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ISING-LIKE STATISTICAL MODELS AND STOCK MARKETS REAL EVOLUTION

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Abstract
Statistical physics have developed a significant arsenal of tools for analyzing many-particle systems with strong, localized interactions, resulting methods such as mean field theory, the renormalization group or finite scaling analysis, which allow physicists to explore complex irreducible systems, but, also non physical systems such as ecological and socio-economic systems (like stock markets). In this work it is realised a critical analysis of the possibility to use the results Ising-like statistical models to understand the real stock markets evolution.

There is a great number of papers resulted from the development of econophysics which are dedicated to the analysis of financial markets based on Ising-like statistical models [1]. In this work we intend to realise a critical analysis of the possibility to use the results of the Ising-like statistical models to understand the real stock markets evolution.

The common advantage of Ising-like models is that they put into perspective standard financial market statistical facts, like volatility clustering, scaling properties etc., which are all present when the asset price formation is analysed. In order to allow an analysis close to real markets developments, the following operations are very important:

- to realize a correct correlation between the microscopic variables of the model (defined as spin variables) and identifying the market agents (traders);
- to choose the right form of the hamiltonian which describes the interactions between the traders identified during the transaction processes (the terms which describe the different interactions between spin variables and the corresponding coupling constants)

As it is known, there are some mean statistical quantities with macroscopic correspondent which are identified within the spin models, like:

- order parameters which are defined as statistical mean values of the spin variable, the spin variable's square, etc.;
- fluctuations of the order parameters by means of square average deviation, etc.

- correlation functions.

It is also known that, within stock markets, there are different types of transactioning agents:

- fundamentalist traders which are agents which take into consideration the real price of a share;
- noise traders which have a random behavior;
- Technical traders which permanently monitor the technical data, regarding transactions and react depending on them.

The traders' attributes are:

- they decide, in every moment, if they perform transactions or not;
- the active ones, choose different ways to make decisions, depending on their own transaction strategy;
- they take different positions regarding every type of action present on the market (choosing a portfolio).

By using Ising-like models for studying stock markets evolution, the following identifications are being made:

- the traders are playing the role of network spins;
- the "spin-up" and "spin-down" states are being attributed to the agents who sell and buy a stock, respectively. (The "zero state" may represent an inactive state from the transaction's point of view);
- the positioning of an agent in a network's node (usually 2D) implies that the distance between nodes represents a social/communications network, an agent from a given node making a "diffusion" of his own preferences to his closest neighbors.

The main Ising-like models, used for studying the behavior of stock markets, are:

- The Ising ½ classic model [2]

In this model, an agent's state is considered a binary spin variable $S_i(t)$, (the two spin values, {+1,-1} meaning {"to buy", "to sell"}. The application of the model:

- explains the forming of stock prices depending on the spin variables;
- presents the disadvantage that the system rapidly evolves towards a market crash, in one of the two stable system states (all agents realizing the same financial operation), which means that the model can be used only in the case of an approaching speculation bubble or crash in the financial market evolution;

- the Ising ½ in a local field model (the Bornholdt model [3])

Like in classical case, in this model, as agent's state is considered the binary spin variable $S_i(t)$, and the agents try to balance the desire to acting in the global minority with the desire to be in the local majority by means of local field.

The model has the following characteristics:

- there are two conflict forces which are important in economic actions ("do what the neighbours do" and "do what the minority does") under the form of a local field

$$h_i(t) = \sum_{j=1}^{N} J_{ij} S_j - \alpha C_i(t) \sum_{j=1}^{N} S_j(t)$$

- it is dependent on:
  - o spin variables;
  - o the coupling constant between the closest neighbour spins;
  - o the $C_i(t)$ variable introduces the strategy of agent i (the $C_i(t)=1$ value shows that the agent joins the global minority, while the $C_i(t)=-1$ shows the agent joins the global majority);
- even if it puts into evidence dynamic properties resembling those in real markets, it does not put into evidence their interpretation depending on the financial markets characteristics.

• K.Sznajd-Weron and R.Weron model[4].

This model, which is similar with Bornholdt one, introduces new dynamic rules describing the behaviour of two type of agents (trend followers and fundamentalists ones). The model is simple and parameter free one, but is a good first approximation of a number of real financial markets, especially for studying the "stylized facts" and "frequency domain analysis".

• The agent-based models[5] take into consideration the presence of the market experts and, at the same time, the usage of the intermediaries (more and more of the individual investors invest through an intermediary which supplies credit, liquidity, matching, accounting, records keeping, informant, etc.).

A different point of view in agent-based models is determined [6] by the existence of the three very different strategies: - the fundamentalist strategy

- the majority strategy

o the chartist strategy (known as strategy for those who monitor market trend for certain history referred horizon); each agent is affecting or being affected by the surroundings on a variable influence strength.

• Starting with the multi-agent microscopic structure of the market, much more complicated models were introduced, like CSEM (Centralized Stock Exchange Model) and DSEM

(Decentralized Stock Exchange Model)[6] in which a lot of parameters are taken into consideration, like:

- market parameters: number of agents, total shares available, average interval between news releases, etc.
- market state variables: stock price at time t, trade volume (number of shares traded) at time t, etc.
- agent state variables (buying and selling) and parameters (friction, news response, price response, etc.)

The agent-based Ising models have the following characteristics:

- take into consideration typical individual agent behavior (the moment of realizing the investment, learning from accumulated experience, herd behavior), which can become more important than obtaining external information or the appearance of modifications of fundamental economic variables;
- are based on the existence of at least two types of agents (fundamentalists and noise traders), resulting a structure which affords a reasonable complexity investigation;
- allow the possibility of the existence of other types of agents (experts, intermediaries, etc.)
- the agents attitude of buying or selling is taken into consideration based on the Ising-type variables (spins or spin-vectors which have spins as coordinates).

- Another type of Ising-like models are determined by using Ising 1 spin models, where spin variable S_i has three values {-1, 0, 1} the corresponding states representing the choices at a moment t :{sell, inactive, buy}, each of them being determined by an agent's strategy.

The Ising 1 model has the following attributes:

- introduces a supplementary state, characteristic to the inactive agents
- although it introduces supplemental stable states, there are still real-life financial market evolution effects which cannot be explained using this model.

It was our opinion [7] that the introduction of the different possible modes for agent response in the evolution of the market may be taken into consideration in the form of spin 1 Ising-like hamiltonian, introducing minimum two spin-spin interaction terms (like S_iS_j and S_iS_j). If we consider a spin 1 model with hamiltonian

$$H = -J\sum_{<i,j>} S_i S_j - K\sum_{<i,j>} S_i^2 S_j^2 - B\sum_i S_i - D\sum_i S_i^2$$

(Blume-Kapel model) we have the possibility to introduce two order parameters ($<S_i>=M$ and $<S_i^2>=Q$) which are not independent of each other. So it arises the possibility of analyzing market evolution by means of M-Q interdependence. There are encouraging facts [8] to evidentiate market evolution by studying the correlations between market index (M-ordering) and market volatility (Q-ordering).

The main advantages of this model are:

- more types of interdependent order parameters can be introduced;
- the interdependence of characteristic parameters in real financial market evolution can be analyzed, parameters which are defined each one depending on a different order parameter (like stock index correlated with $<S_i>=M$, volatility correlated with $<S_i^2>=Q$), this interdependence being characteristic to a given market evolution dynamic. This existence of the two order parameters interdependence has been done for studying the evolution of several financial markets, like the NY stock market (DJ and S&P indices) and BVB[8].

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