Quantum perturbation theory in stock trading (I)[1]

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Abstract

It is a hot topic about how to trade a stock/group of stocks in a non-news day. Author tries to design safe, profitable automated stock trading agents using evolutionary algorithms[2].

*In quantum mechanics, **perturbation theory[4]** is a set of approximation schemes directly related to mathematical perturbation for describing a complicated quantum system in terms of a simpler one. The idea is to start with a simple system for which a mathematical solution is known, and add an additional "perturbing" Hamiltonian representing a weak disturbance to the system. If the disturbance is not too large, the various physical quantities associated with the perturbed system (e.g. its energy levels and Eigen states) can, from considerations of continuity, be expressed as 'corrections' to those of the simple system. These corrections, being 'small' compared to the size of the quantities themselves, can be calculated using approximate methods such as asymptotic series. The complicated system can therefore be studied based on knowledge of the simpler one.*

In Stock Market, for a non-news trading day, stock prices will mostly depend on the initial price at given time, and bid-ask spread.

Keywords: Stock Trading; algorithm trading *stock; Quantum perturbation theory in stock trading; stock trading strategies*

1. Introduction

This method is only applied for the non-news day stock trading. In a news day, the perturbation theory does no longer exist.

Author introduces this model to predict the price in next time frame. The time step could be adjusted to seconds or minutes which depend on the stock trading volume.

Microsoft Corp.(msft) could be a good candidate for this model. It has little volatile performance in the non-news day.

And MSFT[3] has big volume for trader to take profile via perturbation theory.

Data as of Dec. 17, 2012, MSFT volume in past 5 days

If we introduce one minute as time step, and most trading price in that minute as initial price(base Hamiltonian). Perturbation (perturbing Hamiltonian) will be the ask-bid spread in the beginning of the following minute. The final goal will be that we predict the price in the ending of that following minute. If predicted price is larger than the profit price needed, we can set our own ask-bid price. Our trading volume should be smaller enough to be the perturbing part and bigger enough for reasonable profit.

2. Time-independent perturbation theory

We begin with an unperturbed Hamiltonian H_0, which is also assumed to have no time dependence. It has known energy levels and eigenstates, arising from the time-independent Schrödinger equation:

$$H_0|n^{(0)}\rangle = E_n^{(0)}|n^{(0)}\rangle \quad , \quad n = 1,2,3,\cdots$$

H will be the initial price in a given state.

continuously from 0 (no perturbation) to 1 (the full perturbation). The perturbed Hamiltonian is

$$H = H_0 + \lambda V$$

The energy levels and eigenstates of the perturbed Hamiltonian are again given by the Schrödinger equation:

$$(H_0 + \lambda V)\,|n\rangle = E_n|n\rangle.$$

Our goal is to express E_n and $|n\rangle$ in terms of the energy levels and eigenstates of the old Hamiltonian. If the perturbation is sufficiently weak, we can write them as power series in λ:

$$E_n = E_n^{(0)} + \lambda E_n^{(1)} + \lambda^2 E_n^{(2)} + \cdots$$
$$|n\rangle = |n^{(0)}\rangle + \lambda|n^{(1)}\rangle + \lambda^2|n^{(2)}\rangle + \cdots$$

where

$$E_n^{(k)} = \frac{1}{k!}\frac{d^k E_n}{d\lambda^k}$$

and

$$|n^{(k)}\rangle = \frac{1}{k!}\frac{d^k|n\rangle}{d\lambda^k}.$$

When $\lambda = 0$, these reduce to the unperturbed values, which are the first term in each series. Since the perturbation is weak, the energy levels and eigenstates should not deviate too much from their unperturbed values, and the terms should rapidly become smaller as we go to higher order.

Plugging the power series into the Schrödinger equation, we obtain

$$(H_0 + \lambda V)\left(|n^{(0)}\rangle + \lambda|n^{(1)}\rangle + \cdots\right)$$
$$= \left(E_n^{(0)} + \lambda E_n^{(1)} + \lambda^2 E_n^{(2)} + \cdots\right)\left(|n^{(0)}\rangle + \lambda|n^{(1)}\rangle + \cdots\right)$$

Expanding this equation and comparing coefficients of each power of λ results in an infinite series of simultaneous equations. The zeroth-order equation is simply the Schrödinger equation for the unperturbed system. The first-order equation is

$$H_0|n^{(1)}\rangle + V|n^{(0)}\rangle = E_n^{(0)}|n^{(1)}\rangle + E_n^{(1)}|n^{(0)}\rangle$$

Operating through by $\langle n^{(0)}|$. The first term on the left-hand side cancels with the first term on the right-hand side. (Recall, the unperturbed Hamiltonian is hermitian). This leads to the first-order energy shift:

$$E_n^{(1)} = \langle n^{(0)}|V|n^{(0)}\rangle$$

$E_n^{(1)}$ represents that future price we predicted.

If we apply this quantum model to stock trading, we can realize that in a non-news day stock trading price could be well predicted in given time frame on a good volume stock as MSFT.

I will review more technical details in another paper.

3. Interesting discovery

The number of traditional traders who are trading stocks depends on market sense; manual operation has decrease by years.

Report from hedge funds, trading firms reveal the reality that more and more trading will depend on computer and algorithm. Looking for the proper trading math model becomes the daily jobs for talent traders.

4. Conclusion

It is interesting to see if High Frequency Trading will follow the same track, author’s model indicates that combination of math model and actual trading scenarios will lead to a new direction

Algorithm in the model could be adjusted according to the reality.

You are very welcomed to email me for discussion.

5. References

[1]Author’s model is constructed on his multi-years working history, mathematical background and data modeling.
[2] http://en.wikipedia.org/wiki/Algorithmic_trading
[3] http://www.nasdaq.com/symbol/msft/interactive-chart?timeframe=5d&charttype=line
[4] http://en.wikipedia.org/wiki/Perturbation_theory_%28quantum_mechanics%29

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