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## Order aggressiveness and quantity: How are they determined in a limit order market?

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### ABSTRACT

Dealers trading in a limit order market must choose both the order aggressiveness and the quantity for their orders. Since little research has considered how dealers make this trade-off, we empirically investigate how dealers jointly make these decisions in the foreign exchange market using a unique simultaneous equations model. Our model uses an ordered probit model to account for the discrete nature of order aggressiveness and a censored regression model to capture the quantity decision recognizing the clustering of orders at the smallest available quantity, \$1 million. Using two currency pairs with very different trading characteristics, we find evidence of a trade-off between order aggressiveness and quantity. We also find a significant role being played by factors related to the levels of information asymmetry and liquidity in the dealers' choices of both the order aggressiveness and quantity.

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## 1. Introduction

In a limit order market, traders submitting an order must choose both the order aggressiveness (price) and the quantity. Order aggressiveness is defined according to the execution priority, with market orders being the most aggressive because they are executed immediately at the best prices currently standing in the market. Limit orders are less aggressive because they are submitted at a set price, so their execution is not guaranteed and they follow strict price and time priorities in execution. Despite orders being defined by both price and quantity, much of the literature focuses on the relationship between various factors and order aggressiveness (i.e., Griffiths et al., 2000; Rinaldo, 2004,

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and more recently Ellul et al., 2007; Cao et al., 2008). In the majority of existing studies, the quantity dimension is either ignored or treated as one of the explanatory variables rather than as a choice variable. Although the existing studies recognize the costs associated with the risk of being picked-off or not having trades executed, they frequently assume trades of a standard size and therefore ignore a key component of the overall cost to submitting orders.

Studies investigating order aggressiveness have found relationships between market volatility, the bid-ask spread, and the depth of the limit order book on the order aggressiveness decision (e.g., Al-Suhaibani and Kryzanowski, 2000; Ahn et al., 2001; Hall and Hautsch, 2006, 2007; Foucault et al., 2007). Although some studies have empirically examined traders' quantity decisions (e.g., Biais et al., 1995; Al-Suhaibani and Kryzanowski, 2000; Moulton, 2005), their models do not consider the simultaneity of the price-quantity decision and the constraints in placing orders of different sizes. The theoretical literature addressing these issues includes studies such as Easley and O'Hara (1992) and Glosten (1994) and more recent papers such as Dridi and Germain (2004), Goettler et al. (2005) and Foucault et al. (2007). All discuss a role for quantity and price but do not explicitly examine the dynamic trade-offs that are made between price and quantity.<sup>1</sup>

The ability to change the size of the order at different prices plays an important role in determining the price schedule (e.g., the market clearing price) over time and, as a result, in determining the overall cost to submitting orders at different levels of aggressiveness (the overall cost is the feature of most relevance to traders when submitting their orders). Our study therefore seeks to extend the existing literature by empirically examining some of the findings from these studies and how they relate to the price-quantity decision. It is important for researchers and practitioners to gain an understanding of the factors that influence the price-quantity decision in order to obtain some useful information about the ways liquidity is provided to the market and what factors lead dealers to demand or supply liquidity. We accomplish this by simultaneously estimating traders' choice of order aggressiveness and quantity to more completely model traders' order submission strategies. We consider both factors simultaneously because traders choose *both* order aggressiveness and quantity when submitting orders in a limit order market. Although order aggressiveness has been modeled before, the inclusion of the joint role of quantity is new. In our model, order aggressiveness is estimated using an ordered probit model (as in Griffiths et al. (2000), Cao et al. (2008), and Rinaldo (2004)), thereby accommodating the discrete nature of price aggressiveness.<sup>2</sup> Quantity is modeled using a censored regression framework, which allows our model to accommodate a wide variety of order sizes as well as the clustering of orders at \$1 million. Our model therefore captures both the simultaneous nature of the price-quantity decision as well as many of the empirical features of the data—price clustering, quantity censorship, etc.

Beyond being the first study to present a detailed empirical model that, when compared to the existing literature, more completely models the order submission process, our study also contributes to the market microstructure literature by using foreign exchange data on two currency pairs – the Deutschmark–U.S. dollar and the Canadian dollar–U.S. dollar – that possess very different trading characteristics. We use data on firm orders from one of the world's largest foreign exchange electronic broker systems. This system allows dealers to submit and cancel market orders and limit orders of different sizes at different price levels. In this way, we extend the existing microstructure literature that currently focuses on equities markets, especially less liquid markets.<sup>3</sup> To ensure the robustness of our results and investigate the possible role for differences in liquidity on our results and those existing in the literature, we consider data from both the very actively traded Deutschmark–U.S. dollar market (referred to below as the DM) and the less actively traded Canadian dollar–U.S. dollar market (referred to below as the Canadian dollar).

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<sup>1</sup> From a theoretical perspective, the complexity of this problem is highlighted by the need to use numerical methods to obtain comparative static results in Goettler et al. (2005).

<sup>2</sup> The differences between prices are discrete increments. In equity markets, prices depend on the tick size, while in the foreign exchange market, prices are in increments of 1 pip. For our data, 1 pip is DM 0.0001 per U.S. dollar.

<sup>3</sup> The most similar studies investigating the price-quantity decision consider the Saudi market in Al-Suhaibani and Kryzanowski (2000) or the Australian market in papers such as Hall and Hautsch (2006 and 2007) or Cao, Hansch and Wang (2007).

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