Journal of Economic Dynamics & Control 58 (2015) 81–100

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Optimal order display in limit order markets with liquidity competition ☆

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ARTICLE INFO

Article history:
Received 19 January 2015
Accepted 8 May 2015
Available online 30 May 2015

JEL classification:
C51
C60
D01
D4
G1

Keywords:
Hidden liquidity
Liquidity competition
Limit order book
Market impact
Order flow dynamics
High-frequency trading

ABSTRACT

Order display is associated with benefits and costs. Benefits arise from increased execution-priority, while costs are due to adverse market impact. We analyze a structural model of optimal order placement that captures trade-off between the costs and benefits of order display. For a benchmark model of pure liquidity competition, we give a closed-form solution for optimal display sizes. We show that competition in liquidity supply incentivizes the use of hidden orders to prevent losses due to over-bidding. Thus, because aggressive liquidity competition is more prevalent in liquid stocks, our model predicts that the proportion of hidden liquidity is higher in liquid markets. Our theoretical considerations ares supported by an empirical analysis using high-frequency order-message data from NASDAQ. We find that there are no benefits in hiding orders in il-liquid stocks, whereas the performance gains can be significant in liquid stocks.

1. Introduction

The use of hidden liquidity among the major stock exchanges has considerably increased in the recent years. Nowadays, hidden orders, Iceberg orders or the so-called reserve orders have become prevalent features of modern electronic markets.[3][4] Exchanges still require openly displayed quotes to effectively organize trade, though. By giving displayed orders higher execution priority than hidden orders most exchanges encourage market participants to openly display their orders.

☆ Earlier titles: "Optimal display of iceberg orders" and "Market impact of limit orders and optimal exposure strategies".

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[3] A growing body of empirical studies indicate the wide-spread use of hidden orders. For instance, Pascual and Veredas (2009) report that 26% of all trades on the Spanish Stock Exchanges involve hidden volume. Frey and Sandas (2009) report that 9.3% of *submitted* and 15.9% of *executed* shares contain Iceberg orders on the German Xetra Stock Exchange. Further studies confirm that hidden liquidity is particularly prevalent among large investors: D'Hondt et al. (2004) report that 81% of orders with total sizes in the largest quartile are Icebergs or (partly) hidden orders. Supplementing this findings, Frey and Sandas (2009) find that Iceberg orders are on average 12–20 times larger than limit orders.

[4] de Winne and D'Hondt (2007, 2015) and D'Hondt et al. (2004) report that 27.2% (20.4%) of the total liquidity in the book is hidden for the French CAC40 (Belgian BEL20) exchanges and moreover that the *hidden ratios* can even reach 50% at the best limit prices. Tuttle (2003) finds that around 25% of liquidity for all NASDAQ National Market quotes are hidden.

http://dx.doi.org/10.1016/j.jedc.2015.05.004
0165-1889/

At the same time, however, order exposure is associated with risk. For instance, adverse selection, quote-matching and front-running can lead to increased transaction costs when traders expose their trade intentions. Market participants, therefore, need to balance the costs and benefits of order exposure when making trading decisions.

In this paper we design a structural model of optimal order display in a limit order book which lends itself to both, a theoretical and empirical analysis. The model captures the trade-off between benefits and costs of order display and provides implications for optimal display strategies. We show that the intensity of liquidity competition, market depths relative to market order arrivals, and order sizes are key factors in the decision to hide or display trade intentions via limit orders. Our analysis suggests that, due to increased competition in liquidity provision, hidden orders are more beneficial in liquid markets.

Specifically, we consider a broker–trader problem of executing a limit order at minimal cost. Brokers typically face a time constraint within which to execute a client's position and execution performance is benchmarked against a pre-agreed reference price. We consider the case of trade execution of a single limit order when the broker–trader has the option to shield any fraction of the order from public view. Order execution is governed by arrivals of market and limit orders as well as cancellations of standing volume. Incoming order flows determine the execution volume at terminal time. Due to the liquidation constraint, un-executed orders are cancelled and traded against the best prevailing opposite price.

Biais et al. (1995), Ranaldo (2004) and Griffiths and Smith (2000), among others, find that the visible order book and thus order display affects trading dynamics as market participants observe changes in the order book and adapt their trading strategies accordingly. Our key assumption is, therefore, that the trader's display decision affects both, the dynamics of order flow at the same side of the market and opposite-side price dynamics. For a specific case with pure liquidity competition, we provide an explicit characterization of optimal display strategies. This benchmark model assumes that order display only affects the supply side of liquidity. This is a realistic assumption, as trading activity in today's limit order book markets is dominated by the supply side of liquidity. For instance, Hasbrouck and Technology (2009) show that more than 90% of trading activity can be attributed to liquidity provision alone. In this benchmark model, we show that traders increasingly hide their orders when the intensity of liquidity competition is high. We show that this is particularly relevant for liquid stocks that are traded at high prices and have a low (relative) tick size.

Using high-frequency order-message ITCH data from NASDAQ we estimate model parameters and derive optimal display strategies for a range of stocks from the S&P 500 for the period of January to April 2011 for different market and trade settings. Complementing the previous literature on hidden orders including Harris (1997) and Bessembinder et al. (2009), we show that hiding orders – at least partially – can lead to significant cost savings over ad hoc strategies like full-display or zero-display strategies. The benefits of (partial) hiding depend on the state of the market and are most significant when order book depths at the submission price level are low. In contrast to earlier empirical findings which suggest that hidden orders are more prevalent among large orders, we find that using (partially) hidden orders can lead to significant performance enhancements, even for smaller orders. We find that these benefits strongly depend on the order book state.

This paper contributes to the optimal liquidation literature and the literature on market impact and hidden liquidity. The literature on optimal liquidation, pioneered by the work of Bertsimas and Lo (1998) and Almgren and Chriss (1999), follows a qualitative approach to modeling trading and liquidation problems in illiquid markets. The analysis is typically confined to liquidation strategies within a stylized order book model using active (market) orders only. This restriction is mostly owned to the fact that the market impact of active orders is comparably easy to model. When passive (limit) orders are considered, the analysis is usually confined to dark pool orders which induce little or no market impact.[5] An exception is Esser and Mönch (2007) who allow for market impact of passive orders on prices, but not liquidity competition. Complementing previous work on the market impact of limit orders of Hautsch and Huang (2012) we show that limit order placements primarily affect the supply side of liquidity through an increase of liquidity competition.

The theoretical literature on hidden orders is quite sparse. Buti and Rindi (2013) and Moinas (2006) study equilibrium models of optimal order placement. Our approach distinguishes in several ways.[6] Most importantly, we do not assume that information is asymmetric; following the optimal liquidation literature we consider purely liquidity driven trades. In fact, Madhavan et al. (1997) and Huang and Stoll (1997) argue that trading frictions do not derive from informational asymmetries alone. Second, our structural approach to modeling the impact of visible orders is general and flexible enough to account for a wide range of market impact scenarios. Finally, we link display decision to liquidity characteristics. This is particularly important for understanding the origination of hidden liquidity in limit order markets. Our findings show that non-informational mechanisms suffice to rationalize the presence of hidden orders. In that respect, our approach is similar to that proposed in Hollifield et al. (2006). However, while their focus is the trade-off between price and execution risk, our focus is on the trade-off between displaying and hiding trade intentions.

The remainder of this paper is structured as follows. In Section 2, we introduce the model, including the order flow and price dynamics, and derive an explicit representation of optimal display ratios. In Section 3, we estimate the model parameters and provide estimates for the optimal exposure size for various stocks and market settings. Section 4 concludes.

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[5] There is by now a significant literature on optimal portfolio liquidation using market orders including Almgren and Chriss (1999), Almgren (2003), Almgren (2001), Obizhaeva and Wang (2013), Alfonsi et al. (2010) and Horst and Naujokat (2014). Models with market and dark pools orders are analyzed in, e.g. Kratz and Schöneborn (2015), Horst and Naujokat (2014) and Graewe et al. (2015).

[6] For instance, Buti and Rindi (2013) do not account for effects on the demand side of liquidity and Moinas (2010) does not capture effects on the supply side of liquidity. Esser and Mönch (2007) assume market impact only on prices, but not on order flows.