Wall Street Bets: The Game

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Abstract

The stock market is a systems where multiple agents interact. This has inspired us to implement this fun game to educate users to learn more about the economy. Each agent is an investor and agents can have different strategies (based on real life examples) and their goal is to maximize their value. By testing the developed system we hope to learn more about the agent's interactions and how different strategies perform against each other.

1 Introduction

The economy is an every changing environment, and nowadays the stock marked has been on the news due to the subreddit WallStreetBets [2]. So we used a game to simulate the stock market in a fun and educating way. This game is loosely based on the game "A Bolsa".

Each player (agent) is a stock broker who wants to maximize the value of the shares they own. The game works in rounds, when the game starts each agent start with a predefined amount of money and can buy and sell stock once every round. The games ends after 30 rounds have been played. The player with the most value wins. The amount of shares they can buy is limited. They buy and sell shares to the central bank , an entity that knows everything.

The players (agents) are **competitive** towards each other and can have several different strategies. We aim to study how these different strategies perform against each other in an variety of environment setting.

Requirements are that no player can spend more money than they have, if the player loses all his value he loses the game. Our **goals** with this project are to implement intelligent agents that will provide input about strategy and scenario characteristics. It is important to keep in mind that these rules are based on real economic models but are not realistic. This is just a tabletop game.

2 Approach

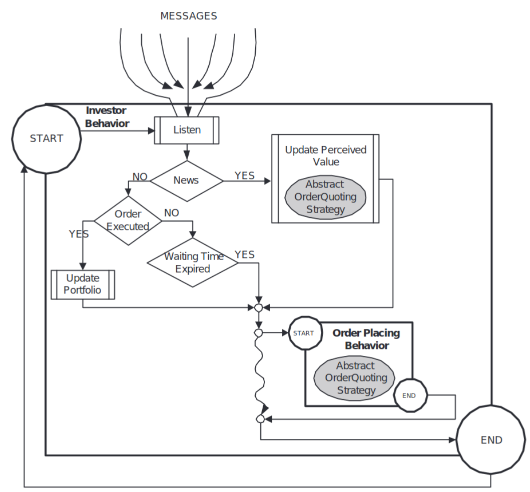
2.1 Agent System

The players (agents) are **competitive** towards each other and can have several different strategies. This game can have from 2 to 8 players, but we plan to simulate up to 100.

We will have multiple agents (MAS) competing and affecting each other with a complex environment with uncertainty and noise. As such we plan to implement complex agents.

The **challenge** in this environment is to balance their investments, with their revenue. Another key challenge is

Figure 1. Example of an investor agent [1]



understand when to sell a share so as not to not lose as much money.

To design the strategies our agents used we studied the work of Boer et al. [1] where they describe several reactive banking agent behaviors, like the one seen in Fig. 1. These agents make decisions based on new market data [1] and are adequate to our problem for that reason. We also plan more complex agents, the planned are:

- Reactive agents with no state:
  1. Gold standard, buy in the beginning and hold.
  2. Simple trend follower [1], if stock price increases buy, if it decreases sell. Just sees one round.
- Reactive agents with state:
  1. Careful trend follower [1], does not invest in any shares until it can see a positive value trend(over a set of rounds). Sells when there's a negative trend.
  2. Risks&Careful, invests without seeing any trends but also tries to follow them.
- Agents with random behaviour, to increase entropy
- A learning agent that will measure its success from each round based on eq. (1). We would like to understand if this agent after learning, will have a better or similar performance to the reactive agents.
- *Future work*: Deliberative agents that will have beliefs about how each stock is going to behave and about the market in general and decide accordingly. These agents would target the problem of adapting to the changing environment, e.g. when there's a recession.

2.2 Actuators and Sensors

Actuators:

- *buy(amount, shareName)*: sell a certain share
- *sell(amount, shareName)*: buy a certain share
- *hold()*: do nothing in a certain round

Sensors:

- *valueOfShare(shareName)*: returns the value of a share;
- *availableShares(shareName)*: returns array of shareNames that are available for buy.

In a certain round all agents have a limit to what they can spend as to not disrupt the trading market. The maximum spending limit is 75% of the agent's value. Nonetheless different agents can choose to spend less (e.g. the careful agent is never going to spend more then 50% of its value). These design choices are adequate as they reflect what a player agent would do.

2.3 Environment

The environment is going to be **inaccessible**, the agents do not know what share other agents have. They only know which shares are for sale and for how much. It is also **deterministic** and **discrete**, as there are a set number of possible actions (see section 2.2), and they always have the same output (e.g. if an agent has money and a share is for sale he is always going to be able to buy that share). While the agent is deliberating the game stops therefore the environment is **static**. The environment is **non-deterministic** as some shares can have random value changes between rounds (see section 2.3.1). It is also **non-episodic** because the rounds are dependent on each other, and the agent's actions have impact in the evolution of the shares' value. This is adequate as is similar to a tabletop game.

2.3.1 Types of Shares. The value of shares depends on several factors and is calculated at the end of each round:

- **Supply and demand**: if at the end of the round there are more shares of company A for sale than in the previous round, the value of A's shares decreases. Likewise, if there are less for sale than in the previous round its' share value increases.
- **Complementary industries**: if two companies are complementary, their value increases proportionally.
- **Competitor companies**: if two companies are competitors, their value changes inversely.
- **Random shares**: some shares are going to have random fluctuations in value.
- **Global events**: sometimes, randomly, global events can take place. For example:
  1. COVID19: after a global pandemic the value of retail companies' decreases
- **Card events**: each round the player plays a dice (1 in 6 chance) to take a chance card, such as:
  1. Inheritance: a distant relative died and the player receives a certain amount of money.

We choose this events based on the original game we based our project in.

2.3.2 Scenarios. When simulating the game we will be able to choose a scenario. Some scenarios include:

Default the default scenario according to Section 2.3.1;
Recession the value of all shares is more likely to decrease;
Inflation the value of shares is more likely to increase;
Random all shares have random increases and decreases.

These scenarios are relevant to learn more about the nuances of agent behavior in different circumstances.

2.3.3 Revenue. The player can gain money two ways: by selling shares to the central bank or by earning dividends. After each round the central bank calculates the dividends each players is due from the shares they own. Because this is a simple game the dividends are calculate for each agent accordingly with formulae 1:

$$dividend = \sum_{s=firstShareName}^{lastShareName} \Delta(valueOfShare(s) \times \text{x}) \quad (1)$$

x : profit multiplier (can be tuned)

3 Evaluation

The main goal agents have is maximize their value. To measure the agents' value we used a metric similar to *wealth* used by Souissi et al. [3] where for each agent:

$$agentValue = moneyValue + \sum_{s=firstShareName}^{lastShareName} valueOfShare(s) \quad (2)$$

In each round we can use the following metrics:

- agent value (money in wallet+share value, eq. (2));
- agent share value;
- agent money in wallet;
- dividend revenue (see Section section 2.3.3).

At the end of the game we can see how the agents evolve throughout the game. We plan to compare how agents with different strategies (see Section 2.1) perform against each other. How different combinations of agents perform. If the number of agents in the game has an impact.

Settings related with the percentage of dividends, share' fluctuations and environment entropy can be fined tuned and tested. We aim to learn more about how different strategies play out and if planning has any impact on the agents' results.

References

[1] Katalin Boer-Sorban. 2008. *Agent-based simulation of financial markets: a modular, continuous-time approach.* Number EPS-2008-119-LIS.

[2] Miguel Prado. 2021. Wall Street Bets: o fenómeno que está a agitar as bolsas dos EUA. https://tinyurl.com/53kv5h53

[3] Mohamed Souissi, Khalid Bensaid, and Rachid Ellaia. 2018. Multi-agent modeling and simulation of a stock market. *Investment Management* (2018).