QB FX TWAP ALGORITHM COMPONENTS

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EXECUTIVE SUMMARY

1. QB's FX algorithm uses 360T's proprietary Essential Data Feed (EDF) for fair valuation and GTX Book for passive placement.
2. FX algorithm will also use an in-house spread and volatility forecast model for opportunistic crosses and fill probability for optimal passive placement.
3. Simulation results are shown for illustration.

INTRODUCTION

The foreign exchange (FX) market is a vast and intricate financial ecosystem that facilitates the trading of currencies. Over the years, the structure and functioning of the spot FX market have become complex and highly fragmented[1]. Navigating in such a market requires superior technology, data, and models. As QB launches the FX algorithm, we highlight some of its unique components. While the markets are new, we have significant experience running schedule-based algorithms for futures and cash Treasury; we have modified them significantly to suit the FX spot microstructure. This version focuses on the time-weighted average price benchmark (TWAP) algorithm only, but our subsequent versions will also cover the details of the VWAP and IS benchmarks FX algorithm.

Before describing our algorithm, it is helpful to mention some crucial data feeds we used in our first version for fair value and passive placement. We use 360T's Essential Data Feed (EDF) to obtain fair value of the spot and GTX book for passive placement. The EDF is simply an aggregate of the full-amount book price of specific dealers chosen based on several criteria for fill execution. See[2] for more details on EDF. The GTX is 360T's spot clob book that allows participants to post and cross. The GTX is somewhat illiquid, and the spreads are wider; therefore, we rely on the EDF mid in real-time for the fair value. Notably, in the absence of the EDF mid, we would use our model to select dealers and aggregate their prices to find a fair value. It will, however require us to obtain individual dealer streams, whereas our current version relies on the aggregated book provided to us by 360T.

Clearly, any algorithm has two major aspects at a high level—opportunistic crosses and the ability to capture spread by seeking passive fills. We discuss the details in the following subsections.

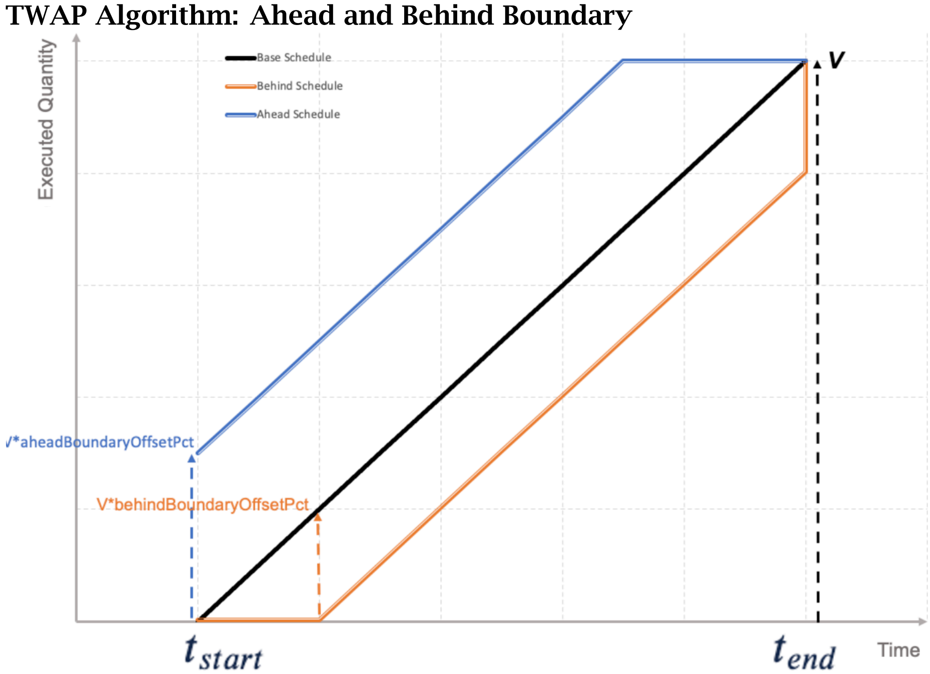
SCHEDULE AND BOUNDARIES

The TWAP schedule is a linear function of time passing through the points. However, the objective is to strike a balance between the cost of sending frequent aggressive orders and the option of allowing the algorithm to diverge from its base schedule by placing passive resting orders to capture the spread. To accomplish the same, the algorithm shifts the base schedule by an offset to generate both behind and ahead schedules based on Almgren's boundary construction, which is one of the unique aspects of QB's schedule-based algorithms. See[3],[4] and[5] for more details. The ahead and behind schedules determine how much ahead, or how far behind, of the ideal base schedule the execution is allowed to be. See Figure 1 below, which shows the TWAP schedule and the offset around the same. The black line is the schedule that grows linearly with time, the blue line is the upper boundary, and the orange is the behind boundary. The $y-axis$ shows cumulative volume, and $x-axis$ is the time of the order.

FIGURE 1

Figure shows the ahead and behind the boundary of a typical TWAP schedule. The $tstart$ is the start time of the order and $tend$ is the end time, and v is the cumulative volume to be executed. The offsets can be constant as defined by the client or based on volatility forecasts.

TWAP Algorithm: Ahead and Behind Boundary



While constant in the first iteration, the offset will be a function of the high-frequency volatility forecast in the subsequent versions. By making it a function of the volatility, we allow the algorithm to deviate from the schedule according to the projected risk. See[6] for high-frequency model details. The modeling of high-frequency volatility is yet another unique aspect of QB's algorithm.

OPPORTUNISTIC CROSSES

Another critical aspect of any algorithm is the opportunistic crosses, specifically when the spread to cross or the price is more favorable. In our case, we use the EDF mid as the fair value price and look at the spread between it and the best bid/offer for the different notional bands.

Sym	Percentiles	AsktoMid
EURUSD	10 25 50 75 90	0.1 0.2 0.3 0.5 0.7
USDCAD	10 25 50 75 90	0.2 0.3 0.5 0.8 1.3
USDCHF	10 25 50 75 90	0.2 0.4 0.5 0.7 1.1

TABLE 1. Table to display the percentiles of the spread between dealer's full-amount best offer to EDF mid for a representative client using historical data. Note that the table will be client-specific. We will output this distribution between EDF mid and dealer offer (far side) for a given currency pair for all our clients.

The opportunistic crosses help minimize our crossing costs. Considering that the dealer streams can be client-specific, we compute the spread percentiles based on the client-specific historical data. Table 1 shows the percentiles of the spread between EDF and the full amount of 1 million best bid/ask band for a representative client. The distribution is based on a previous week's data and aids in opportunistic crosses. For example, based on the table below, for EURUSD, if we are buying and the 1-million full amount offer price relative to the EDF mid is lower than the 50th percentile, we would consider crossing. The state of the order is still critical to consider while considering the opportunistic crosses.

Another way to consider opportunistic crosses is to use a forward-looking price predictor, which is relatively complex. However, crossing on a weak signal can still be advantageous when behind in the schedule as it could minimize our overall variance of the slippage.

EURUSD: Simulation to show the value of opportunistic crosses

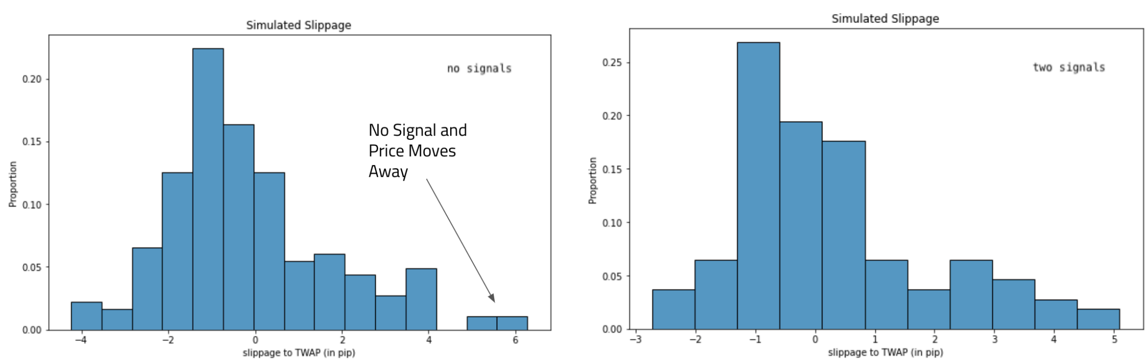


FIGURE 2. The right side has both a spread and a weak trend signal to illustrate the variance of the slippage when compared to a simple time slicer on the left side. Both simulations use TWAP as the benchmark measured using the EDF mid.

Figure 2 shows the same for illustration. We simulate around 150 orders of EURUSD of various notional amounts to see the value added by a simple trend-based signal and spread crosses. The left panel crosses only when the algorithm hits a certain distance to the behind boundary, whereas the right side uses both our trend and opportunistic

FIGURE 3
Best level to post is deeper as volatility or time to hit the behind boundary increases. We fit a functional form for usage in real-time.

EURUSD: Best Level To Post against Volatility and Time

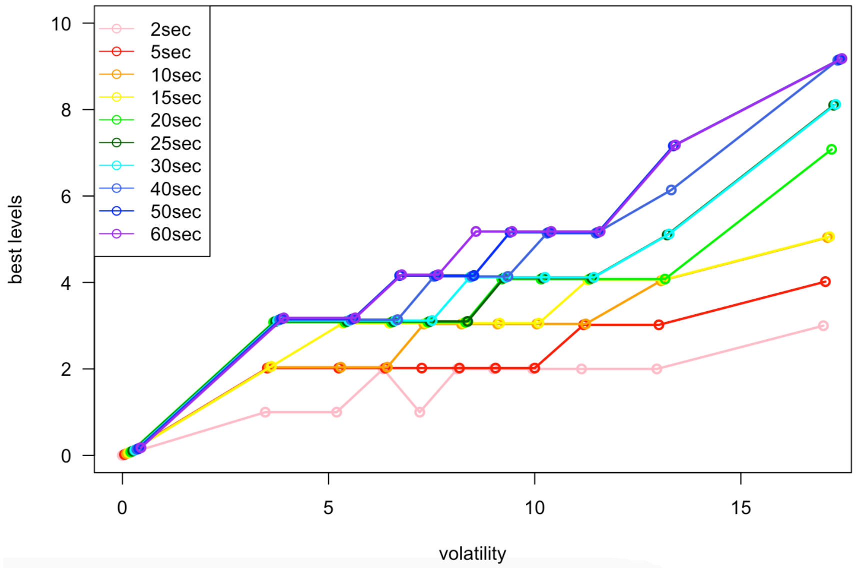
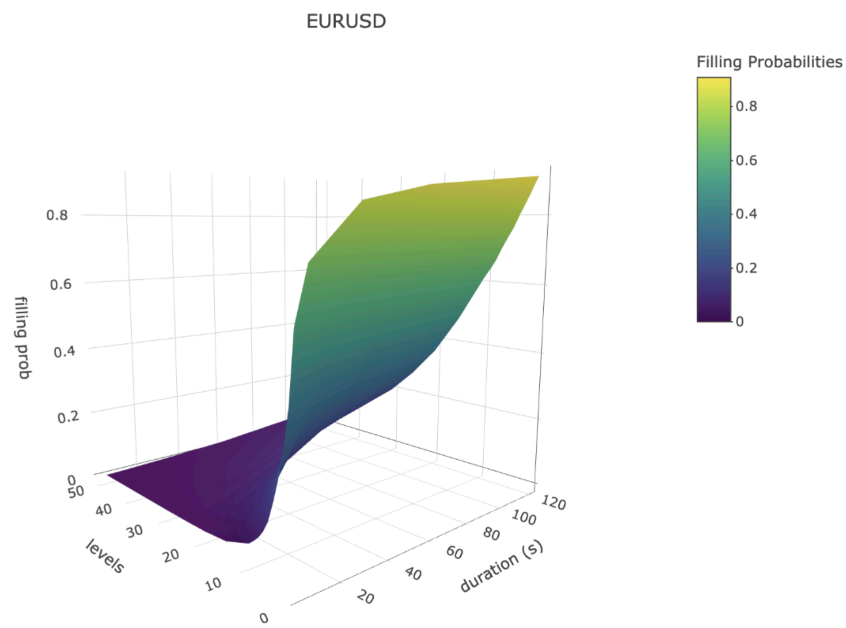


FIGURE 4
Empirically determined fill probabilities. Best level to post is deeper as volatility or time to hit the behind boundary increases. We fit a functional form for usage in real-time.



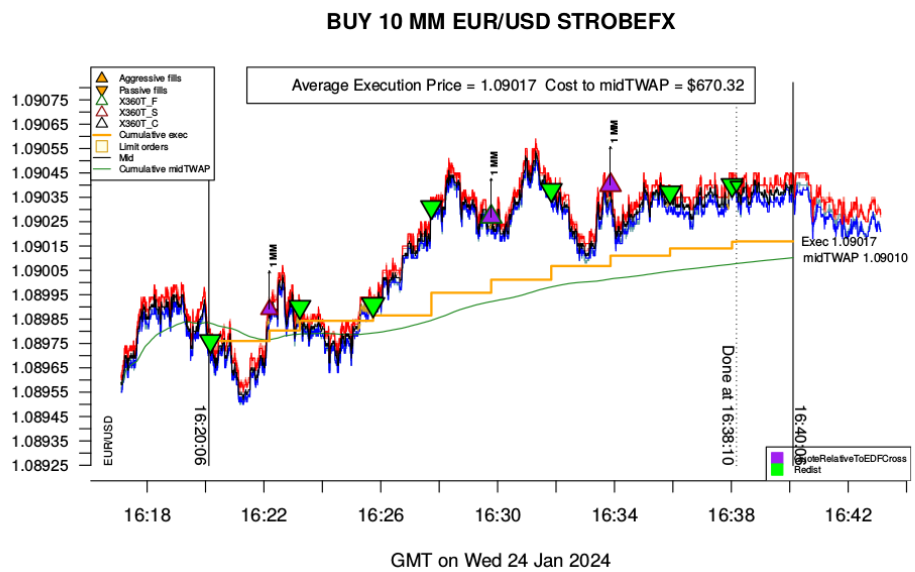
crosses. As we can see, the right side has a lower variance than the left side. The details of the trend signal used are beyond the scope of the current paper.

In our current version of the prod, we only have spread-based crosses. Our subsequent versions will have another input for opportunistic crosses based on the spot's price forecast.

SPREAD CAPTURE OR PASSIVE PLACEMENT

Whereas the FX spot execution is considered predominantly an aggress-only algorithm, there is merit in still getting passive fills, no matter how small. We do this by pegging to the EDF mid at a certain level in the 360T GTX book.

The calculation of the optimal level should have some characteristics. We want our optimum level based on the volatility and the time to hit the behind boundary. So, if the time to hit the behind the boundary is more prolonged, we post it deeper. Similarly, if the volatility is high, we will post it deeper. Figure 3 shows the best level as a function of time and volatility using data for EURUSD from Aug 14 to Sept 25, 2023, as an example. Note that the best level to peg the order is deeper as time or volatility increases. For fill probability modeling, we make a restrictive assumption that the fills in the GTX book will happen only when the price comes to us in a specific duration. We compute our fill probabilities empirically based on the two factors - volatility and time. We then fit a



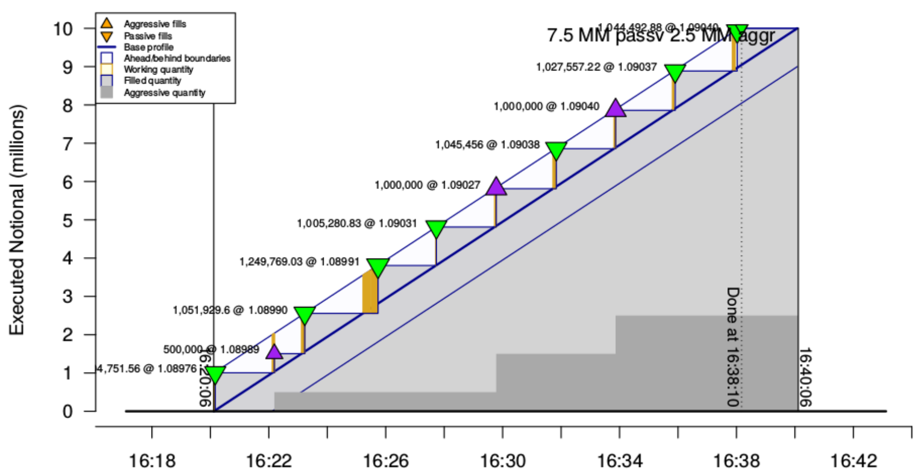


FIGURE 5
The Plot shows the simulation results of EURUSD. The up arrows are opportunistic crosses, and the down arrows are the passive fills. The TWAP benchmark is the mid of EDF measured at fixed intervals.

parametric form $y = a + b * \sigma * \sqrt{t}$, where y is the best level, σ is volatility,t is the time hit the behind the boundary of the schedule, a and b are intercept and slope respectively. The coefficients are determined empirically and periodically evaluated. The parametric form is simple enough to be used in real time. See Figure 4 for the fill probability model of EURUSD based on two weeks of data. Note that the fill probability goes down as the level increases for the same duration, and the fill probabilities for the same level increase as the duration increases.

SIMULATION

Given that the essential pieces are defined, we have a simple simulation plot of our TWAP algorithm. Figure 5 shows the various aspects of the algorithm, which are aggressive opportunistic crosses as up arrows and passive fills as down arrows. We also show the EDF mid, full-amount, and sweepable prices for reference. The TWAP benchmark is the EDF mid-price computed during the order. The yellow line is our cumulative execution, whereas the green line is the TWAP calculated using the EDF mid. The lower panel shows the base schedule along with the ahead and behind boundaries of the TWAP algorithm. Note that while the cost is higher than the benchmark in this example and the percentage of passive fills is significantly higher than expected, it is mainly for illustration.

In summary, we have the critical components for the TWAP algorithm, which combines unique data feeds such as EDF and the QB's proprietary modeling of the key algorithm inputs. In our forthcoming versions, we will report the production slippage and details on the enhancements.

References

[1] Andreas Schrimpf and Vladyslav Sushko. FX trade execution: complex and highly fragmented. *BIS Quarterly Review, December*, 2019.

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