Towards a new cognitive modeling approach for multi-agent based simulation of stock market dynamics

(Extended Abstract)

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ABSTRACT

This paper introduces a new conceptual model representing the stock market dynamics. This model is essentially based on cognitive behavior of the investors. In order to validate our model, we build an artificial stock market simulation based on agent-oriented methodologies. The purpose of this simulation is to understand the influence of psychological character of an investor and its neighborhood on its decision-making and their impact on the market in terms of price fluctuations. Interactions between investors and information exchange during a transaction reproduce the market dynamics and organize the multi-agent based pricing.

Categories and Subject Descriptors

J.4 [**Computer Applications**]: Social and Behavioral Sciences—*Economics, Psychology, Sociology*; I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent agents, Multiagent systems*

General Terms

Economics, Experimentation, Human Factors.

Keywords

Multi-agent based simulation, Cognitive and behavioral modeling, Stock market, Pricing.

1. INTRODUCTION

The stock market is considered as a dynamic and complex system which incorporates large number of actors where everyone is trying to make benefits. Many researches are undertaken in order to model the mechanism of pricing in the stock market and to better comprehend the investor behavior while taking decision (e.g., see [4], [2]). Recently, we identify behavioral multi-agent based simulation like [1]. We introduce in this paper a novel model representing the stock market and based on investors' cognitive behaviors.

Our artificial stock market includes the market supervisor agent essentially responsible for executing transactions via an order book and a several kinds of investor agents depending to their profile. In fact, investor decision making constitute a complex process which is based on cognitive and rational paradigm and biased by behavioral attitudes.

This paper is structured as follows. The second section describes the cognitive and behavioral investor model. In the third section, we define the multi agent based pricing performed by the market supervisor agent. In the fourth section, we present experiments undertaken through our simulator. We study some stylized facts observed in our artificial market. Finally, in the fifth section, we conclude the paper and we summarize future works.

2. NEW COGNITIVE INVESTOR S MODEL

Each agent A_i is identified by an index i and is characterized by his $MarketExperience_i$ which represents its experience degree. The A_i behavioral profile, $Behavior_i$, is defined by three dimensional vector ($OptimismV_i$, $SpeculationV_i$, $MimetismV_i$). Each component of this vector describes a behavioral attitude which can be either checked or reversed (represented respectively by +1 and -1). Initially, every A_i disposes of a number of randomly S_0 stocks and a fixed determined $Wealth_i$. Each step of simulation, based on quantitative and qualitative stimuli, the investor agent takes the decision of buying, selling or doing nothing and actualizes its $Portfolio_i$ (the set of stocks that it disposes).

2.1 Perceptual Process

The **Perceptual Process** (PPr) in our model represents the first step in making decision mechanism which guarantee the information mining and filtration.

2.1.1 Confidence filter

Confidence filter receives as input qualitative stimuli : expert's opinions and advices. Expert's opinion is a message transmitted by agent having $MarketExperience_i$ equals to 1 and defines the recommendation to buy or to sell a specific stock. Although, advice represents a stock judgment. Every qualitative stimulus until circulating in the market has a degree of conviction named $CDegree$. The qualitative information is taken into consideration whenever a confidence threshold is reached. The confidence threshold called $Th\_ConfidenceSensibility_i$.

2.1.2 Privacy filter

Investors are influenced by their observation of the others choice without knowing if it can be benefic or not. In our model, advices can be considered although they are not confident. The purpose of the privacy filter consists in considering the sender of the message instead of its content. We use a dynamic network of trusted neighbors of the agent A_i, the $CNeighborNet_i$. This network is inspired from the six degrees of separation concept [3] and is applied to the field of stock market neighborhood.

2.2 Informational Process

Informational Process treats qualitative and quantitative stimuli filtered by the perceptual process. Investor agent ought to buy stocks which are deemed undervalued. It might sell the stocks which are considered overvalued. We consider in our model three analysis related to fundamental analysis and chart analysis: (1) stock evaluation, (2) performance measuring and (3) Trend determination. Each kind of analysis provides signals to buy or to sell the stock considered.

2.3 Decisional Process

The *Decisional Process* (DPr) provides a final decision based on the IPr outputs. In fact, investor agents' decision making takes place after the four tests relative to: stock evaluation, stock volatility, systematic risk and trend determination. Each test gives out a signal to buy, sell or do nothing. The final decisional signal D is calculated as follows:

$$D = \alpha * d_{StockEval} + \lambda * d_{SVolatility} + \gamma * d_{SysRisk} + \delta * d_{TrD}$$

We notice that the parameters α, λ, γ and δ are generated randomly under the condition that their sum is equal to 1. Therefore, D ranges from -1 (which indicates buying) to +1 (which indicates selling) and just represents a signal. We note that D will be transformed to an order expect if $\|D\| \leq Th\_RunTr_i$. Th_RunTr_i defines a threshold for which the agent A_i run a transaction following its decision-making.

3. MULTI AGENT BASED PRICING

Investors are influenced by their observations of the choices of others. The stronger the social signal, the more they are influenced. Information concerning stocks is available permanently for all investors. Their interactions form the stock price. MarketSupervisor agent plays a crucial role in stock market. It offers the following actions: (1) launching of the stock market transactions, (2) publication of information related to stocks for investors, (3) matching orders of sale and purchase and execution of transactions via the fixing, (4) updating stock information and (5) calculating the market trend.

4. EXPERIMENTS

We present some features by taking into consideration four stocks with different characteristics (see table 1) for our simulation. In figure 1, we represent the price fluctuations of the four stocks, their logarithmic return $(ret(h) = logp(h) - logp(h - 1))$ and the transactions volume. This figure notes the random walk propriety of prices and shows the relation between the price formation and the transaction

Table 1: Stocks characteristics

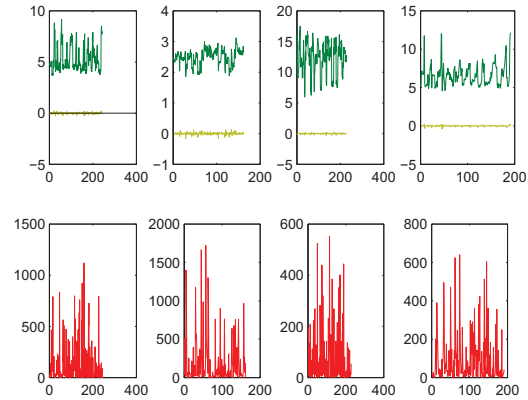| Stock number	Theoretic price	Beta indicator	Trend
1	4.64	1	downtrend
2	2.02	0.6	uptrend
3	6.07	0	uptrend
4	5.33	0.5	downtrend

Figure 1: Stocks volatility and price formation. Top: price fluctuation dynamics. Green: Market prices; yellow : the logarithmic returns. Bottom: the volume transactions of the considered stocks.

volume. In fact, transaction volume has negative and significant effect on price dispersion in stock market. Financial time series usually exhibit a characteristic known as volatility clustering, in which large changes tend to follow large changes, and small changes tend to follow small changes. In this case, changes from one step to the next are typically of unpredictable sign.

5. CONCLUSION AND FUTURE WORKS

We conclude that our behavioral model is able to reproduce some stylized facts observed in real stock market and to assure no predictability of future price developments and an efficient price formation. Different perspectives can be considered in our work. The first is to refine the model and enrich its implementation with including new cognitive concepts at the micro level. Second, we should focus on the study of others stylized facts such as the Multi-scaling and the multi-fractality.

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