minimum* price paid in any transaction in the same instrument in the same second on another trading venue (as occurring in R)

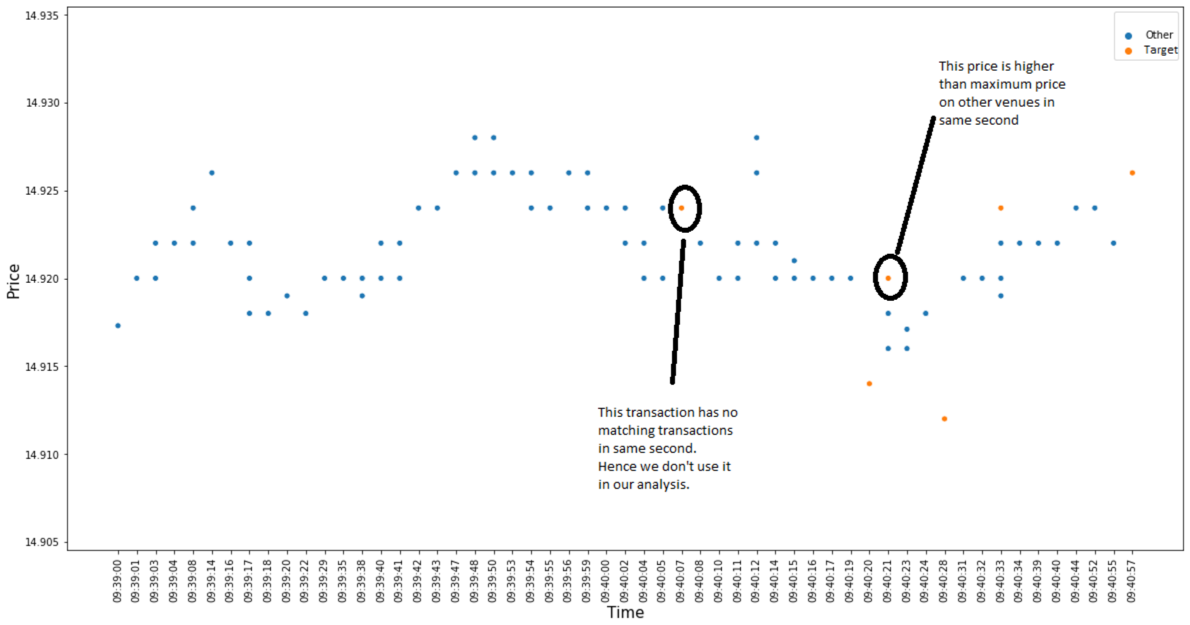
[7] The period of dates/time should be sufficiently large as to allow for a sufficient number of data-points. The prime consideration here is whether – after joining datasets A and R in step 4 – sufficient data-points remain as to allow for valid conclusions. In our analyses we used the period of 2021-01-01 until 2021-07-01.
[8] The number of instruments should be sufficiently large as to allow for a sufficient number of data-points.
[9] The analyses should only be done on financial instruments for which one is Relevant Competent Authority. The reason being that one receives (in principle) transactions done on all trading in the EEA, which allows for comparisons across trading venues.
[10] Excluding the MIC of the relevant market, "XOFF" and "XXXX". In our analyses we took 10 reference markets.
[11] For single dealer trading venues, one can take the side opposite from the side of the dealer. For trading venues with multiple market makers, one can identify all natural persons as being retail-clients and/or focusing on executions by a particular broker, then take those clients as being the relevant side.
[12] An "inner join" of A and R. We round datetime of transactions to the nearest second.

(2) assign the transaction a “Worse execution” if the price of the transaction is *higher* than the maximum price paid in the same instrument in the same second on another trading venue (as occurring in R)

(3) Otherwise assign a “Similar execution”

Vice versa for sell-transactions.

Example: comparing prices relevant market to other venues



6) Report the counts (e.a., number of “Worse execution”, “Better Execution” and “Similar execution”)

In addition one could compute the deviation between the price of the relevant transactions and the average price of all transactions in the same instrument in the same second as occurring on the other trading venues. We convert this deviation to basis points, then take the average to obtain the difference in cost of execution on the relevant market as compared to the reference trading venues.

Example report calculated best-ex indicators for platform X

Reference market = Top 10 liquid markets in relevant instruments in relevant period of time

A = the cost of trading away from the average price on the reference market(s)[13]

B = the number of price improvements compared to the reference markets

C = the number of price deteriorations compared to the reference markets

D = the number of “similar” executions compared to the reference markets

[13] To be calculated under 6).

	TARGET DATASET	REFERENCE DATASET
Quarter	Q1 2021	Q1 2021
Number of transactions	318,053	1,376,872
Value of transactions	EUR 25,997,354,-	EUR 1,524,978,132

INDICATOR	INDICATORS FOR PLATFORM X
A	0.1 % based on total euro value
B	3% based on total number of transactions
C	21% based on total number of transactions
D	76% based on total number of transactions

Annex II Questions and answers

1. Question: *Could other National Competent Authorities also use the Comparative Pricing Model?*
   Answer: Yes, they can. The model is applied to MIFID II-data and any National Competent Authority that receives such data can apply it. Furthermore, the AFM is happy to share the code used to do these analyses, so other NCAs can easily apply the method to their own datasets.

2. Question: *Could trading venues or investment firms also use the Comparative Pricing Model?*
   Answer: Trading venues or investment firms could combine data from their own client trades with the transaction publications mandated by MiFID II transparency, to arrive at similar reports.

3. Question: *Why isn't pre-trade data included in the analysis? And wouldn't it be better to do so?*
   Answer: One could argue that analyses based on pre-trade/order-data are also accurate when it comes to assessing the quality of execution across trading venues. The reason being that pre-trade/order-data provides continuous prices, which means it could provide a reference for the quality of execution at *any* point in time – not only at the points in time for which there is at least one matching transaction (in the same instrument) in the same second on another trading venue.

   The AFM has taken the approach based on post-trade data and discrete time for the following reasons:

   (1) While MIFID II-data is readily available for National Competent Authorities, pre-trade/order-trade isn't necessarily so. Therefore, using transaction-data makes the model much easier to implement and apply by NCAs.

   (2) The continuous time data used in pre-trade based analyses can be affected by significant data quality issues related to latency and exact timestamps, where even a nanosecond can make a difference. Hence, methods solely using continuous time data might be more prone to error.

   (3) Also, transaction-data should be a better source for measuring the quality of execution than pre-trade data since pre-trade data does not display *hidden* liquidity (e.g. iceberg-order and/or sniping orders). While pre-trade data surely is an indication for the *likely* price of execution of any transaction, it nearly always differs from the actual price paid or received by the client.

4. Question: *What timestamp is used to match transactions on the relevant market to the reference markets? And isn't a period of one second too long to compare prices across trading venues?*
   Answer: The AFM used the timestamp of each transaction rounded to the nearest second, and compares transactions happening within that same second. The AFM realizes that prices *could* change (across trading venues) within that one second due to normal market dynamics. Hence a *difference* in the price of execution between trading venues in the same second *doesn't* necessarily imply that quality of execution on one trading venue is better or worse – it could simply be due to uneven distribution of buying and selling orders.

   For example: one could have a client's buy-transaction occurring at the start of a particular second (say "10:12:13:121") being qualified as having "Worse Execution", simply because the price on other trading venues moved down due to overall selling activity in the *latter* part of the same second (say "10:12:13:931"). However, using the same logic there will also be cases in which the transaction is qualified as "Better Execution" – even though this isn't the case either.

   By including a sufficiently large number of data-points, these two "errors" should cancel each other, resulting in percentages that are an accurate reflection of the actual quality of execution on the relevant market.

5. **Question**: *Could the Comparative Pricing Model also be used to assess the quality of execution in other types of financial instruments than shares?*
   Answer: In principle the same method could be applied to many other asset classes. However, one (most likely) would have to make some modifications. One should for example take into account the liquidity of the relevant financial instrument: an illiquid instrument might have none/few transactions with the same second on another trading venue, forcing one to possibly extend the period beyond 1 second, for example.

6. **Question**: *Why don't you include volume in your analysis? Surely volume is relevant when comparing the quality of execution of transactions?*
   Answer: The AFM realizes that comparing transactions with small volumes to transactions with large volumes could distort the results. After all: due to price-impact it can be expected that larger transactions have (with regards to price) a worse execution than smaller transactions would have had.

   For the purposes of this paper, the AFM assumes the distribution of volume per transaction to be relatively similar across trading venues. This would imply that wrong classifications due to differences in order sizes would approximately cancel out (according to the logic similar to the Answer to Q.4 "*What timestamp is used to match transactions on the relevant venue to the reference markets? And isn't a period of one second too long to compare prices across trading venues?"*).

   The *Comparative Pricing Model* could – for future purposes – be extended as to correct for difference in volume per transactions. One could – for example – compare the quality of execution on a trading venue for different volumes per transaction ("Bottom 10%, "Median", "Top 10%").

7. **Question**: *Why don't you look at different order types (market-orders versus limit-orders)? What are implications of not doing so?*
   Answer: The AFM doesn't have data on order type available for each trading venue. Yet the AFM realizes that order types can play a role in determining quality of execution. For example: a buy-transaction (entered via a "market order") on the relevant market (which is matched to best offer of e.a. "10.72") might be compared to transactions executed via limit orders occurring on other trading venues ("10.70"). Strictly speaking, this first transaction shouldn't be qualified as having "Worse Execution". However, according to the same reasoning, there will also be cases in which the transaction is qualified as "Better Execution", even though this isn't the case.

   By taking a sufficiently large number of data-points, these two "errors" should cancel each other, resulting in percentages that are an accurate reflection of the actual quality of execution on the relevant market.

   Still, the method could be refined by distinguishing between order-types.

8. **Question**: *What is the impact of Data Quality on the output of your analysis?*
   Answer: Data Quality can have a large impact on any analyses. Since MIFID II-data is data *reported* by trading venues and firms, there could (in principle) be reporting issues. Therefore, we recommend always doing sanity-checks on at least the most important variables in your dataset.

   The most apparent example being the "timestamp" of a transaction, as it is crucial that trading venues and firms use synchronised clocks for different time-zones when reporting their transactions. Otherwise, one might be comparing transactions that were not actually executed within the same second.

9. **Question**: *What does the analysis conclude about the practice of payment for order flow*
   Answer: The objective of these analyses is not to draw final conclusions about PFOF or the effect of PFOF on the price of execution: the objective is to assess the execution quality with regards to the execution price – for both PFOF and non-PFOF trading venues. However, according to our analyses,

the studied PFOF paying trading venues offered worse execution prices than the reference markets Other factors might be responsible for the worse execution prices, such as the lack of competition for the execution of orders on the particular trading venue.

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