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Review of the article "High-frequency trading in a limit order book" by Marco Avellaneda and Sasha Stoikov, 2006

In algorithmic trading a problem of choosing proper strategy depends on risk preferences and profit gained. Marco Avellaneda and Sasha Stoikov proposed a model of a sole trader who maximises his utility function which is more fluctuating at the start and becomes more stable with time (as t increases and $T - t$ decreases). Basic assumptions of the model:

- Agent's preferences are rational but inconsistent over time.
- Mean price S_t is considered to be a market price at time t, so one evaluates agent's assets as $x + qS_t$.
- S_t changes proportionally to Brownian motion.
- Distribution of real observed gap (Δp) is proportional to $\ln(Q)$ where Q is a market size. Density of market order size in turn obeys a power low distribution.

Limit orders strategy defines as follows: agent chooses bid/ask prices (p_a, p_b) and with probability $\lambda(p_a)$ he sells his inventory increasing money wealth on p_a, with probability $\lambda(p_b)$ new inventory is bought and wealth decreases on p_b. Author's contribution consists of determining the best p_a and p_b according to wealth maximization goal. As bid/ask spread was calculated the issue of centering arises. We can center the spread around the mid-price ("symmetric strategy) or indifference price ("inventory strategy") which is defined as the price level at which the agent does not care whether to make a deal or not. As simulations show, *inventory strategy shows less profit results but with much lesser standard deviation* (on 31% per average) and both strategies have a positive profit. Moreover, an important achievement of the model is that investor can regulate this "inventory effect" by changing a single parameter.

Notwithstanding a positive profit on simulations, on real markets this strategy faces some obstacles. Implementation of the algorithm on the presented data has showed positive profits only in symmetric strategy which is far more unstable than inventory one. Further, A. Cartea, R. Donnely, S. Jaimungal (2018) claimed that such approaches would be washed off the market because of negative profit and inefficiency in execution limit orders. Placing them deeper into limit order book makes them less probable to be executed.

Ways to improve the strategy

1. Use information about buying/selling pressure on market (A. Cartea, R. Donnely, S. Jaimungal, 2018). For instance, if buying pressure is strong agent can buy at less price.

2. Model probability of arriving influential market orders (MOs)(A. Cartea, S. Jaimungal, J.Ricci, 2014). Such MOs can change direction of a price and pressure.

3. The algorithm does not take into account broker's fee which can be a restriction to optimal spread. If commission is $s > p_a - p_b$, it is not profitable to make orders. Therefore, in real trading algorithm should use a restriction $p_a - p_b > \delta$

4. If agent trade with sizeable amount of property, strategy will probably need enhancements with calculating optimal q_a, q_b to place. The reason is that orders can be executed partly which is influence to total profit.

Review of the article "Enhancing Trading Strategies with Order Book Signals" by A. Cartea, R. Donnely, S. Jaimungal, 2018

Simple limit orders algorithms which post LOs deeper than bid/ask prices will be inefficient due to a lack of probability to be executed (as LOs in limit order book have a power-low distribution). Thus, trader should use information about direction of market pressure (buy or sell). In (A. Cartea, J. Rissi, S. Jaimungal, 2014) authors model a probability of arriving influential market orders which change price significantly. Nonetheless, one of the best predictors of market pressure is imbalance in sell/buy best LO's. Authors proposed a *volume index* to measure it.

$$\rho = \frac{V_b - V_a}{V_b + V_a}, \rho \in [-1, 1]$$

When ρ is near -1, there is a strong selling pressure and agent should put his p_a higher. Otherwise, when ρ is about 1, agent should decrease his p_b price. It's a general idea can be implemented in many ways. Market states can be divided into 3 groups sell-heavy ($\rho < \frac{1}{3}$), neutral ($\rho \in [-\frac{1}{3}, \frac{1}{3}]$), buy-heavy ($\rho > \frac{1}{3}$). Authors show that with high buying pressure next market order is probable to be a buying one, the same with selling pressure.

The algorithm they proposed is based on predicting a sign of order and whether to post it with given spread. For instance, in neutral market condition it's usually not optimal to post any orders (in case of small spread). *Results on real NASDAQ data have higher Sharp ratio than any other LO strategy which proves efficiency of using volume index.*

Downsides of the algorithm are the same as in the previous review (see points 3-4). Also, limits of ρ to classify market states can vary by specific equities and need to be calibrated.