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Volume Discovery: Leveraging Liquidity in the Depth of an Order Driven Market

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A b s t r a c t

Electronic order book trading has evolved in being recognized as the best-practice for trading small and mid-sized orders. Yet, this mechanism does not properly address the needs of large-sized orders which tend to execute off order book in over-the-counter markets. Order book trading provides for public price discovery but not for quantity discovery. Off book executions generally fragment the order flow which again adversely impacts price discovery.

We propose a market model innovation to close this gap: 'Volume Discovery' introduces the new order type 'volume order' to integrate large sized orders into the book. The volume order builds on the concept of iceberg order but is enhanced by two parameters 'hidden limit' and 'minimum volume', which continuously search order book depth for matching quantity.

For large orders, Volume Discovery leverages already existent liquidity to benefit block trading by increased likelihood of execution and reduced opportunity costs. For all orders, Volume Discovery promotes the integration of OTC markets and order book trading in order to improve liquidity while protecting price/time priority.

Keywords: quantity discovery, block trading, market microstructure, order book, iceberg orders, OTC

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INTRODUCTION

'A well-functioning equity market should provide reasonable price and quantity discovery for all participants. The task is not simple ...' (Schwartz and Francioni 2004: 118).

Order book trading is well recognized as a best-practice mechanism in trading liquid equities. Yet it is not fully suited for trading large orders because of their adverse price impact in a fully transparent order book market model. While order book trading provides for efficient public price discovery, it does not provide for efficient quantity discovery. For that reason, large orders are often executed alternatively on OTC (over-the-counter) venues. These OTC venues are especially designed to meet the execution requirements of large orders, with regard to anonymity, immediacy or limited pre-trade transparency (Weinhardt and Gomber 1999). Today, a large part of total order flow is executed off order book, for example, approximately two-thirds of equity trade value in the United Kingdom. This fragmentation of order flow across execution venues negatively affects the price discovery function of equity markets and in turn efficiency of capital allocation (Schwartz and Francioni 2004: 16–17).

Market design in European markets has traditionally focused on

providing a high level of pre-trade transparency for the interaction of order flow. This transparency regime attracted small and mid-sized orders in liquid equities. Subsequently, order book trading has been enriched by elements of hidden liquidity. For example, iceberg orders are designed to provide for an optimal pre-trade transparency regime to protect orders against adverse price impact and information spill-over. With the introduction of central counterparty services throughout European exchanges in the early 2000s, hidden liquidity in order book trading has increased significantly (D'Hondt *et al.* 2003). Although iceberg orders have been successfully implemented in the order book market model, they have not been able to achieve a full integration of order flow yet.

Based on this background, the authors propose the market model innovation 'Volume Discovery'. It introduces the new order type 'volume order' into order book trading. Volume order builds on the concept of iceberg order that is enhanced by two parameters 'hidden limit' and 'minimum volume' to continuously search order book depth for matching quantity.

Volume discovery is designed to overcome one drawback of order book trading – the disjuncture of price and quantity discovery in continuous trading. It integrates large orders into an already existent liquidity pool and, therefore, tries to avoid the typical 'chicken and egg' problem of new stand-alone block trading platforms: the lack of initial liquidity.

Volume orders participate in order book matching as well as in block order execution. For large orders, the goal of the Volume Discovery model is to overcome the dichotomy between passive and aggressive orders to increase their execution likelihood, to reduce opportunity costs and to enable for new trading strategies. For all orders, Volume Discovery aims to integrate OTC markets and order book trading and to increase the available liquidity while protecting price/time priority.

The paper is structured as follows. The next section outlines the functional principles of order book trading including a short review of market microstructure literature on hidden liquidity and parallel trading venues. After a discussion of both the merits as well as the drawbacks of the electronic order book, off-the-book alternatives for large order trading are presented. The third section introduces the market model innovation 'Volume Discovery'. It details the functionality, provides matching examples for the main execution cases and discusses the proposed model. The last section concludes.

OPEN ORDER BOOK – PRINCIPLES, MERITS AND CHALLENGES

Principles of order book trading

Order book trading embodies a double auction market, whereas public orders are electronically routed, stored in a (physical or electronic) 'book' and automatically matched according to pre-defined criteria. For high and mid-liquid equities, trading is in most cases organized continuously, which means that orders can be matched throughout the trading day. In contrast, less liquid equities are often traded periodically by 'call auctions'.

Market models based on order book trading adopt the principle of transparency and anonymity. Pre-trade transparency means that all stored orders are displayed to the public. Post trade transparency requires that all transaction details are published instantly. Anonymity ensures that market participants' identities are not revealed. Although these basic principles of transparency and anonymity can be found in most order book implementations, some deviations from these principles may apply depending on the respective institutional design. Examples include the display of a participants' identity (e.g., in Nasdaq's SuperMontage),[1] delayed publication of transactions above a pre-defined size or the (partial) non-display of certain orders in the order book, commonly known as 'iceberg', or 'hidden' orders.

A short literature review on hidden orders and parallel trading venues is given. While electronic order book trading has been discussed in the past (e.g., Glosten 1994), literature addressing the particular issue of hidden orders in an electronic order book is scarce. Some recent work is provided by Pardo and Pascual (2003) and D'Hondt *et al.* (2003). The authors analyse the usage of iceberg orders on the Spanish Stock Exchange and on Euronext Paris respectively. Pardo and Pascual find that this order type contributes to the reduction of adverse selection costs, whereas the authors for the Euronext study find that a significant part of liquidity in the order book is hidden.

Several studies have addressed the issue of competing trading venues. Hendershott and Mendelson (2000) model intermarket competition between a dealer market (where orders are executed immediately upon arrival at the dealers' quotes) and a crossing network (where orders are executed at specified times at prices imported from the dealer market). The authors find – among others – that traders try to first fill their orders on the crossing network, and switch to the dealer market if no match is found there. As a result, dealers will widen their spread.

Intermarket competition is experimentally investigated by several authors. Campbell *et al.* (1991) study the effects of introducing a bilateral search possibility in addition to a double auction market. The authors find that participants prefer OTC trading when the spread on the main market is wide. Also, participants tend to execute large orders off-exchange. A similar issue is investigated by Lamoureux and Schnitzlein (1997) who investigate the effects of an additional search and negotiation option within the scope of a dealer market.

Their results show that the additional trading venue significantly reduces dealer profits. The aforementioned studies observe trading behaviour when an additional trading venue is introduced, whereas the additional venue is not integrated into the existing market. This issue is addressed by Budimir (2003) who replaces the dealer market setup of Lamoureux and Schnitzlein by a public limit order book in order to integrate two parallel price discovery mechanisms within the scope of one market. The introduction of a parallel and bilateral negotiation option within the scope of an order book significantly increases the order book spread, which is explained by a decrease in pre-trade transparency.

Studies that focus on the possibility of fully electronic quantity discovery within the scope of an order book are – with the exception of the aforementioned hidden order studies – not known to the authors. The aim of this work is to address this gap by the Volume Discovery proposal.

The merits of order book trading

Both academic literature and practical experience emphasize the following key advantages of order book trading:

- *Price discovery*: A central public limit order book pools the order flow in one trading venue, ensuring fair price discovery: Transaction prices reflect the unbiased conditions of market demand and supply at any given moment. In contrast, the existence of several different execution venues splits the order flow. This fragmentation most likely generates different transaction prices at the various venues.
- *Automated execution*: An automated order book matches buy and sell orders immediately as they arrive in the system and the matching algorithm detects an executable situation. In contrast, non-automated market models (like dealer markets or specialist markets) entail a technical delay[2] in execution. The wait 'from executability to execution' might result in significant opportunity costs to the trader as a change in market conditions during the wait might lead to a price less favourable in contrast to an immediate order execution.
- *Price/time priority*: Order book trading usually operates by 'Price and Time' priority, meaning that buy (sell) orders with the highest (lowest) limits are executed first. If several orders with the same limit exist, the time of order entry decides ('first-in-first-out' principle). While other market models also implement price priority, several different secondary priority rules exist. The price and time priority rule implemented with order book trading is widely accepted as fair among market participants throughout Europe,[3] as they are all treated equally on the basis of the objective criteria 'time of order entry'.

- *Pre-trade transparency*: Open order books enable traders to determine ex ante the average price at which their order gets filled. This is important for larger orders that 'walk the book', i.e. orders consuming liquidity at several price levels thereby causing an adverse market impact to the order. In contrast, other market models based on closed order books (e.g. the specialist market at the NYSE previous to the introduction of OpenBook in 2002 (see Boehmer *et al.* 2005) or the German regional exchanges as of today) do not offer this possibility. This might affect traders' strategies as they will be less willing to submit orders without knowing the execution price in advance. One strategy they might want to follow in such a setting could be to use discretion when giving the order to the broker. The broker would then dissect the order in several slices (reducing market impact) and pass it to the specialist for execution. However, this procedure contains the risk of information leakage.
- *Anonymity*: Traders are usually reluctant to show their presence in the market as this information might serve as a signal to other participants, enabling them to anticipate strategies and rapidly take or unwind positions. Non-anonymous market models always bear the risk to become a victim of order anticipators (see Harris 2003: ch. 11).
- *Value distribution*: Order book trading in its pure form enables traders to interact directly without the necessity for an intermediary. Impatient (aggressive) orders (i.e. arriving marketable orders) pay a 'liquidity' premium to patient (passive) orders (i.e., limit orders 'waiting' – i.e. 'sitting' – in the book for execution) in form of the bid-ask spread. This premium is distributed within the traders themselves. Other market models, especially quote driven markets, require dealers providing liquidity to the market and capturing the premium.

Despite these advantages of order book trading there still are some shortcomings to it. These are now discussed.

The challenges of order book trading

The major obstacle of order book trading for large orders is the missing incentive to post these orders into a transparent environment and the associated level of total trading costs. In order book trading, public price discovery is usually performed at the 'inside market', i.e. within the price range determined by the best bid and offer, the orders are visible to all participants. A large order is very unlikely to be submitted to the book as any other limit order in this environment. The mere existence of the order represents new information and the market would start to 'move against' the order.

Participants adopt their expectations about the asset's consensus value and the limits of their own orders correspondingly. Eventually, this decreases the likelihood of the large order to be executed.

Therefore, market participants tend to avoid public price discovery for large orders. Instead, they prefer private price discovery without displaying their order to the public market but seeking counterparties (with the corresponding negotiations about the execution price) off the order book. One means to overcome this issue is the introduction of hidden liquidity with iceberg orders into order book trading. Iceberg orders are orders that are only partially disclosed to the market by size. The order consists of a visible, or 'peak' part, and a hidden part.[4]

Some recent empirical studies have shown that a significant portion of liquidity is hidden and that iceberg orders are often placed with a certain distance to the inside market. D'Hondt *et al.* (2003) investigated hidden liquidity on Euronext by rebuilding the order book for six CAC40 stocks. They show that about 30 per cent of liquidity is hidden at the best bid or offer whereas this ratio increases to 50 per cent when the first five bid and ask levels are considered. When the total depth is considered, about 30 per cent of liquidity is hidden throughout the entire order book.[5] In a comparable investigation, Pardo and Pascual (2003) found similar results for the Spanish Stock Exchange, with 26 per cent of orders in the IBEX-35 being hidden.[6] After the introduction of SuperMontage, Nasdaq Economic Research (2003: 11) has also found a significant usage of the 'reserve size' (which is to some extent comparable to hidden orders) compared to total depth in the order book.[7]

In October 2003, Deutsche Börse investigated the submission of iceberg orders in the order book. As the task of identifying total iceberg order volume is trivial but of little information content,[8] an alternative methodology – taking into account the distance of the hidden order volume from the current inside market – was applied. The results – outlined in Figure 1 – showed that most of the hidden order volume is somewhat away from the inside market. For instance, a hypothetical €25k round trip in high-liquid German equities (DAX) would result in total market impact costs of 20.4 bps on average,[9] whereas the depth actually displayed via the order book would indicate 20.5 bps market impact costs. The difference (0.1 bp; roughly one per cent in terms of visible liquidity) can be considered as a proxy for hidden liquidity for a given order size. The figure also shows that hidden liquidity increases with the distance to the inside market: For an order volume of €1m, for instance, 14 per cent of liquidity is hidden. When quadrupling the order volume to €4m, hidden liquidity increases to 27 per cent. The pattern is similar for equities in the midcap segment (MDAX) whereas trading in this index is not as liquid as in the DAX (e.g. a €500k order amounts to 66 bps in the DAX and 748 bps in MDAX).
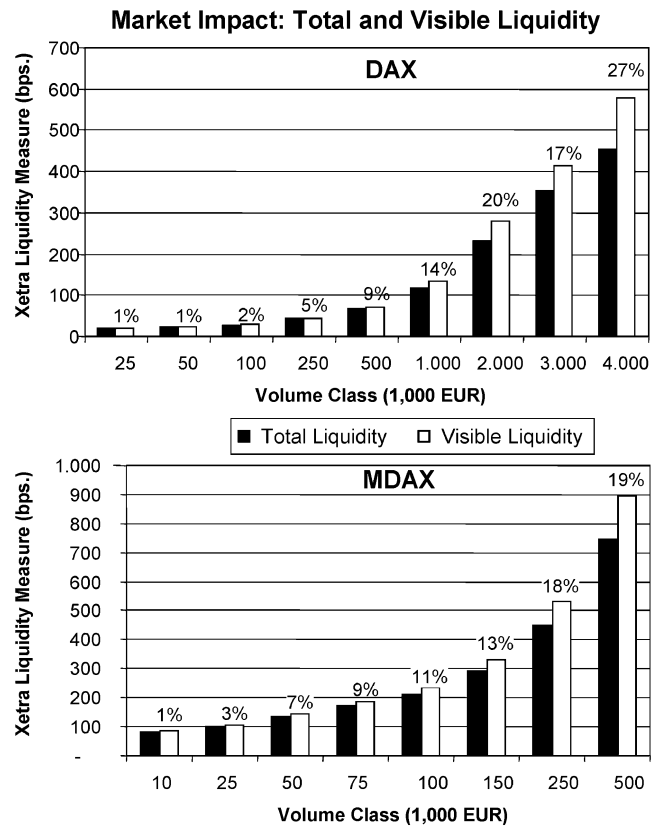

Figure 1. Displayed and hidden liquidity in Xetra. *Source*: Deutsche Börse, Market Development. *Notes*: 'Xetra Liquidity Measure' (XLM) quantifies the market impact of a hypothetical round trip for a given order size (volume class). XLM is expressed in basis points. It is calculated as the difference between the average execution price and the midpoint of the best bid and offer prevailing on the order book at the time of the hypothetical order entry. As XLM is calculated for a round trip, the market impact for a buy and a subsequent sell order are calculated separately. The two figures are added up to form the XLM for the respective volume class (Gomber and Schweickert 2002). In this example, the index XLM is calculated as a naïve average of the index constituents, in contrast to its usual, weighted calculation. Visible Liquidity: For a €4m market order in DAX equities, visible (i.e., displayed) order book liquidity *shows* 578 bps market impacts costs for a round trip. Total Liquidity: For a €4m market order in DAX equities, total order book liquidity (including hidden orders) *is effectively* 454 bps market impact costs for a round trip. The difference: 27 per cent of liquidity is hidden for the €4m volume class in DAX equities. Analysis is based on two trading days (21 and 22 October 2003).

When deciding where to execute the order, investors will typically consider total transaction costs – which depend on the order size. Smaller orders will face the lowest execution costs on the central limit order book. Although small orders might also be executed off the book, the search costs – in terms of time and effort – will in most cases outweigh the relatively small explicit and implicit costs of order book execution. In contrast, large orders will face significant market impact costs when traded on the order book. Here, it can be rewarding to seek execution off the order book and to make

considerable efforts in finding an appropriate counter-party in the OTC market.

Alternatives for large order trading

Alternatives to order book trading include both broker-based solutions as well as Alternative Trading Systems (ATS).

Brokers facilitate the execution of large orders off the order book by either

1. seeking for an eligible counterparty with a subsequent negotiation (i.e., broker acts as an agent); or
2. serving as counterparty themselves and providing 'risk capital' to the investor (i.e., broker acts as principal); or
3. working the order successively.

In the first case, the broker brings buyers and sellers together for a commission. Today, this is mainly done via the telephone. Brokers are networked into the community and, therefore, have knowledge of the market, e.g., potential counterparts with latent trading interests. In addition, brokers perform the negotiations for the customer, making use of their skills to ensure a favourable overall price for the order. These orders do not participate in public price discovery. They engage in private price discovery instead, whereas they also search for volume, i.e. quantity. In this regard Schwartz and Wood (2003: 44–5) note that:

> Closely related to price discovery is quantity discovery. Large investors should be able to find each other and trade. Even if a stock is trading at a price that appropriately reflects an underlying consensus value, institutional investors may have undisclosed orders at the price simply because of the cautious way they bring their orders to the market.

However, there is a downside to the fact that these orders are undisclosed to the public. Finding an appropriate counterparty for large orders, or orders in others than high liquid securities, might be a difficult and time-consuming task. In addition, the investor faces opportunity costs due to delayed execution, and in the worst case a counterparty might not even be found at all.

In the second case, the broker acts as a dealer by committing his capital to a trade. The broker/dealer does not charge a commission, but provides the customer a net price (whereas the price includes the usual cost components – operations, risk, adverse selection – incurred by the dealer).

In the third case, brokers execute large orders by breaking the order into smaller pieces and work them throughout the trading day. Brokers usually perform this service, whereas the recent trend is towards automation. The role of the human broker in this process is increasingly taken by algorithms, i.e. automated trading programs (Celent 2005; Domowitz and Yegerman

2005). Algorithms monitor the market and submit orders on the basis of the current market situation. However, these strategies might not work well when a significant portion of liquidity is hidden.

There are shortcomings to off-exchange order executions by brokers. First, there is the danger of information leakage. A broker may engage in illegal practices such as front running. Second, a principal–agent problem exists between the broker and the customer as the customer cannot observe his broker's best execution effort. This problem is aggravated into a true conflict of interest when the broker also acts as a dealer (dual trading problem). Finally, the costs for providing risk capital might be disproportionately high, especially in volatile and/or fast markets.

ATSs, on the other hand, provide platforms especially designed for large order executions. These can be classified as:

- Crossing networks, such as POSIT, E-Crossnet or Instinet's Intraday Cross;
- Continuous 'order books' for large orders, such as Pipeline ATS or Instinet's Continuous Block Crossing; and
- Buy side trading networks, such as Liquidnet.

Crossing networks provide a marketplace where large orders are matched at pre-defined times with several crossing sessions per day. Matching prices are not determined endogenously but are imported from reference markets. Crossing networks are not pre-trade transparent (closed order books) and anonymous. Although the idea of a crossing network is appealing – operators of such systems promise their customers executions with (by definition) no market impact, confidentiality and anonymity – their success is limited due to high opportunity costs.

Continuous order books for large orders provide a venue exclusively for block orders which enable for potential matching throughout the trading day.

Liquidnet – a buy side trading network – connects the order management systems of institutional investors within a peer-to-peer network which monitors their latent trading demands (Sisk 2005). The system is based on full anonymity and no display of pre-trade transparency information. Liquidnet scans for possible matches on a continuous basis. Whenever a potential match is found, an anonymous, chat-based negotiation procedure on prices and quantities is initiated.

MARKET MODEL INNOVATION VOLUME DISCOVERY

Background and key elements

'While allowing for hidden orders helps, further market structure is needed for handling institutional order flow' (Schwartz and Francioni 2004: 134).

Since the introduction and the successful establishment of electronic order book models in Europe and immediately thereafter in the US in the late 1990s, market model and trading system innovation has been focusing on identifying new approaches to support block trading electronically. Most of these approaches failed (e.g., Optimark) or attracted a marginal market share. Literature on market microstructure lists various reasons for these failures/problems (Clemons and Weber 1998). Beyond functional complexity or principal–agent problems between the buy side and the sell side, a key reason is the lack of initial liquidity which creates a 'chicken and egg problem' as traders are reluctant to place large orders in illiquid markets facing high opportunity costs. Block trading venues were set up as completely new liquidity pools and often failed to attract a critical mass initially.

Therefore, the basic idea of the market model innovation presented in this paper is the integration of a facility for automated block trading into an existing liquidity pool, i.e. an order book of a liquid trading platform. This integration provides a means to leverage existing liquidity and to overcome the 'chicken and egg problem' as orders get two execution opportunities in the proposed model: a chance of being executed against other block orders and in parallel the opportunity of execution in regular order book trading. Contrary to other block execution mechanisms that often failed to build up a critical mass from day one, the integration of the market model into an existing order book and liquidity pool provides execution opportunities for the block trader, for example against iceberg orders, even if no other block order has been entered into the system.[10]

This market model innovation was developed at Deutsche Börse AG in 2004. It was formally named 'Integrated Order Matching System Combining Visible and Hidden Parameters'. The patent application was filed under 04 009 752.9 in Europe and 10/928,265 in the US. It enables searching for liquidity in the order book depth instead of providing execution opportunities merely at the inside market (the current best bids or offers).

The Volume Discovery model is realized by extending the iceberg order type (current parameters: visible limit, peak volume, overall volume) with two new parameters:

1. a hidden limit (defined by the order submitter); and
2. a minimum volume (defined by the market operator).[11]

Orders that are based on these five parameters are called 'volume orders'. The hidden limit of a volume order is never displayed to the market. It specifies the maximum (minimum) price for a buy (sell) volume order which is conditional upon availability of a minimum volume on the contra side. This reflects the potential willingness of block traders to pay (receive) a different price for larger executions.

The parameters of a volume order enable this order type for a dual role to participate both in order book matching and in block order execution.

In *order book matching*, a volume order sits passively in the order book with the visible limit and the peak size displayed to the market. Like any iceberg order it is eligible for execution when it is hit by an incoming contra-side marketable order (the volume order in this case sits either at the top of the order book or within the next limits if the marketable order is hitting several limits). After the peak is executed, a new peak is displayed if there is remaining overall volume. Correspondingly, a volume order might also be executed as any aggressive (i.e., impatient) order entering the market.

For *block execution*, the hidden limit of a volume order checks the other side of the market for potential executions both when the volume order is entered and whenever there are *relevant* changes in the order book (e.g. additional orders or increase in order volumes on the contra side). It executes orders on the contra side if the total volume that can be executed exceeds the minimum volume. Those executions can take place against 'regular' orders (including iceberg orders) or against other volume orders.

Execution principles

The following cases apply for the block execution of volume orders in the Volume Discovery market model:

- A. Volume orders execute against regular orders in order book trading.

    A1. Volume order executes as an aggressive order when entering the order book.
    A2. Volume order executes as an aggressive order when sitting in the order book.

- B. Volume orders are executed against each other.

    B1. Volume orders execute within the current bid/ask spread of the order book.
    B2. Volume orders execute outside the current bid/ask spread of the order book.

In order to illustrate these principle cases of volume order execution, the following stylized order book shown in Figure 2 with three limit orders on the bid side and four limit orders on the ask side (including an iceberg order at 17) serves as a starting point for each of the following execution examples:

A1. Volume order executes as an aggressive order when entering the order book. A new buy volume order (parameters: visible limit: 9, overall volume: 100, peak volume: 10, hidden limit: 17, minimum volume: 50) is submitted (see Figure 3).
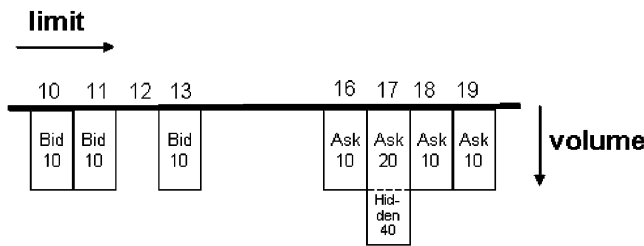
limit

Figure 2. Starting point for description of the volume order execution principles
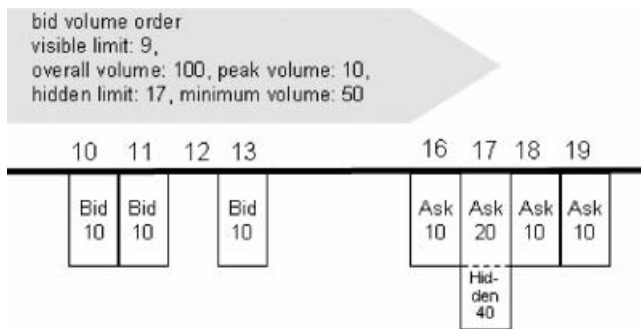

Figure 3. Volume order executes as an aggressive order when entering the order book

The trading system checks whether the overall volume at the contra side of the market (including icebergs) available up to the hidden limit exceeds the minimum volume. As this is the case in the example (10+20+40≥50), the volume order is executed in full against the orders on the other side of the order book that are executed according to price/time priority.

A2. Volume order executes as an aggressive order when sitting in the order book. A new buy volume order (parameters: visible limit: 9, overall volume: 100, peak volume: 10, hidden limit: 16, minimum volume: 50) is submitted (see [1] in Figure 4). As the overall volume at the contra side of the market available up to the hidden limit does not exceed the minimum volume (10<50), the volume order is entered into the order book. No executions take place.
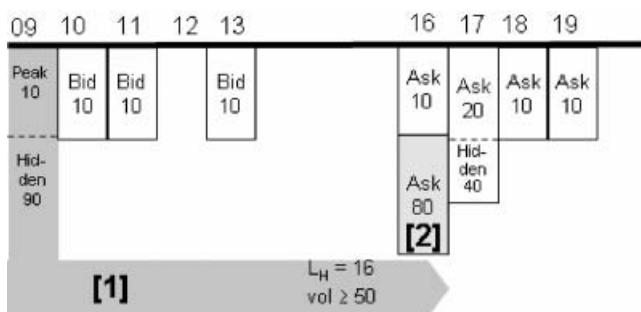

Figure 4. Volume order executes as an aggressive order when sitting in the order book

A new sell limit order (limit: 16, volume 80) enters the book (see [2] in Figure 4). Due to this change in the order book, the minimum volume condition applies (10+80≥50) and the algorithm executes the available volume on the ask side. Again, the orders on the contra side of the order book are executed according to price/time priority.

B1. Volume orders execute within the current bid/ask spread of the order book. A new bid volume order (parameters: visible limit: 9, overall volume: 100, peak volume: 10, hidden limit: 15, minimum volume: 50) is submitted (see [1] in Figure 5). As there are no sell orders available with a limit at or below the hidden limit, the volume order is entered into the order book. No executions take place.

A new sell volume order (parameters: visible limit: 20, overall volume: 200, peak volume: 10, hidden limit: 14, minimum volume: 50) enters the book (see [2] in Figure 5). The volume orders are executable within a matching range between 14 and 15. In case the hidden limits of two volume orders overlap, the execution price is determined by the hidden limit of the order that was submitted earlier, i.e. 15 in this example. Any other price determination, for example, the midpoint of the hidden limits or the hidden limit of the order that was submitted later would provide an incentive to submit buy (sell) volume orders with a very low (high) hidden limit to use an electronic order submission algorithm to successively increase (decrease) the hidden limit until a match can be found. This would result in a significant message load for the trading system and is avoided by the applied price determination mechanism

B2. Volume orders execute outside the current bid/ask spread of the order book. A new buy volume order (parameters: visible limit: 9, overall volume: 100, peak volume: 10, hidden limit: 12, minimum volume: 50) is submitted (see [1] in Figure 6). No executions take place, the volume order is entered into the order book.

A new sell volume order (parameters: visible limit: 20, overall volume: 200, peak volume: 10, hidden limit: 12,
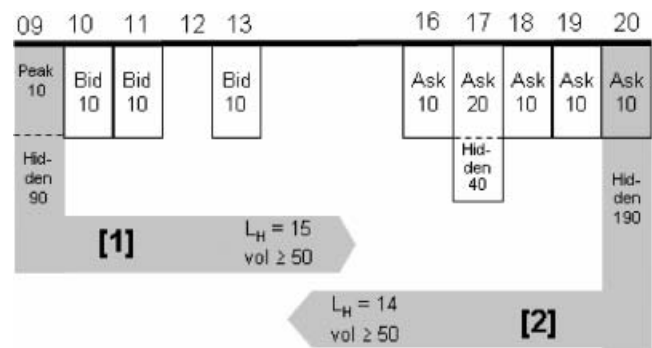

Figure 5. Volume orders execute within the current bid/ask spread of the order book
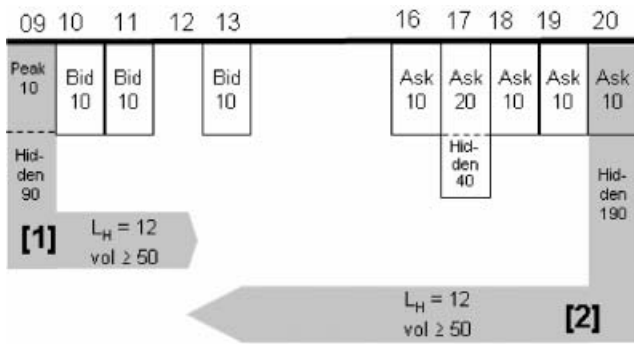
Figure 6. Volume orders execute outside the current bid/ask spread of the order book

hidden minimum volume: 50) enters the book (see [2] in Figure 6). Based on their hidden limits, the volume orders are executable at 12. In order to protect prioritized orders already sitting in the book and to sustain an incentive to provide limit orders, those limit orders that have a better limit than the execution price of the volume orders are executed in advance. Therefore, in the example, the buy order at 13 will be executed ('clean-up') against the sell volume order (matching volume: 10) before the two volume orders match at 12 (matching volume: 100).

Discussion of the Volume Discovery model

The goal of the volume order model is to fulfil requirements of traders that have to execute large orders[12] and in parallel to enhance overall market liquidity. In detail it aims to provide the following benefits:

- *Increased execution likelihood and reduction of opportunity costs*: Due to the simultaneous exposure of volume orders to regular orders in the order book and to other volume orders within a single liquidity pool, the likelihood of execution is increased and opportunity costs are reduced. In this respect, the model provides for an integration of a crossing facility and order book trading. It enhances the concept of discretion orders that is already applied with the major US ECNs. Discretion orders can sit passively in the book and in parallel be executed against other orders in a discretion zone that is specified by the trader. As discretion orders are based on front-end functionalities, the discretion orders only execute visible liquidity within the discretion zone, whereas the volume order model as a back-end functionality within the order book allows interaction of the full order sizes on both market sides. The concept of dual exposure of orders in a Crossing network and an open order book is also included in ATS solutions like the NYFIX Millennium ATS or ITG POSIT. In these

concepts, the full order size of a block order (e.g., the NYFIX Shadow Order type) is exposed within the ATS and a proportion is routed to an exchange or an ECN with an open order book. Again in contrary to the volume order concept, there is no full integration of the two markets at the back-end level as the full order size can only be executed within the (closed) ATS block order book and the visible portion can only be accessed by other orders on the primary market or the ECN where this portion of the order was routed.

- *Searching in the order book depth*: In existing order book models, two large orders can only be executed against each other if at least one trader uses aggressive orders to execute limit orders or iceberg orders that are sitting on the other side of the market and, therefore, pays the spread for each aggressive execution. Larger limit orders or iceberg orders sitting in the order book can not interact or execute against each other. The hidden limit can thus be seen as a 'radar' functionality that overcomes this shortcoming and the dichotomy between passive and aggressive orders. Given the extent of hidden liquidity in order books like Xetra as described above, the search in the order book depth will allow to leverage this hidden volume for executions providing for quantity discovery.

- *Prevention of 'gaming the market'*: Executions of volume orders only take place above the minimum volume, i.e. there is no opportunity to 'fish' for volume orders as this effort would lead to an immediate execution. As most of the order book trading systems provide post-trade anonymity, the identity of the volume order traders is not revealed to each other. Furthermore, the execution and the print of two volume orders only informs the market that there was larger trading interest on both sides of the market without revealing any imbalance on the bid or the ask side. If volume orders are executed against regular orders, they can not be distinguished from any other iceberg order.

- *Aggregation of liquidity*: The hidden limit continuously scans the other side of the market for executions better than or at the hidden limit. Therefore, it continuously aggregates the volumes of smaller and bigger orders and computes whether their total volume fulfils the minimum volume requirement. In contrast to front-end algorithms that are only able to aggregate the visible volumes, in the Volume Discovery model the aggregation functionality is provided by the market operator at a back-end level. This allows for the inclusion of the hidden liquidity of icebergs and other volume orders in the aggregation.

- *New trading strategies and business opportunities based on Volume Discovery*: The model does not prescribe the specification of the hidden limit relative to the visible limit. This allows to reflect individual business

models in the order submission: For example a trader who wants to provide liquidity in the order book depth (e.g., as a buyer) is enabled to specify a hidden limit significantly below the current best bid and significantly lower than the visible limit of the respective volume order.

- *Positive liquidity externalities to all order book traders*: As the model integrates a block trading facility into an order book market, the likelihood of execution increases for both the volume order traders *and* the other traders participating in order book trading: First, the mere existence of volume orders in the market and their continuous scanning of execution opportunities increases the likelihood of execution of regular limit and iceberg orders. Second, in case of a match between two volume orders, the 'clean up'-concept (see example B2) leads to the execution of all limit orders with a limit superior to the execution price of the volume orders.

- Today, the separation of OTC and order book trading in European markets prevents this participation of smaller orders in block execution. In this respect, the Volume Discovery model can be seen as an electronification of the NSYE crossing rules for block transactions.[13]

There are potential drawbacks of the model at three levels:

1. *Market transparency*: Although the Volume Discovery model provides a new alternative for OTC executions, it might impose a risk to the overall *visible* market liquidity if traders use the volume order type to hide liquidity instead of splitting the total order sizes and trading it by either aggressively executing smaller parts against the other side of the market or exposing these split volumes by using limit orders. Though this shift in behaviour would affect transparency and visible liquidity, it has no negative effect on accessible overall liquidity.

2. *Informed trading*: Large order traders are often driven by informational motives. The information trader possesses superior information regarding the asset's fundamental value. This subject has been addressed since the 1980s in the market micro-structure literature, whereas these models have incorporated concepts of Bayesian learning (i.e., Glosten and Milgrom 1985) as well as strategic behaviour (i.e., Kyle 1985). In Kyle's framework, a market participant with superior knowledge about the asset's fundamental value ('insider') exists who exploits liquidity motivated order flow to conceal his trading activity from the dealers in order to slow down the price discovery process and maximize trading profits. The main insight from the literature is that information motivated traders have incentives to conceal their orders from the remaining market participants. In general, Volume Discovery enables the concealment of large order flow.

3. *Intraday volatility*: Integrating volume orders into the order book could also cause comparatively large price swings as these orders may walk the book once they are triggered and execute various price levels due to the clean-up concept (see previous section). Therefore, the Volume Discovery concept might lead to an increase in intraday volatility.

Further research, based on experimental economics or field studies after the introduction of the model, is required to reveal a potential change in traders' order placement strategies and to assess the effects of such functionality on market transparency, informed trading and market volatility.

CONCLUSION AND OUTLOOK

> For the benefit of the broad market, market architecture should be structured to integrate institutional and retail flow more effectively. Given the intricacy of the issues involved and our past experiences with the unintended consequences that can attend market structure change, we suggest that market structure development be the responsibility of the marketplaces and the innovators who inhabit them. (Schwartz and Francioni 2004: 149)

Today, state of the art order book trading already provides for the efficient execution of a wide range of small and mid-sized orders. Yet, especially large-sized orders are not properly addressed. Therefore, a sizeable portion of total order flow is still excluded from interaction in public price discovery and fully electronic matching in order book trading. The Volume Discovery model is designed to overcome this gap with the introduction of continuous quantity discovery to order book trading.

Volume discovery responds to actual market trends where optimal – in contrast to maximum – order book transparency is required in order to address the needs of large-sized order flow and thus has potential to attract new types of market participants to order book trading. It provides for an innovative approach to integrate total order flow in one central marketplace and can add a missing piece in current market design to the market model of order book trading.

The implementation of Volume Discovery into an electronic trading system such as Xetra is no trivial undertaking both from a market structural as well as from a technical perspective. With regard to market structure, Volume Discovery alters the well established execution framework in order book trading and will surely affect market participants' behaviour in trading strategies or, as Weber (1998: 31) notes, 'introducing new market structures, can be difficult and can lead to

unanticipated outcomes.' In the negative case, this may include unintended consequences for the sound functioning of current order book trading.

Technically, Volume Discovery affects the core of the trading system architecture with its necessary matching algorithm modifications and significantly increased system performance needs due to the continuous search for block order execution opportunities in market depth.

Current work on Volume Discovery concentrates on the design and specification of the required matching algorithms for trading system implementation and the market assessment of structural implications for order book trading. This includes the challenges of Volume Discovery being discussed with market participants. In addition, further academic research might focus on the aforementioned issues of intraday volatility, asymmetric information and the impact of the functionality on order submission strategies. These questions might be addressed by theoretical as well as empirical and experimental research.

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Notes

1. As Nasdaq was traditionally a dealer market, dealers' quotes along with their identities were displayed on Nasdaq screens. Execution was not automated, trades had to be executed on the telephone (with some exceptions provided by the SelectNet order routing system or SuperSOES, the small order execution system). As Nasdaq introduced the hybrid trading system SuperMontage (which combined an electronic order book with dealers providing quotes) in October 2002, the display of dealers' identities was not compulsory from a market model perspective, as SuperMontage provided for automated matching. Anecdotal evidence indicates that dealers understand the identity display as prestigious as it offers them an opportunity to show the quality of their market making service. However, as a special feature, Nasdaq enables traders to hide their identity from the market. In this case, the identifier 'SIZE' is displayed instead of their market participant ID.
2. This technical delay is not to be confused with the delay in execution an order might face when no corresponding trading interest is present in the market. Within the scope of a dealer market, there is always trading interest ('immediacy') provided by the dealers, but the order is not executed within milliseconds after reception of the order (delay due to non-automated execution).
3. In the US, however, the price and time priority rule is not as widely accepted, which is partly explained by the advent of decimal pricing in 2001. The subsequent decrease in the

minimum tick size made penny-jumping (stepping ahead the best bid or offer by improving it by one cent) more attractive. This, in turn, might deter liquidity providers from exposing their trading interest in an open order book (SEC 2004: 11166).
4. An iceberg order peculiarity regards to time priority, which is lost whenever the visible part is fully executed. Then, the visible part is 'refilled' from the remaining volume, and the new peak receives a new timestamp which eventually leads to a loss of time priority.
5. See D'Hondt et al. (2003: Table 4).
6. It must be noted that the data set used by Pardo and Pascual (2003) does not include hidden orders flagged as such. Instead, the authors operate with publicly available order book information, whereas they compare reported executions with the order book information available for the respective execution time. On this basis, the existence of hidden orders is reconstructed. One assumption underlying this methodology is that the findings 'are conditional on the implicit assumption that the sub sample of executed iceberg orders is representative of the whole sample of iceberg orders submitted' (Pardo and Pascual 2003: 14).
7. Figure 5 in Nasdasq Economic Research (2003) indicates that about 40 per cent of total liquidity is hidden.
8. The trivial approach compares total iceberg order volume to total submitted volume. In terms of nominal (i.e., Euro) volume, the overall share of iceberg orders on Xetra is about 10 per cent.
9. Within the scope of this paper, XLM for the indices is calculated on the basis of naïve averages. In contrast, the XLM usually calculated by Deutsche Börse is on the basis of the respective index weights. For example, the DAX XLM for the €25k-volume class amounted to 9bps in October 2003. As the purpose of this illustration is to point out the differences in hidden and visible liquidity, the naïve average might serve as a fair proxy for the usually performed, weighted calculations.
10. An example for this execution opportunity is provided in Figure 4 which will be presented in the next section.
11. This parameter is in addition to (and not to be confused with) the minimum volume for an iceberg order.
12. Harris (2003: 323–7) discusses four problems of block initiators in executing large order sizes: Latent demand, order exposure, price discrimination and asymmetric information. Addressing these problems reflect block initiators key requirements in trading. Whereas the problems of price discrimination and asymmetric information are often in the nature of large order sizes and hardly solvable at all, Volume Discovery addresses the problems of latent demand and order exposure. The latent demand problem refers to high search costs for block initiators to find a matching counterparty. Volume Discovery addresses this problem with the simultaneous double exposure of volume orders within a single liquidity pool. The order exposure problem refers to the increased market impact costs that block initiators can expect by unintended information spill over if they expose their large trading interest to other market participants. Volume discovery

addresses this problem as volume orders are not disclosed to the market with their full size in the order book.

13. NYSE Rule 127 (Block Positioning) facilitates public limit orders on the Floor to participate in block crossing transactions at the clean-up price if the crossing shall take place outside the prevailing quote (NYSE 2005).

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