

The Committee of European Securities Regulators
11-13 avenue de Friedland
75008 Paris
France

Nice, March 16th 2007

Dear Sirs,

The EDHEC Risk and Asset Management Research Centre has recently been involved in a number of studies related to MiFID and the forthcoming Best Execution obligation.

As part of a newly created research programme focusing on 'Best Execution and Operations Performance', our research team has actively contributed to the review of existing approaches to measuring execution quality and recently introduced an innovative framework for analyzing transaction costs and measuring execution performance: EBEX.

In response to your public consultation on Best Execution under MiFID and specifically to your second question, we strongly believe that the analysis of the total net proceeds of financial transactions represent the most important factor for assessing execution quality. But this analysis also represents the most significant conceptual and technical challenge the industry will face in order to consistently monitor execution quality, and therefore allow Best Execution to become a tangible and measurable objective for Investment Firms.

Because the Best Execution obligation is a cornerstone within the arsenal of protective provisions the Directive has put in place so as to ensure a possible fragmentation of market will not be detrimental to investors, it is important that the regulator ensure the stated obligation can actually be monitored independently.

In order to contribute to the public debate, we include a detailed analysis of the various aspects of Transaction Cost Analysis, a review of the pertinence and biases exhibited by current practices and an introduction to our innovative framework which was published in the last issue of the *Journal of Asset Management*.

We will be pleased to exchange with CESR and industry representatives on this matter and hope this contribution will allow a smooth and effective implementation of the Best Execution provision.

Sincerely Yours



Jean-René Giraud

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Response to CESR public consultation on Best Execution under MiFID *“On the importance of Transaction Costs Analysis”*

Catherine D’Hondt, Associate Professor of Finance

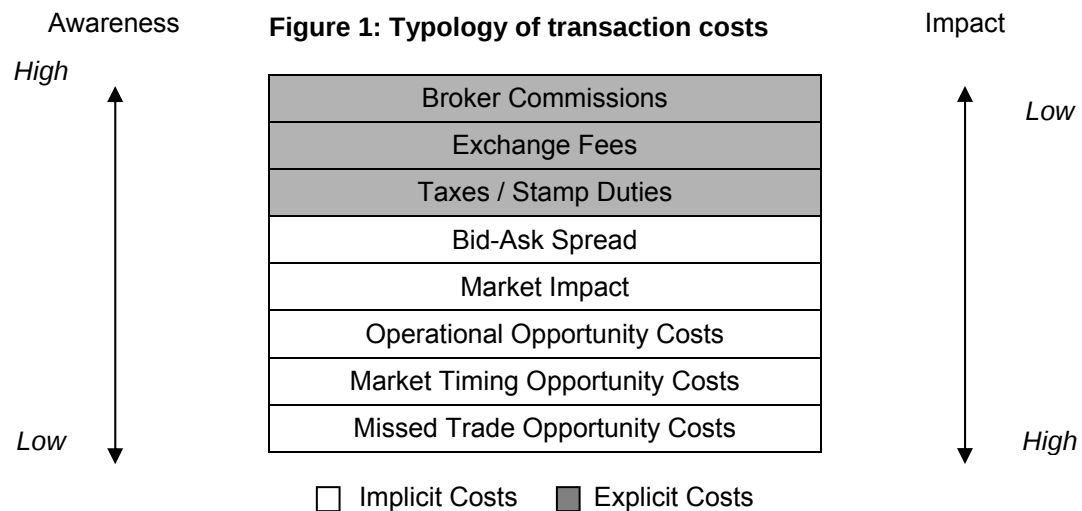
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Jean-René Giraud, Director of Development

1 The reality behind Transaction Cost Analysis

1.1 Trading Cost Components

Transaction Cost Analysis (TCA) should be a scorecard that helps traders, investment managers and firms to better understand how well they traded and their possible strategies for performance improvement. The complexity inherent in TCA is mainly due to the various components of trading costs. They are usually categorized into explicit (can be defined ex-ante, usually documented separately from the price obtained) and implicit costs (measured ex-post and 'part' of the price obtained).



Explicit costs represent the visible part of trading costs, which could be determined before the execution of the trade. However, explicit cost measurement is not as easy as it seems because brokerage commissions are often paid for bundled services, not just for order execution. The part related to services such as research, analytics or trading technology are commonly referred to as soft-dollar commissions. These practices can inflate execution costs and make explicit cost measurement more difficult.

The bid-ask spread is compensation for the costs incurred by the liquidity provider (market maker, dealer, specialist, etc.). When buying at asking prices or selling at bidding prices, traders pay the bid-ask spread. As such, the market spread is an obvious and important cost of trading. Three kinds of cost are usually included in the spread:

- order processing costs
- inventory control costs
- adverse selection costs

Order processing costs are the natural outcome of the liquidity provider's business which consists of supplying an immediacy service to the market [Demsetz (1968)]. The compensation for this is in the form of the bid-ask spread: he sells a given security at a higher price than he buys it.

Inventory control costs are related to the holding of a non-optimal inventory position. Indeed, accommodating other market participants' trades makes the liquidity provider deviate from his optimal inventory based on his own risk-return preference. To restore his optimal position, he adjusts his bid and ask prices to attract and/or avoid some trades. The spread is here viewed as a compensation for the risk of bearing unwanted inventories [Ho and Stoll (1981)].

Adverse selection costs are due to the presence of informed traders¹. As the liquidity provider loses to informed traders, he widens the bid-ask spread for all market participants to cover his potential losses [Copeland and Galai (1983)]. Freyre-Sanders et al. (2004) offer a quite complete review of all empirical and theoretical studies related to each spread component.

¹ In the market microstructure literature, traders who have some private information that allows them to know or better estimate the true value of a security are commonly called informed traders.

Market impact costs refer to the difference between the price at which the trade was executed and the market price that would have prevailed if the trade had not taken place. In other words, the market impact cost is the price shift induced by the size of the order, and its visibility to other market participants. When the order size is equal to or less than the quoted depth, the order will be executed at the best quote and the market impact will be half the bid-ask spread. When the order size exceeds the available depth at the best quote, a purchase pushes prices up or a sale pushes prices down and the market impact will be greater than half the bid-ask spread. Indeed, large orders shift the market price towards less favourable prices because they will consume several quotes in the order book or because they will initiate signals that are interpreted by other broker-dealers. The resulting price shifts exceeding the spread represent an implicit execution cost. This cost is a positive function of the order size.

Opportunity costs arise when traders fail to fill their orders or fail to fill their orders in a timely manner. The opportunity cost comprises any cost related to the risk resulting from the effect of time on market prices during the delay required to implement the trade. Market movements due to new information, the intrinsic volatility of the security or simply the price formation process may result in a loss with reference to the initial price. **Operational opportunity costs** arise between the time the trading decision is made and the time the broker receives it. These time gaps result from operational processing time on the buy and sell sides (transmission delay). **Market timing opportunity costs** refer to adverse price movements between the time the broker receives the order and the time the order is executed. This time gap results from deliberate market timing under the control of the broker. **Missed trade opportunity costs** arise when traders fail to fill their orders. Failing to trade can also be costly for the end investor who will have missed an opportunity to be invested in the security requested.

1.2 Relative Importance of Explicit and Implicit Costs

In an analysis of equity trading costs across a sample of 42 countries, Domowitz, Glen and Madhavan (2001) document wide variations across and within regions. While declining from 1995 through 1998, trading costs remain economically significant, especially in emerging markets. According to the authors, France is one of the lowest cost countries while emerging markets like Korea are consistently among the highest. They also report variations in the composition of trading costs across countries.

Both explicit and implicit costs are economically substantial in all cases. Overall, the authors find that explicit costs represent about two-thirds of the total trading cost. A remarkable exception is the US where implicit costs account for over 60%². They attribute the decline of explicit costs in the US to both technological innovations and increased institutional presence in the market, resulting in a more competitive environment. Domowitz, Glen and Madhavan (2001) insist on the importance of considering explicit and implicit costs together because they are positively correlated. Markets with high market impact costs also generally exhibit high commission fees.

1.3 Measuring Transaction Costs

Trading costs are made up of a series of explicit costs that can be quite easily assessed pre-trade and a series of implicit costs for which measurement is rendered more difficult by their inherent structure.

Reference to a price benchmark is the most commonly used method to assess implicit transaction costs for specific trades. By using a specified benchmark price, the per unit transaction cost is measured as the signed difference between the trade price and the benchmark price, where the sign is understood to be positive if the trade is a purchase and negative if the trade is a sale. It is also possible to measure transaction costs with econometric models based on statistical methods to assess the impacts that traders have on prices. These models generally examine either price reversals or the relation between order flow and price changes. They are mainly used to estimate average transaction costs for a whole market and not to measure the implicit costs of specific trades. When they are used to assess the estimated market impact ex-ante, they are very often used as a reference benchmark (e.g. arrival price + estimated market impact).

The implementation shortfall is a more recent and widely recognized approach used to measure implicit transaction costs for specific trades. This method was introduced by Perold (1988) and refers to the difference in value between an actual portfolio and a corresponding paper portfolio.

² Alba (2002) shows that these costs might represent up to 87.5% of transaction costs.

1.3.1 Benchmarking methods

Traders commonly use benchmarks such as the spread midpoint; the volume weighted average price (VWAP); the closing (or opening) price or an average of the opening, highest, lowest, and closing prices (LHOC). The signed difference between the trade price and the benchmark price provides an indicator of implicit transaction costs. According to the benchmark price used, the indicators are diverse and can be classified in three categories.

1.3.1.1 Absolute indicators without consideration of time

These indicators are the most convenient to implement, since they do not need to address the issue of order time stamping. The most frequent are computed by comparing the trade price to one of the following benchmarks: daily VWAP, LHOC, closing price, opening price, average of the daily highest and lowest midpoints, etc.

1.3.1.2 Time-related indicators based on market data only

These indicators are based on benchmarks computed around or at the time the order is sent to the broker or the trade is executed. The benchmarks used in these cases are the contemporaneous best quote (best bid for sales or best ask for purchases), the last trade price, the contemporaneous midpoint, the next midpoint, the interval VWAP (i.e. the VWAP calculated over a fixed interval around the trade or the order) or the available VWAP (i.e. the VWAP calculated from the market opening to the order time or the trade time).

1.3.1.3 Time-related indicators based on models

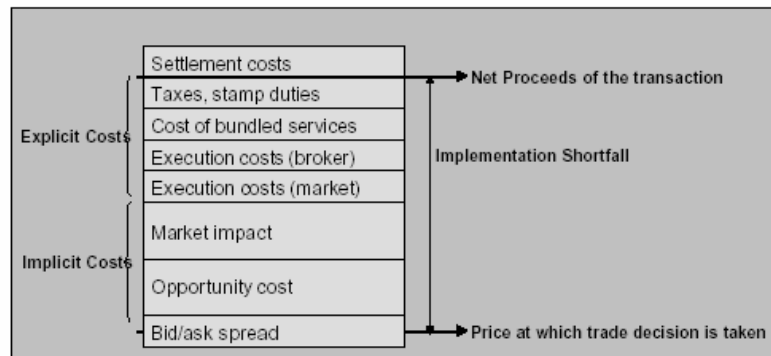
The growing importance of transaction costs has generated several market impact models developed by the brokers and third-party services providers. The most famous include the ITG, Barra and Plexus market impact models, which provide support in searching for optimal trading solutions. The risk inventory model, which directly relates transaction costs to the liquidity provider's risk of carrying excess inventories, is also commonly used in the industry. Freyre-Sanders et al. (2004) offers a very complete description of the implicit transaction cost indicators delivered by these models.

1.3.2 Implementation shortfall

This method involves calculating the difference in value between an actual portfolio and a corresponding paper portfolio. To measure transaction costs, traders have to specify a reference price at which they buy or sell the instruments in their paper portfolio. At the beginning of the trading horizon, both portfolios are assumed to have the same value. At the end of the trading horizon, the difference in value between their actual portfolio and the corresponding paper portfolio measures the costs of implementing their trading decisions relative to the reference. Indirectly, this approach also requires the determination of an appropriate benchmark price used as reference. One of the significant advantages of this methodology is that it allows the entire spectrum of opportunity costs to be taken into consideration at different investment horizons (*specifically the Missed Trade Opportunity Costs*).

The quotation midpoint at the time the decision to trade is made is the benchmark most frequently used as a reference price, providing an easy-to-interpret measure of transaction cost. In this case, implementation shortfall includes all trading cost components [See figure 2]. Commonly, the total implementation shortfall is broken into components regarding whether the order was filled. If the order is totally executed, the shortfall equals the total trade size times the signed difference between the average trade price and the benchmark price at the trading decision time. This first component assesses the execution cost of completed trades. If the trade did not take place or the order was not completely filled, the shortfall is the unfilled size multiplied by the difference between the current market price and the benchmark price. This second component estimates the opportunity cost. With this approach, trading results cannot be easily manipulated by delaying or not executing difficult orders because they appear in the opportunity cost component, which is a reason why this methodology often has preference over others among industry professionals.

Figure 2: Implementation shortfall components



Source: Giraud (2004)

Another important feature of this approach is the possibility to emphasize different aspects of transaction costs by varying the reference price. Some modified versions of the basic implementation shortfall presented in Freyre-Sanders et al. (2004) are the following:

- market-adjustment implementation shortfall is a measure adjusted for a market related movement in the portfolio value;
- execution implementation shortfall is a measure using as benchmark the market price prevailing at the time the broker receives the order, instead of the price at the time the decision to trade is made;
- post-execution implementation shortfall is a measure using the post-trade price as benchmark in order to control the informational content of the trade.

1.4 Weaknesses of Transaction Cost Measurement

Implicit transaction cost indicators are numerous and often depend on the benchmark used to calculate them. Identifying the appropriate benchmark for computing the indicators is not always as easy as it seems. Some indicators can present weaknesses that relate to the benchmark price they use. Five issues have to be considered when measuring transaction costs.

1.4.1 Noisiness of indicators

In general, the longer the time between the trade and the determination of the benchmark price, the noisier the transaction cost indicator will be. Hu (2004) classifies measures of implicit transaction costs into three categories regarding the price benchmarks used. Pre-trade measures use prices prior to the trade. During-trade measures use some kind of average price over the trading horizon. Post-trade measures use prices after the trade. Hu (2004) empirically shows that a pre-trade measure can be decomposed into a market movement component and a during-trade measure. As the market movement component is dominant in pre-trade measures, the author suggests that during-trade measures are more suitable for assessing execution quality.

1.4.2 Biases of indicators

Transaction cost indicators should only assess the costs of implementing a trading strategy given the current market conditions. When they are biased, transaction cost measures depend on how or why the trade is made. According to Harris (2003), biases may arise when trading decisions depend on past price changes or when traders are well informed about future price changes. For example, some benchmark prices can deliver transaction cost indicators that will be systematically high or low depending on whether the investor pursues momentum or contrarian strategies.

1.4.3 Relevance of indicators

The ideal benchmark price used to compute indicators should be an appropriate reference price in relation to both the trade's level of difficulty (size, liquidity of the security traded, etc.) and the client's requirements (constraints related to timing, execution probability, etc.). For example, the market price or the midpoint at the time the trading decision is made might not be relevant for the size of the order. Institutional investors in the UK tend to avoid trading at the opening of the

markets. The market price at that time might therefore not deliver a relevant indicator of transaction costs for a block order. Furthermore, market fragmentation and the proliferation of trading venues sweep away the concept of a single market price, as a trade could potentially be executed internally at a better price than the best quote published by the market at a given time. This phenomenon complicates the search for an appropriate benchmark.

1.4.4 Gaming of the indicators

When intermediaries know that their clients will use transaction cost indicators to assess their trading, they can arrange trades to optimize their evaluation rather than to provide best execution services to their clients. This gaming problem can be serious when the broker can estimate the benchmark price that will be used to calculate the indicator and can obtain a new benchmark by deferring the trade. Harris (2003) describes several situations in which brokers can game their evaluations. For example, brokers who have discretion over how aggressively they fill their orders can easily game an indicator based on the midpoint quotation prevailing at the time of the trade. To game this measure, brokers always supply liquidity and never take it. Consequently, they always buy at the 'bid' or sell at the 'ask' and their estimated transaction cost indicators will always be negative. This behaviour can be questioned if their clients are impatient to trade.

1.4.5 Absence of opportunity costs

As explained before, opportunity costs are an integral part of implicit transaction costs. Varying the time at which the benchmark is defined allows for indicators that measure operational and market timing opportunity costs. However, most indicators do not include missed trade opportunity costs. Nevertheless, failing to trade can be costly. To assess the opportunity cost of an uncompleted trade, traders should use the average price at which the trade would have taken place if it had been completed as a benchmark.

1.5 A Review of the Most Popular Indicators

The price benchmark used when evaluating transaction costs determines what really is measured. Different benchmarks can therefore serve different purposes. Even if they have virtues, all the benchmark prices have also serious drawbacks which complicate their use and the interpretation of the indicators they deliver. No price benchmark seems perfect and traders have to make trade-offs between calculation costs and various properties of indicators.

1.5.1 Spread midpoint benchmark price

The average of the bid-ask spread is the easiest benchmark to compute. Different transaction cost indicators are obtained according to which quotation midpoint is used. The quotation midpoint prevailing at the time of the trade produces the effective spread (sometimes called the liquidity premium) while the post-trade quotation midpoint will produce the realized spread. The advantage of an indicator based on this benchmark price is its simple interpretation: the cost of a buy at the 'ask' (or a sell at the 'bid') is one-half of the spread. However, an important limitation to this basic approach is that the spread midpoint benchmark does not indicate whether the trade is well timed. Buys should be cheaper than sells when dealers lower prices to move excess inventory or when prices are depressed in response to a large uninformed seller. Another problem with this method is that large orders may require many trades between which quotes typically change. The total transaction cost will be underestimated if a different midpoint benchmark is used for each particular trade. Finally, brokers may defer the trade until it can be filled when the spread is narrow.

1.5.2 Volume weighted average price (VWAP)

This price benchmark is constructed by aggregating intraday prices multiplied by their volume, brought back to the unit price by dividing by the daily volume. This simple summary statistic for all trades in a day provides an attractive indicator because it allows traders to know whether they received a higher or lower price than the average trader that day. The measurement interval can also be longer (multi-day VWAP) or shorter than one day (interval VWAP or available VWAP). This method suffers from several disadvantages. Firstly, the transaction cost indicator based on VWAP is zero if you are the only buyer (or seller) in the measurement interval. In addition, traders who can postpone their trades to obtain a new measurement interval can game this indicator. Finally, the portfolio selection/implementation decomposition is blurred. Momentum traders estimate positive costs while contrarian traders estimate negative costs.

1.5.3 Closing price benchmark

The transaction costs can also be estimated through the difference between the average trade price and the closing price on the day of the trade. Using this price benchmark provides several advantages. Firstly, closing prices are easily obtained. Secondly, brokers cannot game the resulting transaction cost indicator because the benchmark price will only be known in the future. Third, momentum and contrarian traders measure unbiased transaction costs in efficient markets. Finally, many traders prefer to use closing prices because portfolios are valued at these prices, allowing them, for example, to avoid favouring new entrants or existing investors in a fund when investing/divesting fund subscriptions and redemptions. The biggest disadvantage is that this price benchmark can deliver transaction cost indicators noisier than the VWAP estimates when the time gap between the trade and the closing price calculation is large.

1.5.4 Average of the lowest, highest, opening and closing prices (LHOC)

This price benchmark is widely recognized but as a simple average of prices, it loses the dimension of market depth included in the VWAP. Moreover, the LHOC provides transaction cost indicators which greatly depend on opening and closing prices (50% of the measure) which cannot always be considered relevant as references. The opening (closing) price produces very noisy transaction cost estimates for orders filled at the end (start) of the day.

1.5.5 Implementation shortfall

As discussed earlier, the most important advantage of the implementation shortfall approach is that trading results cannot be easily manipulated by delaying or not executing difficult orders because they appear in the opportunity cost component. Using the implementation shortfall as an indicator of trading costs is an attractive option but faces many constraints.

First of all, the implementation shortfall requires decision time and order size data. Investment managers can collect these data at some cost but not all have implemented infrastructures that allow for time-stamping at all stages of the order flow (from the time the trading decision is taken to the time the trade is completely filled).

Next, similarly to benchmarking methods, the implementation shortfall requires a reference price to value the paper portfolio and measure transaction costs. Which price benchmark is used determines what the implementation shortfall really measures.

Finally, the biggest problem with this method is how to use the results practically to analyze and improve the trading performance. The implementation shortfall produces an absolute indicator of implicit transaction costs expressed in basis points. Determining whether the estimated costs are low, normal or large is not straightforward.

2 EDHEC proposal: a new framework for advanced TCA

Because it is our aim to attempt to provide solutions, EDHEC is currently developing an innovative framework for the analysis of transaction costs. Indeed, the role of TCA in the industry is set to become even more than essential with the arrival of MiFID. However, as we have seen previously, the current absence of a standardised framework to easily assess the quality of the entire trading process is problematic. The EDHEC approach tries to fill this gap by offering a unified framework for measuring *ex post* the quality of execution.

Because peer groups or relative analysis are frequently demolished by market participants that consistently identify good reasons not to accept a benchmark or a peer group as relevant for assessing the quality of their trade (under the justification of more or less relevant arguments), we have opted for an absolute measure of the price obtained, which is a score between 0 (bad performance) and 1 (good performance).

More precisely, our approach, the EBEX framework (EDHEC Best Execution), is based on two fundamental principles.

- First, the average trade price is the primary component of the quality of an execution, even if other dimensions exist. The price includes all the implicit costs related to the execution, except the missed trade opportunity cost.³ It must be said that other explicit costs (brokerage fees, stamp duties and IT and operational costs) can be assessed separately on a global basis rather than trade by trade. Furthermore, other factors suggested by the Directive find their place in the framework (for example speed of execution translates into cost as the price obtained is the result of a trade-off between market impact and opportunity costs, size of the order and nature of the order are taken into consideration too)
- Secondly, we consider that the best reference for assessing the quality of a price *ex post* is the universe of all trades relative to the same security, executed on the available trading venues, under similar timing.

Specifically, the EBEX framework relies on a couple of indicators allowing an easy comparison of a large universe of trades and providing insightful information not only about the final performance (the absolute EBEX indicator) but also about the possible justification of the performance (the directional EBEX indicator), thereby actually providing a measure of the quality of the market timing.

EBEX exhibits several advantages, especially in comparison with current practices witnessed in the industry. On the one hand, this approach is very simple, provides a standardised framework to assess the quality of execution across a series of trades aggregated at any level, and is in total compliance with MiFID's requirement to demonstrate that the objective sought has been reached. On the other hand, this approach delivers absolute measures of the quality of execution, allowing straightforward and objective interpretation, and also includes trade-timing consideration. Such an approach allows the investor to easily determine whether or not the quality of his intermediary, trader or even algorithm can be considered to be in the first quartile.

EBEX is being actively discussed between professionals and academics, and we are confident that positive developments will be proposed in the very near future to allow it to cope with specific situations that the first version did not cater for, such as the client's constraints or the cost for the client associated with the broker's performance.

Several enhancement are currently being discussed to cater for specific situations not currently supported (constraints on orders, volume objectives, price objectives ...) and will be documented in the very near future.

³ The missed trade opportunity cost is a component of opportunity costs that refer to the cost associated to unfilled orders or partially filled orders. The principle behind it is that failing to trade can be costly for the end investor, who will have missed the opportunity to invest in the security requested.

3 The EBEX indicators

3.1 General presentation

EDHEC approach provides to the following question an answer in a simple manner:

“Given a transaction handed over to a broker, trader or algorithm and executed for a given price at times that are recorded under given time constraints, to what extent have other brokers, traders or algorithms executed comparable volumes to this transaction, either before or after this transaction, at a better price?”

The answer to this question can be split into four important elements:

1. The time at which the order is handed over (release time) to an intermediary (being a broker, a trader or an algorithm) is the first point of reference while the time at which the order is entirely filled (execution time of the last lot referring to the order in case of splitting) is the second point of reference.
2. The size of ‘competing trades’ is not important as such, the relevant measure is how many times a volume comparable to the order has been executed at a better price, which is a first measure of the quality of the price obtained. The price has to be compared to small trades executed at better prices (the broker, trader, algorithm could have split the order better) as well as with larger trades (the order could have been grouped with a larger flow of orders to be executed in block if such trading capability is offered).
3. Volumes traded before at a better price allow one to measure whether the broker, trader or algorithm has been too patient or not.
4. Volumes traded after at a better price allow one to measure whether the broker, trader or algorithm has been too aggressive or not.

Based on these elements, the EBEX methodology measures the quality of execution as part of a peer group review and identifies whether the broker, trader or algorithm has implemented the execution too aggressively or too slowly. Specifically, this approach relies on a couple of indicators.

The Absolute EBEX indicator measures the quality of execution in a peer group review. The Directional EBEX indicator identifies whether the broker, trader or algorithm has implemented the execution too slowly or too aggressively. In other words, the first indicator assesses the quality of execution itself while the second indicator brings information about why the quality of execution is as observed.

3.2 Detailed presentation of the indicators

Our two indicators rely on the same philosophy and are easy to both compute and interpret. For a question of convenience, we will begin with the presentation of the second indicator.

3.2.1 Directional EBEX

3.2.1.1 Definition and components

Directional **E**stimated **B**est **E**xecution for an order indicates how the broker⁴ could have traded over time to provide a better execution. This indicator results from the combination of two sub-indicators that respectively measure the volumes traded at better prices before and after that the trade was executed. Specifically, the directional EBEX indicator for order i is computed as follows:

$$EBEX_{dir,i} = NBBEX_{i,j} - NABEX_{i,t}$$

$NBBEX_{i,j}$ and $NABEX_{i,t}$ are thus the components of the directional EBEX indicator. Their definition and computation are very similar, only the measurement window of reference differs.

- $NBBEX_{i,j}$

$NBBEX_{i,j}$ stands for **N**umber of **B**efore-**B**etter **E**xecutions for order i over the time interval j . This component can be defined as a ratio between the aggregate volumes traded at a price better than the average trade price of order i divided by the size of order i and the aggregate volumes without

⁴ Or any other intermediary.

consideration of price divided by the size of order i . This ratio is computed over the interval j which goes from the time the broker receives order i (release time) to the time order i is completely filled (execution time).

The mathematical notations referring to $NBBEX_{i,j}$ are given here below, respectively for sell orders and buy orders.

$$NBBEX_{i,j} = \frac{\sum_{n=1}^N V_{n,j}^{P > AP_i}}{(S_i)} \quad NBBEX_{i,j} = \frac{\sum_{n=1}^N V_{n,j}^{P < AP_i}}{(S_i)}$$

$$\frac{\sum_{m=1}^M V_{m,j}}{(S_i)}$$

In both equations, each element is defined as follows:

- $NBBEX_{i,j}$ is the number of better executions for order i during the time interval j
 - j is the interval between the time the broker receives order i and the time order i is completely filled
 - S_i^5 is the size of order i
 - AP_i is the average trade price obtained for order i
 - N is the number of trades at a price better than AP_i during time interval j
 - $V_{n,j}^{P > (<)} AP_i$ is the size of trade n at a price higher (lower) than AP_i during interval j
 - M is the total number of trades during the time interval j ; $M \geq N$
 - $V_{m,j}$ is the size of trade m during time interval j
- $NABEX_{i,t}$

$NABEX_{i,t}$ stands for **N**umber of **A**fter-**B**etter **E**xecutions for order i over the time interval t . This component can be defined as a ratio between the aggregate volumes traded at a price better than the average trade price of order i divided by the size of order i and the aggregate volumes without consideration of price divided by the size of order i . This ratio is computed over the interval t which starts at the time order i is completely filled (execution time) and which ends at the market close of the day.

The mathematical notations referring to $NABEX_{i,t}$ are given here below, respectively for sell orders and buy orders.

$$NABEX_{i,t} = \frac{\sum_{n=1}^N V_{n,t}^{P > AP_i}}{(S_i)} \quad NABEX_{i,t} = \frac{\sum_{n=1}^N V_{n,t}^{P < AP_i}}{(S_i)}$$

$$\frac{\sum_{m=1}^M V_{m,t}}{(S_i)}$$

In both equations, each element is defined as follows:

- $NABEX_{i,t}$ is the number of better executions for order i during the time interval t
- t is the interval between the time order i is completely filled and the next market close
- S_i^6 is the size of order i
- AP_i is the average trade price obtained for order i
- N is the number of trades at a price better than AP_i during time interval t
- $V_{n,t}^{P > (<)} AP_i$ is the size of trade n at a price higher (lower) than AP_i during interval t
- M is the total number of trades during the time interval t ; $M \geq N$
- $V_{m,t}$ is the size of trade m during time interval t

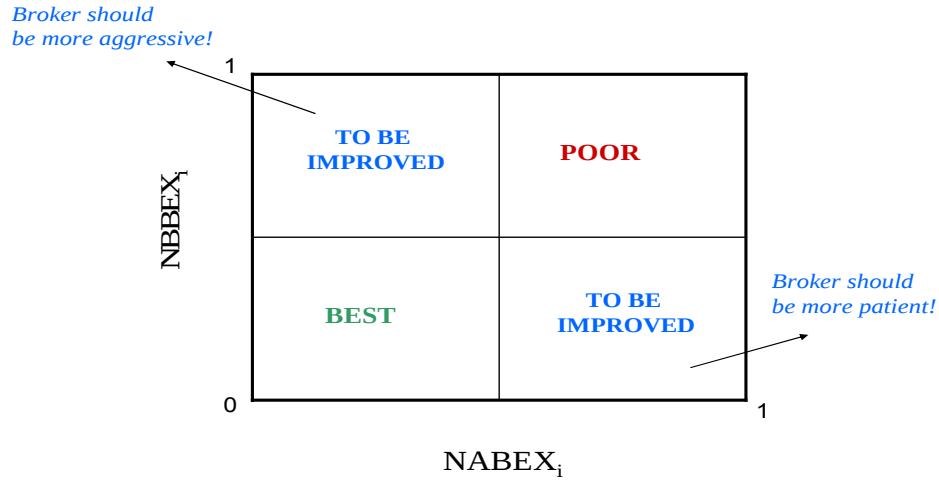
3.2.1.2 Interpretation

Now that both components of the directional EBEX indicator have been presented, we can focus on how they can be interpreted to characterizing the timing of the trade. This interpretation is very easy because both range from 0 to 1, given the way they are built. Figure 1 will help for understanding how the interpretation can be made.

⁵ S_i can be simplified but is still displayed for clarity purposes.

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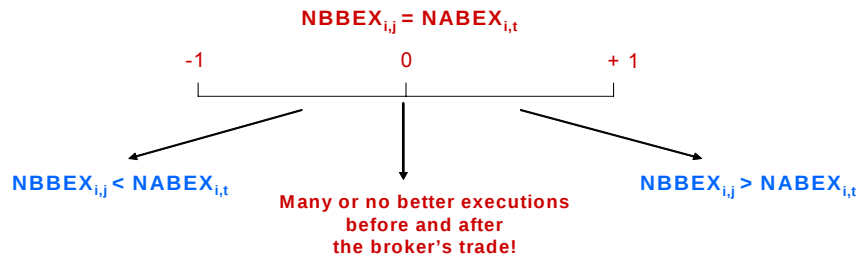
Figure 1: Interpretation of directional EBEX components
ORDER_i EXECUTION



A direct comparison of both indicators delivers our directional EBEX indicator, for which the interpretation is even easier. The goal of this indicator is to give information about how the intermediary could have traded over time to provide a better execution. Given its construction, a simple difference between NBBEX and NABEX, the directional EBEX indicator can range from -1 to +1. The figure here below (Figure 2) summarizes the interpretation of the directional EBEX indicator.

Figure 2: Interpretation of the directional EBEX indicator

$$EBEX_{dir,i} = NBBEX_{i,j} - NABEX_{i,t}$$



3.2.2 Absolute EBEX

3.2.2.1 Definition

The absolute indicator of **Estimated Best Execution** for an order is defined as the difference between one and a ratio between the aggregate volumes traded at prices better than the average trade price obtained for the order divided by the order size and the aggregate volumes without consideration of price divided by the size of the order. The ratio is then computed over the interval going from the time the broker receives the order (release time) to the next market close. Specifically, the absolute EBEX indicator for order i is calculated as follows, respectively for a buy or a sell.

$$EBEX_{abs,i} = 1 - \frac{\sum_{n=1}^N V_{n,day}^{P < AP_i} (S_i)}{\sum_{m=1}^M V_{m,day} (S_i)} \quad \quad \quad EBEX_{abs,i} = 1 - \frac{\sum_{n=1}^N V_{n,day}^{P > AP_i} (S_i)}{\sum_{m=1}^M V_{m,day} (S_i)}$$

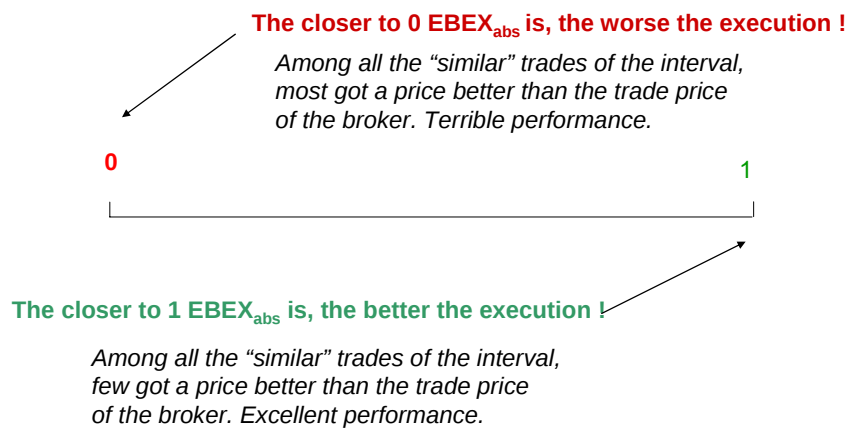
In both equations, each element is defined as follows:

- $EBEX_{abs,i}$ is the absolute best execution indicator for order i during the trading day
- day is the interval between the time the broker receives order i is and the next market close
- S_i^7 is the size of order i
- AP_i is the average trade price obtained for order i
- N is the number of trades at a price better than AP_i during the time interval
- $V_{n,day}^{P>(<)AP_i}$ is the size of trade n at a price higher (lower) than AP_i during interval day
- M is the total number of trades during the time interval day ; $M \geq N$
- $V_{m,day}$ is the size of trade m during the time interval day

3.2.2.2 Interpretation

Given the way it is built, the absolute EBEX indicator can only take values between zero and one. This makes the interpretation very easy, as illustrated in Figure 3.

Figure 3: Interpretation of the absolute EBEX indicator



3.2.3 Implementation

An important pre-requisite for EBEX framework to be implemented consistently is to benchmark the transactions in light of the entire universe of transactions on the same security. This strong requirement is currently not fulfilled as no central database of transactions exist for all European markets, we expect however this to be the case soon after the implementation of MiFID as most data vendors are currently envisaging building such a global tape on the basis of the new harmonized post-trade reporting obligation.

⁷ S_i can be simplified but is still displayed for clarity purposes.