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An empirical behavioral model of liquidity and volatility

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Abstract

We develop a behavioral model for liquidity and volatility based on empirical regularities in trading order flow in the London Stock Exchange. This can be viewed as a very simple agent-based model in which all components of the model are validated against real data. Our empirical studies of order flow uncover several interesting regularities in the way trading orders are placed and cancelled. The resulting simple model of order flow is used to simulate price formation under a continuous double auction, and the statistical properties of the resulting simulated sequence of prices are compared to those of real data. The model is constructed using one stock (AZN) and tested on 24 other stocks. For low volatility, small tick size stocks (called Group I) the predictions are very good, but for stocks outside Group I they are not good. For Group I, the model predicts the correct magnitude and functional form of the distribution of the volatility and the bid-ask spread, without adjusting any parameters based on prices. This suggests that at least for Group I stocks, the volatility and heavy tails of prices are related to market microstructure effects, and supports the hypothesis that, at least on short time scales, the large fluctuations of absolute returns $|r|$ are well described by a power law of the form $P(|r| > R) \sim R^{-\alpha_r}$, with a value of α_r that varies from stock to stock.

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1. Motivation and background

1.1. Toward a more quantitative behavioral economics

In the last two decades the field of behavioral finance has presented many examples where equilibrium rational choice models are not able to explain real economic behavior¹ (Hirschleifer, 2001; Barberis and Thaler, 2003; Camerer et al., 2003; Thaler, 2005; Schleifer, 2000). There are many efforts underway to build a foundation for economics directly based on psychological evidence, but this imposes a difficult hurdle for building quantitative theories. The human brain is a complex and subtle instrument, and in a general setting the distance from psychology to prices is large. In this study we take advantage of the fact that electronic markets provide a superb laboratory for studying patterns in human behavior. Market participants make decisions in an extremely complex environment, but in the end these decisions are reduced to the simple actions of placing and cancelling trading orders. The data that we study contain tens of millions of records of trading orders and prices, allowing us to reconstruct the state of the market at any instant in time. We have a complete record of decision making outcomes in the context of the phenomenon we want to study, namely price formation. Within the domain where this model is valid, this allows us to make a simple but accurate model of the statistical properties of prices.

1.2. Goal

Our goal here is to capture behavioral regularities in order placement and cancellation, i.e. *order flow*, and to exploit these regularities to achieve a better understanding of liquidity and volatility. The practical component of this goal is to understand statistical properties of prices, such as the distribution of price returns and the bid-ask spread. We will use logarithmic returns $r(t) = \pi_m(t) - \pi_m(t-1)$, where t is order placement time² and π_m is the logarithmic midprice. The logarithmic midprice $\pi_m = \frac{1}{2}(\log p_a(t) + \log p_b(t))$, where $p_a(t)$ is the best selling price (best ask) and p_b is the best buying price (best bid); on the rare occasions that we need a price rather than a logarithmic price, we will use $p = \exp(\pi_m)$. We are only interested in the size of price movements, and not in their direction. We will take the size of logarithmic returns $|r(t)|$ as our proxy for volatility. Another important quantity is the bid ask spread $s(t) = \log p_a(t) - \log p_b(t)$. The spread is important as a benchmark for transaction costs. A small market order to buy will execute at the best selling price, and a small order to sell will execute at the best buying price, so someone who first buys and then sells in close succession will pay the spread $s(t)$. Our goal is to relate the magnitude and the distribution of volatility and the spread to

¹This may be partly because of other strong assumptions that typically accompany such models, such as complete markets. Until we have predictive models that drop these assumptions, however, we will not know whether more realistic assumptions in rational choice models are sufficient to solve these problems.

²All results in this study are done in order placement time, i.e. we increment $t \rightarrow t+1$ just before each order placement occurs. There can be variable numbers of intervening cancellations.

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