**Integrating irrational behavior into agent-based financial models**

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**Overview**

One method for making financial predictions is to employ an agent-based model (ABM) which simulates the behavior of traders and the effect of this behavior on the market. These agents can have a variety of properties which determine their behavior, such as age, gender, personality, etc (Helbing, 2014). Most implementations of ABM for financial modeling have assumed that agents behave rationally, that is, making their decisions as a result of careful analysis. However, a market comprised of entirely rational investors is a far cry from reality; this statement can be evidenced by any financial bubble (Dhesi, 2016). The goal of this research is to remedy that shortcoming, by accounting for irrational tendencies innate to all humans. To accomplish this goal, research in the emerging field of neuroeconomics will be used to create a more realistic model for agent behavior

**Independent Variables**

The independent variables of this experiment will be the irrational agent parameters which were not included by previous research. These parameters will account for individual dispositions, and will consist of quantified values for factors such as: risk tolerance, optimism, contrarianism, adaptability, etc (Rocha, 2013).

**Dependent Variable**

The dependent variable of this experiment will be the accuracy of the model’s predictions. This accuracy will be expressed as the mean absolute percentage error (MAPE).

**Constants**

The constants for this experiment include population size (amount of agents) and trading frequency (each agent will be allowed to buy/sell once a day).

**Controls**

For this experiment, the control will be previous research which did not account for irrational agent behavior (Ehrentreich, 2002). The performance of these past models will be compared to the performance of the new model, and the effect of including irrational parameters will be determined.

**Assumptions**

The efficient market hypothesis (EMH) states that prices in a financial market follow a random distribution. For this experiment, the EMH is assumed to be false. The reason this assumption is made is because if the EMH were to be true, then predictive modeling would be futile. Also, it is assumed that an accurate agent-based model for a market can be developed without simulating the behavior of agents trading at high-frequency (a significant portion of trading today is done by computers). This assumption is made due to the difficulty of simulating the behavior of such agents.

**Materials**

The only material required for this research is version 3 Python. In python, the project Mesa package will be utilized. This package allows for agent creation, network visualization, and result analysis, using python’s data analysis tools. This package can also be customized, so that different types of agents can be developed.

**Data Collection**

The data for this research will be collected by running the developed agent-based model with a set of initial conditions which are identical to those found in the market which is to be modeled. Then, the predicted behavior of the market will be recorded and compared to the actual behavior of the market. The discrepancy between predicted and actual will determine the accuracy of the model.

**Procedure**

1. **Agent Parameterization -** For this research, parameters will take the form of either analytical or emotional, with each agent taking into account a mixture of both when formulating a decision. The analytical parameters present in each agent will be designed to closely resemble the analytical process of humans, and to this end will be mostly equations which are used for technical analysis of stocks. Emotional parameters will be derived from the different ways in which an individual’s personality could affect their financial decisions (Rocha, 2013).
2. **Agent Implementation -** The implementation of the agents will take place in a python environment, utilizing the Project Mesa framework for ABM.  Once implemented, the agent populations can be generated, and their interactions simulated.
3. **Market Implementation –** The implementation of the simulated stock market will be based on the market mechanics used by previous research (Ehrentreich, 2002). The effect of agent behavior on stock price will be determined by the discrepancy between demand and supply. The stock will also pay a slightly stochastic dividend, so that analytical agents will be able to assess it’s “real value”.
4. **Population Generation -** Once agent and market mechanics have been implemented, a set of agent populations will be generated.  These populations will vary greatly in agent personality.  To assess the impact of these different makeups, each population will be simulated for several years, with market patterns analyzed afterwards.  For example, population A may contain 70% high risk investors, and 30% low risk investors, with population B containing 30% high risk investors, and 70% low risk investors.  Each population could be simulated, and each will likely exhibit unique features.
5. **Performance Analysis ­–** The performance of each population will be analyzed, and the most accurate population will then be compared to similar agent-based models which did not account for irrational behavior. In this way, the benefit of incorporating irrational behavior will be determined. Specifically, the ability of the population to model market indices, such as the S&P500 will be assessed. This is because attempting to model singular companies would introduce many more factors and variables specific to that company, which would be too complex to incorporate into the model.

**References**

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