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Do stylised facts of order book markets need strategic behaviour?

Dan Ladley [a,*], Klaus Reiner Schenk-Hoppé [b,**]

[a] Department of Economics, University of Leicester, Leicester LE1 7RH, UK
[b] Leeds University Business School and School of Mathematics, University of Leeds, Leeds LS2 9JT, UK

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ABSTRACT

This paper studies the role of the order book market mechanism in shaping price movements and the order flow in a zero-intelligence agent model of a dynamic limit-order market. The results indicate that many stylised facts of limit-order markets are not dependent on individual strategic behaviour; they can be obtained from the interaction of the market mechanism and non-strategic agents. Positive correlation in order types, the shape of the order book and short term price predictability, for instance, do not require strategic considerations by individual traders. In contrast the absolute probabilities of order submission highlight the contribution of strategic behaviour to market dynamics.

1. Introduction

The strategic behaviour of traders is generally thought to be the dominant force influencing market dynamics, however, many of the key properties of double-auction markets, such as high allocative efficiency, are present even in its absence. Gode and Sunder (1993, 1997)'s seminal contributions have shown us that much of the 'intelligence' of markets can arise from the interaction of the market mechanism and non-strategic traders. This paper furthers this line of enquiry by studying a dynamic limit-order driven market populated by zero-intelligence agents.

Empirical and analytical studies have both demonstrated and offered possible explanations for the presence of regularities in the order submission process and order book dynamics. By employing a model based on non-strategic individual behaviour we wish to determine if these regularities can be observed as a natural consequence of conducting trade through an order book or if they require additional strategic considerations by agents. The submission of market and limit orders give rise to the shape and dynamic behaviour of the order book. Characteristics of the order book (depths, spreads and tick size dependence) will be analysed to determine which match empirical evidence and which fail to do so in the absence of individual strategy. Empirical work has also shown us that the order book contains information about future price movements. From examining the order book dynamics we wish to understand the source of this information and the circumstances in which the order book provides predictive power. The zero-intelligence approach will allow us to investigate the driving forces behind these stylised facts and gain insight into the relationship between agent behaviour, the order flow and the market mechanism.

* Corresponding author. Tel.: +44 116 252 2880.
** Also Corresponding author. Tel.: +44 113 343 5187.
E-mail addresses: d.ladley@le.ac.uk (D. Ladley), K.R.Schenk-Hoppe@leeds.ac.uk (K.R. Schenk-Hoppé).

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1.1. Dynamics of order book markets

Issues regarding the submission of limit orders by traders and how the limit-order book affects trade have received considerable attention. Empirical studies of limit-order markets have documented their behaviour both in pure limit-order markets (e.g. Biais et al., 1995 on the Paris Bourse, Griffiths et al., 2000 on the Toronto Stock Exchange and Hall and Hautsch, 2007 on the Australian Stock Exchange), markets with specialists (e.g. Huang and Stoll, 1994; Harris and Hasbrouck, 1996; Harris and Panchapagesan, 2005) and the contrast between the two (e.g. Lehman and Modest, 1994's comparison of the NYSE and the Tokyo stock exchange). The exact trading mechanisms of the above markets can differ markedly, however, some features seem common amongst many of the markets. For instance several authors (e.g. Hasbrouck, 1991a; Hamao and Hasbrouck, 1995; Biais et al., 1995) report positive correlation in order submission (i.e. orders of the same type following each other) that orders away from the best quotes have relatively little effect on market behaviour (e.g. Griffiths et al., 2000; Harris and Panchapagesan, 2005) and that the order book carries information about future market movements (e.g. Hall and Hautsch, 2007; Huang and Stoll, 1994). In our study we will principally be focusing on explaining the behaviour of non-specialist markets. The reason for this is that in pure order book markets only the interaction between the traders and the order book have to be considered. The addition of the specialist, however, adds extra interactions that initially we would prefer to avoid considering. Even in the simpler system of a pure order book market explaining these behaviours has not been straightforward. Experimental work has made contributions in this area. Campbell et al. (1991) have shed light on factors effecting the variability in the bid-ask spread and Smith et al. (1988) have provided possible explanations for the occurrences of bubbles and crashes in financial markets.

Analytical work has also attempted to explain some of this observed behaviour (e.g. Cohen et al., 1981; Foucault, 1999; Hollifield et al., 2004). For instance the work of Glosten (1994) provided a theory of the effect of order on price movements and as a consequence the relative profitability of orders. Parlour (1998) developed a model based on optimal order submission which provided the relative probabilities of buy and sell market and limit orders in different situations. Chakravarty and Holden (1995) develop an optimal strategy for order submission and show that in certain circumstances it can be optimal to submit limit orders on both sides of the market. There are, however, difficulties in forming these models, the order book by its very nature is relatively difficult to analyse. The sheer complexity of trader decisions and their effects has meant that analytical models frequently have to make significant simplifying assumptions in order to derive results. For instance restricting the price grid to very few prices (Parlour, 1998), only allowing a single market order (Handa and Schwartz, 1996), or potentially infinite liquidity (Seppi, 1997). For these reasons a computational approach is very attractive for studying this system. The following subsection will highlight key work in this area with particular focus on those model relating to our own.

1.2. Related literature

Simulation has provided a powerful tool for investigating the effect of the market mechanism. By holding the behaviour of traders constant whilst varying the market architecture it has been possible to draw conclusions regarding the interplay between individuals, strategies and the market mechanism. Bottazzi et al. (2005) and Anufriev and Panchenko (2006) conduct such experiments examining the Walrasian auctioneer, batch auction and order book systems. They show that whilst market dynamics are formed from the interaction of traders and the market mechanism, certain aspects such as time series properties are more heavily influenced by the architecture. LiCalzi and Pellizzari (2006) examine the performance of different market mechanisms by measuring statistics such as time to convergence, excess volume and price dispersion. They demonstrate that there is no optimal market design, however, generally specialist-organised markets and batch auctions perform best. Focusing on the order book mechanism, Chiarella and Iori (2002) and Chiarella et al. (forthcoming) employ heterogeneous agent models to show that the mixture of trading strategies, such as chartist or fundamentalist, present within a market affects many properties including spread and volatility. Whilst similarly LiCalzi and Pellizzari (2003) examines the effect of fundamentalists on the market time series.

Much of the above simulation work has been based around the presence of strategic traders, however, work involving non-strategic traders has also provided much insight. Taking inspiration from Becker (1962)'s work on budget constrained traders behaving randomly, Gode and Sunder (1993) were able to use computational simulation to explain much of the efficiency and convergence of the double-auction market mechanism. This work has also been employed in settings closer to financial markets by Bollerslev and Domowitz (1992) who added an order book to the original model of Gode and Sunder. They found that the addition of a limit-order book entailed an improvement in efficiency as well as in the convergence to the competitive equilibrium price. The first, however, experiences only a minor improvement because all the cases considered in Gode and Sunder (1993) exhibit a high degree of allocative efficiency. Bollerslev and Domowitz (1992) also obtain positive results in cases in which the individual demand and supply functions show less symmetry as in Gode and Sunder (1993). Cliff and Bruten (1997) give a fuller discussion of the effects of asymmetry in supply and demand within the Gode and Sunder model. Gode and Sunder (1997) went on to use this approach to examine which market rules within double auctions were responsible for the high allocative efficiency. Whilst LiCalzi and Pellizzari (2007) used zero-intelligent agents to evaluate the performance of four different market mechanism.