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The optimal bid/ask spread in a Specialist System

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ABSTRACT

In this work we propose a simple market model where some features of the Specialist System are analyzed. In particular, the specialist's obligation to display bid/ask quotes on the book within the bounds imposed by the Exchange is considered. The proposed model allows to analyze the effects of the specialist's interventions on the short term dynamics of bid/ask prices and address a relevant market design issue, that is determination and analysis of the optimal endogenous upper bound that – according to economic conditions – should be imposed by Stock Exchange on the quoted bid/ask spread. The institutional details are summarized in a few structural parameters and the focus is on the aggregate effects of excess demand/supply.

1. Introduction

The architecture of Stock Exchanges represents a key issue which continues to receive great attention in theoretical and empirical literature, especially during time periods characterized by financial turmoil. Over the past fifteen years, research in this area has focused mainly on the impact of alternative trading systems on market quality and efficiency, since one of the most important factors characterizing the development of financial markets has been the proliferation of new markets and automated trading systems. Many automated markets use a pure order driven system characterized by a high degree of transparency, in which public limit orders are continuously displayed. Some other markets also offer the alternative of trading under a hybrid order driven system with a specialist and limit order book. Stocks traded in a hybrid order driven system are usually sampled on the basis of certain parameters subject to annual review (i.e. capitalization, average quoted bid/ask spread, daily average trading volume, turnover, market touch, floating supply, etc.) and ranked into bands of liquidity (Nimalendran and Petrella, 2003, for a detailed description). Under this scheme, the specialist has the duty to continuously display ask and bid prices on the book and negotiate a minimum lot of shares daily. Maximum spread and minimum number of lots per day are commonly determined by some Stock Exchanges. The bid/ask quotes are posted by the specialist on the limit order book for being displayed on trading terminals to all market participants. Accordingly, specialist is not monopolistic in managing and displaying the book since any intermediary has access to electronic limit order book and can place limit orders that compete with the specialist's quotes. Specialists are generally rewarded for their market making services with a reduction on trading fees, bid/ask spread revenues and lower information costs due to a greater knowledge of the issuer company. In some instances, they may also receive a side payment from the issuer company and, if this is the case, the relationship between the specialist and the issuer is regulated by an agreement which can take two forms: the issuer company may provide some funds to specialist or, alternatively, share the specialist's profits (and losses) related to market making activity.

The analysis of the Specialist System is relevant for several reasons. First, the specialist continues to be the focal point of the order flow especially during time periods characterized by low liquidity and financial crisis. Specialists maintain a fair, competitive, orderly and efficient market, meaning that all orders have equal opportunities to interact and receive the best price. Even though specialists can never completely prevent a fall in prices, they have the chance to buy stocks at different prices to fill in gaps and make the transition from one price to another more orderly. This cushioning process provides buyers and sellers with a better opportunity to enter the market and, eventually, restore the equilibrium (Heidle and Huang, 2002; Nimalendran and Petrella, 2003). Second, adopting a Walrasian approach, specialist's intervention may contribute to explain price discovery processes of actively traded stocks. In particular, by optimizing the spread, the specialist controls the imbalances arising from excess demand/supply and participates to processes that lead markets toward equilibrium.

In analogy with several previous empirical and theoretical studies, the focus of this paper is on the analysis of the Specialist System for markets in which stocks are actively traded (Anand and Weaver, 2006; Corwin, 2004; Parlour and Seppi, 2003; Fernando, 2003; Bondarenko and Sung, 2003; Madhavan, 2000; just to name a few of them), and on market makers that actively adjust the spread in response to fluctuations in the excess demand/supply (see amongst others: Stoll 1978; Madhavan and Smidt, 1993).

In this work, some features of the Specialist System are modeled. In line with the literature which relates to the microstructure of price processes, we examine the effects of the specialist's trading behavior, taking into account her/his obligation to display on the book the bid/ask

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quotes that do not differ for a percentage (spread) higher than that established by the Exchange, i.e. *maximum allowed spread*. In other words, within the framework of a simple market model, we aim at analyzing the primary function of the specialist, that is her/his commitment to provide liquidity to the market and, consequently, quote bid/ask prices in accordance with the maximum allowed spread.

First, we set up a model with an exogenous maximum allowed spread. In particular, the setting of the endogenous optimal bid/ask quotes, in accordance with the maximum allowed spread fixed by the Exchange is determined, taking also into account stabilization costs. Secondly, we endogenize the maximum allowed spread by solving a dynamic optimization problem. Since spread dynamics are endogenous, we are able to derive a solution for the optimal maximum allowed spread and provide specific insights related with the effectiveness of the specialist's role. The solution of the model contributes to the literature on market architectures and highlights that the effectiveness of the Specialist's strategy is improved by a greater flexibility in the setting of the maximum allowed spread whose level should not be fixed *a priori* by the Regulator, but adapted to economic conditions and characteristics of the traded stock.

The paper is structured as follows: in Section 2 the theoretical model is presented; Section 3 reports the methodology followed to solve the dynamic optimization problem and optimize the bounds on the specialist's trading strategy; Section 4 reports some numerical results and their implications in terms of market architecture; concluding remarks are presented in Section 5; Appendix A reports some algebra.

2. The economic framework

In this section, a model for stock price dynamics which takes into account the specialist's interventions on bid/ask prices is presented. Here, the economic environment in which the specialist operates and her/his actions in the setting of the bid/ask quotes are explored.

In this respect, we propose a simple market framework where, refraining from modeling the various components of the market microstructure explicitly (i.e.: order arrivals, mechanism of order clearing, etc.), the institutional details are summarized in a few parameters and the focus is on the effects of the excess demand/supply on price changes.

We assume that trading on secondary market, at time t, takes place in a market where all trades clear at the same price subject to transaction costs. We follow the process of price formation suggested by Brennan and Subrahmanyam (1996) and Farmer and Joshi (2002), and assume that the infinitesimal transaction price change at time t, dP_t, is a linear function of the order flow X_t, also driven by a stochastic noise ξ_t:

$$dP_t = \lambda \cdot X_t + \xi_t, \tag{1}$$

where $\lambda > 0$ represents the transaction cost parameter whose inverse can be regarded as a proxy for the factors determining the liquidity of the stock and a measure of market depth (i.e.: λ parameterizes the liquidity continuum between the case in which the stock is frictionless, $\lambda = 0$, and the case in which it is perfectly illiquid, $\lambda \to \infty$). The stochastic term ξ_t may represent the position taken in the market by noise traders, or liquidity traders, who submit orders at random; otherwise, it can simply represent some random perturbation in the price (Farmer and Joshi, 2002).

Define the bid/ask spread at time t, S_t, as:

$$S_t = P_t^a - P_t^b, \tag{2}$$

where P_t^a and P_t^b are the bid and ask prices, respectively. Since the specialist has to promote an orderly transaction of prices, it is assumed:

$$dP_t = \gamma S_t, \tag{3}$$

where $\gamma > 0$ represents the percentage of the spread providing a change in the observed stock price. In this respect, Eq. (3) formalizes that the change in the trade price at time t, dP_t, linearly depends on the bid/ask spread which is controlled by the specialist for influencing the price of the transaction, cover the cost associated with its functions and yield a reasonable profit from her/his market making activity (Copeland and Galai, 1983; Glosten and Milgrom, 1985).

Denote by Z_t the excess demand, with the convention that $Z_t > 0$ represents positive excess demand and $Z_t < 0$ positive excess supply. The excess demand is assumed to show a high correlation with order flows (Asparouhova et al., 2003, Bondarenko, 2001) and, at an intuitive level, this implies that, with decreasing order flow, demand becomes more elastic. Therefore, there exists a constant $\tilde{k} < 0$ such that:

$$Z_t = \tilde{k} \cdot X_t. \tag{4}$$

By Eqs. (1), (3) and (4), the excess demand becomes:

$$Z_t = k\gamma S_t - k\xi_t, \tag{5}$$

where $k = \tilde{k} / \lambda$.

Assuming the specialist stands ready to sell Q_t^a, for partially or completely offsetting an excess demand, and to buy Q_t^b in case of excess supply, the transaction size at time t is defined as:

$$Q_t - \overline{Q}_t = \begin{cases} Q_t^a > 0 \\ Q_t^b < 0, \end{cases}$$

where $\overline{Q}_t$ is the quantity at which normal demand and supply are balanced.

In this framework, it is assumed that the specialist is equipped with a reserve fund, $I_t > 0$, measured in equivalent units of the stock. The fund is provided by the issuer and it is used by the specialist for maintaining a fairly ordered and liquid market. Following Stoll (1978), we assume that short sales are not allowed, since the specialist should maintain a minimum capital in each stock to avoid extra costs due to short selling. As a consequence, the specialist is automatically suspended from her/his obligations when $I_t \leq 0$.

Let us now introduce the underlying value, or equilibrium price, of the stock at time t and denote it as P_t. The specialist manages bid and ask prices also accordingly to the evolution of P_t (Goldman and Beja, 1979; Stoll, 1978, 1989).

Following Goldman and Beja (1979), the dynamics of P_t^* are assumed to be stochastic:

$$dP_t^* = P_t^* \left[\mu_t dt + \sigma_t dB_t \right], \tag{6}$$

where μ_t is the instantaneous drift of the process, representing the expected rate of return at time t; σ_t^2 is the instantaneous variance; B_t is a standard Brownian Motion.

The stochastic differential for the bid/ask spread, dS, is given by:

$$dS_t = \frac{Q_t^a - Q_t^b}{I_t} \cdot dP_t^*. \tag{7}$$

The drift of the process describing the spread dynamics, given in (11), clearly depends also on the sign of $Q_t - \overline{Q}_t$

If $Q_t - \overline{Q}_t = Q_t^a > 0$ the specialist sells at a higher ask price to compensate for excess demand and, for a fixed bid price, this would increase the spread. On the contrary, if $Q_t - \overline{Q}_t = Q_t^b < 0$, the specialist buys at a lower bid price to compensate for excess supply and this, for a fixed ask price, would increase the spread. The changes in the spread are inversely related to the value of the inventory, $I_t > 0$. In other words, the specialist does not anticipate price changes, but reacts to the order flow by assuming the role of *passive* stabilizer in that she/he buys when prices fall and sells when prices go up.