EURONEXT QUANTITATIVE RESEARCH REPORT

VBBO Trading: a best execution solution for Retail Investors or for Market Makers?

10 July 2020

On average there is an overall negative price improvement of −0.5 bps for VBBO trading vs EBBO. These deteriorations worsen with wider spread and larger trade sizes (see Table 2, p7)

- We observe a strong negative relationship between the trade size and the price improvement of Volume Weighted Best Bid and Offer (VBBO) trades. The larger the trade size, the more negative the price improvement (see Figure 7, p9). For example, the average improvement for a €2,500 trade is −0.4 bps, while it is −1.0 bp for a €7,500 trade.
- Likewise, we also observe a strong negative relationship between price improvement and average spread size (measured at the time of the trade). Thus, for a 5 bps spread we observe a −0.3 bps price improvement, while for an 18 bps spread we observe a −1.0 bp price improvement versus European Best Bid and Offer (EBBO) (see Figure 9, p10).

VBBO seems to be a better best execution solution for market makers than for retail investors

- We show that the worsening of execution price versus EBBO (+0.5 bp on average) is mostly attributable to the cases where the second best limit price contributes to the VBBO. Enabling trading at a reference price including a second limit computation, when the first limit is still valid (see Figure 18, p15), provides a unique opportunity to the market maker to sell at a higher price than the available best ask (+4.1 bps), even 100 milliseconds after the trade took place.
- Overall, buying at EBBO +0.5 bps should not necessarily be considered as a proof of best execution for a retail order. This net reference is achieved by most compliant institutional investors. As evidenced by the improved quotes versus EBBO offered by market makers to retail investors, an execution price that is better than standard EBBO should be expected to demonstrate best execution for these highly prized flows.
- More fundamentally, any kind of reference price system that does not allow market makers to compete on prices, thus prevents retail investors from benefitting from the price improvements these uninformed flows are entitled to receive. Therefore a central orderbook model with improved quotes for retail flows seems the most natural design to transparently pass on price improvements to retail investors.

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Purpose

In this study we aim to compare Equiduct VBBO trades with the corresponding EBBO quotes to assess the performance of these types of trading. Performance of VBBO trading will be measured by the relative difference between executed prices and their corresponding EBBO reference prices. We have therefore reviewed all VBBO trades from Equiduct from December 2019 to February 2020. This corresponds to 1.16 million individual retail trades.

EBBO computations were provided by QuantHouse, the leader in high frequency data, chosen for its strong real-time data expertise.

We will focus on 4 main objectives:

- Compare prices for VBBO trades with EBBO prices to determine the price improvement or price deterioration observed in these trades;
- Study how this relative performance behaves with the corresponding underlying trade sizes and the bid-ask spreads of stocks;
- Explain the Equiduct VBBO trading performance by considering independently those trades with sizes available on the EBBO first limits, and larger trades with sizes that were not available on the EBBO first limits;
- Consider the question of best execution for VBBO trading.

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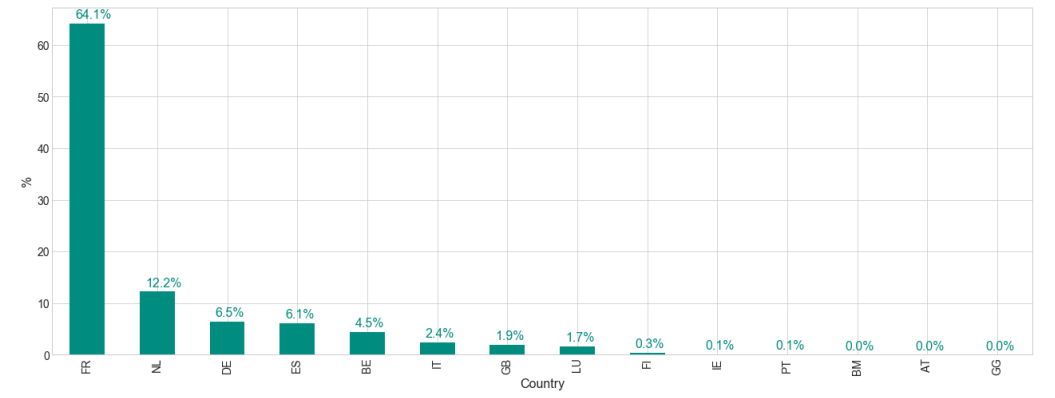
OVERVIEW, UNDERLYING DATA AND METRICS

UNDERLYING DATA UNIVERSE

- Underlying data comprises Equiduct VBBO trades, as well as reference prices (EBBO and VBBO, defined below).
- Trade data are provided by QuantHouse. The data cover every Equiduct trade from December 2019 to late February 2020, including its execution price, quantity, side, timestamp (microsecond granularity) and MMT Flags (these allow us to identify the type of trade flow, in particular VBBO trades). All these metrics are transmitted via QuantHouse, but the trade characteristics are directly produced by Equiduct.
- In this study we consider all VBBO trades during this period. There are 1.16 million trades and 797 stocks with the country distribution shown in Figure 1 below.
- The benchmark metrics (EBBO and VBBO) are computed by QuantHouse.

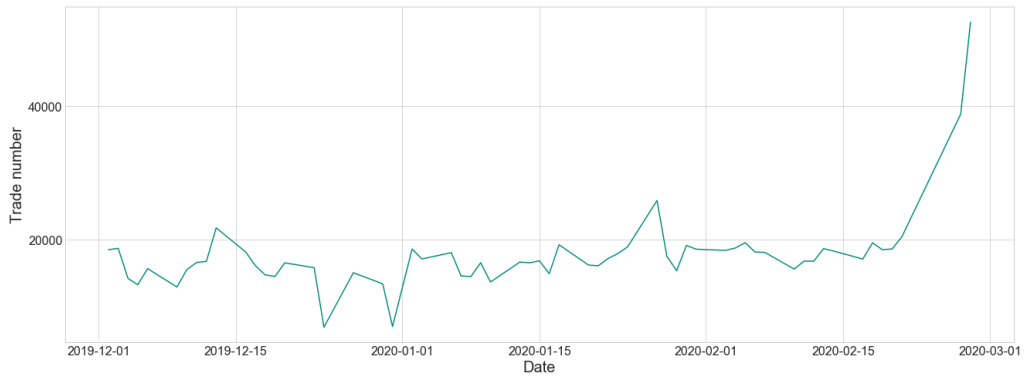
Figure 1: Distribution of VBBO trades by country. Euronext countries account for more than 80% of all trades



Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

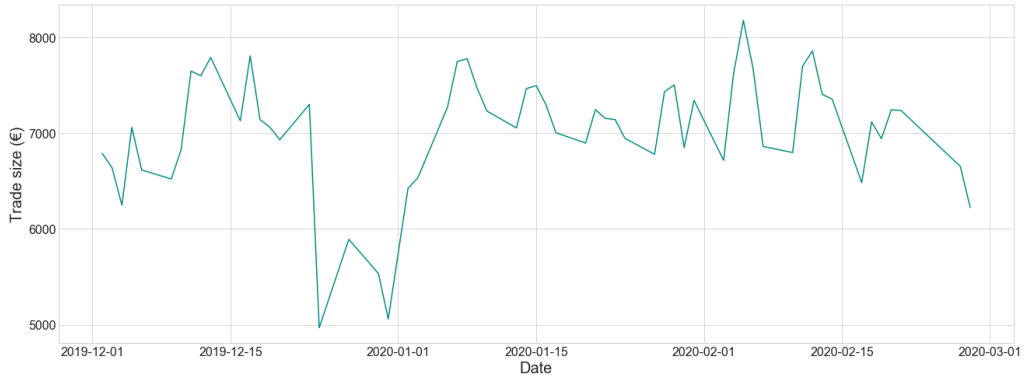
Trade size and number of trades by date are distributed as follows:

Figure 2: Daily number of VBBO trades over time remained steady before the Covid-19 crisis



Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

Figure 3: Average VBBO trade size over time



Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

MEASURING EXECUTION PERFORMANCE

QuantHouse provided us with a range of metrics for every execution time as well as a range of different lags: −100ms, −10ms, −1ms, −0.1ms, 0s, +0.1ms, +1ms, +10ms, +100ms.

- **"EBBO improvement" for a given VBBO trade at t:** In the following, we will refer to *Improvement*, for buy trades as:

$$EBBO\ Improvement\ (buy\ trade) = \frac{EBBO\ ask\ price(t + lag) - Trade\ price(t)}{Trade\ price(t)}$$

  Improvements are expressed in bps and where the EBBO (from Quant House) is the European best bid and offer computed by consolidating the books from the exchanges below (see Table 1, p6).

- **EBBO and VBBO underlying venues:** Consistently with Equiduct EBBO computation rules, we required QuantHouse to consider the following venues for their consolidated measures. It should be noted that only "standard quotes" are considered on main venues; for example, "RLP quotes", for which only retail trades are specifically eligible, are not part of our computation.

Table 1: Exchanges considered to build the EBBO and VBBO references for QuantHouse computations

Market type	MIC	Operating MIC	Name
Primary Markets	MTAA	XMIL	Electronic share market, Borsa Italiana
	XAMS	XAMS	EURONEXT – Euronext Amsterdam
	XBRU	XBRU	EURONEXT – Euronext Brussels
	XCSE	XCSE	NASDAQ COPENHAGEN A/S
	XETR	XETR	Xetra – Deutsche Börse
	XHEL	XHEL	NASDAQ HELSINKI LTD
	XLIS	XLIS	EURONEXT – Euronext Lisbon
	XLON	XLON	London Stock Exchange
	XMAD	BMEX	BOLSA DE MADRID
	XPAR	XPAR	EURONEXT – Euronext Paris
	XSTO	XSTO	NASDAQ STOCKHOLM AB
MTF	AQXE	AQXE	AQUIS EXCHANGE PLC
	TRQX	TRQX	Turquoise
	BATE	BCXE	CBOE EUROPE - CXE ORDER BOOKS
	CHIX	BCXE	CBOE EUROPE - CXE ORDER BOOKS
EQUIDUCT	EQDT	XBER	BOERSE BERLIN EQUIDUCT TRADING

VBBO TRADES NEGATIVE PRICE IMPROVEMENT VERSUS EBBO

VBBO TRADES WORSEN EBBO BY −0.5 BP

On average, VBBO trades deteriorate against the corresponding EBBO reference (best ask for buy trades, or best bid for sell trades) by −0.49 to −0.53 bps respectively (see Table 2, line 2). This corresponds to a negative price improvement.

Table 2: VBBO executions: number of trades and price improvement

	VBBO Orders	
	Buy	**Sell**
Number of trades	0.61 million (52.4%)	0.55 million (47.6%)
EBBO improvement	−0.53 bps	−0.49 bps

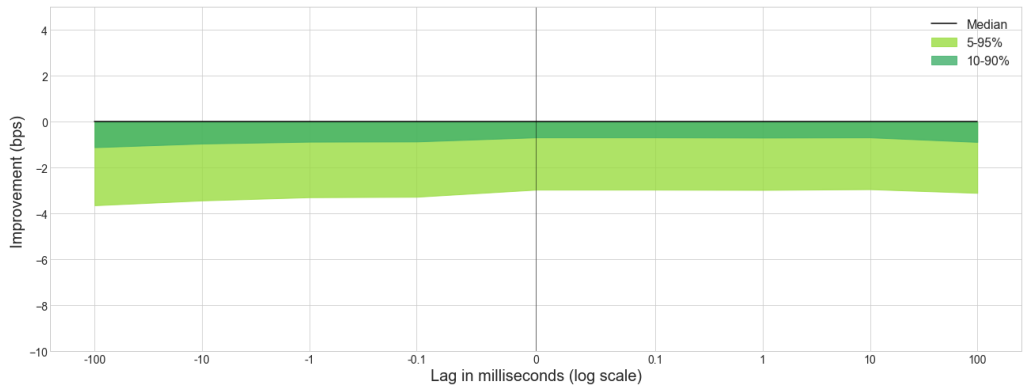
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

VBBO trades worsen EBBO by −0.5 bps for buy and sell orders

PRICE IMPROVEMENT TIMELINE

In addition to measuring the price improvement at the time of the trade, it is key to measure how this improvement changes over time. This analysis enable us to observe whether execution takes place on average at an adverse timing, or not. This analysis is also particularly useful to assess if a market impact can be observed after a trade has taken place, as is the case on Lit and Dark venues.

Figure 4: EBBO price improvement shows no market impact and no contribution to price formation



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

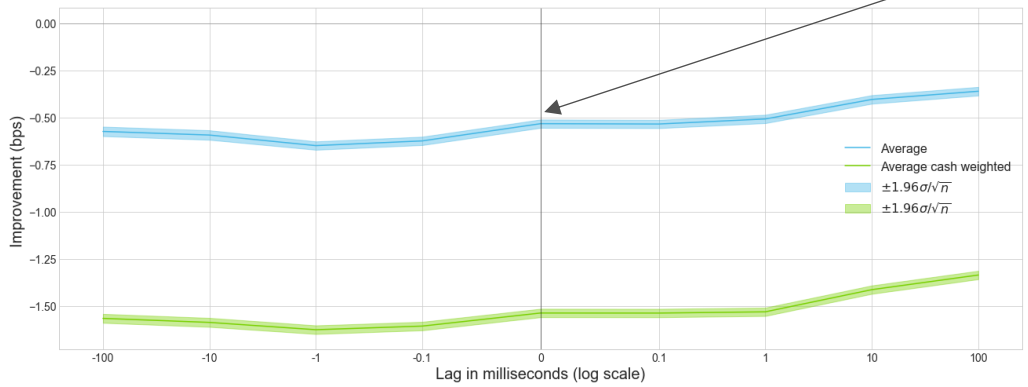
Price improvement profiles over time show that no obvious difference can be observed between −100ms before and +100ms after a trade has taken place. This confirms the fact that, on average, no EBBO change is observed after the trade has taken place. This

confirms that these retail orders do not create market, since unlike institutional trades, these trades are not part of a larger order. This unique feature make retail orders particularly attractive to market makers, as after a trade, the ensuing adverse selection risk is almost negligible. This is also why retail trades are referred to as 'uninformed' by many academics. This property explains why market makers often agree to improve quotes on Lit venues, when these quotes are only tradable by retail investors (see Figure 4, p7).

Moreover, the fact that price improvement profiles over time show no market impact at the time of the trade, confirms that VBBO trades do not participate in the price formation process, unlike standard Lit and Dark trades (see Figure 5, p8). This feature can be understood by the fact that the VBBO reference prices are imported.

No market impact takes place at the time of the trade. These trades do not take part in the price formation process

Figure 5: Average EBBO improvement timeline shows no market impact and no contribution to price formation



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

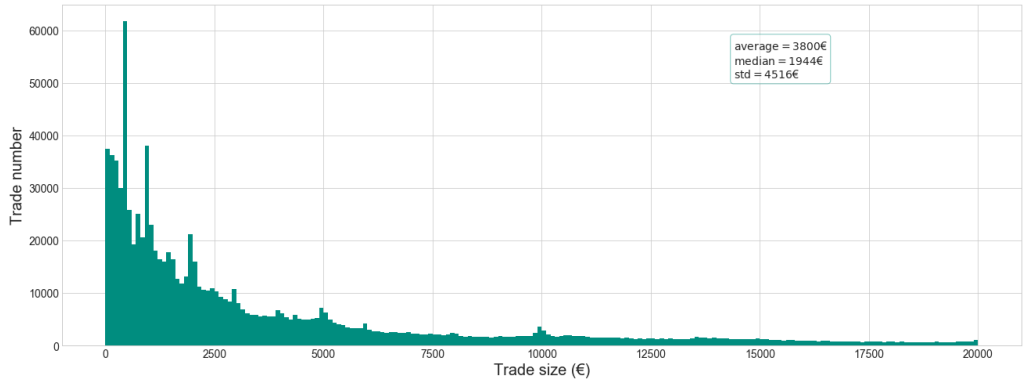
At the time of the trade (Lag = 0) we observe a −0.5 bps improvement on average, as depicted by the mid-blue line in Figure 5. This shows that, on average, the buy price is 0.5 bps higher than the EBBO ask price on average. It can also be observed that the cash weighted average performance is much worse; it amounts to −1.5bps at the time of the trade (see green line at Lag = 0).

VBBO PRICE WORSENS WITH WIDER SPREAD AND LARGER TRADE SIZES

LARGER TRADE SIZES ARE DETRIMENTAL TO EXECUTION PERFORMANCE

The average VBBO trade on Equiduct amounts to €3,800 with a median of €1,944 as depicted in Figure 6.

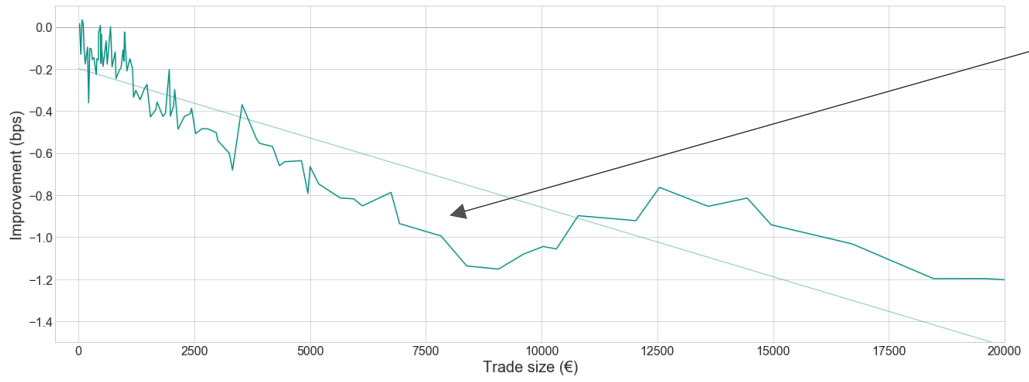
Figure 6: Trade size distribution



VBBO buy orders, trade size < €20,000, 1.06 million trades
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

We observe a strong negative relationship between the trade size and the price improvement of VBBO trades. The larger the trade size, the more negative the price improvement (see Figure 7, p9). For example, the average improvement for a €2,500 trade is −0.4 bps, while it is −1.0 bps for a €7,500 trade.

Figure 7: Improvements worsen with increasing trade size



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

Execution prices worsen with trade size, reaching −1 bp for a €7,500 trade

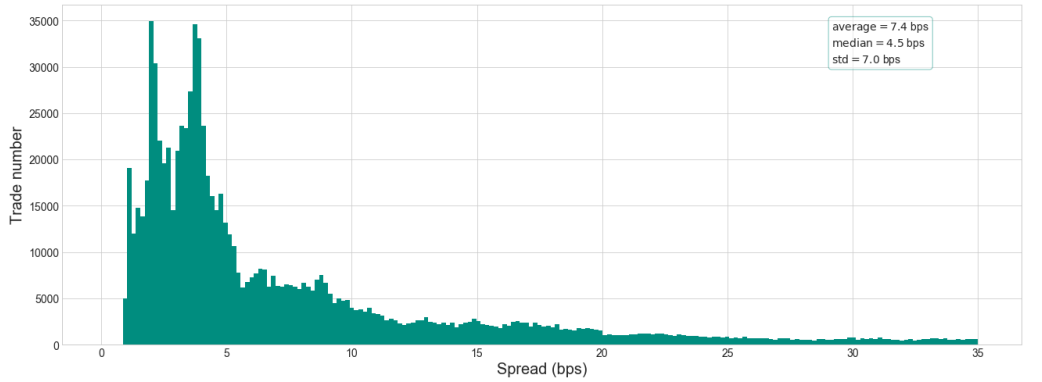
When trade size increases, everything else being equal, the likelihood increases that the first consolidated limit will be fully depleted by the incoming trade. Therefore it is more

likely that the second limit will be taken into account, worsening the average trade price and thereby the resulting trading improvement versus EBBO.

WIDER SPREADS ARE DETRIMENTAL TO EXECUTION PERFORMANCE

Average VBBO trade spreads on Equiduct amount to 7.4 bps with a median of 4.5 bps as depicted in Figure 8.

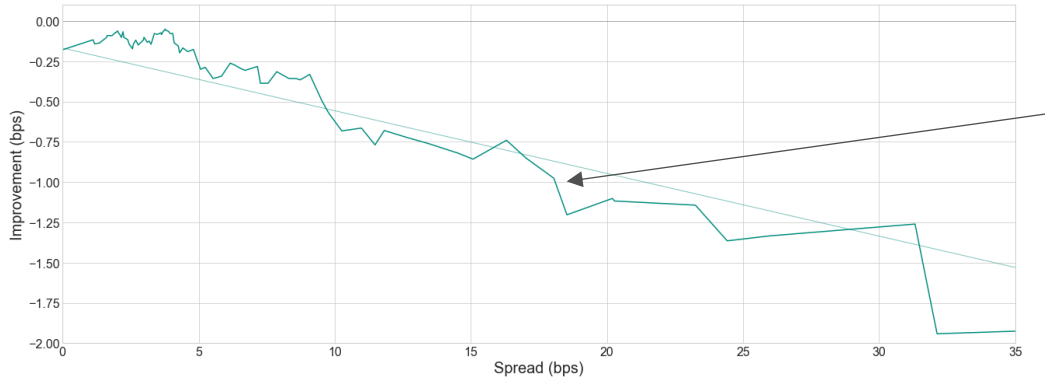
Figure 8: Spread distribution (spread < 35 bps)



VBBO buy orders, spread < 35 bps, 0.98 million trades
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

Likewise, we also observe a strong negative relationship between price improvement and average spread size (measured at the time of the trade). Thus, for a 5 bps spread we observe a −0.25 bps price improvement, while for an 18 bps spread we observe a −1 bp price improvement versus EBBO (see Figure 9).

Figure 9: Average EBBO improvement VS spread by spread percentile (spread < 35 bps)



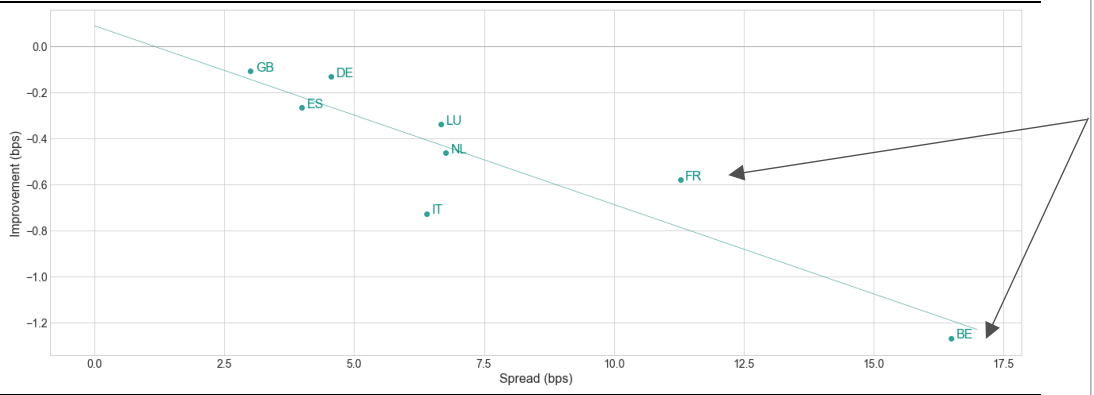
VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

Execution prices worsen on less liquid stocks. A spread of 18 bps leads to a −1 bp price worsening

AVERAGE EBBO IMPROVEMENT BY COUNTRY

The same decreasing relationship is observed when computing the average corresponding spreads and improvement by country or by stock as displayed in Figure 10 and Figure 11 respectively.

Figure 10: Average EBBO improvement vs average spread by country

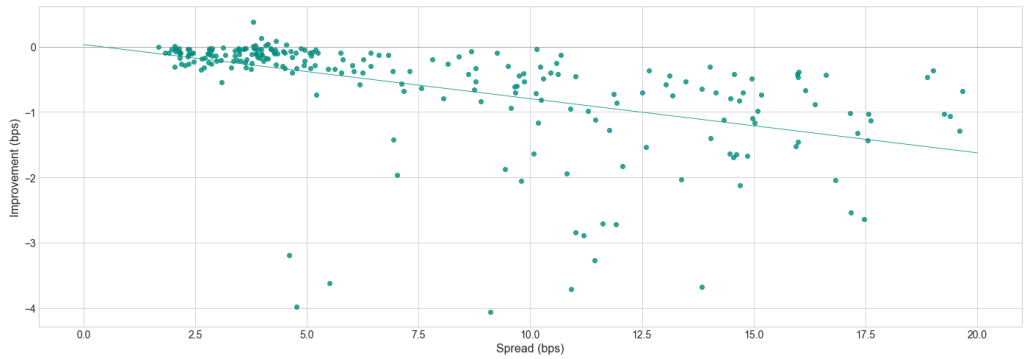


VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

On average a −0.6 bps price worsening on French stocks and −1.2 bps on Belgian stocks

The decreasing relationship between spreads and the EBBO improvement can be easily understood by the fact that when spreads are larger, the orderbooks are not filled at every tick; therefore taking into account the second best limit when computing an EBBO trade will be considerably more detrimental for a larger bid ask spread stock, than for a tighter bid ask spread stock.

Figure 11: Average EBBO improvement vs average spread by stock



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

VBBO PRICE WORSENING WHERE SECOND LIMIT PRICES ARE USED IN VBBO COMPUTATIONS

OVERVIEW OF ALL VBBO TRADES

Table 3: Number of VBBO trades taking place at the first limit or at both first and second limit

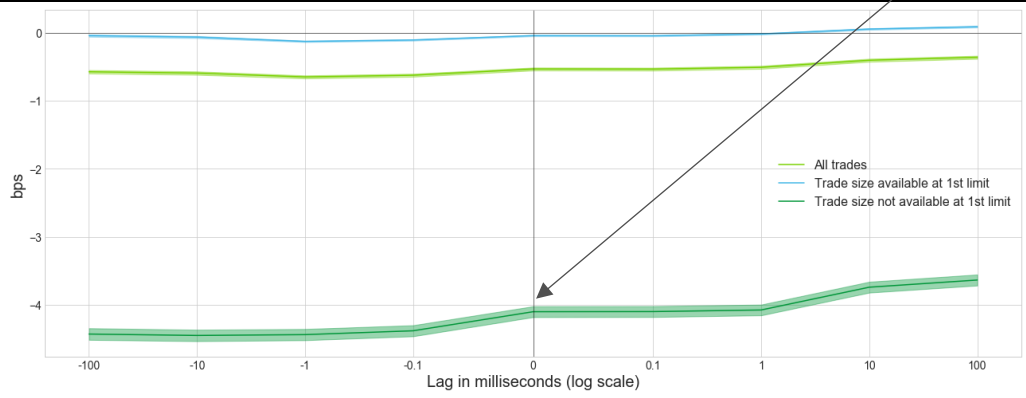
	VBBO Orders	
	Trade size available at first limit (where EBBO = VBBO)	Trade size not available at first limit (where EBBO ≠ VBBO)
Number of trades	0.48 million (87.8%)	0.07 million (12.2%)
EBBO improvement	−0.04 bps	−4.10 bps

VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

Most detrimental VBBO executions (−4.1 bps versus EBBO) result from trade sizes exceeding first limit availability

We first observe that 12.2% of the VBBO trades correspond to situations where the traded quantity is not available on the first EBBO limit. In these cases there is a strong negative price improvement of −4.1 bps (see Table 3, bottom line, last column, as well as the dark green line in Figure 12, p12). However, in the case that only the first limit is involved in the VBBO computation, the trade improvement is almost 0 (see Table 3 above, and light blue line in Figure 12, p12).

Figure 12: Average EBBO improvement

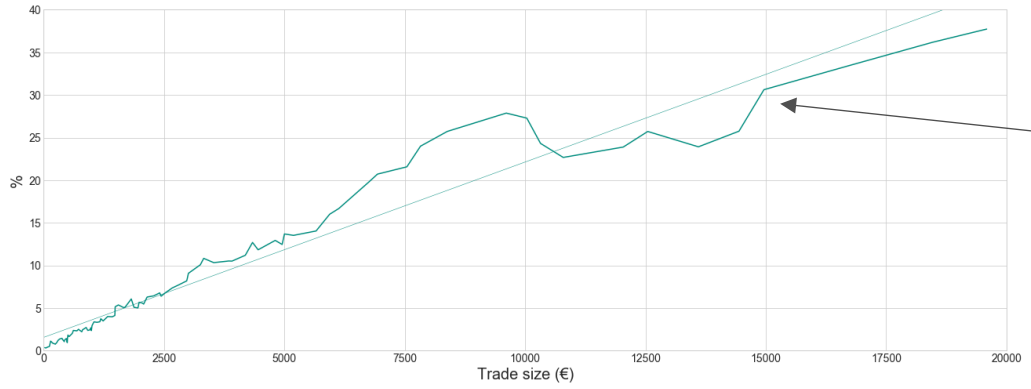


VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

RELATIVE EBBO ASK PRICE VS VOLUME

The worsening of price improvement with trade sizes can be understood very precisely when looking at the proportion of cases where quantities are not met at the first limit only. For a €2,000 trade, the quantity is not available at the first limit in only 7% of cases. This proportion increases up to 30% when considering €15,000 trades as shown by the rising dark-green line in Figure 13.

Figure 13: VBBO orders: proportion of trades involving second limits rises with trade size (trade size < 20,000€)



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

With larger trade sizes, the probability of depleting the EBBO first limit increases, thus worsening trade prices

The rising proportion of trades involving the second limit worsens the price improvement as displayed by the descending light green line in Figure 14.

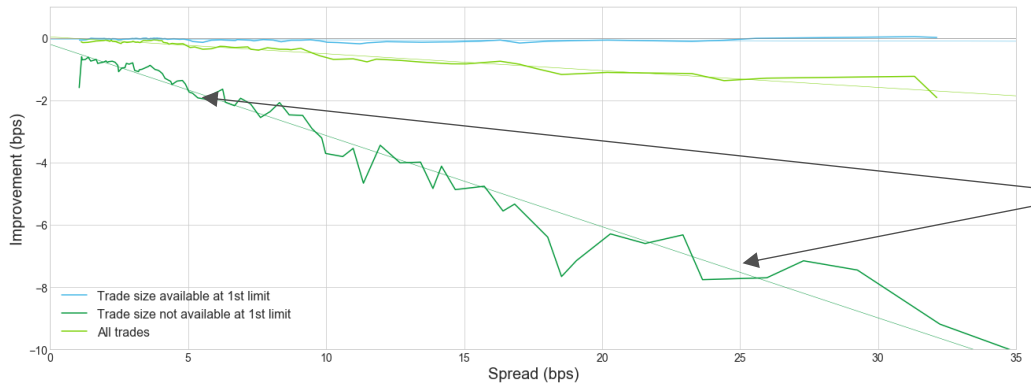
Figure 14: Average EBBO improvement VS trade size by trade size percentile (trade size < 20,000€)

VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

RELATIVE PRICE VS SPREAD

The worsening of price improvement with spreads is caused by the strong deterioration of price improvement on VBBO trades involving second limit computations, as displayed by the dropping dark green line in Figure 15 : from −2 bps for a 5 bps spread trade, to −6 bps for a 20 bps spread trade.

Figure 15: Proportion of trades involving second limits rises with spread

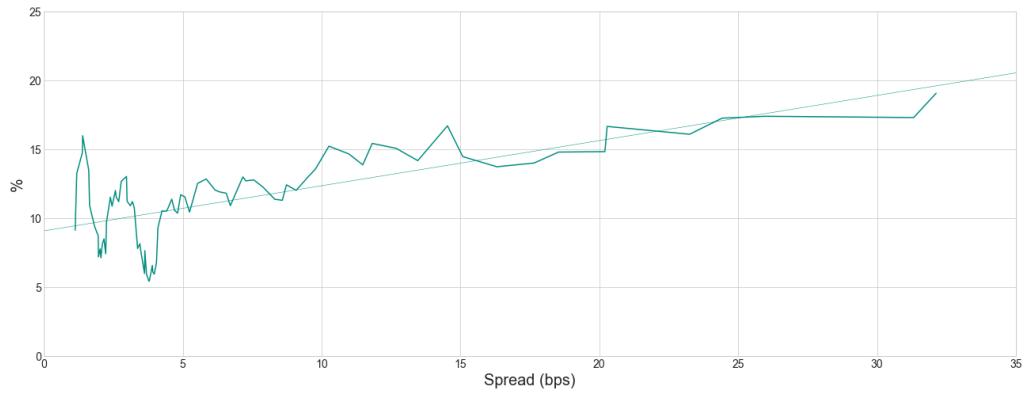


Trading on the second limit results in a −2 bps loss for stocks with a 5 bps spread, but a −6 bps loss for a stocks with a 20 bps spread

VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

The proportion of VBBO trades involving the second EBBO limit also increases with bid-ask spreads, as shown in Figure 16. This rise is also consistent with the worsening of trade improvement with spreads.

Figure 16: Proportion of trades involving second limits rises with spread



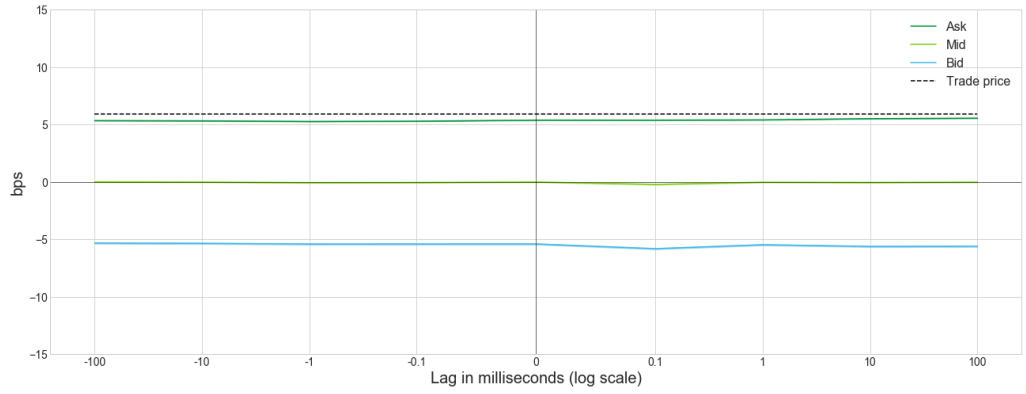
VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

BEST EXECUTION AND VBBO TRADES

VBBO TRADES AND EBBO QUOTES

As already mentioned earlier in our report in (Table 2, p7), on average VBBO prices display a negative price improvement of −0.5 bps. This corresponds to a buy trade at a price +0.5 bps higher than the corresponding EBBO ask price (see dotted black line in Figure 17).

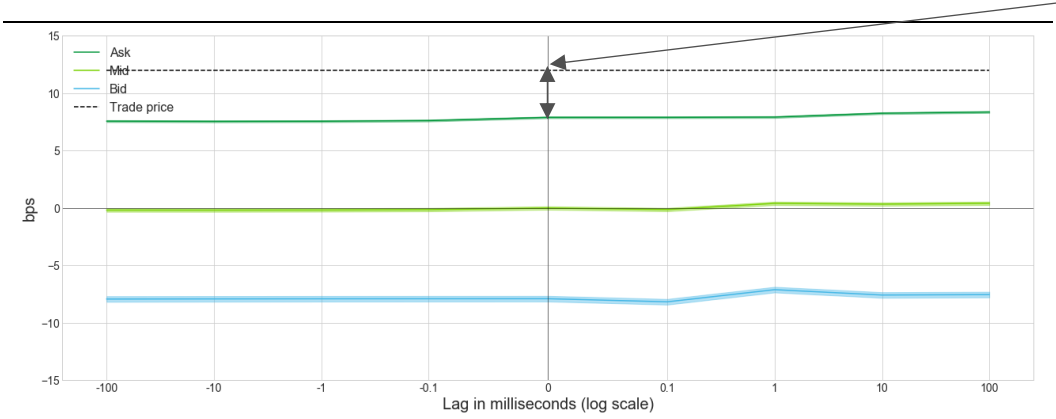
Figure 17: All VBBO buy orders: quote and trades vs mid-point



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

This +0.5 bps widens to +4 bps (see dotted black line versus dark green line in Figure 18) when considering trades for which the available size was not available on the best limit. In this case no immediate market impact is observed just after the trade.

Figure 18: Orders when VBBO trades involve second limit: quote and trades vs mid-point

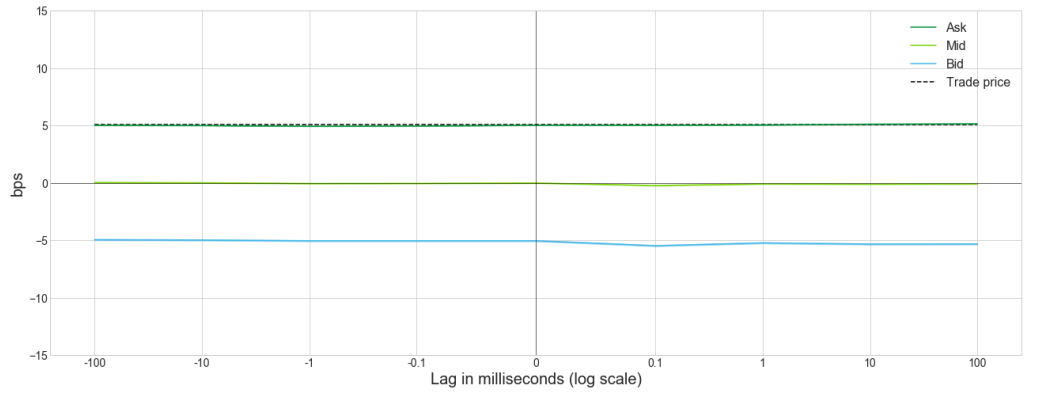


VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

Trading on the second limit results in an average worsening of −4 bps, despite there being no impact on EBBO

In cases where trades only involve first limits, no price worsening is observed, as shown by the respective positions of the dotted black line and the dark green line in Figure 19.

Figure 19: Orders when VBBO only involves first limit: quote and trade vs mid-point



VBBO buy orders
Underlying data: QuantHouse
Period: 2019-12-02 to 2020-02-28

BEST EXECUTION FOR MARKET MAKERS, OR RATHER FOR RETAIL INVESTORS?

VBBO trades display on average a negative price improvement of −0.5 bps. As shown earlier, this worsening is mostly attributable to the cases where the second best limit price contributes to the VBBO. Enabling trading at a reference price including a second limit computation, when the first limit is still valid (see Figure 18, p15), provides a unique opportunity to the market maker to sell at a higher price than the best ask. The uniqueness of this situation comes from the fact that even 100 milliseconds after the trade, the EBBO first limit has not changed. Three questions arise from this situation:

- An opportunity for arbitrage is thus created, since the market makers that sold this stock are in a situation where they can buy, just after their sell, at a strictly lower price (dark green line, versus dotted black line in Figure 18, p15). The VBBO mechanism thus enables market makers to benefit from a 4 bps discount in 13% of cases. This −0.5 bps (4 bps x 13%) matches the overall worsening of VBBO prices versus EBBO.
- The question of 'best execution' for these executions (involving second best limits) could be challenged, as splitting the initial trades into two subsequent EBBO trades would have most probably been preferable for the retail investor, since the same EBBO ask price remained 100 milliseconds after the trade. It is therefore difficult to claim that trading immediately is in the interest of retail investors, when in practice their trades do not impact prices and consuming fully the first limit and trading on the second limit is detrimental to execution performance.
- Lastly best execution for a retail trade differs from best execution in general: Best execution is a question that can only been answered for a given type of flow. Best execution means ensuring that the trades take place at the best price for the particular type of flow in question. In the case of a retail trade, as market makers are inclined to offer improved quotes to trade against uninformed investors. Even in cases where trades match EBBO, this result cannot necessarily be considered as a proof of best execution for a retail order.

BEST EXECUTION SOLUTIONS FOR RETAIL ORDERS

Retail orders are less risky for market makers: Academics often refer to retail trades as 'uninformed trades'. This notion characterises the fact that, unlike other institutional orders which often form part of a larger order sliced into several executions, retail orders do not generate the same market impact as institutional orders and are therefore much less risky for market-makers.

Two main types of market model design provide price improvements for retail trades: Because retail trades are less risky, market makers are keen to provide price improvement for trading against retail flows and avoid adverse selection. Two types of market design exist to serve this specific aim:

- **Market maker quotes for retail flow**: The first solution is for Lit Markets to allow market makers to post specific quotes that can only be executed by retail flows. This way, market makers can compete against one another to attract retail flows and competition ensures that retail investors will get the best price improvement that market makers are willing to pay based on current market conditions. In order to ensure best execution, retail brokers must rely on a smart order router that will compare the best available quotes for retail investors.
- **Retail venues using reference price**: In order to alleviate the burden for retail investors of comparing prices available on different venues, retail venues have emerged which offer prices based on a reference price, often portrayed by these venues as the best available price. The use of a consolidated reference price is made to convince retail investors that best execution will thus be enforced by construction. In addition, these venues often offer lower execution fees than Lit venues, some even proposing negative fees.

Academics often refer to retail trading as 'cream-skimming'. They insist on the fact that the price improvements should be passed on to final participants for this model to be efficient. Structurally, as market makers cannot effectively compete on price in a reference price model, it is not surprising that the improvements made by market makers on their retail trading are not passed on to investors thanks to competition, but instead kept by market makers (as shown earlier in the VBBO case).

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