How Game Theory is used to Predict Stock Market Trends

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Abstract: This paper explores the use of Game Theory to analyze data collected from the stock market, model our findings, predict decisions made by businesses and understand what scenarios will produce a stable stock market. Next, we understand the basis of Game theory and Investing techniques, then we talk about the greater fool theory and Zero-Sum Analysis. Then the Basic Game theory metrics. Towards the end, we look at how game theory has the potential to evolve stock market trading in the future. More specifically, we expect to find the impact changes in the stock market have on each business and predict the behavior, or the "best next move," they should have.

1. Introduction

To begin, "the stock market is a financial organization that connects potential buyers and sellers of a company's equity" [3]. At its foundation, the stock market is a company. A business is financially stable if it is efficient with its resources, profitable, make prudent investments, and rises in wealth, according to our definition. In order to improve an economy's performance, a corporation must be profitable. Furthermore, the system must be capable of dealing with financial imbalances produced by internal problems or unforeseen external events. This suggests that a corporation trading on the stock market must be able to withstand adversity and stay in the game if they make poor investment choices or a rival company takes some action. Stock market businesses will benefit from the Game Theory approach to obtaining financial stability.

In the game, players make choices that are best for them while also taking other players' actions into account. Our definition of financial stability includes both success and survival, which is exactly what a player wants [9].

2. What is Game Theory?

In the 1920s, Emile Borel and John von Neumann developed Game Theory to help us understand interactions between decisionmakers [5]. It is properly defined as the study of mathematical models of the strategic interactions of rational decision makers. Von Neumann differentiated two kinds of games: "Participants make judgments in the first category, rule-based games." interact according to predetermined 'rules of engagement' The second category is uninhibited. "Participants in games participate without regard for external limitations." [2].

Business, namely the stock market is a cross between these two types of games. Game theory is incredibly versatile and may be used to a broad variety of situations. According to Franklin Allen [1] "game theory has provided an approach that has led to insights into numerous previously incomprehensible phenomena by allowing asymmetric information and strategic information to be included in the investigation." Among the most common applications of game theory are economic theory, political science, and psychology.

Economists studying a specific economic environment can use game theory in business to foresee the moves of companies (or players). It may also be used by private companies to make business decisions or to strategically monitor and assess the many aspects and competitive behaviours inside their relevant economy. Business instructors may also use game theory models to educate their pupils a set of techniques and various solution concepts that they may encounter in the real world.

Game theory may help firms make strategic decisions within and outside of their organizations, especially while competing. Simple games that create hypothetical circumstances in order to simulate real-world occurrences and predict a player's behavior are used to demonstrate diverse situations.

2.1 Prisoners dilemma

The prisoner's dilemma is a well-known and essential tactic in game theory. This topic looks at the decision-making process utilized by two people who, by acting in their individual best interests, end up with worse outcomes than if they had collaborated in the first place.

In the prisoner's dilemma, two suspects apprehended for a crime are separated and unable to communicate with one another. The prosecution informs Suspects 1 and 2 individually that if he confesses and testifies against the other, he will be released; however, if he does not cooperate and the other suspect does, he will be sentenced to three years in prison. If they both confess, they will face a two-year jail sentence. If both confess, they will be sentenced to two years in prison; if neither confesses, they will be sentenced to one year in prison.

While collaboration is the best option for the two suspects, research suggests that in such a situation, most rational people choose to confess and testify against the other person rather than keep silent and risk the other individual confessing.

It is assumed that game players would be rational and will want to maximize their payoffs.

	Prisoner 2	
	Quiet	Confess
Prisoner 1 — Quiet	$(1, 1)$	$(4, 0)$
Prisoner 1 — Confess	$(0, 4)$	$(3, 3)$

Matching Pennies

This is a zero-sum game in which two participants (let's call them Player A and Player B) simultaneously place a penny on the table, with the pay-out decided by whether the pennies match. If both pennies are heads or tails, Player A wins and keeps Player B's coin. If they do not match, Player B wins and keeps Player A's penny.

Business competition Inclusion - Cournot model

This model is connected to the prisoner's dilemma and is named after Augustin Cournot, a French mathematician who devised it in 1838. The Cournot model is most typically used to describe a market with a duopoly or two dominant manufacturers.

Assume that firms A and B produce the same product in big or small quantities. If they both collaborate and agree to manufacture at low levels, the commodity's limited supply will result in a high market price and considerable profits for both businesses. If they do not defect and produce at a high level, the market will become saturated, resulting in a low price for the product and, as a result, lower revenues for both.

However, if one cooperates (i.e., produces at a low level) and the other defects (i.e., produces at a high level), the former just breaks even while the latter profits more than if they both cooperate. The incentive matrix for companies A and B is shown (figures represent profit in millions of dollars). As a result, if company A cooperates and produces at a low level and company B defects and produces at a high level, the pay-out is as shown in cell (b)—break-even for company A and $7 million in profits for company B.

Cournot Payoff Matrix		Company B	Company B
		Cooperate	Defect
Company A	Cooperate	(a) 4, 4	(b) 0, 7
	Defect	(c) 7, 0	(d) 2, 2

How Can Companies Apply Game Theory in Competitive Situations?

Cournot competition, for example, is an economic model that explains an industrial structure in which competing businesses that offer the same product compete on the quantity of output they create independently and concurrently. It's essentially a prisoner's dilemma game.

3. Data collection and analysis

The information will be taken from the Nasdaq online stock market database, and we will record the stock price and share volume for each firm in order to compute payback values.

The stock price of each stock is the price at which it is sold. We chose to record it because we believe it will offer us with valuable information on how the company is operating on the surface. Share volume refers to the number of shares traded in a certain time period. We chose to record it since it will provide us additional information about how the company is operating on a deeper level. The effort required to move stock prices is quantified by share volume.

3.1 Data

In March 2020, for example, information on the stock prices and volume of shares of Apple, Microsoft, and Google right after Covid-19 was declared a worldwide pandemic.

	3/5	3/10	3/16	3/20	3/25	3/30
Stock Price	292.92	285.34	242.21	229.24	245.52	254.81
Vol of Shares	46,893,220	71,322,520	80,605,870	100,423,300	75,900,510	41,994,110
Variation	8.14	17.07	19.08	23.83	13.95	6.12

Table 4.1: Apple

Data type\Date	3/5	3/10	3/16	3/20	3/25	3/30
Stock Price	166.27	160.92	135.42	137.35	146.92	160.23
Volume of Shares	47,817,250	65,354,390	87,905,870	84,866,220	75,638,220	63,420,330
Variation	5.18	8.45	14.35	11.24	9.89	10.59

Table 4.2: Microsoft

Data type\Date	3/5	3/10	3/16	3/20	3/25	3/30
Stock Price	1319.04	1280.39	1084.33	1072.32	1102.49	1146.82
Volume of Shares	2,561,288	2,611,373	4,252,365	3,601,750	4,081,528	2,574,061
Variation	53.81	62.38	77.83	78.50	62.89	55.15

Table 4.3: Google

As an example of more detailed market swings, the table below shows data for the same three stocks at an hourly rate on April 10, 2020.

Stock\Hour	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm
Apple	268.30	270.10	269.43	264.25	265.96	266.04	263.13	260.17	259.43	258.45
MSFT	169.36	169.81	167.95	165.50	166.33	167.30	166.34	164.48	163.46	163.08
GOOGL	1219.09	1220.50	1214.18	1191.63	1198.98	1207.19	1202.69	1196.55	1186.51	1184.00

Table 4.4: Hourly data

3.2 Findings

The table clearly depicts a steep drop in the market value of Apple, Google and Microsoft. This is a direct result of the pandemic as production was at halt, unemployment at an all-time low and consumers where at home under lockdown to prevent the pandemic from spreading. Consumer behaviour plays a major role in Predicting the stock market trends. Higher the purchasing power, higher will be their demands.

4. Profits (Game theory and Stock Market)

Our daily lives are pervaded by game theory. We can use game theory to assist us make daily strategic decisions. So, why not use game theory to boost stock market returns? We should use game theory to improve our financial performance.

In reality, it's "The strategic interaction of all investors trying to figure out how all other investors feel about a stock, each of whom knows that everyone else is going through the same decision process, is Sentiment".

Stock market assessments of regular investors or speculators in terms of various investing approaches and different players (investors) (in game theory format). The basic idea stated by Hunt was that traders should properly foresee other participants' investment decisions and then devise profit-maximizing strategies for themselves based on those decisions.

Because of the vast number of participants and different types of actors (investors, Federal Reserve, governments, enterprises) in the stock market, as well as the sheer quantity of methods, this game theory issue is highly tough (buy, short, hedge, limit orders, stocks, bonds, real estate). This is in contrast to value investing, which maintains that investors should not put too much stock on the opinions of other investors [11].

Assume you're debating whether to buy or sell Tesla with a 6-month holding period (you are a short-term investor). If you opt to go long, you will earn if the majority of other investors (in terms of investment money and investor population) also go long. As the table illustrates, if you agree with the general market sentiment, you will earn in the short term. You will lose in the short run if you disagree. In this basic case, there is no pure strategy Nash Equilibrium or dominant strategy.

Your earnings are decided by how well you foresee the majority of other investors' investment decisions, yet the stock market and its investors are tough to predict. Nash Equilibrium outcomes, as we learned in class, are ones in which no investor would want to change his or her strategy.

It seems to reason that the stock market is rarely in a Nash equilibrium, which explains why it is so volatile and fast-paced. After all, the stock exchange is a place where people go to gain money, not to find peace. Following this theory explains why the stock market is so erratic. In contrast, game theory may make it easier to examine and comprehend in certain contexts.

| | | Majority of Other Investors | |
		Long	Short
You	Long	(10,10)	(-20,40)
	Short	(-20,40)	(10,10)

The Greater Fool Theory

According to the Greater Fool Theory, during a market bubble, one can profit by acquiring overvalued assets and then selling them for a profit, because there will always be someone willing to pay a Greater price [9].

A Greater Fool Theory investor will buy potentially overvalued assets without regard for their intrinsic value. This speculative approach assumes that you may earn by speculating on future asset values and that there will always be a "greater fool" willing to pay more than you did. Unfortunately, when the bubble bursts (as it always does), there is a massive sell-off, leading asset values to collapse precipitously. You might lose a lot of money if you are the last person holding the asset and cannot find a buyer during the sell-off.

The Greater Fool Theory becomes important in the stock market when the price of a company climbs so significantly that it is driven by the notion that buyers for the shares can always be found, rather than by the firm's underlying value (cash flows). According to this theory, any price can be justified since another buyer is willing to pay even more.

The Zero-Sum problem

The Zero-Sum assumption in game theory explains the occurrence in which the net change in the benefits or wealth of all market players equals zero. One investor's loss is another investor's gain in the 'futures and options' market, which is sometimes considered as a manifestation of this concept.

Long-term investing, on the other hand, generates either a 'positive sum' or a 'negative sum' phenomenon, allowing for wealth accumulation and subsequent improvement in future production, savings, and investments. This implies that over time, all market participants may be "winners" or "losers."

In contrast, intraday trading is primarily a 'zero-sum' game. Everyone wants to be the first to buy a rising stock, which is an important element of game theory decision making. Individual losses are worsened by the payment of GST, brokerage, and securities transaction fees, transforming the game from a 'zero-sum' game to a 'win-win' game.

Dominant trading Strategy

A dominant trading strategy has the same cost as another but is certain to outperform it and exists if it is possible to start with no money and guarantee a trading profit.

Traders believe that in order to make the most use of game theory, they must first define their "dominant strategy" in the stock market. A 'dominant strategy' is one that yields the highest payoff after taking into account all other viable alternatives considered by a player. This, however, is never achieved, much as a 'nash equilibrium' point in the stock market is never seen (a 'nash equilibrium' position is when the parties do not desire to amend their decisions since the outcome would not be affected by the other party's decision at the time).

As a result, even over a six-month period, the stock market is experiencing heightened volatility and unpredictability.

5. Price Data Sets

First, we estimated Apple, Microsoft, and Google's average stock price, daily high and low stock prices, and share volume in 2019. The average stock price of each firm was then charted during the course of 2019 (see Figures 6.1, 6.2, 6.3 below).

Figure 6.1: Apple (AAPL) Stock Price

**Figure 6.2: Microsoft (MSFT) Stock Price**

Figure 6.3: Google (GOOG) Stock Price

[9] Because general stock prices have always varied, this data should be standardized before it can reflect market variations more effectively. To acquire the normalized stock prices for each business, we took the daily stock price and divided it by the yearly average stock price. The corresponding graphs are displayed below in Figures 6.4, 6.5, 6.6.

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Figure 6.4: AAPL Normalized Price
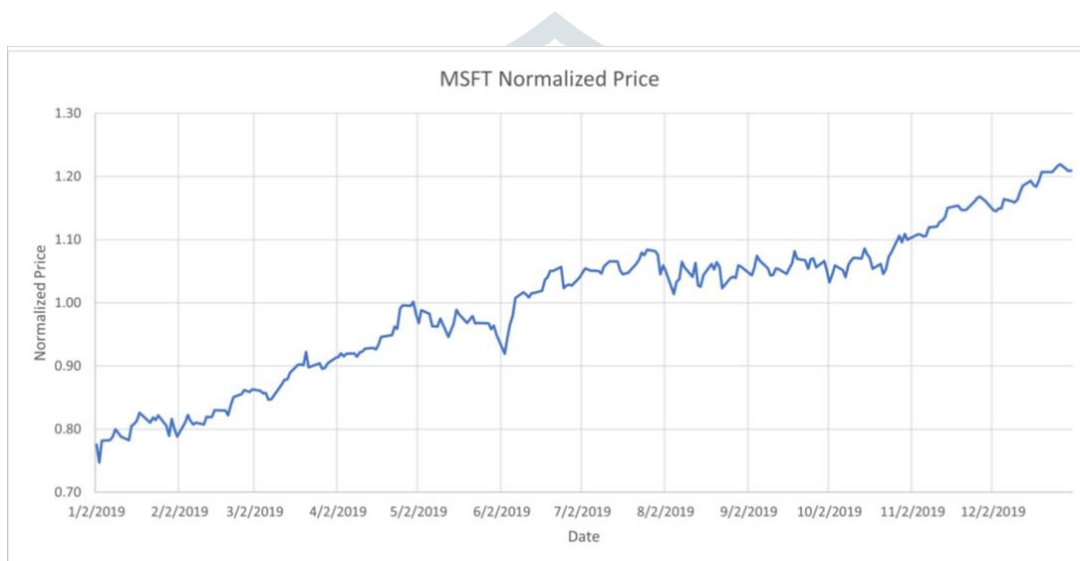
Figure 6.5: MSFT Normalized Price

Figure 6.6: GOOG Normalized Price

As seen from the graphs, the volume of stocks has been steadily increasing.

6. Game Theory and Cryptocurrency trading

Game theory is critical to the growth of cryptocurrencies, and it is one of the reasons why Bitcoin has lasted over a decade despite several attempts to disrupt the network.

To explain the incentive structures behind distributed blockchain systems, crypto-economics blends game theory, economics, and cryptography. [10] Understanding rational nodes engaging within a network using game theory improves the security and sustainability of distributed peer-to-peer networks. Miners must establish consensus on which block to approve since blockchain is a distributed synchronized database comprising verified blocks (i.e., transactions). In the case of Bitcoin, each new block is validated by miners solving a computationally challenging issue.

Investing in cryptocurrency creates a whole different dynamic. Unlike traditional financial markets, in normal conditions, anybody, everywhere, at any time has access to cryptocurrencies and a say in determining the underlying asset's value. This "populated interference" with the market complicates anticipating an item's price.

However, because humans share common behavioral patterns, knowing game theory may help predict an asset's value based on how market participants react to the asset's fundamentals.

For example, in FUD (fear, uncertainty, and doubt) situations, such as the recent Russia-Ukraine conflict, market participants are concerned about how it will affect the price of their assets and commonly refer to prior instances of war.

Cost Benefit Analysis (CBA)

Cost Benefit Analysis is defined as [7]"a systematic method of evaluating the advantages and disadvantages of various solutions."

If we have two possibilities, cost-benefit analysis, like the fundamental risk-reward analysis, analyzes what it costs and takes to pick one of them. A favorable CBA position in cryptocurrency investment Choosing between two Defi projects to buy on Solana. You might weigh the expense (the amount you're investing in relation to your portfolio or pocket size) against the benefits (the possibility that your token increases in price and the expectations).

A decent CBA is never a bad investment in general.

7. Conclusion

In this paper, we looked at various Game Theory models and data analytic approaches for studying stock market behavior. In the future, one may merge the two concerns and create a game theory model that illustrates the Nash equilibrium of the data we obtained. Combining game theory with the crypto currencies could be a groundbreaking result in finding major investments and lower the market volatility rate.

All of this boils down to the capacity to receive signals and market information while predicting and absorbing the judgments of other market participants. While the stock market does not quite fulfill the criteria of game theory, an investor can develop 'dominant tactics' to make a marginally higher profit than other investors or minimize losses on their bets.

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