Simulated Order Book Data Adapter Overview

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February 3, 2014

1 Overview

Strategy Studio's SDK includes a Local Development Server to facilitate local debugging of strategies without the need to access a fully licenced server with valid market data credentials. This server type uses a purely simulated market data feed to send input data to strategies. We approach the task of simulating a limit order book by utilizing the zero intelligence (ZI) model developed by Smith et al [1].

In the ZI framework the price formation process is a mechanistic result of order flow interacting via the double auction process. This model is termed a zero intelligence model since the order flow that arrives to the market does not depend on the state of the limit order book nor does it depend on the history of orders. The strength of this model lies in its simplicity and in the fact that it manages to display several statistical properties observed in real financial markets. Thus, this is an ideal framework to generate synthetic orders for fast prototyping.

The flows in the ZI framework are modeled as independent Poisson processes and they interact via the limit order book. The model consists of three processes

- *alpha* - The rate of limit orders arriving in each price level of the book
- *delta* -The rate of cancelations per order sitting in the book
- *mu* - The rate of market orders

A limit order is defined as an order that does not result in an immediate trade. A market order is defined as an order that results in an immediate trade. Thus, any order can be decomposed into a limit order and a market order. Since the limit order arrival rate is per level, the total number of limit orders arriving at the book is given by

$$N_{limit} = \alpha M, \tag{1}$$

where M is the number of available levels at the book.[1]

[1]The model as defined thus far results in an infinite number of levels.

The order cancellation process is slightly different since the rate is per order resting at the book, which means that the total rate of cancelations depends on the number of orders in the book. This is a natural way to describe the process and it ensures that the depth of book is finite in the steady state. One can expect that the depth of book, far from the best bid and ask , will obey the following relation

$$\delta D = \alpha, \tag{2}$$

where we define the depth D as the number of orders in each price level.

Finally, the market order process is defined such that the limit order flow is independent of the number of orders resting in the book and of the number of available levels. Thus, the rate describes the total number of market orders (both buy and sell) arriving to the market.

2 The model implementation and parameters

The basic ZI model uses some assumptions that while useful are not realistic: log spaced ticks, an infinitely wide book, and a single exchange. When converting the resulting book to actual prices with penny increments, the log spacing would cause ask levels to be spaced further apart than the bid levels. It would also result in an increasing depth of book at smaller price levels.

To overcome the above problems we distribute the generated orders among a set of market centers and forego using log prices, using constant price increments instead. As a result, the price will perform a a regular brownian motion and as such it can go to zero. To deal with the zero bound and to ensure a finite number of price levels we bound the price from above and below. Thus we add two parameters to the model B_U and B_L, the upper and lower bounds respectively. The number of levels in the book is thus

$$M = 1 + \frac{B_U - B_L}{\Delta p}, \tag{3}$$

where Δp is the price increment (usually a penny for most instruments above 1\$). And the total number of orders is given by

$$N = \alpha \left(1 + \frac{B_U - B_L}{\Delta p} \right) \tag{4}$$

2.1 Parameters

The model parameters described in Section 1 are not necessarily the most intuitive nor the easiest to measure empirically. Instead we choose to work with the total order rate per second ρ, the fraction of trades f_T, and the average depth D. The model parameters can be approximated as

$$\mu = f_T \rho \tag{5}$$

$$\alpha = \frac{(1 - f_T)\rho}{M}$$
$$\delta = \frac{\alpha}{D}$$

Our implementation of the ZI model is governed by 5 variables

- D - The depth of book
- rho -The total rate of incoming orders
- f_T - The fraction of trades out of all the order flow
- B_L - The lower price bound
- B_U - The upper price bound

2.2 Configuration

Strategy Studio's SimulatedMarketAdapter allows configuring the following variables via the LocalDevServer's main config file:

- SIM_MARKET_CENTERS_TO_SIMULATE
  - A comma separated list of market centers for which to generate order book entries. Defaults to "NYSE,ARCA,NASDAQ"
- SIM_SYMBOL_HIGH_LOW_DATA_FILE
  - Path to a file containing symbol specific price bands. File should be ASCII with lines formatted *symbol,priceLowerBand,priceUpperBand*
- SIM_MD_UPPER_PRICE_BOUND/SIM_MD_LOWER_PRICE_BOUND
  - Default upper and lower prices to use for symbols not configured via a symbol high/low data file. Defautls to 17.5 and 22.5
- SIM_MD_DEPTH
  - D as explained above. Defaults to 2
- SIM_MD_ORDER_RATE_PER_SEC
  - *rho* as explained above. Defaults to .1
- SIM_MD_TRADE_FRAC
  - f_T as explained above. Defaults to .025

References

[1] Smith, E., J. D. Farmer, L. Gillemot, and S. Krishnamurthy. *Statistical Theory of the Continuous Double Auction*, Quant. Fin. 3(6) (2003): 481-514