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Order Book Projects

Market participants can post either limit orders or market orders. A limit order is an order to buy or sell a certain amount of a security at a given price (or better). The collection of outstanding limit orders can be summarized by the total volume posted at each price level. This is called the limit order book. The ask price is the lowest price for which there is an outstanding sell order, and the bid price is the highest price at which there is an outstanding buy order (i.e. the "inside" quotes). In an order-driven market, a "market order" is an order to buy or sell a certain quantity of the asset at the best available price in the limit order book. (Note that in the NYSE specialist system, this is not the case. The specialist must fill a market order with a specified time, at a price no worse than the relevant inside quote, but might, for example, match the order with an equal and oppositely-signed order at the mid price).

In an order-driven market, when a market order arrives it is automatically matched with the best available price in the limit order book and a trade occurs.

A limit order sits in the book until either executed against a market order or canceled. Note that a limit order that crosses the book is a marketable order and is instantly filled (e.g. if the bid is 23.81 and the offer is 23.84, then a limit buy at 23.85 would be instantly filled as a market order against the inside offer of 23.84)

The first challenge is to map the state of the order book onto a set of relevant variables, for example

a) the mid-price, defined as the average of the bid and the ask,
b) the number of buy orders at a distance from the ask,
c) the number of sell orders at a distance from the bid.

The second challenge is to describe the dynamics of the order book as it is updated by the inflow of new market orders, limit orders, and cancellations.

We will provide order book data.

Project 1

Students can try to reproduce the stochastic model proposed by Cont et al [1]. This model assumes that order arrival rates follow a Poisson process that depends on the distance to the bid/ask, with most orders being placed close to the current price.

Students can also see if they can reproduce some of the empirical observations in eg. Farmer (2004) [2] , or Bouchaud (2002) [3] .

Project 2:

Students will generalize the model in Cont et al [1] to include a random arrival rate. In other words, the arrival process swill not only depend on the state (or past states) of the order book, but also on some external information modeled by an appropriate stochastic process.

Project 3:

Probability Distribution of Time to Execution:

Along the lines of Lo, MacKinlay, Zhang (LMZ) [4], can one model the probability distribution of times to execution. The first challenge is to tie the arrival of an order to execution of that same order. It might be possible to deduce this from the order book data itself. We could also use EvA's limit order history, as long as the clock is synchronized with the order book data. The second challenge to find the most appropriate set of explanatory variables for the model. One can probably follow the approach in the LMZ paper as a first pass.

Options Projects

Project 4

Look at strike-independent implied volatility changes (e.g. from q-alpha model, see Borland (2008) [5] for a review). We would provide these volatility numbers. Students would for example, perform a Principle Components Analysis and find clusters. Perform the same analysis for stock returns. Compare the clusters found in volatility space with the clusters found in stock space. The first question is to explore the correlation structure between stocks in volatility space and in price space. Can also look at the correlation structure based on historical volatility changes (instead of implied). The second question is to look at residual returns in implied volatility space, and in normal stock return space.. Which ones are more predictable, and over which horizon?

Project 5

How do volume and open interest for a particular strike evolve as a function of current stock price, time to expiration, current volatility and any other explanatory variables that one can think of? Is there any pattern that one can detect here, e.g. as a function of moneyness? What are the statistical signatures of these quantities? Is there any model that can be fit to describe the properties that one observes?

Prediction and Optimization Projects

Project 6

Short and long-term prediction combination. Given two–term predictions with different certainty, trading costs, how to construct optimal portfolio. Use “adiabatic elimination” of slower moving variable? Or follow the approach as in Garleanu and Pedersen (2009) [5]. We could provide expected returns from a near term prediction model (EvA’s stat arb strategy) and a longer term prediction model (EvA’s Equity Market Neutral (EMN) strategy.

Project 7

Perform, over time, an independent component analysis (ICA) of the US stock universe that we can provide. The first task would be to examine them and see if they have any economic meaning. The second task would be to see if changes in ICA’ are predictable over some time horizon. The third task would be to look at residuals relative to the ICA factors and to see if the can be modeled and are predictable.

Project 8

We are curious to use wavelets as a pre-filtering tool for analyzing time-series of prices/returns. Is it possible to enhance prediction substantially using such techniques? How can we utilize these types of filters to help detect dynamics on multiple time scales? In particular, we could provide commodities time series and students could try and create trading strategies using wavelets.

1. Rama Cont, Sasha Stoikov, Rishi Talreja, A stochastic model for order book dynamics

2. Bouchaud, J.-P., M. M´ezard, M. Potters. 2002. Statistical properties of stock order books: empirical results and models. Quantitative Finance 2 251–256.

3. Farmer, J. D., L. Gillemot, F. Lillo, S. Mike, A. Sen. 2004. What really causes large price changes? Quantitative Finance 4 383–397, and references therein.

3. Andrew W. Lo, A. Craig MacKinlay, June Zhang, Econometric models of limit-order executions, Journal of Financial Economics 65 (2002) 31–71

4. Borland L., Non-Gaussian option pricing: successes, limitations and perspectives (2008) and refernces therein.

5. Nicolae G^arleanu and Lasse Heje Pedersen, Dynamic Trading with Predictable Returns and Transaction Costs