Order Book

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An *order book* is a compiled list of orders (prices at which traders are willing to buy or sell) received.

- Bollerslev and Domowitz (1993) used computer simulations to study the effects of varying the length of an electronic order book. They state that the appearance and increasing persistence of serial correlation in the variance of transactions price returns is traced to the existence and length of the electronic book, as is the degree of non-normality in transactions returns. Whilst increases in the serial correlation of the market bid-ask spread as the book lengthens is isolated as one possible transmission mechanism of serial dependence in the variance of transactions prices.
- Hamao and Hasbrouck (1995) investigated the behaviour of intraday trades and quotes for individual stocks on the Tokyo Stock Exchange. They found that when orders that would otherwise walk through the limit order book are converted into limit orders, execution is delayed, but some orders execute (at least in part) at more favourable prices; an order that is held with an indicative quote has a larger cumulative price impact than one that is immediately executed in full; and after a market order is executed the quote hit by the market order generally tends to continue to move in the same direction (this is due in part to order autocorrelation and in part to the cancellation of limit orders).
- Biais, Hillion and Spatt (1995) analysed the history of the order book for the 40 stocks in the CAC 40 and found evidence of information effects in the order process.
- Harris and Hasbrouck (1996) examined NYSE SuperDOT market and limit orders. Their results suggest that the limit order placement strategies most commonly used by NYSE SuperDOT traders do in fact perform best; limit orders placed at or better than the prevailing quote perform better than do market orders, even after imputing a penalty for unexecuted orders and after taking into account market order price improvement; and unconditional order submission strategies that use SuperDOT to offer liquidity in competition with the specialist do not appear to be profitable.

- Using data from the Helsinki Stock Exchange, Hedvall, Niemeyer and Rosenqvist (1997) studied the limit order book. Although the order flow was found to be quite symmetric in general, they identified clear asymmetries for various trade categories suggesting differences between the order submission of buyers and sellers using a limit order book.

- Jarnecic and McInish (1997) calculated the option value of the limit order book for four snapshots each day (1100hrs, 1200hrs, 1430hrs and 1558hrs) for thirty firms listed on the Australian Stock Exchange (the value of bid and ask limit orders to other market participants can be considered analogous to put and call option prices respectively). They found that the option value of the limit order book is stable from day to day with changes in value due to changes in spreads offsetting those due to changes in depth; the option value of the limit order book is lowest at 1100hrs when the relatively higher bid/offer sizes do not offset the wider spreads and the option value of the limit order book increases throughout the trading day; and approximately 65% of the option value on the bid (ask) side is at the best bid (ask).

- Coppejans and Domowitz (1998) used durations (the time between transactions) to compare the relative importance of information sets in limit order book trading.

- Kavajecz (1999) investigated a database of 144 NYSE-listed securities and found that specialists' quotes may reflect only the limit order book on the side (or sides) of the market where they believe there is a chance of informed trading.

- Brown, Thomson and Walsh (1999) used stocks on the Australian Stock Exchange to estimate and examine certain characteristics of the order flow through an electronic open limit order book. They found that the proportion of informed orders is less than 10%, informed traders choose smaller orders than uninformed traders, there are U-shaped intraday patterns in order arrival and the information content of the order flow appears to follow this pattern across the day.

- Al-Suhaibani and Kryzanowski (2000) analysed the order book, and order flow and execution on the Saudi stock market and described the microstructure.

- Bisière and Kamionka (2000) studied the flow of orders to buy and sell Alcatel shares at the Paris Bourse. Their model offers evidence of information and liquidity effects, as put forward by market microstructure theories.

- Maslov and Mills (2001) studied high-frequency NASDAQ Level II order book data and found that a large imbalance in the number of limit orders placed at bid and ask sides of the book was shown to lead to a predictable

short-term price change (which is in accord with the law of supply and demand).

- Challet and Stinchcombe (2001) reported on a statistical analysis of the Island ECN (NASDAQ) order book, providing static (the size and lifetime probability distributions, the average shape of the orders distribution and market impact functions) and dynamic properties of the system. They then analysed them from a physicist's viewpoint and identify the fundamental dynamical processes.

- Coppejans and Domowitz (2002) evidenced that the information gleaned from the limit order book substantially affects the timing of trades, order submissions and cancellations.

- Declerck (2002) considered the trading costs in the limit order book market of the Paris Bourse and graph some interesting results concerning the spread. She also found that the conditional probability of the reversal of the order flow appears constant at 26%.

- Bouchaud, Mézard and Potters (2002) investigated several statistical properties of the order book of three liquid stocks of the Paris Bourse. They found that incoming limit order prices follow a power law around the current price with a diverging mean and also described the shape of the average order book.

- Daníelsson and Payne (2002) considered dynamic trading patterns in limit order markets, primarily foreign exchange and money markets. Clear feedback was observed between liquidity, volatility and volume.

- Zovko and Farmer (2002) defined the relative limit price as the difference between the limit price and the best price available. Using a data set of roughly two million orders from the London Stock Exchange, they demonstrated that the unconditional cumulative distribution of relative limit prices decays roughly as a power law with exponent approximately -1.5. They discovered that time series of relative limit prices show interesting temporal structure, characterized by an autocorrelation function that asymptotically decays as $C(\tau) \sim \tau^{-0.4}$. They also found that relative limit price levels are positively correlated with and are led by price volatility, and note that this feedback may potentially contribute to clustered volatility.

- Bates, Dempster and Romahi (2003) used order flow data coupled with order book data in an evolutionary reinforcement learning algorithm to automate FX trading. Their preliminary results showed that using order flow and order book data is usually superior to trading on technical signals alone.

- Potters and Bouchaud (2003) analysed order book data from the NASDAQ. They (a) found that the statistics of incoming limit order prices

revealed a very slowly decaying tail, (b) described the shape of the average order book, and (c) found that the life-time of a given order increases as one moves away from the bid-ask. They also determine the 'price impact' function using French and British stocks, and found a logarithmic, rather than a power-law, dependence of the price response on the volume; and concluded that the 'weak time dependence of the response function shows that the impact is, surprisingly, quasi-permanent, and suggests that trading itself is interpreted by the market as new information.'

- Hall, Hautsch and McCulloch (2003) used limit order book data from the SEATS system of the Australian Stock Exchange (ASX). They showed that the state of the order book as well as the observed trading process had a significant impact on the bivariate buy and sell intensity, and thus influenced traders' decisions when to trade and on which side of the market.

- Ranaldo (2004) analysed order and transaction data from the Swiss Stock Exchange (SWX). His results showed that patient traders become more aggressive when their own side (the opposite side) of the book is thicker (thinner), the spread wider, and the temporary volatility increases. He also found that the buy and the sell sides of the book affect the order submission differently.

- Using data provided by the Australian Stock Exchange (ASX), Cao, Hansch and Wang (2004) assessed the informational content of an open limit order book and found that the order book beyond the first step provides 30% of the information and provides additional power in explaining future short-term returns.

- Hall and Hautsch (2004) looked at limit order book data from the Australian Stock Exchange (ASX). They showed that buy-sell pressure is particularly influenced by recent market and limit orders and the current depth in the ask and bid queue; they found evidence for the hypothesis that traders use order book information in order to infer from the price setting behaviour of market participants; and they state that their results indicate that buy-sell pressure is clearly predictable and is a significant determinant of trade-to-trade returns and volatility.

- Using trades and quotes data for liquid stocks on the Paris stock market, Bouchaud, *et al.* (2004) found that market orders exhibited persistence, whilst limit orders were mean reverting; with the interplay between the two processes resulting in traded prices following a random walk.

- Lillo and Farmer (2004) made use of a data set from the London Stock Exchange and demonstrated that the signs of order flow, order size and liquidity are all long memory processes. The persistence in order signs is compensated for by anti-correlated fluctuations in transaction size and liquidity.

- Kavajecz and Odders-White (2004) considered data for limit order books for NYSE stocks and showed that the limit order book depth manifests itself in the price (reconciling technical analysis with market efficiency).

- Pascual and Veredas (2004) studied limit order book data from the Spanish stock exchange. They found that most of the explanatory power of the book concentrates on the best quotes, although the book beyond the best quotes also matters in explaining the aggressiveness of traders. They also deduced that liquidity providers benefit more from an increased degree of pre-trade transparency than liquidity consumers, and that no piece of book information matters in explaining the timing of orders.

- Using order book data from the Australian Stock Exchange, Hall and Hautsch (2006) found that market depth, the queued volume, the bid-ask spread, recent volatility, as well as recent changes in both the order flow and the price play an important role in explaining the determinants of order aggressiveness. In short, order book information plays the dominant role in explaining order aggressiveness.

- Harris and Panchapagesan (2005) examined SuperDOT limit orders in the TORQ database for the NYSE. They found that the limit order book is informative about future price movements; that specialists use this information in ways that favour them (and sometimes the floor community) over the limit order traders; that the results are more evident for active stocks where the competition between specialists and limit order traders is more intense; and they found strong evidence that specialists in lower-priced stocks are less likely to initiate such actions because of the large relative tick size.

- Weber and Rosenow (2005) studied the Island ECN order book. They calculated the average price impact of market orders and also used the order book to match market orders with limit orders to calculate the 'virtual price impact'. It turns out that the virtual price impact function is convex and increases much faster than the concave price impact function for market orders. This difference can be explained by the strong anticorrelation between returns and limit order flow; the anticorrelation leads to an additional influx of limit orders as a reaction to price changes, which reduces the price impact of market orders.

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