

Research Report

Flexible Volume Weighted Average Price Executions

CONCEPTUAL DEVELOPMENT OF A DARK POOL TRADING MODEL THAT INTENDS TO BALANCE MARKET IMPACT COSTS AND FLEXIBILITY IN SECURITIES TRADING.

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Introduction

The size of individual institutional investors' orders for securities can range up to several percent of the average daily trading volume. In equities trading, there is no quantity discount. Instead, trading large order volumes significantly rises transaction costs. Trading such orders in the markets is subject to explicit as well as significant implicit transaction costs of trading, i.e. market impact and opportunity costs. The market impact results from the information potentially carried by the orders and from the premium paid for liquidity provision. Opportunity costs are due to orders and execution strategies that can not be implemented in full due to this market impact.

Therefore, institutional investors as a first option can execute large orders by delegating the execution to a broker (agency order) who preserves the anonymity of the investor and does not reveal the (large) order as a whole to

the market. The broker releases the order successively manually or via Algorithmic Trading tools into the markets. Benchmarks are applied to measure the execution performance of the broker. As of today, the most established benchmark is the Volume Weighted Average Price (VWAP) in a market for a specified period of time. As this benchmark is easy to measure, easy to communicate, and is provided electronically and continuously updated by most information vendors (Reuters etc.), agency VWAP trading established as a standard execution mechanism in the industry.

As a second option, the investor can execute these orders without broker intermediation within an electronic trading system that imports prices from a reference market. These systems are named "Dark Pools" as they provide no or minimum pre trade information and have been intensively discussed in the industry for the last two years. There are already around

40 Dark Pools in the U.S. with a market share estimated at 10-15% of total equity trading. For 2008 in Europe, multiple Dark Pools have been announced that will enter competition for order flow. These Dark Pools are provided by agency only brokers (e.g. ITG Posit, Liquidnet, Nyfix Euro-Millennium), or by full service brokers, broker-consortia or broker-exchange consortia (e.g. Goldman Sigma, Turquoise or SmartPool). In these Dark Pools, typically orders are crossed at the midpoint of the bid-ask spread of a reference market (Electronic Crossing).

Agency VWAP vs. Electronic crossing

In case of agency VWAP orders the broker splits an order into smaller chunks and executes them over time and mostly across multiple execution venues trying to achieve or beat the VWAP benchmark. Although agency VWAP is subject to relevant explicit transaction costs and to principal-agent issues, it offers flexibility to the investor:

- (i) the investor can specify a flexible time period other than the whole trading day, for example the VWAP for several hours,

- (ii) unfilled parts of the order can be cancelled during execution, for example if important news regarding the traded instrument are released and
- (iii) the investor has the chance that his order is executed at a price better than the VWAP if his broker performs in order execution.

Electronic Crossing in Dark Pools at the mid-point of the bid-ask spread is subject to lower explicit and implicit transaction costs (Naes and Skjeltorp, 2003) but entails the problem that large orders might be crossed at an unfavorable price relative to the daily average price for one of the counterparties, specifically in the very volatile markets that we see since mid 2007. One approach to mitigate this issue are electronic VWAP crossing models that apply an average price instead of the current mid-point of the bid-ask spread. The New York Stock Exchange (NYSE), e.g., provides four different crossing sessions after its market close. One of those sessions applies the (already known) full-day VWAP for orders submitted to the system. As associated trade

| Symbol | VWAP Start | VWAP End | Open | Close | High | Low |
|--------------|------------|----------|--------|--------|--------|--------|
| DE0007100000 | 10:00 | 10:30 | 69.00 | 68.42 | 69.12 | 67.81 |
| | 10:00 | 11:00 | 69.00 | 68.42 | 69.12 | 67.81 |
| | 10:00 | 12:00 | 69.00 | 68.42 | 69.12 | 67.81 |
| | 11:00 | 12:00 | 69.00 | 68.42 | 69.12 | 67.81 |
| DE0008404005 | 13:00 | 15:00 | 69.00 | 68.42 | 69.12 | 67.81 |
| | 10:00 | 11:30 | 140.33 | 139.26 | 141.94 | 138.25 |
| | 10:15 | 11:45 | | | | |

Figure 1: Order book snapshot at the system's prototype front-end

prices are already known before an order is submitted, this crossing obviously is unfavorable for one side of the market depending on whether this full day VWAP is higher or lower than the current market price (closing price of the day). Instinet provides a model for crossing customer orders at the (future) full-day VWAP twice a trading day, where crossing takes place in two separate sessions and where price and volume negotiations are separated. Here, orders are crossed against each other within a session before the reference market opens and trades occur but only the quantities are determined. In a second step, after the reference market closes, the full day VWAP is imported and serves as the execution price for the previously matched trades.

Thus, existent approaches either provide ex post VWAPs or full day VWAPs only. The full day VWAP exposes an order to the risk of significant price movements between execution before the market opening and price determination at the market close. Moreover, it does provide no flexibility in specifying the desired trading window. We took these trade-offs as a starting point to develop a new flexible VWAP execution model that

- (i) is designed as a fully electronic market, i.e. allows to trade at low explicit execution costs,
- (ii) protects large orders as it provides only minimum pre trade information to the market, i.e. is designed as a Dark Pool,

- (iii) enables to trade at the VWAP within trading windows that can be specified by the trader, i.e. provides full flexibility.

This electronic trading model named "flexible VWAP executions" will be detailed in the following sections.

Flexible VWAP Executions

The key idea of the developed model is that crossings are triggered based on the start times (and end times) of the VWAP periods submitted as order parameters by investors rather than being fixed and specified by the provider of the execution venue. This provides full flexibility concerning the time windows in which the VWAP is determined and thereby differs substantially from existing VWAP crossings. At the investor's front-end only the specified VWAP calculation periods of orders sitting in the book, i.e. the submitted start times and end times for the VWAP calculations, are displayed (see Figure 1). Thereby, other institutional investors can react to the order submissions and liquidity can concentrate at specific time windows, i.e. investors can join time periods already present rather than specify new ones. Additionally, the Graphical User Interface may provide information from the reference market.

Besides the desired start and end times the order book is closed in a way that neither volume nor market side information is shown in order to prevent market impact. In this respect our model can be characterized as a Dark Pool mechanism. Trading is anonymous,

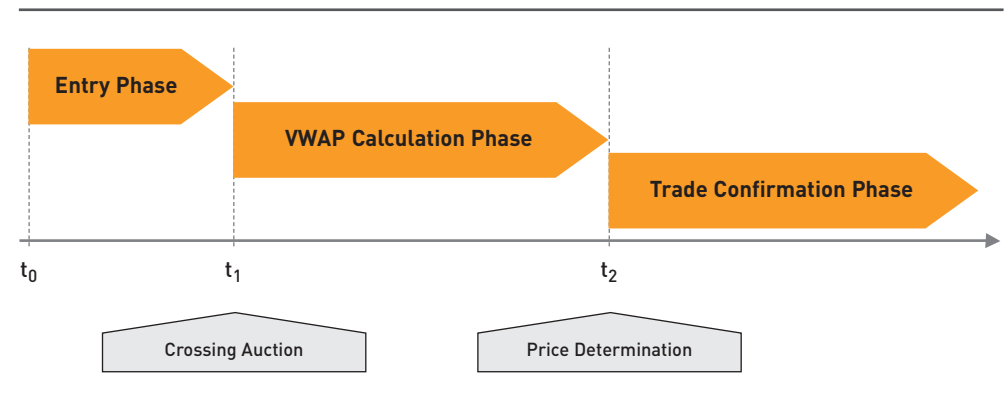


Figure 2: Trading phases for a single crossing session

so investors do not know each other in advance of the trade.

The crossing auction, that is the algorithm matching supply and demand, is performed right before the VWAP calculation starts. The VWAP is imported and set as the transaction price after the calculation period ends.

Trades are finally and fully confirmed at time of completion, including the trade price. For investors' protection safeguards against extreme events and reference market movements are included in the model.

Order Types in the new model

Splitting supply and demand over multiple auctions for different VWAP periods increases risk of non-execution because two investors can choose incompatible periods. However, the flexible VWAP crossing model allows for crosses not only against exactly matching time periods (e.g. 10:00 – 12:00), but also

against partially overlapping ones. To provide this flexibility to the investor, we developed several new types of orders designed for our flexible VWAP Dark Pool:

- (i) a basic order type named "strict order". This type carries the minimum parameters needed, namely buy/sell indication, quantity, start time, and end time. A strict order participates only in crossing auctions with exactly matching parameters (start and end times), any unexecuted quantity is deleted,
- (ii) an additional order type, "start fix order", that allows for partial period matches. Such orders can be executed against orders with the same start time but different end times,
- (iii) a third order type are "carry forward orders". Any unexecuted quantity of the orders is forwarded to the next crossing session.

Trading Phases in the new model

The trading phases of the flexible VWAP executions model are the *order entry phase*, the *crossing auction*, the *VWAP calculation period*, the *price determination*, and the *trade confirmation phase* [see Figure 2]. In the order entry phase, the first order submitted into the system sets an event driven time window between this first order entry time (t_0) and the specified VWAP calculation start time (t_1). During this phase, the order book shows the submitted start and end times to enable other traders to join these VWAP calculation windows.

Immediately before start time t_1 , a crossing auction occurs, matching orders based on the implemented matching rules. As the system matches based on time priority, the order entry time is an important parameter for the matching mechanism. Price priority obviously does not apply as the price is the imported VWAP of the reference market.

First, all orders with exactly matching time periods – i.e. these orders have identical t_1 (start times) and t_2 (end times) – are matched. This includes forwarded orders from previous auctions. In the example in Figure 3, this would affect orders in the block marked as A with specified intervals between 10:00 and 12:00 and the crossing would occur at 10:00 (t_1). Additional auctions would occur at the same time for orders in block B and for orders in block F.

Whenever there is unexecuted quantity from orders submitted as “start fix orders”, additional auctions are triggered for partially over-

lapping intervals (for example orders in block A against orders in block B in Figure 3). Here, available quantities are adjusted for the shorter interval based on historical volume pattern. Orders can not be withdrawn as soon as the auction starts. Details on the matching mechanism are provided by Gomber et al. (2007).

After the crossing, execution confirmations with the executed quantity are sent to investors. The execution confirmations have no counterparty information to prevent a black board effect where investors could submit only a small quantity to the crossing system and negotiate their real quantity bilaterally with counterparties disseminated through the confirmations.

Immediately after the end of the crossing auction, the VWAP calculation period starts. The VWAP for the matched time period will represent the price for the trades crossed in the auction. At the beginning of the VWAP calcula-

tion, unexecuted quantity is handled: Remaining quantity for strict orders is deleted. Remaining quantity or unexecuted orders from carry forward types are waiting for the next suitable crossing session. If time constraints, e.g., submitted end times, are reached, the remaining quantity is also deleted.

At t_2 , the calculation of the VWAP ends and price determination takes place. This price completes the trade data of a transaction.

After t_2 , the trade confirmations are sent to the investors, including all data required for post trade processing.

Since investors are free to specify the time periods, the trading phases described above are present for every single trading period in the system.

Conclusions

Investors can submit a VWAP agency order to a

broker or make use of a fully electronic crossing facility in a Dark Pool. Existing crossing facilities are characterized by low explicit costs, but also by price risk and inflexibility as either a midpoint of the current bid-ask spread or the full-day VWAP of a reference market is applied for crossing sessions. We proposed a conceptual market model for non-intermediated crossing sessions in a fully electronic environment, which provides anonymity and lifts the constraints of existing Dark Pools by introducing the possibility of crossing investors' orders at flexible intraday VWAPs.

The next step in the project will be a systematic discussion of the model with interested potential users (please do not hesitate to contact us for discussion of the model) and based on this input a development of a full prototype of the proposed model that can be further analyzed, e.g., by means of the methodology of laboratory experiments.

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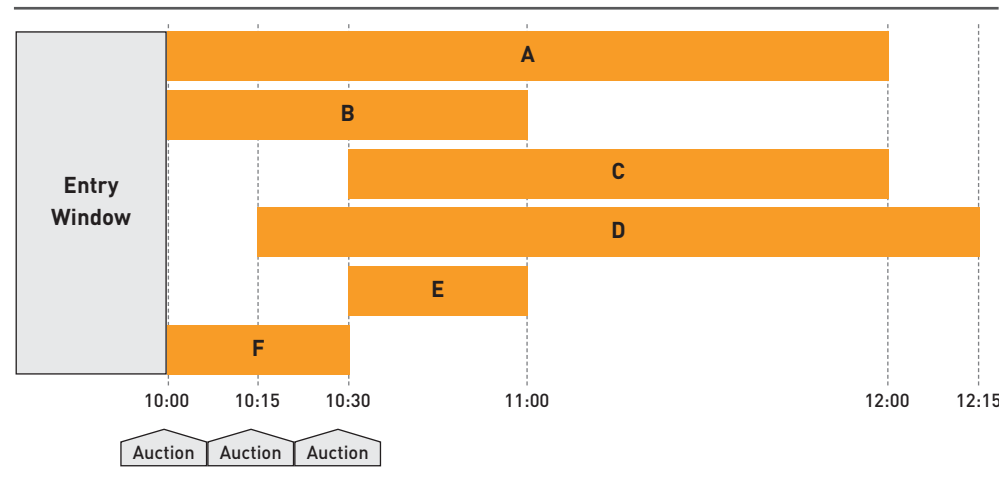


Figure 3: Allocation of orders to crossing auctions based on the specified start and end times