Transaction Cost Analysis (TCA)

Working Group

TCA Reference Manual and Guide to Best Practices

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1 Introduction

Transaction Cost Analysis (TCA) is a collection of methodologies used to determine the cost of trading at any or all points in the investment life cycle. A lack of industry-defined standards and consistency across TCA providers causes the practice to face many obstacles to wider adoption by all market participants. Some of the challenges faced (in order of concern) as per a survey sent to the FIX TCA Working Group include:

- Confusion around terminology and methodology;
- Limited consensus on relevance of TCA practices to other asset classes;
- The inconsistency and lack of clarity around condition codes / liquidity flags used in the construction of universe data sets;
- Need for additional timestamps and instruction tags to provide more support for analysis of the full order lifecycle;
- Lack of transparency and objectivity in analytical tools
- Complex TCA scenarios, such as fungible stocks trading simultaneously in different currencies across borders;
- In Europe, the lack of a good consolidated tape.

Strong interest by FIX member firms to address and hopefully eradicate these issues has prompted the development of two new FIX TCA Working groups. Working Group #1 will focus on TCA terminology and methodology, and Working Group #2 will focus on the more granular (data and technology) aspects of TCA. Both Working Groups will collaborate to produce a single consolidated document but will work in successive order. Thus far, only WG #1 has started up, by design.

1.1 Purpose

The purpose of the TCA working group #1 is as follows:

- To create a glossary of industry-acceptable TCA terminology. The glossary will be used to catalogue existing TCA methodologies. It will allow providers to relate their products to this baseline, and hopefully, for consumers of TCA to better differentiate the offerings to their unique needs.
- To define a standardized set of guidelines/best practices that will allow for a more consistent evaluation of the investment process, and providing fund managers transparency into the cost of implementing their investment ideas.
- To promote the idea of creating a permanent neutral body to provide global validation and ongoing maintenance of TCA standards.

1.2 Scope

The initial version will develop industry-wide terminology and methodology for Equities, from pre-trade to post-trade analytics.

Phase 2 of this project will expand the document to include TCA perspectives on the following asset classes:

- Futures and Listed Options
- Foreign Exchange
- Fixed Income

Phase 3 will review the FIX Protocol Specification to determine if it is possible to add support for TCA-specific data items.

1.3 Target Audience

The intended audience for this document is broad, spanning a range of roles in Buy-Side, Sell-Side, Vendor organisations, and Institutional Investors.

The content is as yet relatively high-level in nature. It serves as a good introduction to the purpose, practice and practicalities of TCA. It lacks full detail on some of the more niche or complex metrics and methodologies, in large part because of the wide range in active use, and thus may not be as useful to technical quantitative specialists.

2 TCA Fundamentals – Basic Analytics

2.1 What is the cost of trading?

The process of buying or selling securities by institutional and retail investors involves several parties such as brokers, exchanges, custodian banks, and regulatory/taxing agencies. To support the trading process, these entities issue charges referred to as commissions, taxes, and fees (such as agency, custodial or transfer fees)[1] that are incurred by the process participants along the way. These charges are one of the components of the cost of trading and are referred to as **Explicit Costs**.

Explicit costs calculated using a predictable formula and clearly broken out[2]. For this reason, they are usually segregated or optionally removed altogether in a TCA analysis. When considering Explicit Costs within TCA, they should be limited to only those charges that are incurred during the execution process, and should not include post-trade settlement or custodial fees.

Once a decision to trade has been made (i.e., order creation), there could be **Delays** before the order begins executing. These delays can be caused by process, environment (i.e., hardware, network connectivity), or both.

The act of executing a trade has an effect on the price of the security that varies in its duration. There are several variables that can influence the price during execution and when combined are known generically as **Execution Cost.** These variables are discussed in more detail in section 2.3.2 (Implementation Shortfall).

Execution Cost and Delay Cost are never explicitly known but can be measured in various ways. The combination of Execution Costs and Delay Costs are known as **Implicit Costs**.

It is also possible that once the order begins executing, it may not be completed during a trading session (for example, due to a lack of participants to take the other side of the trade at desired quantities and price, portfolio manager constraints, etc.). An estimate of this variable can be calculated and categorized as **Opportunity Cost**, aka **Opportunity Risk**. The classic situation for a trader is weighing the trade-off between how much market impact can be tolerated versus the risk of not trading and second-guessing market behavior on subsequent days. *While we recognize the importance of measuring Opportunity Cost, in practice it is usually not included as part of the process to calculate the cost of trading.*

This section is meant as a basic overview. Terms and cost computation methodologies are discussed at greater detail throughout this document.

2.2 What do we want to measure?

A basic TCA process should measure the costs listed above against a set of benchmarks to derive a sense of performance and quality of the decision and its execution. The benchmarks most commonly used are either against a Point-In-time reference price (i.e., Market Open/Close) or an Average value (i.e., historical volume, participation threshold). A minimal TCA should be able to isolate Implicit Cost, and preferably decompose it into the Delay and Execution Cost components. While more advanced techniques can further break out Execution Cost into its various sub-components (e.g. price impact and momentum), the authors feel that Implicit Cost at its first level of decomposition is the best recommendation as a standard practice.

[1] Milan Borkovec, Hans Heidle (2009) Building and Evaluating a Transaction Cost Model: A Primer.

[2] It should be noted that given their nature, some of these commission and fee amounts may not be fully known until sometime after the order is executed, and/or may be calculated across a collection of orders. Examples include sliding commission scales dependent on trading volume, or national taxes calculated on a fund's net purchase across the day's tickets.

A TCA analysis may also include a separate accounting of Explicit Costs, at minimum separating commissions from other taxes and fees. Explicit costs should be expressed in the same terms as Implicit costs, so they can be combined to provide a total cost metric. See section 2.3.1 for more details.

Another important factor in guiding the measurement and reporting process is to know the intended audience for the TCA report. Consider the investment lifecycle and its participants; at the high-level there are investors, investment managers, and brokers, all of whom play a part and have their own perspective regarding the cost of trading. Understanding your target audience and tailoring to their perspective will provide for a more meaningful TCA.

2.3 Computing Cost

The mathematic aspect of computing cost metrics is quite simple and fits nicely within spreadsheets, database environments, and financial tools. The difficulty lies in obtaining the underlying timestamps and subsequent market reference data to be used for benchmarks. It is out-of-scope of this document to discuss the procurement and management of execution data and market data details. We assume the user has access to the necessary trading and market data for analysis, either acquired through their internal systems or through a TCA provider.

In general, TCA costs are calculated to show results as either a gain (positive number) or loss (negative number) when comparing an execution price to its benchmark. A gain indicates that the execution outperformed the benchmark, whereas a loss indicates underperformance. **Thus, the term "cost" is used generically to mean either a gain or loss**, despite connotations that it implies a loss**.** It should be noted that some academic literature references a positive number as denoting an under-performance versus benchmark; in this document we follow instead the more pragmatic "positive is a good result" convention prevalent in practical use. The formula is simple subtraction, the difference between the benchmark price and the execution price and it is assumed that both are the same currency. But the caveat of this formula is that it must be adjusted by side (buy or sell) since outperformance will mean that one bought below or sold above the benchmark. The adjustment can be accomplished in two ways:

- **Using simple subtraction and incorporating a multiplier (1 or -1) to adjust for the side**.
  The Execution Price is always subtracted from the Benchmark Price.
  Example: **Difference = (BM – EX) * BSI**
  (where BM = benchmark, EX = Execution, BSI = Buy/Sell indicator buy=1, sell=-1)

- **Adjusting the subtraction order by side without using a multiplier**
  For buys, the Execution price is always subtracted from the Benchmark Price.
  For sells, the Benchmark Price is always subtracted from the Execution Price.
  Example: **Buy difference = BM – EX**
  Sell difference = EX – BM
  (where BM = benchmark, EX = Execution)

Either method is acceptable, for illustrative purposes this document will always use the first method for consistency.

But the simple difference in raw price data can be too miniscule to measure, so it is standard practice for TCA to express costs as the percentage difference in basis points. This expands our simple difference formula as follows:

- **Gain/Loss in basis points = (((BM – EX) * BSI) / BM) * 10000**
  (where BM = benchmark, EX = Execution, BSI = Buy/Sell indicator buy=1, sell=-1)

With this formula, we now have a standard way to compute the "cost" of any single execution, regardless of asset class. Please refer to section 2.4 to aggregate cost across multiple executions.

2.4 Aggregating Cost

A common practice is to calculate TCA metrics at the per-order level, and then to aggregate those metrics across orders to understand the underlying cost trends with the per-order fluctuations smoothed out via averaging.

Weighted averages are typically computed, grouped across various dimensions such as time period, trade size ranges, country, volatility ranges, fund, trader, participation rate, sector etc.
The weighted averages are typically computed in basis points, as that methodology alone works across currencies.

The most mathematically correct methodology for aggregation is to weight by the "benchmark value", but in practice the executed value is used, in some normalized currency such as USD. Please refer to Appendix 2, "Examples of Cost Aggregation".

2.5 Expression of Cost

It is recommended that Implicit and Explicit costs be expressed in basis points since that appears to be the most prevalent convention in use today. We do recognize there are reasons for using alternative units of measure, some of which are listed below:

- Actual cost for the whole order, converted into an agreed currency e.g. USD, EUR
- Cost per unit (e.g. per share, per contract) converted into an agreed currency. It can be common in the US and Canada to measure in Cents per Share.
- Cost per unit, expressed in multiples of the asset's tick size – common in Futures

Regardless of the convention used, it is important to provide a uniform expression of units throughout a TCA report, such that costs can be decomposed and summed in a consistent manner.

2.6 Explicit Costs

As previously stated, Explicit Costs are composed of Commissions, Taxes, and Fees. Fees should include only those charges that were incurred during the execution process, such as SEC fees, and should not include custodial or settlement fees. Additionally, commissions should always be segregated from taxes and fees. For TCA, Explicit Costs should always be segregated from Implicit Costs and should always be expressed in the same terms as Implicit Cost (e.g., in basis points).

Computing Explicit Cost in basis points is different from deriving a benchmark-based cost. The underlying value of explicit cost items is generally expressed as the total value (currency dependent). The following formula can be used to express the cost of any explicit charge in basis points:

- **(Total Value of the Charge / Total Value of the Execution) * -10000**
  Where the Total Value of both items is expressed in the same currency
  10000 converts the ratio into basis points, negative forces this as a Loss

The interesting part of this calculation is that it forces the basis point cost to a negative number. The reasoning is that all explicit charges should be considered a loss, when compared to the gain/loss cost that is possible with Implicit Costs. Converting to this form allows us to derive the overall total cost by adding both the Explicit and Implicit portions.

The exception for Explicit Cost lies with U.S. and Canadian equity markets, where commission charges are typically expressed as cents per share. If a report is single currency and gauged exclusively to either of these markets, then it is acceptable to express the commission cost in terms of both cents/share and basis points (both negative). Under any other circumstances, commission cost should be expressed in basis points only.

2.7 Implementation Shortfall for TCA

In its original usage[3], Implementation Shortfall is defined as the difference between the portfolio's paper return and the return of the portfolio after investment ideas are implemented in the real market. It is essentially the measure of dollars lost due to implementation of investment ideas. Evidence[4] shows that the difference between the paper return and the actual portfolio's return can be significant, and thus warrants measurement and analysis. Implementation Shortfall, as defined this way, is applicable to all asset classes.

Broadly speaking, Implementation Shortfall can be split into Explicit and Implicit Costs.

Common Definition and Usage of the Term "Implementation Shortfall"

For TCA purposes, **we define Implementation Shortfall simply as the sum of Explicit and Implicit costs**. In that context, TCA is primarily focused on a measurement framework specific to the **Implicit Costs of executed orders**. It is often defined as a framework that involves two basic steps:

1. Measurement - How much value is lost due to implementation of investment ideas, focusing primarily on Implicit Costs.
2. Analysis - Understanding the factors that affect the measurement of Implicit Costs and devising ways to minimize that shortfall.

For the purposes of this document, our focus is narrowed even further to the measurement component, specifically describing a method of calculating implicit trading costs using a market-based reference price relative to a timestamp or time range in the lifespan of an order. In its simplest form, this requires:

- A **timestamp** or **time range** (e.g., when an order was created by a Portfolio Manager)
- A **market price** (e.g., the mid of the current bid and ask) or average price
- The **execution price** (not including commissions and fees)

Implicit costs, using this narrow definition, are calculated order by order using the following process:

- Determine the start time of the order (e.g., 10:31 AM local market time)
- Lookup the market price at the time of that order (e.g., 13.47). This is the "reference price" or "benchmark price"
- Determine the average execution price for the order (e.g., 13.52)
- For a buy order, we use the formula defined in section 2.3, where BSI = 1 for buys:
  (((13.47 – 13.52) * BSI) / 13.47) * 10,000 = -37 bps
  This is the implicit cost of trading for the executed portion of the order.

The default order timestamp for Implementation shortfall is the PM Order Creation Time (as shown in Order Lifecycle chart in Section 5.3. This point-in-time represents the start of the order lifecycle which provides for the most complete cost measurement to the end of execution.

Implicit Cost "Decomposition" and Analysis

There are many ways to decompose Implicit Costs into individual components. When multiple asset classes are taken into consideration, the number of methods for decomposition increases significantly. Each firm (be it vendor or asset manager) that calculates Implicit Costs may choose its own methodology for the cost decomposition. The availability of timestamps, market data and models may determine the type of cost decomposition that is possible. Some common methods of Implicit Cost decomposition for equity securities are:

[3] Perold, A. (1988) The implementation shortfall: paper versus reality, J. Portfolio Management, 14(3), 4-9.

[4] Treynor, J. (1981) What does it take to win the trading game?, *Financial Analyst Journal*, 55-60

Delay and Execution Cost

- Delay - The price movement from order creation to when it is released to the market. Delay costs may be decomposed further into intermediate delay components such as order creation to trader acknowledgement, and trader acknowledgement to release to the broker/market. The Order Lifecycle chart in section 5.3 illustrates the decomposition of delay cost.

- Execution Cost - The price movement from when the order is released to the market until it is executed.

Market Trend, Market Impact, and Spread

- Spread - The immediate cost to purchase a security at higher than the bid price or sell a security lower than the ask price.

- Market Impact - The price movement caused by the initial or immediate action to purchase or sell a security, not already attributed to Spread.

- Market Trend - The component of total Implicit Costs not explained by Spread and Market Impact.

Own Impact, Impact of Others, and Market Trend

- Own Market Impact - The price movement caused by one's own trading activity, including spread costs, temporary price impact and permanent price impact.

- Market Impact of Others - The price movement associated with the trading of other market participants.

- Market Trend - The price movement not caused by Own Impact or the Impact of others.

From these examples, one can see that a single term may have multiple definitions (e.g., Market Impact). Because these terms are used in conjunction with different methodologies, overlapping definitions may occur. It is not in the scope of this document to suggest standard definitions for the terms associated with the decomposition of Implicit Costs.

Summary and Definition
In summary, **Implementation Shortfall for TCA** is defined as the **sum of Explicit and Implicit Costs**. The using the Order Lifecycle Diagram in Section 5.3 as reference, the definition of **Implicit Cost** is as follows:

> *The signed, realized price difference between the market price at PM Order Creation Time and the weighted average Execution Price for an order.* ***Implicit Cost*** *can be decomposed into the following two components:*
>
> - ***Total Delay Cost*** *– The price difference between PM Order Creation (T1) and Broker Effective time (T4)*
> - ***Execution Cost*** *– The price difference between Broker Effective Time (T4) and the average execution price calculated after Broker Expire Time (T7).*

While this definition covers the total cost incurred during the entire lifecycle, providers are free to use any point-in-time or time-range to determine specific results as needed.

2.8 Benchmarks and Reference Prices

This section provides an overview of the characteristics of different types of references prices used for TCA. For this purpose, we use the terms "benchmark" and "reference price" synonymously and interchangeably. We would also like to note that outside of TCA, the term "benchmark" commonly refers an underlying index to which a portfolio can be compared for performance purposes. This use is considered outside the scope of TCA.

For TCA there are two basic types of reference prices: **Point-in-Time** benchmarks and **Average Price** benchmarks. Both types of prices can be used in the formulas for computing cost as defined in section 2.3, however, there is a subtle difference in the context of the result. The cost derived between a point-in-time benchmark and execution price reflects the net result of trading decisions and market forces during the trading of the security. This result can be interpreted as transaction cost. The result using an average price benchmark in the cost calculation expresses the variance from an average price. This variance is often construed as cost, but essentially it is a comparison to the weighted average price of all participants during the measured time range. While this is significant information, it does not represent the cost of trading.

Please refer to section 5.2 for more information about specific benchmarks for TCA.

2.8.1 Point-in-Time Benchmarks

Point-in-time benchmarks are prices that are derived from a specific, single point in time, usually contained within the order lifecycle. The price may be an actual traded price or a quoted price (i.e., a bid or an ask price, or "tick"). Market open and close prices are also considered point-in-time benchmarks.

There are occasions when a desired point-in-time may occur outside a market's operating hours, and a substitute price will be required. A common example is the PM Order Creation Time (T1), which can occur before a market is open, hence there is no trading activity to generate trades or price quotes. In this case we have two choices available for a substitute price: either rolling back to use the prior market closing price, or rolling forward to use the next market open price. Convention in this case will be dictated by perspective, as a portfolio manager may be interested in measuring cost from the prior market close, while a trader may be interested in the cost starting at the market open.

A variation of this situation can also occur while the market is open, i.e., there is no reference price available for a given timestamp. This can occur simply due to lack of trading activity in a particular instrument, or perhaps to the timestamp itself. Again, convention should be dictated by perspective as to whether one rolls back or forward to obtain the benchmark price.

A final note about point-in-time benchmarks is that they adapt very well into other asset classes. The basic order lifecycle (section 5.3) and most of the event points are meaningful outside of Equities.

2.8.2 Average Price Benchmarks

Average Price benchmarks come in a variety of flavors. The most well-known and perhaps controversial is Volume Weighted Average Price, or VWAP. Volume-weighted averages are meaningful primarily for equities and equity derivative products, but other asset classes have their own variations of average price benchmarks. This section will discuss three of the more well-known versions in use today for equities.

2.8.2.1 Volume Weighted Average Price (VWAP)

Volume Weighted Average Price (VWAP) is a range-based average price benchmark calculated using actual trades reported over a specified time interval. The formula for VWAP for an equity security is typically calculated as:

$$\text{VWAP} = \sum(\text{Price}_{\boldsymbol{n}} * \text{Quantity}_{\boldsymbol{n}}) \,/\, \sum(\text{Quantity}_{\boldsymbol{n}})$$

Where $\boldsymbol{n}$ represents each individual trade that occurs during a defined period of time.

There are 3 major items to consider when calculating a VWAP:

1. Time Period – The starting point and ending point to be used
2. Filtering – Which reported trades to be include
3. Markets – Which venues to be included

The Interval

VWAP can be calculated between any two points in time. A common usage is to calculate VWAP between t6 (Broker Effective Time) and t9 (Broker Expiry Time). The table on the next page lists different types of VWAP calculations and their suggested usage:

VWAP Type	Start Point	End Point	Usage
Interval VWAP (IVWAP)	Any event timestamp such as t6 (Broker Effective Time)	Any event timestamp chronologically after the Start Point, such as t9 (Broker Expiry Time)	Used as a comparative benchmark to evaluate the quality of execution over a period of time.
Available VWAP (AVWAP)	Any event timestamp such as t6 (Broker Effective Time)	Market Close, including a closing auction, if available.	Used as a comparative benchmark to measure the quality of execution given discretion to trade until the close of the trade date.
Full Day VWAP	Market Open	Market Close, including a closing auction, if available.	Generally used as a comparison of prices from day to day and not for specific benchmarking, unless start and end times span the entire trading day.

Filtering

A VWAP calculation is dependent on which types of trades are included, determined using market-specific condition codes attached to the trades by the trading venue and/or market data provider. The set of codes selected for inclusion will typically vary across TCA providers, and should be disclosed. Additionally, TCA providers may additionally filter using price and/or volume considerations, in relation to price/volume limits specified on the order.

Note: For interval VWAP calculations, since the starting timestamps and ending timestamps are used to narrow the calculation, only trades with proper sequencing (known to have occurred at a specific point in the day) should be included and thus the filtering may be more restrictive.

Markets

A VWAP calculation is dependent on which markets/venues are included. For countries with a "consolidated tape" like the USA, composite trades should be used. For countries or regions without a consolidated tape the choice of which markets to include can be left up to each individual broker or buy side institution. The list of markets included in the VWAP calculation should be those the institution has access to, and should be disclosed. For practical purposes VWAP is then defined as the aggregated VWAP calculation for each Market/Venue that the institution has access to.

Differences Between Real-Time and Historic VWAP Calculations

It is accepted that VWAP calculated in real-time or near real-time may differ from VWAP calculated on an ex-post basis. The main reasons are due to the available technology for real-time market data consolidation across venues, condition code filtering differences and data corrections. Additionally, real-time VWAP calculations will exclude the trader's own executions, which is not necessarily a requirement in post-trade TCA.

The Recommended VWAP Benchmark

Given all of the above, the recommended approach to VWAP is as follows:

Volume Weighted Average Price (VWAP) = The trade size weighted average trade price from Broker Effective Time to Broker Expiry Time using market/venue provided valid trade condition codes, aggregated for each market/venue to which an institution has access. When either or both of the recommended time points are not available, one can substitute the closest available timestamp for the start and/or end points.

The reality of situation is that it is not feasible at this time for this group to make a specific recommendation about filtering. With other groups addressing this topic and the recent failure to bring about a consolidated European tape, we have decided to postpose this decision until there is better guidance while continuing to liaise with the FPL Trade Standardization Working Group. In the meantime, since there are many variations in the composition of VWAP, it is recommended that providers disclose their guidelines used in computing this metric.

2.8.2.2 Participation Weighted Price (PWP)

This average price benchmark is determined by a target participation rate, order quantity, and starting time. The participation rate represents a percentage of the total volume with respect to the order quantity. For example, a 37,500 share order with a 25% participation rate will be completed once 150,000 shares have been traded in the market. The end time of the PWP calculation is not known until the order quantity is satisfied. The resultant PWP price will vary with the participation rate, which allows a post-trade metric to help determine if better quality execution could have been achieved by increasing or decreasing the participation rate.

Another way of thinking of PWP is that it is essentially a VWAP benchmark but with one key difference. Instead of defining an interval by setting a specific end-point time, the end-point is rather calculated such that N shares are traded from the defined start-point to the end-point, with N being some defined standard multiple (e.g. 4) of the order's executed quantity. In the above example, N = 4 (or the inverse of 25% ($\frac{1}{0.25}$)).

All other considerations regarding filtering and markets per VWAP section 2.8.2.1 apply to PWP as well.

2.8.2.3 Time Weighted Average Price (TWAP)

The price of a security as averaged over a number of equal-size time slices. TWAP is computed by iteratively deriving the average price over a consecutive set of pre-determined time ranges, with each time slice defined in seconds or minutes. Any of the following can be used to determine pricing of the individual time slices:

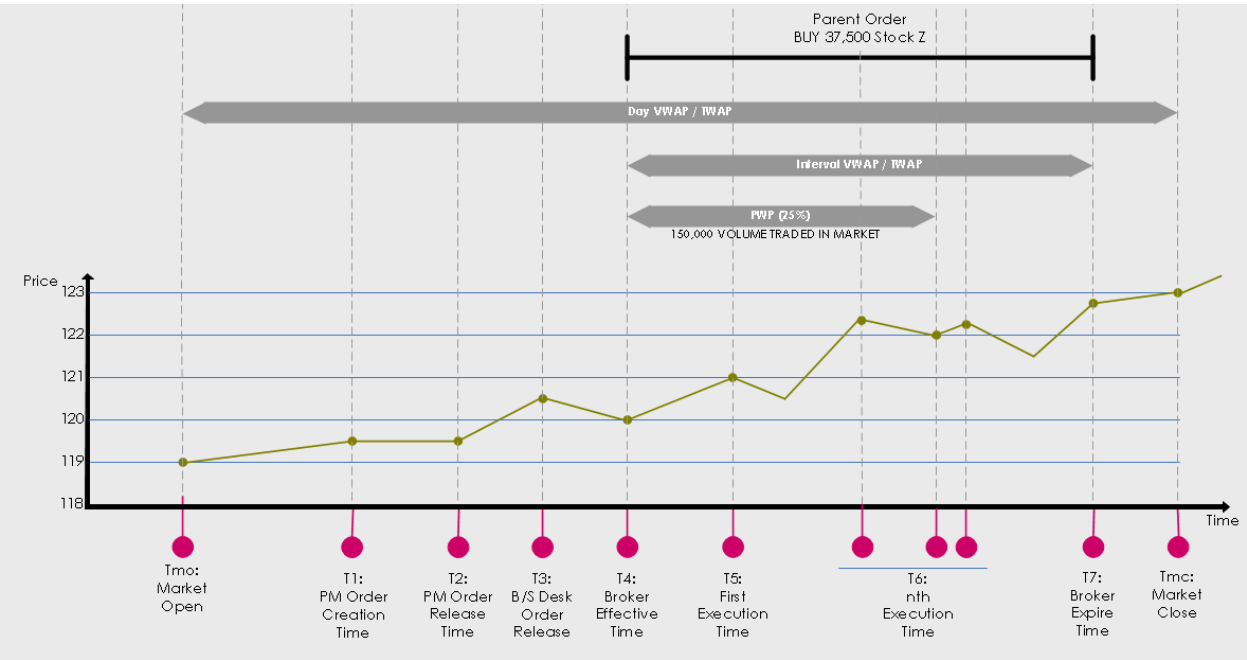
- VWAP within the interval
- Simple Average of all prices within the interval
- Midpoint within the interval

The total time horizon (number of time slices) is user defined.

Given the number of variables involved in TWAP calculations, we feel it is difficult to recommend any best practice or standard with regards to computing TWAP. TWAP is used more frequently with algorithmic trading strategies than in TCA. As with PWP, all considerations regarding filtering and markets per VWAP section 2.8.2.1 apply to TWAP as well.

2.8.2.4 Timeline of Average Price Benchmarks

The following chart illustrates the differences between the average price benchmarks, using a sample order of buying 37,500 shares of sample stock Z. The gray bars represent the time range that would be used to calculate an average price for each style.



3 Perspectives of Practical Applications of TCA

Section 2.2 discusses the basic expectations of TCA along with the need to understand the perspective of the target audience. Perspective is sometimes overlooked in the quest for accurate analytics but is just as important. This section provides insight from both provider and recipient aspects in order to gain a better understanding how perspective is an important factor in preparing TCA.

The Order Lifecycle chart on page 32 presents a 2-dimentional view of an order, showing both time (horizontal) and participant (vertical) in the execution process. Each vertical level represents a different perspective in the life of an order, and each participant will have a combination of overlapping and unique insights as the order progresses through execution. For example, the Buy-Side Desk Order Release (T3) is the same metric (overlapping) as the Broker Arrival Time, but they are known by different names from each participant. Therefore if a TCA report is traversing the different levels of participants, it is recommended that the terminology provided on that chart be used to avoid confusion.

Except for the overlapping time points, the participants at each level may not be privy to the time points in other levels. For example, we have defined "Execution Cost" to be the cost incurred between points T4 and T7. However, point T4 is unknown to the Portfolio Manager and Buy-Side Trader, so unless that time reference is provided back upstream, the Execution Cost calculated by a broker may be different from that computed by Buy-Side Desk, which will most likely use T3 to T7. Conversely, the Broker will probably not have T1 or T2 timestamps.

It is recommended to follow the Order Lifecycle chart as a guide to understanding TCA perspective. The remainder of this section is dedicated to providing TCA insight as seen from the different participants in the investment process.

3.1 Buy-Side Perspective

An asset manager should be able to provide multiple perspectives of TCA to satisfy both internal and external (client) views of transaction costs. They may further be required to provide multiple internal perspectives to satisfy diverse investment-level and regulatory needs of the firm.

One of the key items driving effective TCA on the buy-side is the portfolio manager's trading instruction. The importance of the instruction is that it will translate to the primary benchmark for cost measurement. The primary benchmark may often be one of the event points listed in the Order Lifecycle chart, but not always, so the instruction provides guidance for selection. For example, we may want use a VWAP benchmark derived between T4 and T7 instead of the mid-price at T4 if the instruction was to trade using a VWAP strategy. Additionally, you would not use an Arrival Time benchmark for a Market-On-Close order, and vice versa. This is the fairest and most accurate way to define a benchmark in order to compute transaction costs.

Having defined the primary benchmark does not prevent us from using other secondary benchmarks as well. Sometimes a combination of benchmarks provides more dimension and perspective than just focusing on the single primary benchmark. Therefore the use of secondary benchmarks is optional and best determined by an asset manager's experience.

3.1.1 External (Client) Perspective for the Buy-Side

Investors should be focused primarily on fund performance and that their investment objectives are being met. But they also need assurance that their investment manager is delivering Best Execution. While regulatory officials have provided general guidelines for describing Best Execution, the onus is clearly on investment management firms to provide precise definitions of their Best Execution policies. The term "Best Execution" is often misconstrued as being synonymous with TCA, when in fact it isn't. A true Best Execution report might include high-level TCA metrics, but must also include metrics that support the other aspects of the firm's Best Execution policy.

TCA reporting will be most meaningful for clients who have separately managed accounts. Transactions are easily tracked and activity can be distinguished between cash flows, rebalances, and the like. Client

TCA reports for these accounts should be delivered on a periodic basis at a summary level, but are generated on the same granular data as provided for portfolio managers and traders. There may be occasions where a client would like to see a more detailed report on a particular cash flow or rebalance, which is certainly possible, given the ability to isolate the transactions. Clients may also be interested in both the results of both trading and performance benchmarks.

Traditional TCA reports for clients invested in commingled or pooled accounts will have little meaning, given the structure and management of these funds. TCA at this level is only meaningful to the investment manager, so participants should receive standardized performance reports in lieu of TCA.

Overall, providing TCA reports to buy-side clientele is popular in supporting Best Execution, but the actual benefit is uncertain given the current disparity in reporting styles and interpretations of TCA. This is one area that will greatly benefit from standardized TCA reporting practices. TCA can provide the framework to demonstrate buy-side diligence in in support of Best Execution for our clients.

3.1.2 Internal Perspective for the Buy-Side

There are generally three traditional views of TCA from within a buy-side firm: Portfolio Manager, Trader, and Management. A fourth and upcoming group comprising TCA professionals should also be considered. There are various ways that investment professionals can be categorized within these groups and it will be dependent on a firm's size and organizational structure. The following descriptions assume a larger asset management organization.

3.1.2.1 Portfolio Managers

PMs are interested in TCA for both a pre-trade and post-trade perspective. PMs need to consider transaction costs during the portfolio construction process and source this information from pre-trade cost models, historical realized costs, or both. Typically this data stream is built into the order creation process. We are also seeing a benefit when pre-trade cost models utilize post-trade information to improve their predictive capabilities.

From a post-trade level, PMs are very keen to understand how transaction costs affect fund performance. Transaction costs, and subsequently fund performance, can be affected by stock selection, rebalancing cycles, trading constraints, industry events, and the like. Standardized daily reports for PMs are important to show the results of a single days' trading, but these also are very narrowly focused. It is best to develop a lower frequency reporting scale such as monthly or quarterly which can be better at revealing trends. PMs are most interested in gauging total execution cost based on PM Order Creation Time (T1).

Categorization of execution metrics are another important way to help reveal where costs may be hidden. Groupings such as *Days to Completion*[5] and *Market Cap*[6] for equities, or *Product*[7] and *Maturity Groupings*[8] for Fixed Income, are a few examples. There is no standard set of categories and needs may vary amongst managers of different investment styles, so again, work with your target audience to understand their perspective.

It is equally important that a PM's funds/strategies are defined and represented in the TCA. Individual client funds that are trading under a single strategy may need to have their orders aggregated in the TCA report to show the true size of the order and level of trading difficulty.

Equity and Fixed Income PMs who are managing funds across multiple currencies and/or utilizing futures for hedging should also have those asset classes represented in their TCA reports.

[5] The number of days it takes to complete an equity order, counted between T2 and T7.

[6] Market Capitalization groupings for equities, typically defined as Large, Mid and Small. Definitions vary in the industry.

[7] Sub-asset classes for Fixed Income, such as Treasuries, Corporates, European Credit, etc.

[8] Grouping trades by Years-to-Maturity, e.g., 1-year or less, 1-5 years, etc.

3.1.2.2 Buy-Side Traders

Traders will have similar needs to Portfolio Managers for both daily and lower frequency reporting, and most likely will be interested in the same groupings. Where they differ will be the benchmark used for deriving the actual implicit cost. Traders will be more interested in Buy-Side Order Arrival Time (T2) since that is when they become responsible for the order. These PM-Trader differences need to be taken into consideration for TCA reporting purposes, but simply boils down to whether or not you include the PM Delay Cost component of the overall Implicit Cost calculation. This can be easily broken out on a TCA report that can be shared between PMs and Traders.

Traders share another similar need with PMs to use Pre-trade TCA, such as determining aggregate order difficulty or to gauge eligibility for MOC trading. Pre-trade TCA also provides cost estimates that can be used as benchmarks

Traders have an additional and unique perspective of TCA as orders are released into the market for execution. Traders can gauge real-time TCA from their OMS and/or EMS platforms to monitor the effectiveness of algos or their P&L versus a PM-designated benchmark or Pre-trade estimate.

3.1.2.3 Buy-Side Management

Management teams can represent different areas of the organization but typically share the same interests for TCA purposes. These teams represent CIOs, Risk, Compliance, and internal governance committees, such as trading oversight boards. Management structure will depend on firm size, where smaller organizations may have a single CIO and larger firms may have a hierarchy of CIOs with responsibility at the asset class level.

Buy-side management requirements for TCA are very high-level and low frequency. Typically CIO management will defer to the hands-on investment teams to act as primary recipients of TCA but may request TCA as part of a more comprehensive review once or twice per year. The process is similar for oversight boards, which among other responsibilities will require Best Execution reviews with the CIO and head of trading.

Head Traders may be categorized as Traders, Management, or both, which again depends on a buy-side firm's size and trading hierarchy. Larger, global firms with distributed desks may have regional heads, allowing the global trading head to fall more into the high-level management category. Smaller firms will find head traders as more "hands on" may need to have both trader and management level reporting. In very small buy-side firms, the trader may also be the portfolio manager, so TCA will need to be structured accordingly.

3.1.2.4 Buy-Side TCA Professionals

Aside from the traditional players in the investment management world, TCA professionals are starting to make their mark in buy-side firms. These individuals are dedicated to providing TCA across their firms and are typically employed within the Trading department. Without dedicated TCA personnel, the responsibility becomes a part-time job or left to individual contributors within the PM and Trader teams.

TCA Professionals provide the following advantages for Buy-Side firms:

- Responsibility and ownership of firm-wide TCA.
- Ensuring that TCA is integrated into the investment process.
- Maintaining a regular TCA review cycle across investment and trading teams.
- Supporting management-level TCA
- Managing the relationship with 3rd-party TCA providers.
- Managing internal TCA systems.
- Promoting TCA standardization within the firm.
- Beneficial for Clients

In 2011, Greenwich Associates[9] released the results of a TCA-based survey that indicated only 10% of the respondents had personnel dedicated to TCA. As buy-side firms tackle TCA for non-equity asset classes, it may become a requirement that resources be dedicated to this endeavor.

3.2 Sell-Side Perspective

As with the Buy-Side, a broker will provide multiple perspectives of TCA to satisfy diverse internal and external (client) views of transaction costs.

3.2.1 External (Client) Perspectives for the Sell-Side

Brokers will typically provide a combination of several TCA-related services to clients, serving the needs of the diverse audiences and personnel within the client-base as described in the Buy-Side Perspective section above. This preserves, strengthens and deepens the long-term partnership between broker and client.

Pre-Trade analysis and models will inform clients' portfolio construction and clients' trade execution strategy. Additionally, pre-trade cost estimate models facilitate comparisons of post-trade execution performance that are normalized to account for trade difficulty.

Intra-trade execution performance analysis and tracking will highlight any need for mid-trade execution strategy changes. This analysis may be performed by the broker's trading desk and/or the client on a self-service basis using various tools. This process tends to focus on fewer and simpler execution performance metrics, along with alerts around non-standard volume or price patterns in names currently being traded, which need further examination.

Post-Trade analysis covering the day's trading will ensure a tight feedback and communication loop between client and broker. This assists in spotting short-term trends and issues, and in planning the next day's activities. This analysis typically focuses on fewer and simpler metrics. It is often accompanied by tools providing more detailed insight into outlier trades, often of a graphical nature.

Post-Trade analysis spanning longer time periods will use statistically significant amounts of data, including potentially comparisons across anonymous peer clients in aggregate, to help the client meet their Best Execution requirements, to spot key trends in market structure and the client's trading strategies, and ultimately to produce actionable advice leading to sustainable long-term improvements in investment returns. This type of analysis may also need to be reconciled against equivalent reports from 3rd-party providers, or indeed the client's own internal TCA reporting, when specific broker performance concerns are raised. Given the volume of data involved, graphical representations are often a useful and intuitive complement to traditional tabular representations. Additional levels of service for key clients may include intensive bespoke analysis to help understand a specific area in greater depth.

3.2.2 Internal Perspectives for the Sell-Side

The first key focus of a broker's TCA activities is on servicing the needs of its clients, as detailed above.

A second key TCA focus for brokers is as an input into the research and development process. Brokers will analyse TCA data in great detail, including a particular focus on outlier trades, to continuously improve execution quality, for example through improvements to both new and well-established automated strategies. Brokers will also analyse large amounts of TCA data in order to identify and track key trends in market microstructures, and their effects on Transaction Costs : these findings will typically be widely published, and will inform and drive the overall product development strategy.

A third key TCA focus for brokers is to self-monitor adherence to Best Execution policy requirements.

[9] Greenwich Market Pulse Survey, August 2011, "TCA: Taking the Next Step", pg. 3

3.3 TCA Provider Perspective

To meet the needs of the multiple consumers, TCA Providers offer a wide variety of applications, data and reports as part of a profit-making business. By definition, a Provider has an External (client) focus, however, given the different client segments, the nature of the tools offered differ significantly. Because Providers are in the business of making a profit, they have an incentive to see TCA as an evolving topic, so that products and services can be extended over time. There is also an incentive to create proprietary solutions, or to promote one's offerings as "unique" or "superior", to gain market share and stay profitable.

3.3.1 Solution Categories

Although not limited to a single approach, the products and services offered by Providers often fall into two categories:

1) Standard solutions promoted by the provider
2) Custom solutions driven by client-specific requirements

Standard Solutions

For Providers offering standard solutions, the goal is to apply the same methodology to all clients. This often requires changing client order and trade data to fit the model of the provider. One benefit of this approach is the ease of comparison across customers. The drawbacks include the challenge of representing different investment styles in a single methodology, and the length of time it may take to roll out changes to the methodology.

Custom Solutions

For Providers offering custom solutions, the goal is to provide products and services that can meet the specific needs of each client. This may include support for multiple benchmarking options, conditional benchmarks (based on strategies, countries, etc.), configurable order aggregation, and ad-hoc reporting. One benefit of this approach is the ability to support different investment processes and styles. One drawback is the risk of providing a solution that may meet the client needs, but may actually disguise the true cost of trading.

In both cases, Providers often provide consultative services that go along with their product offerings. These services help customer interpret results and may also include suggestions for improvements in the investment management and trading process.

3.3.2 Client Segments

TCA Providers will offer services that differ based on the client segment.

- **Sell-Side Brokers** – Some Providers offer services to the sell-side. They may "white" or "grey" label their offering so that the sell-side firm can offer it to its own customer base. This type of offering will need to be flexible enough to be configured to the needs of each sell-side firm. Services offered to the sell-side focus on timestamps and data points relevant to this segment (e.g., point T4 in the lifecycle diagram).

- **Asset Managers** – This is typically the largest segment for TCA Providers. Providers may offer products geared towards compliance officers, portfolio managers, traders and analysts. The products and services are often interactive and report-based. The frequency of analysis ranges from intraday to annual. The offerings provided to Asset Managers typically cover the full investment lifecycle. It is also common to provide both Allocation and Execution-based report to Asset Managers.

- **Plan Sponsors** – Some Providers focus on the Plan Sponsor community. The products and services offered by these providers typically source custodial data to generate time-series reports that a Plan Sponsor can use to evaluate the cost of trading done by the Asset Managers they employ.

3.3.3 Unique Offerings and Perspective

Being a provider to multiple customers allows for an additional level of TCA services; the concept of a peer group analysis. With access to data from multiple clients, Providers can aggregate actual customer data (implicit costs, explicit costs, participation rates, traded values, etc.) across multiple dimensions and provide this information back to individual customers in aggregate or comparative form (often as rankings vs. the peer group).

In addition to Peer analyses, a Provider has access to information about the analytical interested of multiple customers and can develop product offerings that incorporate the ideas of multiple customers across segments. This perspective often drives the innovation and product plan at the Provider.

3.3.4 Conclusion

If the goal of TCA for the Asset Manager is to lower the cost of trading, the goal of the TCA Provider may be thought of as increasing profitability by offering products and services that aid customers in lowering the cost of trading. Given this perspective, the Provider often sees the full lifecycle of TCA, from order creation to final execution. The definition of TCA can be very broad for a Provider, and that definition may change depending on the customer segment being serviced.

4 Fundamentals of Market Structure and TCA

The metrics, methodologies and focus areas for TCA relate in large part to key aspects of market microstructure and commercial priorities, which vary to some degree across asset classes. In this section we attempt to briefly summarise some key relevant market characteristics, and how those influence the TCA agenda. We will also add other asset classes as the document is expanded.

4.1 Equities

Equity markets, particularly those in the more developed economies, tend to operate as Central Limit Order Books. Any given equity may trade on a single Order Book, or across multiple such Order Books, with the long-term trend tending toward greater fragmentation across trading venues.
There is typically a high degree of transparency in equity markets : pre-trade transparency via the real-time dissemination of data on current bids and offers, and post-trade transparency via the real-time dissemination of data on the trades that have taken place (with some very selective provision for delays)
Electronic, and more specifically Algorithmic Trading, is in general well established in global equity markets, and accounts for the majority of trading in many markets.
Equity market structures continue to evolve, driven by both regulatory and competitive/commercial pressures.
Two key trends in global equity markets are the growth of “Dark Pools”, a category of trading mechanisms characterized by their lack of pre-trade price transparency, and of High Frequency Trading, whereby participants seek to profit from technological advantages related to speed and sophisticated automated strategies

Given the above, some general trends can be identified within the TCA space in relation to Equity markets:

- High transparency, coupled with a mature array of algorithmic trading providers, has made for a competitive environment for algorithmic providers, and thus a focus on TCA to differentiate and market competing capabilities
- TCA may often compare execution prices to the bid/offer, as the spread may be material for some markets
- US equity markets have long been fragmented, but organized into a cohesive national market infrastructure with a consolidated tape. EMEA equity markets have fragmented progressively since MiFID in 2007, and more recently also in APAC, but neither has any real consolidated infrastructure. The global equity market data collection, consolidation and calculation processes required for TCA has become more complex as a result. Given the relative newness of market fragmentation in certain geographies, TCA may well be used to optimise the selection of trading venues.
- The growth of newer phenomena such as High-Frequency Trading and Dark Pools has caused concern for some market participants ; TCA is often now used to understand avoid any potential adverse consequences.

5 Defining a Framework for Comparative Analysis

January 2017

The original FIX TCA WG document has provided a baseline of knowledge to promote a general understanding of TCA components. It has presented facts describing the computational rudiments, industry-specific perspectives, and in some cases, the pros and cons of using various benchmarks. The initial purpose of this paper (section 1.1) has been realized but there was also an optimism that this would help to promote TCA standardization in the industry. That inherent standardization has not materialized in the three years since this paper was released in January 2014.

In contrast, this chapter, and perhaps subsequent chapters, intends to explicitly set a direction for defining a common and defensible TCA methodology that can provide comparative cost metrics. The FIX TCA Working Group would like to thank the U.K.-based **Investment Association's TCA Working Group** for providing the content of this chapter commencing in section 5.1, and for agreeing to partner with us to refine ongoing TCA requirements across asset classes. Our common goal is to provide the industry with specific guidelines to promote TCA standardization.

In order to promote standardization, core TCA needs to be defined by the asset management community. The asset manager generates the orders and has the most complete knowledge of its investment and trading objectives. Orders as received by their counterparties contain limited information beyond size and execution guidance. The complete execution picture is not known until all orders are filled or canceled, and is only known fully by the asset manager. So it is from that perspective, with knowledge of original order sizes and intended instruction, we can begin to lay the foundation to categorize execution objectives to enable common TCA metrics. Adoption of these standards by the asset manager should ensure not only the provision of comparative analysis to outside parties, but also that counterparties are in turn providing standardized time stamps, data and trade information back into the TCA process. Once the relevant parties embark on TCA standardization, then a more holistic level of TCA can be achieved.

We would also like to recommend some boundaries as to the scope of TCA standardization:

1. Will not immediately address what is known as "Venue Analysis". Depending on their level of technological sophistication, asset managers may not have the ability to access all the disaggregated execution fills that occur in large orders or via algos.

   With that said, we recognize the FIX Trading Community has made inroads into the standardization of reporting, as evidenced by the fact that Tag30 is routinely attached to fills received on an order. The adoption of these FIX tags is a positive step but the receipt and storage of this information is critical if core TCA is to expand to Venue Analysis.

2. TCA will focus on execution analysis and not fund performance. While the two are linked, a PM's objective may be to outperform a forward-looking benchmark. Such benchmarks are unknown to traders so TCA will need to focus on measuring their trading under the actual time and market conditions.

3. TCA is considered a component of Best Execution, but alone cannot address a firm's proof of Best Execution.

4. TCA Standardization recommendations will most likely not fulfill the requirements as being laid out by the regulatory bodies (e.g., PRIIPs, MiFID II).

From here, a rough agenda regarding the future of the FIX TCA Working Group

1. Publish the IA's Equity TCA WG Paper within the FIX TCA Best Practices Doc for Equities.

2. Reopen the FIX TCA Equity WG. This will include a Call for Participation from the general FIX TCA body, and also including any IA TCA Equity WG members who wish to participate. This new group will consider the IA proposals and will create specific guidelines for the standardization of TCA for Equities.

3. Create a new FIX TCA Fixed Income WG. There will be a Call for Participation among the general FIX TCA body, and also including any IA TCA Fixed Income WG members who wish to participate.

FIX TCA Working Group Co-Chairs
Michael Caffi – State Street Global Advisors
Sera Boden - Instinet

5.1 Context and Scope

Transaction Cost Analysis (TCA) is becoming ever more important as the scope and requirements placed upon it increases. Upcoming legislation (e.g., PRIIPs, MiFID II) will see greater requirements layered on to firms to demonstrate 'best execution' and to improve the reporting of frictional costs experienced by clients. Despite TCA's growing importance, progress is needed on a standardized methodology.

Lack of standardization in TCA is evidenced in the growing trend for clients to ask for raw transaction data so that they can conduct their own standardized analysis. When clients began to pose increasingly sophisticated questions of the cost of implementation in order to compare managers and funds, the data provided was not consistent between firms and as a result has been largely unsuitable for comparative purposes.

It is worth noting that compliance with the aforementioned PRIIPs regulation demands a similar methodology to TCA but differs significantly with respect to its intentions. The upcoming disclosure requirements under PRIIPs aim to provide comparable, consistent transaction costs to end clients; they are not intended to measure the efficiency of the trades. Referencing PRIIPs is relevant to this paper for a number of reasons. First, the onset of PRIIPs has galvanized closer scrutiny of the trading process. Second, the PRIIPs framework itself provides an opportunity for greater consistency in how costs are reported. Third, PRIIPs compliance will need to be borne in mind when implementing systems which will likely need to accommodate methodologies for the purposes of both PRIIPs and TCA.

In an attempt to foster a standardized approach to TCA, this paper highlights both the broader challenges to building a series of benchmarks comparable across clients, managers and asset classes, and the particular challenges which have tended to limit the utility of peer analysis. With regard to scope, this paper is focused on Equities. First, this approach builds on the progress made by FIX in this space. Second, standardization of TCA from an equities perspective should provide a useful and versatile basis from which to develop and refine standardization for the remaining asset classes.

5.2 Comparable benchmarks

Transaction costs are compared in a number of scenarios:

- In response to queries from regulators or clients.
- Internally for best execution and management information system purposes (via third party peer analysis tools).
- Through mandated client reports (for example commissions on level II reports).

As mentioned earlier in this document, transaction costs can be split into explicit and implicit costs. When producing views of transaction costs, all costs within the trader's remit of control should be considered. It is important to look at explicit and implicit costs in relation to one another. While commissions are often looked at independently of slippages, for the purpose of comparability, it makes sense to look at trades holistically. When trades utilize higher commission execution channels, they do so with the expectation of decreasing the implicit costs of the trade (or of greatly reducing the risk of the trade).

Implicit costs represent the difference between a benchmark price and the execution price, (adjusting for side[10]). These costs are driven by many factors including order size, price momentum, spread and volatility; they exhibit significant variance. In order to provide industry wide consistency for the calculation of implicit costs, the following questions need to be answered in a consistent way.

5.3 What constitutes an order?

In order to generate standardized analytics, first, it is important to agree exactly what is being measured. The Order Lifecycle Diagram (OLCD) in section 6.3 illustrates a typical order lifecycle. From this, it is evident that there are a number of critical timing points (denoted by timestamps) throughout the order.

[10] Buy or sell.

Each of these timing points is useful for a different purpose and is important as part of a wider transaction cost framework. For example, when looking at costs on a particular fund or for a given fund manager, the price achieved would typically be compared to the price at time T1. When measuring the performance of a broker, it would be compared to the price at time T3.

The correct choice of critical timing point is imperative for the generation of consistent TCA metrics. This is evident when you consider that large parent orders are often split up by the trading desks into smaller child orders. These smaller child orders, will then have their own series of timestamps denoting where they were generated, released and completed. For example, if an order to buy 100 shares is raised by a portfolio manager, this could subsequently be released in four slices of 25 shares each into a broker algorithm. Depending on the perspective, the single order of 100 shares could constitute the order, or it could be viewed as four orders of 25 shares each. Moreover, the inverse of this process is also common. The placement made to a broker could contain shares from a number of separate orders rolled in together. As a result, the market impact, duration and implementation style would be reflective of a larger order. In both cases, consistency across order types is key.

Such a consistent approach would involve trading desks being concerned with the slippage between the arrival on the trading desk (time T2 on OLCD) and the average executed price. This would give a fair measure of the performance of the trade while it is within the control of the trading desk. It is important to note, however, that using this perspective introduces a bias against firms with large amounts of aggregation. While this method does not provide a clean view of the actual trading performance, it does give a fair view of the cost of implementation and relates back directly to portfolio performance.

5.4 How are additional trade instructions handled?

The additional instructions that come with an order can have a significant impact on the perceived efficiency of execution. These instructions are often not passed on to third parties for peer analysis. However, orders with additional instructions are included in samples despite introducing a strong bias. Below is a non-exhaustive list of the additional instructions which can significantly impact how an order is executed:

- Benchmark e.g. IS, VWAP, TWAP, MOC, $POV_{x\%}$ 3pm[11].
- Price e.g. Limits, holds, contingencies, hedges against non-covered instruments.
- Motive e.g. Cash, investment decisions, rebalance, high conviction, high urgency.
- Restrictions e.g. Counterparty restrictions.

An example of this is an order which does not actively target the arrival price but instead targets another point in time. This is common with cash flow orders being benchmarked against the underlying funds pricing point (e.g. the close). Traders will actively execute to the fund's benchmark in order to reduce the benchmark risk. Using an arrival price comparison in this scenario would reflect inappropriate implementation costs. This would not provide a meaningful comparison for peer analysis.

As a result of these discrepancies, many of the current TCA frameworks are unable to compare transaction costs between market participants accurately. This can be confusing to clients who will not necessarily be seeing a like-for-like comparison between their managers/brokers. To mitigate this, trading data should be clustered by benchmark and by discretionary/non-discretionary flow. While an ideal model would have categories for each type of restriction or benchmark, implementing this across multiple clients is likely to be highly complex. As such, we propose that the subset of orders where traders had full discretion and an arrival benchmark are used for comparison purposes. On a longer term basis, there is merit in comparing performance of orders with a point in time benchmark.

[11] Implementation Shortfall (IS), Volume Weighted Average Price (VWAP), Time Weighted Average Price (TWAP), Market On Close (MOC), Percentage of Volume (POV).

5.5 How is a benchmark price obtained?

When reviewing a price for a given timestamp there are a number of different approaches which can have a significant impact on the cost. Furthermore, the approach used should differ given the scenario being analyzed, namely:

- Is the current quote or next / last trade most appropriate?
- If no price is available what should be the fall-backs?
- How do we benchmark orders arriving outside of market hours?
- Should we look at primary or composite market prices?
- Should we use a publicly available spread or the spread visible in the market?
- In the case of some asset classes, the market data available will differ by institution – in these cases should an external composite be used?

The price used will also differ throughout the lifecycle of an order. For example, a Portfolio Manager (PM) would be interested in using the price available on their screen at order start as a baseline (which could even be theoretical – e.g. an imputed fixed income price); whereas, a trader is interested in the next available price.

For the purposes of comparative analysis, the following pricing methodology and fallbacks are proposed.

For orders arriving during continuous trading:

1. The current, composite best bid or offer mid price.
2. The next, composite best bid or offer mid price.
3. The next traded price.
4. The next market close.
5. The next market open.

For orders arriving outside of continuous trading:

1. The next market open.
2. The next traded price.
3. The next market close.

It should be highlighted that this framework deliberately falls forward, not backwards. Trades arriving outside market hours are benchmarked to the next achievable price. While this makes the most sense for benchmarking the performance of a trade, there is also an error term to be considered. When the decision price of an order (price on which the trade was initiated) differs notably from the trader's arrival price, it is worth tracking the discrepancy as a measure of the alpha loss within the implementation process. This can often simply be driven by PMs raising orders after market hours based on closing prices. While this makes sense to consider in the context of a portfolio's implementation shortfall, it adds noise to a comparative analysis of transaction costs.

5.6 Data Collection

Should the industry succeed in deciding upon a consistent set of answers to the above questions, it must also turn its attention to ensuring it has effective means of collecting the necessary data to generate meaningful analytics. As a general principle, the order management system, and its associated data set, should aim to capture time stamps, snap available prices or quotes, and retain all order attributes with any currently applicable instructions whenever a change in order state occurs. This will enable more granular analysis, should new standards evolve over time, particularly in the handling of potential exclusions, such as secondary placements, or large cash flows.

5.7 Peer Analysis

One of the key methods for comparing buy side transaction costs is through the use of third party peer analysis. Given the importance of peer analysis in measuring the performance of funds, it is often viewed as something which should apply equally to trading. Third party providers are able to handle many of the issues described above, including how to obtain prices consistently. However, there are a number of variables which peer analysis does not adequately take into account. First, their approach does not sensitively reflect the significance of the differences between timestamps.

Second, and equally as difficult, is the identification of additional trade instructions and associated trading patterns within the peer group. For example, it is difficult to compare one firm that executes all of its orders to the close, with a firm that actively targets arrival price. Similarly, comparing firms that trade opportunistically with tight limits, to firms that are always required to complete orders is not appropriate. Without this granularity of data, it is difficult to compare the trading performance of funds fairly. As it currently stands, peer analysis measures the efficiency of the fund's underlying implementation process which is borne out in the fund's return rather than in its transaction costs. As noted above, in these cases, trading data should be clustered by benchmark and by discretionary/non-discretionary flow.

Third, to compare firms fairly, the datasets need to be normalized. Whilst this is typically done by breaking down orders into bands of liquidity, market cap and region, this does not fully account for differences in trade intention. This could only be done by clustering funds based on implementation style, which is information third parties do not have access to.

5.8 Summary of Recommendations

Correctly tagging the subset of orders which are discretionary and arrival benchmarked would give peer data considerably more value. Moreover, a consistent approach to what constitutes the arrival timestamp or, indeed, an order would make significant progress towards a more meaningful set of data for analysis. Notwithstanding these recommendations, for use in performance benchmarking by trading desks, an even cleaner methodology for normalization is still likely to be required (e.g. a modified pre-trade model) or a more intelligent order level clustering. We invite the analytics supplier community, which possesses the relevant data, to offer technical solutions to these issues.

TCA remains a valuable tool for buyside firms. Above all, it is important to recognize that TCA needs to be appropriately calibrated on a firm by firm level to produce meaningful analysis. If members are able to take into account that they cannot guarantee the consistency of data from other firms, comparative TCA methodologies can be used in a meaningful way.

This document is intended to improve TCA functionality through encouraging standardization across the industry. Enhanced TCA will lead to a better understanding of firms' processes. In turn, this will be reflected in more efficient trading and ultimately better returns for clients.

6 TCA Terminology

As mentioned earlier in this document, the number one problem identified in the initial TCA Working Group survey was the inconsistent and often confusing use of terminology and methodology. Methodology was addressed in section 2, TCA Fundamentals – Basic Analytics. Here we provide a recommended vocabulary for TCA which is divided into two major categories: General Definitions and Benchmark Definitions.

General definitions are terms that are commonly found within TCA and represent the aggregate contribution of all the member firms of this working group. We are also providing guidance on appropriate asset class usage.

Benchmark definitions are derived from the order lifecycle with an attempt to provide a neutral naming convention, since the same point in time may have different names dependent on perspective (buy-side versus sell-side). We have provided synonyms in order to acknowledge the variety of terms in use today. Most benchmarks relate to three pieces of information: Time, Price, and Cost. For example, the "Broker Arrival" benchmark will associate the Time (of arrival), which dictates the Price related to that time, which is used to compute the Cost between that Price and target execution price. We also provide guidance on the time-space that the benchmark is meaningful: Pre-trade, Real-time, and/or Post-Trade TCA, in addition to the applicable asset class.

6.1 Section 1 – General Terms

Ask				
Applicable Asset Class	**Equities**	**Futures**	**Currency**	**Fixed Income**
The price or rate at which a seller is willing to receive.				

Average Daily Volume				
Applicable Asset Class	**Equities**			
For Equities: The simple average of a set of consecutive daily total volumes (i.e., shares traded) for a security. When appropriate use composite volumes if available. Example: Stock XYZ had trading activity on 3 consecutive days consisting of 10500, 12000, and 13100 shares. The ADV = (10500+12000+13100)/3 = 11866.67 shares This metric is meaningful only when the period contains a minimum of 3 to 5 days but is common to span 10, 20, or more consecutive trading days. The purpose is to provide an average volume number that is more representative of a security's trading activity while attempting to eliminate volume spikes caused by singular events which may exaggerate trading activity on a single day. It is important to normalize the daily total values for Corporate Actions before averaging. Also see Median Daily Volume. **For Futures:** **TBD**				

Benchmark				
Applicable Asset Class	**Equities**			

A reference price against which other prices (either other points in time, or achieved execution prices) are compared, as a means of measuring execution quality and/or the effect of elapsed time on Implementation Shortfall.

For equities, most commonly this is a reference price (Arrival, VWAP, PWP, Previous Close, etc.) to which the average execution price of an order is compared. Post-trade benchmarks are intended to measure the Implicit Cost of Implementation Shortfall. It can be coupled with a pre-trade benchmark to estimate the opportunity cost of an order.

Benchmarks for execution quality fall into two categories:

- Point in-time benchmarks are marked to a particular time of day or relative to the order arrival time. Common examples are open, close etc. The benchmark is what the trader or portfolio manager wants to perform well against, not what is easiest for a particular algorithm to achieve.
- Average benchmarks include some level of averaging of market trades. Common examples are VWAP over the day, VWAP over the lifetime of an order (Interval VWAP) and participation benchmarks such as PWP.

One should note certain complexities around accurately and consistently measuring market prices and especially market volumes, with 2 issues particularly prominent amongst them: the variety of practices in effect around consolidation across trading venues, and the definition of which specific trade types to include. These details are covered elsewhere.

Benchmark Gain/Loss				
Applicable Asset Class	**Equities**			

A measurement of how a given price compares to a benchmark price. Regardless of the order's side, a positive number represents a gain while a negative number represents a loss. The gain/loss can be nominal in the case of agency trading, or it can be real in the case where the party responsible for executing an order has guaranteed the benchmark price. When used without any qualifier, this term refers to the realized gain/loss, that is, a comparison of the average execution price achieved versus the benchmark price.

Benchmark gain/loss can be measured in various units. In these examples, the case illustrated is measurement of the achieved execution price against the selected benchmark ; it's also possible to replace Avg Exec Price by some other benchmark, to calculate the Gain/Loss between those 2 time points e.g. from PM Decision Time to Broker Arrival Time, for example.

- **Total Cost Value =**
  ((Benchmark price - Average execution price) * BSI) * Quantity executed

- **Total Cost in Basis points =**
  (((Benchmark price - average execution price) * BSI) / Benchmark price) * 10000
  Note there are different practices in effect around whether the denominator should be the Benchmark Price, the Average Execution Price, or some other price. Our recommendation is to use the Benchmark Price as the denominator.

- **Total Cost Per share =**
  BSI * (Benchmark price - average execution price) * BSI

where BSI = 1 for a buy order, -1 for a sell order.

Bid				
Applicable Asset Class	**Equities**			
The price or rate at which a buyer is willing to pay.				

Explicit Cost (needs review)				
Applicable Asset Class	**Equities**			
Known charges that will be incurred for any transaction, which may include commissions, taxes and fees, excluding custodial fees and transfer fees.				

Fill (needs review)				
Applicable Asset Class	**Equities**			
This is a synonym for the term 'execution', in other words, the combination of price and quantity received at a particular point in time. An order can be completed in one or more fills. For example: a trader places an order to purchase 500 shares of XYZ stock at 10:00am. The order is executed in 3 'fills' as follows: Fill # / Point in Time /Shares/ Price Fill1: 10:00:01 /100/ $15.01 Fill2: 10:00:03 /200/ $15.02 Fill3: 10:01:05 /200/ $15.01				

Impact Cost				
Applicable Asset Class	**Equities**			
The price movement caused by the initial or immediate action to purchase or sell a security, not already attributed to Spread. Synonymous with Market Impact Cost and Price Impact Cost				

Implementation Shortfall				
Applicable Asset Class	**Equities**			
The sum of Explicit and Implicit Costs. Please see section 2.3.2 for a detailed explanation.				

Implicit Cost				
Applicable Asset Class	**Equities**			
Variable costs that cannot be known with precision prior to executing the order, and relate to the interaction of the selected trading strategy with variations in market price and liquidity. Please see section 2.3.2 for a detailed explanation.				

Median Daily Volume				
Applicable Asset Class	**Equities**			
The median value in a set of consecutive, daily total volumes (i.e., shares traded) for a security. The median is the middle value of a group of numbers such that half of the values are less than the middle value, and the other half are greater than the middle value. Example: Stock XYZ had trading activity on 5 consecutive days totaling of 10500, 13100, 9500, 15200, and 12000 shares. The MDV = 12000 shares. This metric is meaningful only when the period contains a minimum of 5 days but is common to span 10, 20, or more consecutive trading days. While not required the set should contain an odd-number of consecutive daily volumes. It is important to normalize the daily total values for Corporate Actions before computing the median. The purpose is to provide a volume number that is more representative of a security's trading activity while attempting to eliminate volume spikes caused by singular events which may exaggerate trading activity on a single day. Because the median eliminates the highest and lowest values, it tends to do provide a more consistent volume than ADV.				

Mid-Price				
Applicable Asset Class	**Equities**			
In equities, at a given point in time, the average of the bid and the ask price. For example, if the bid is $10.00 and the ask is $10.01, then [(10.00 + 10.01)]/2 = $10.005. Synonymous with the terms "midprice", "mid", and "mid-quote".				

Nominal Spread				
Applicable Asset Class				**Fixed Income**
The spread of a bond or portfolio above the yield of a Treasury of equal maturity.				

Opportunity Cost				
Applicable Asset Class	**Equities**			
Opportunity Cost is the risk of not completing an order and is often also known as "Opportunity Risk". It represents the missed opportunity of being able to execute trades at favorable prices in advance of a price move. Opportunity Cost can be quantified by comparing the unfilled portion of an order with a benchmark. Benchmark considerations include the elapsed time after trading, whether chronological or volume time is used in the benchmark computation, and the length of timescale considered by the analysis, from minutes to days. In addition the Opportunity Cost can optionally include an estimate of future market impact of executing the unfilled portion of an order. Note: Current practice does not typically include Opportunity Cost calculations in standard TCA.				

Order				
Applicable Asset Class	**Equities**			
In its most basic form, an order is simply a PM instruction to buy or sell a particular security. The term used in its plural form ("orders") typically refers to a group of securities, sometimes called a "basket" or a "set of orders". A set of orders that have been sent to a broker for execution is also known as a Release. See the term ***Release*** in this section for additional information				

Participation Rate				
Applicable Asset Class	**Equities**			
Ratio of executed size to the market traded volume within the time period of the life of the order, often expressed as a "Percentage Complete". See also the Notes under Benchmark above, which apply also to Participation Rate. See also Execution Style, the choice of which typically influences the achieved Participation Rate.				

Percent of Average Daily Volume				
Applicable Asset Class	**Equities**			
The relationship between shares traded and Average Daily Volume expressed in percentage terms. For example, let ADV = 1,000,000 shares, and shares traded = 1,000. Percent of Average Daily Volume = [(1,000/1,000,000)] * 100 = 0.1%. This metric provides guidance in estimating relative liquidity, i.e., difficulty in executing an order. The smaller the %ADV, the easier and more liquid an order will be to execute. It is generally accepted that an order under 20%ADV can be completed within one full trading day.				

Percent of Median Daily Volume				
Applicable Asset Class	**Equities**			
The relationship between shares traded and Median Daily Volume expressed in percentage terms. For example, let MDV = 1,000,000 shares, and shares traded = 1,000. Percent of Median Daily Volume = [(1,000/1,000,000)] * 100 = 0.1%. This metric provides guidance in estimating relative liquidity, i.e., difficulty in executing an order. The smaller the %MDV, the easier and more liquid an order will be to execute. It is generally accepted that an order under 20%MDV can be completed within one full trading day.				

Release				
Applicable Asset Class	**Equities**			
The term Release can be used as both a noun and a verb. In its use as verb, a Release is simply the action of sending orders to a recipient. PMs will send/release orders to the Buy-Side Desk, which in turn will send/release orders to a broker. The terms "PM Order Release Time" and "Buy-Side Desk Release Time" in section 5.2 refer to the time that the action (release) occurs. In its use as a noun, a Release refers to one or more orders that are being sent to a broker. Typically a Release is the same as the entire set of orders that a Buy-Side trader needs to have executed. But there are times when one or more of the individual orders can represent a substantial position and becomes a liquidity concern. This requires the Buy-Side Trader to divide the orders into subsets of more reasonable size with the intent of sending multiple order subsets, or Releases, over a given period of time. In this scenario the first Release starts the clock for TCA purposes and will comprise Delay and Execution cost between T3 – T7. Each subsequent Release will also incur its own Delay and Execution cost.				

Spread				
Applicable Asset Class	**Equities**			
The difference between the Bid and Ask prices or rates. The spread can be expressed in various units, such as basis points, ticks, or cents, and is an item common to all asset classes. The spread represents information that is security specific and provides an indication of liquidity of the specific asset. It is typically used in conjunction with other metrics to assess transaction costs in pre-trade and real-time analytics.				

6.2 Section 2 – Benchmark Terms

The following codes and/or calculations are used within these definitions:

- In Synonyms, (B) refers to buy-side, (S) refers to sell-side.
- In Order Lifecycle, Tn refers to its time position on the Order Lifecycle chart.
- Unless otherwise specified, all costs are defined as using the Benchmark Gain/Loss definition in basis points.

Broker Arrival Time				
Synonyms	**Arrival Time (S)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T3**			
Overlaps with	**Buy-Side Desk Order Release Time**			
Term Definition	**Time order is received by executing broker**			
Price Definition	**Midprice at Broker Arrival. If the market is closed then roll forward to the next Market Open.**			

Broker Expire Time				
Synonyms	**Order End Time (B),(S)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T7**			
Overlaps with	**PM Order End Time and Buy-Side Desk Order End Time**			
Term Definition	**The time that all interaction with the market has stopped for a particular order. Note: Order may NOT be completely filled.**			
Price Definition	**Midprice at Order End Time**			

Broker Effective Time				
Synonyms	**Order Start Time (S)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T4**			
Overlaps with				
Term Definition	**The time that an order becomes eligible for execution by the broker.**			
Price Definition	**Midprice at Broker Effective Time. If the market is closed then roll forward to the next Market Open.**			

Buy-Side Desk Order Arrival Time				
Synonyms	**Arrival Time (B)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T2**			
Overlaps with	**PM Order Sending Time**			
Term Definition	**Time order is received by the Buy-Side Desk**			
Price Definition	**Midprice at B/S Desk Arrival Time. If the market is closed then roll forward to the next Market Open.**			

Buy-Side Desk Order End Time				
Synonyms	**Order End Time (B),(S)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T7**			
Overlaps with	**PM Order End Time and Broker Expire Time**			
Term Definition	**The time that all interaction with the market has stopped for a particular order. Note: Order may NOT be completely filled.**			
Price Definition	**Midprice at Order End Time**			

Buy-Side Desk Order Release Time				
Synonyms	**Arrival Time (S), Commitment Time (B), Placement Time (B)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T3**			
Overlaps with	**Broker Arrival Time**			
Term Definition	**Time order is sent to the broker.**			
Price Definition	**Midprice at Broker Arrival. If the market is closed then roll forward to the next Market Open.**			

(First) Execution Time				
Synonyms	**(First) Fill Time**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T5**			
Overlaps with	**Unique**			
Term Definition	**The time that the broker executes the first fill for a particular order. An order may not require more than one fill to be completed. An order requiring more than one fill will record each successive execution time (see nth Execution Time)**			
Price Definition	**Midprice at First Execution**			

(nth) Execution Time				
Synonyms	**(nth) Fill Time**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T6**			
Overlaps with	**Unique**			
Term Definition	**The time of any fill following the first execution.**			
Price Definition	**Midprice at "nth" Execution**			

Market Close				
Synonyms	**Market-on-Close; MOC; The Close**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**N/A**			
Overlaps with	**Unique**			
Term Definition	**Order execution at or near the closing time of a particular market. Some exchanges operate closing auctions and have time constraints on when orders can be received for participation in the auction.**			
Price Definition	**The exchange-calculated closing price, which may or may not be represented by the last traded price of the day.**			

Market Open				
Synonyms	**Market on Open; MOO; The Open**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**N/A**			
Overlaps with	**Unique**			
Term Definition	**Time of the first trade of the day for a security unless an opening auction is operated.**			
Price Definition	**Price of the first trade of the day for a security or the exchange declared open price if an opening auction is operated.**			

Market Prior Close				
Synonyms	**Previous Close; Prior Night Close**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**N/A**			
Overlaps with	**Unique**			
Term Definition	**The previous business day's Market Close.**			
Price Definition	**The previous business day's Market Close price. Please see "Market Close" for additional information.**			

Participation Weighted Price				
Synonyms	**PWP, PWAP**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**N/A**			
Overlaps with	**N/A**			
Term Definition	**A benchmark price as determined by a target participation rate, order quantity, and starting time. The participation rate represents a percentage of the total volume with respect to the order quantity.**			
Price Definition	**Calculated Price**			

PM Order Creation Time				
Synonyms	**Decision Time (B)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T1**			
Overlaps with	**N/A**			
Term Definition	**The time at which the PM conceives the order. Orders are created for numerous reasons, e.g., news; alpha signals; client direction; index constituent change, to name a few.**			
Price Definition	**Midprice at Creation Time. If the market is closed then roll back to the Market Prior Close.**			

PM Order End Time				
Synonyms	**Order End Time (B),(S)**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T7**			
Overlaps with	**Buy-Side Desk Order End Time and Broker Expire Time**			
Term Definition	**The time that all interaction with the market has stopped for a particular order. If multiple brokers are used, then the PM will know only the time from the last participating broker. Note: Order may NOT be completely filled.**			
Price Definition	**Midprice at Order End Time**			

PM Order Release Time				
	Arrival Time (B)			
Applicable Asset Class	**Equities**			
Order Lifecycle	**T2**			
Overlaps with	**Buy-Side Desk Order Arrival Time**			
Term Definition	**The time at which the PM sends the order to the internal trading desk.**			
Price Definition	**Midprice at PM Order Sending. If the market is closed then roll forward to the next Market Open.**			

Time Weighted Average Price				
Synonyms	**TWAP**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**N/A**			
Overlaps with	**N/A**			
Term Definition	**The price of a security as averaged over a number of equal-size time slices. TWAP is computed by iteratively deriving the average price over a pre-determined time range, usually seconds or minutes. Any of the following can be used to determine pricing of the individual time slices:** ▪ **VWAP within the interval** ▪ **Simple Average of all prices within the interval** ▪ **Midpoint within the interval** **The total time horizon (number of time slices) is user dependent.**			
Price Definition	**Calculated Price**			

Volume Weighted Average Price				
Synonyms	**VWAP**			
Applicable Asset Class	**Equities**			
Order Lifecycle	**N/A**			
Overlaps with	**N/A**			
Term Definition	**A range-based average price benchmark calculated using actual trades reported over a specified time interval. Please refer to the separate section on VWAP.**			
Price Definition	**Calculated Price**			

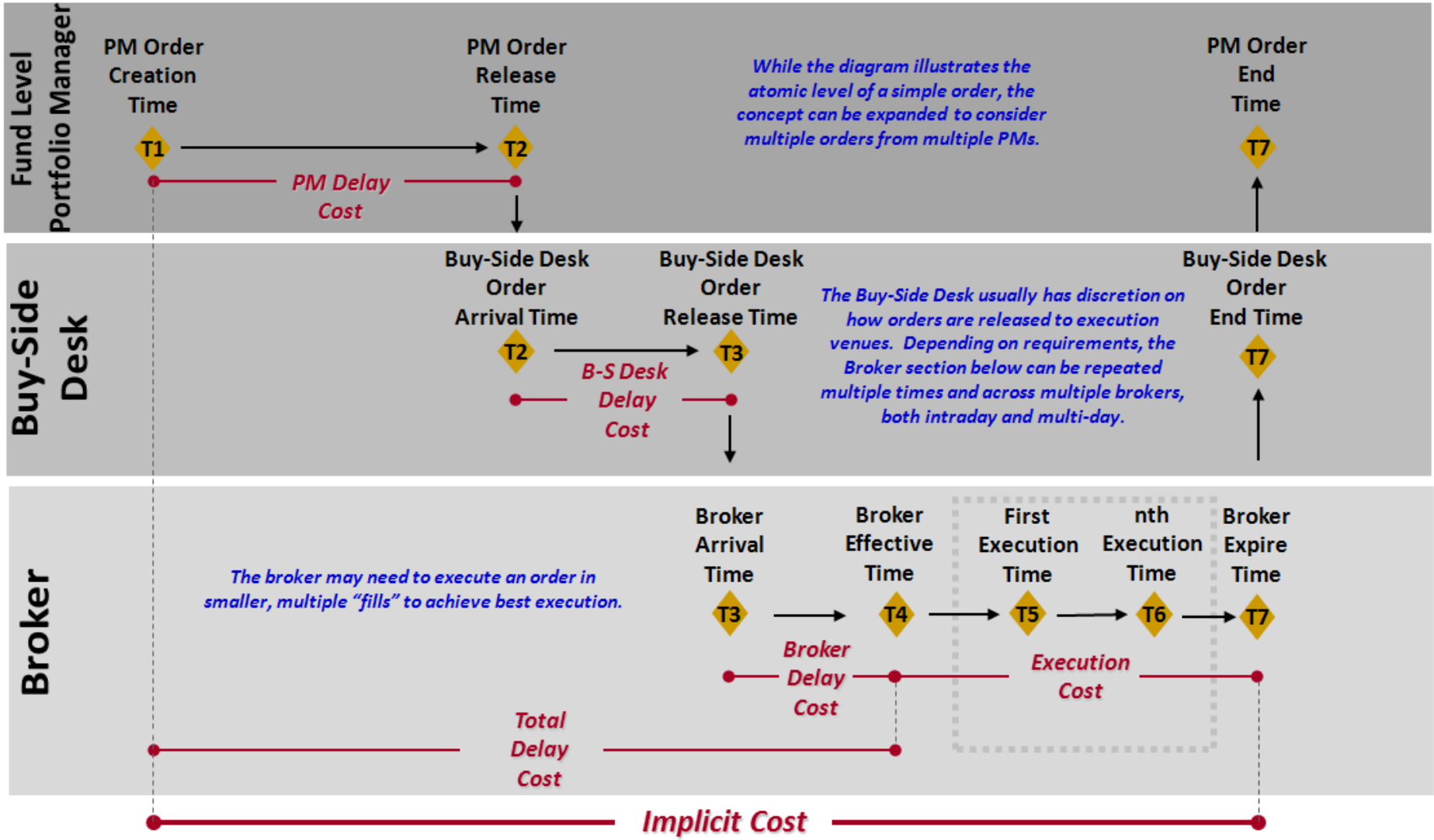
6.3 Order Lifecycle Diagram

Please see the diagram on the next page which illustrates the critical timing points in the life cycle of a single order.

Implementation Shortfall for TCA

Model of the Order Lifecycle and Implicit Cost

This diagram illustrates the critical timing points in the life cycle of a single order. Each ◆ represents a timestamp from which price movement can be measured. The price to be measured can be either an execution price or a price at another timestamp. Any point in time prior to execution is considered a component of Delay Cost.



Appendix 1 Quick Reference Guide to TCA Terminology

General TCA Terminology				
Term	Applicable Asset Class			
	Equity	Futures / Listed Options	Fixed Income	Foreign Exchange
Ask				
Average Daily Volume				
Benchmark				
Benchmark Gain/Loss				
Bid				
Explicit Cost				
Fill				
Impact Cost				
Implementation Shortfall				
Implicit Cost				
Median Daily Volume				
Mid-Price				
Nominal Spread				
Opportunity Cost				
Order				
Participation Rate				
Percent of Average Daily Volume				
Percent of Median Daily Volume				
Release				
Spread				

Benchmark Pricing Terminology				
Term	Applicable Asset Class			
	Equity	Futures / Listed Options	Fixed Income	Foreign Exchange
Broker Arrival Time				
Broker Expire Time				
Broker Effective Time				
Buy-Side Desk Order Arrival Time				
Buy-Side Desk Order End Time				
Buy-Side Desk Order Release Time				
(First) Execution Time				
(nth) Execution Time				
Market Close				
Market Open				
Market Prior Close				
Participation Weighted Price				
PM Order Creation Time				
PM Order End Time				
PM Order Release Time				
Time Weighted Average Price				
Volume Weighted Average Price				

Appendix 2 Cost Aggregation Examples

Like many things in TCA there are often multiple ways to accomplish a specific task, and cost aggregation is no different. The technique chosen here is straight-forward and readily translates across multiple computation environments. This means it is functional in Excel, as well as database languages like SQL, to name a few. One caveat with this formula is that it is intended for deriving weighted average costs in units of basis points or percent (i.e., a ratio). Other methodologies are better for deriving total-dollar cost and can be provided in a future version of this document if necessary.

Deriving the aggregate cost is nothing more than computing a weighted average, similar to computing VWAP. As mentioned in section 2.4, the method demonstrated here uses a normalized execution value in order to weight the cost (and effect) of each transaction in the total. Our example converts the execution value of each trade (local price * shares) into U.S. dollars, but any currency can be used for this purpose. We will refer to this normalized value as the "Reporting Currency". If the trades in the analysis are all based in the same currency other than the Reporting Currency, then it is not necessary to derive the normalized value. But it is recommended that you always convert to your Reporting Currency for consistency.

The formula to derive the aggregate cost of the basket is

$$\text{Aggregate Cost} = \sum(\text{TradeValue}_n * \text{ComputedCost}_n) \;/\; \sum(\text{TradeValue}_n)$$

Where n represents each trade within the basket, and TradeValue is expressed in the Reporting Currency.

Finally, this methodology is appropriate across all assets classes.

Example 1 – Simple Aggregation

In this example, we have 5 transactions from a single day across various markets and currencies. Each stock has its individual cost computed in the far right column using the formula from section 2.3 on page 8, using the local price for both the execution and benchmark[12]. This methodology requires that only the Execution Value be converted into the Reporting Currency, which is listed in the example as "Trade Value US$". The converted Execution Price is shown for clarity only. Additionally, the FX Rate used is assumed to be relative to the Trade Date.

In this example, the total value of the 5 trades is $198,736 with an aggregate cost of -13.6 basis points. The example below shows all the columns and final total. If you were to only present the summary without the detail trades, then you can only show Total Shares Traded, Total Trade Value US$, and Total Cost. None of the other columns are meaningful in a summary context.

Market	Security	Market Cap Group	Side	Currency	Execution Price (local)	Shares Traded	Trade Value Local	FX Rate	Execution Price (US$)	Trade Value US$	Benchmark Price (Local)	Computed Cost (bp)
Australia	Au_Stock	Mid	Buy	AUD	7.76	1,920	14,899	0.9583593	$8.10	$15,547	7.74	+25.8
Denmark	De_Stock	Large	Buy	EUR	531.5	640	340,160	5.86675	$90.60	$57,981	531.48	+0.4
Italy	It_Stock	Mid	Sell	EUR	1.256	5,230	6,569	0.7867202	$1.60	$8,350	1.276	-156.7
United Kingdom	Uk_Stock	Mid	Sell	GBP	6.086	11,030	67,129	0.629287	$9.67	$106,674	6.096	-16.4
United States	Un_Stock	Large	Buy	USD	33.95	300	10,185	1	$33.95	$10,185	33.97	-5.9
Total						**19,120**				**$198,736**		-13.6

[12] If a single FX rate is applied to derive both the execution and benchmark prices, then it will result in the same computed cost as when using the unadjusted local currency. There are situations, driven by user preference, where different FX rates can be used for the execution and benchmark prices. For example, if the benchmark price is from a day that is not TradeDate, then an FX rate from the benchmark date can be used to convert the benchmark price in the Reporting Currency. This will result in a different cost than when calculated in local currency. For our purposes, this is an unusual practice and we recommend using a single FX rate as described in these examples.

Example 2 – Subtotal Aggregation

Using the same 5 trades for this example, we will present two aggregations based on Side and Market Cap Group. The methodology is identical, but the subgroups will be smaller based on the common categories within each. And the aggregate total of the subgroups are still equal the overall total (we hope this is not a surprise).

By Market Cap Group:

Category	Shares Traded	Trade Value US$	Computed Cost (bp)
Mid Cap Total	18,180	$130,570	-20.3
Large Cap Total	940	$68,166	-0.6
	19,120	198,736	-13.6

By Side:

Category	Shares Traded	Trade Value US$	Computed Cost (bp)
Buy	2,860	$83,713	+4.3
Sell	16,260	$115,024	-26.6
	19,120	198,736	-13.6