ANALYZING OLIGOPOLY
COMPETITION IN GAME THEORY
USING MONTE CARLO SIMULATION

THE COURNOT MODEL

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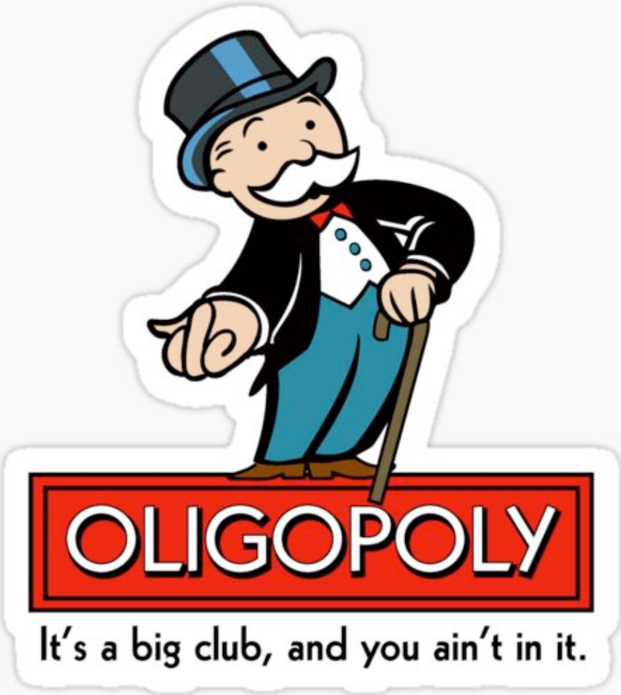
AGENDA

- Game Theory
- Oligopoly Market
- Cournot Model
- Demand Supply Curve
- Simulations(1-6)
- Conclusion



GAME THEORY

- Game theory studies how people make choices in situations where their decisions affect each other.
- Players pick strategies, and the outcomes depend on what all the players choose.
- The results or payoffs can be rewards, profits, or losses based on everyone's decisions.
- Nash equilibrium is a key idea where no player can do better by changing their strategy.
- It is used in economics, biology, politics, and more to understand behavior and make smarter decisions.
- Game theory helps predict behaviors and make strategic choices in many real-life situations.

OLIGOPOLY MARKET

- Oligopoly markets are dominated by a small number of powerful firms.
- These firms actions significantly affect each other due to their interdependence.
- Entry barriers are high, making it tough for new competitors to enter.
- Pricing strategies involve careful calculation due to mutual influence.
- Competition extends beyond prices, including advertising and innovation.
- Demand for products can be responsive to price changes.
- Collusion among these firms sometimes occurs, but it is regulated.
- Despite few players, they often hold substantial market control.
- Governments regulate oligopolies to maintain fair competition and prevent monopolistic behavior.

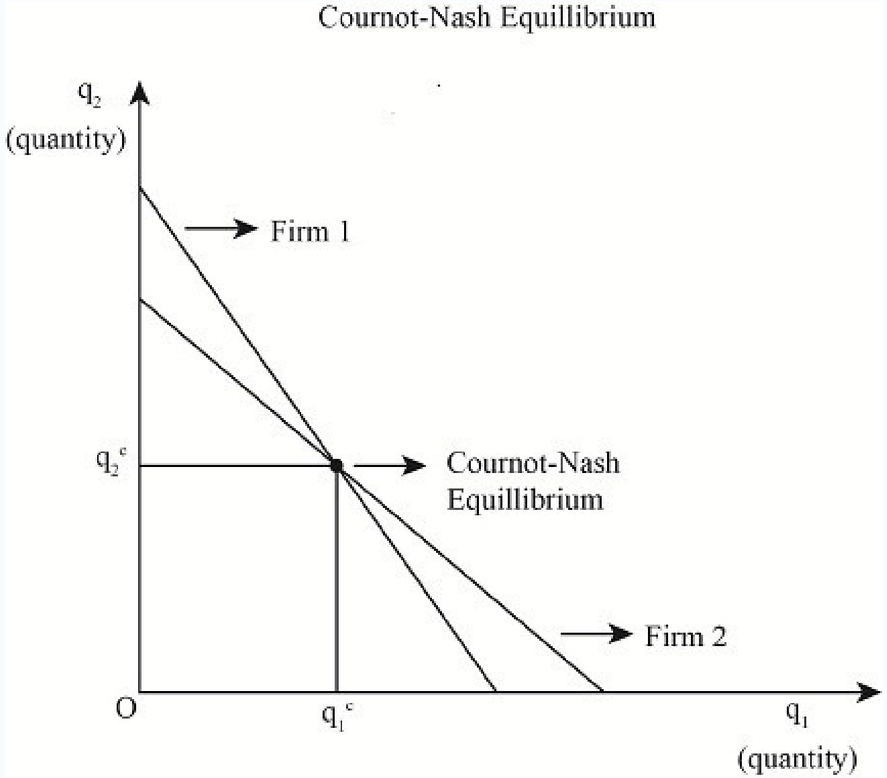
Ex: Coca Cola & Pepsi; T-Mobile, Verizon & AT&T, Marvel & DC

THE COURNOT COMPETITION

The Cournot model, named after the French economist Antoine Augustin Cournot, firms compete in quantities rather than prices. The Nash equilibrium in the Cournot model represents a situation in which each firm, given the quantity produced by its rivals, maximizes its profit by choosing the optimal quantity to produce. At the Nash equilibrium, no firm has an incentive to unilaterally change its quantity because any deviation would result in a lower profit.

The Cournot model assumes the following:

- Number of Firms (n): There are n identical firms in the market.
- Output Decision: Each firm decides its quantity of output to maximize its profit, taking into account the quantities produced by its rivals.
- Homogeneous Products: Firms produce homogenous (identical) products.
- Simultaneous Decision: Firms make their production decisions simultaneously!
- The profit-maximizing condition for each firm is based on the marginal revenue and marginal cost.



Graph of Cournot Model:

The graph usually shows quantity on the x-axis and price or revenue on the y-axis.

Demand Curve: It's a downward-sloping line showing how many products customers will buy at different prices.
Reaction Functions: Each company's line on the graph shows its best response (how much to produce) based on what it thinks the other company will produce.
Intersection: The point where these lines cross is the equilibrium, showing the quantity each company will produce and the resulting market price.

This model is commonly used to analyze Oligopoly markets where a small number of firms dominate the industry

THE COURNOT COMPETITION

Following are the variables which have been used to model the Cournot competition using Monte Carlo Simulation.

- number of iterations
- demand curve coefficient mu
- demand curve coefficient sigma
- Cost of production (Ci)
- Quantity of Production
- Market Demand

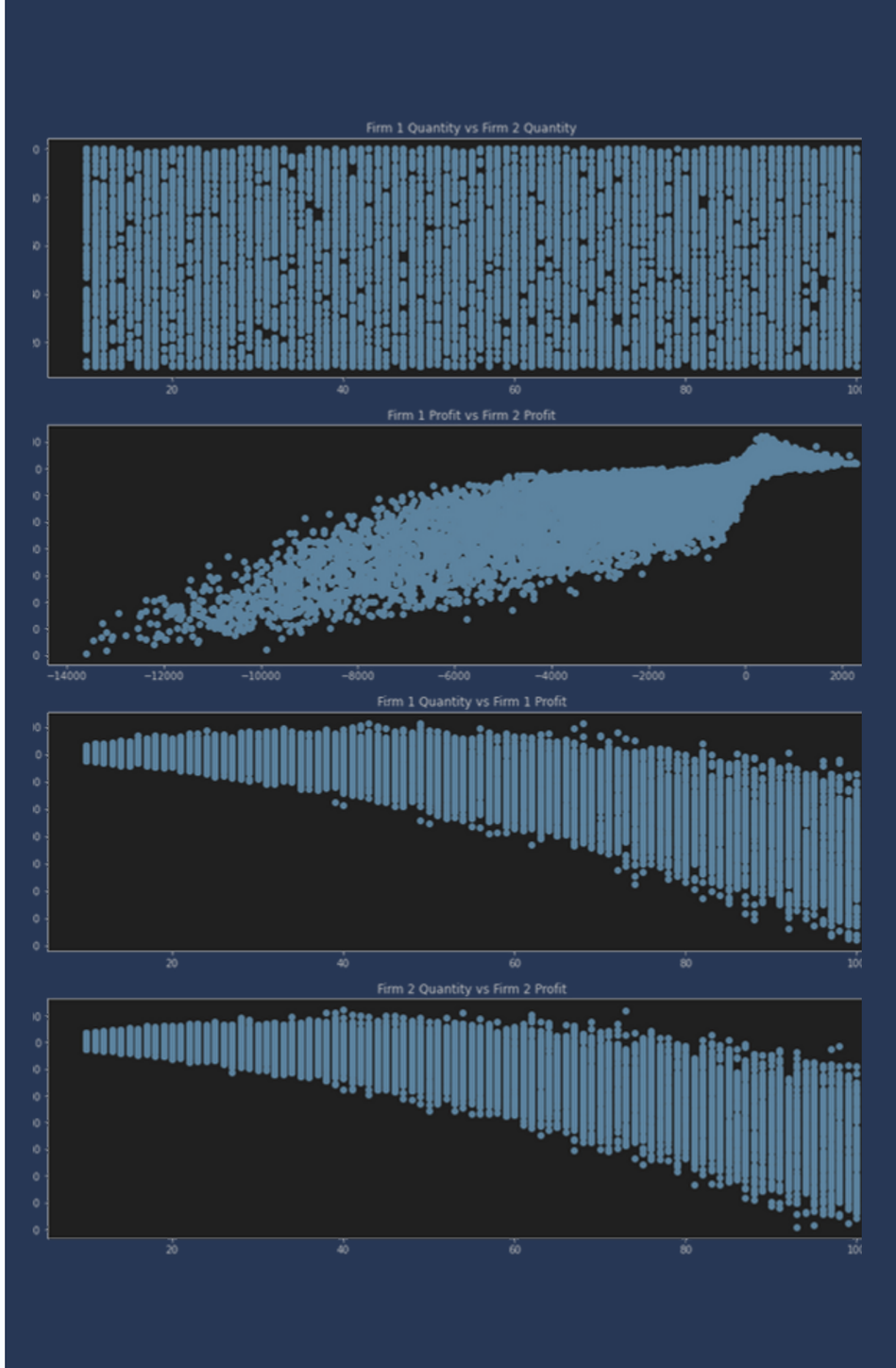
SIMULATION 1

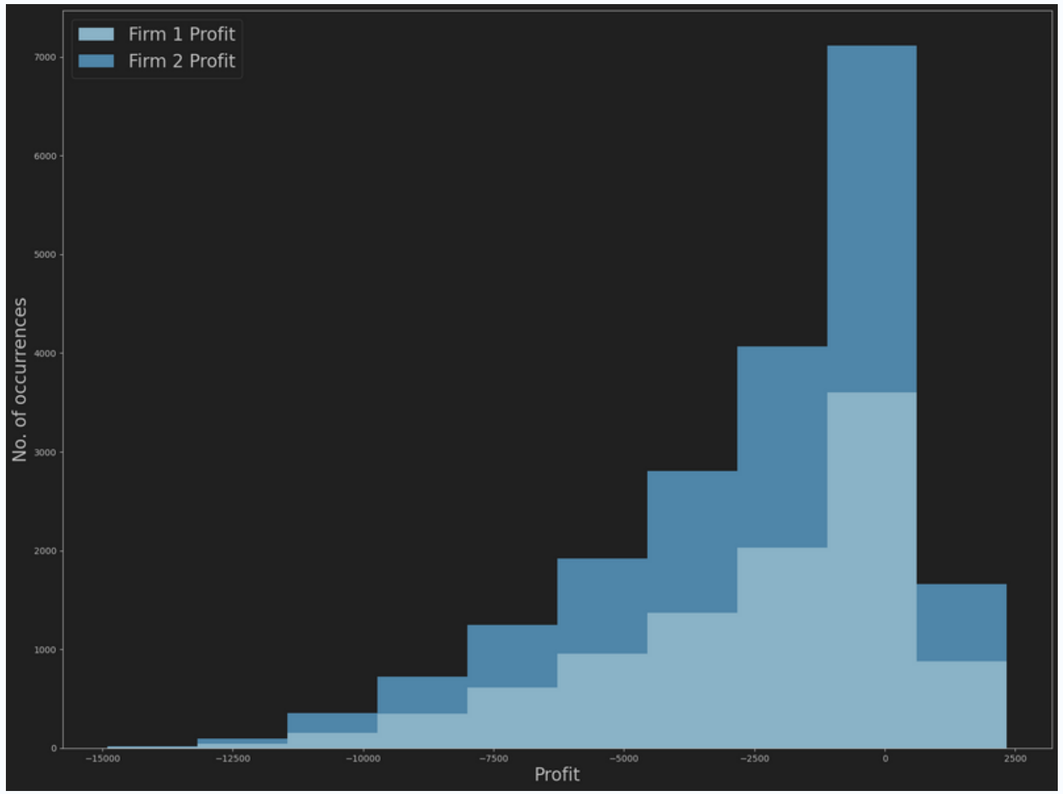
FIRM 1 & FIRM 2 HAVE RANDOM QUANTITY OF PRODUCTION

Simulation 1 delineates a truly random scenario wherein all variables in question are randomly chosen.

Mean Profit for Firm 1: -2413.2882
Mean Profit for Firm 2: -2552.9929

Out of 10000 iterations, Firm 1 made a profit 27.86% of the time, Firm 2 made a profit 27.18% of the time, and both firms profited simultaneously 26.36% of the time.





F1 VS F2 PROFIT

CONCLUSION

In a truly random scenario, both firms undertake heavy losses for a majority of iterations. If these losses are not optimized and curbed it will make it difficult for the firms to survive in such a market.

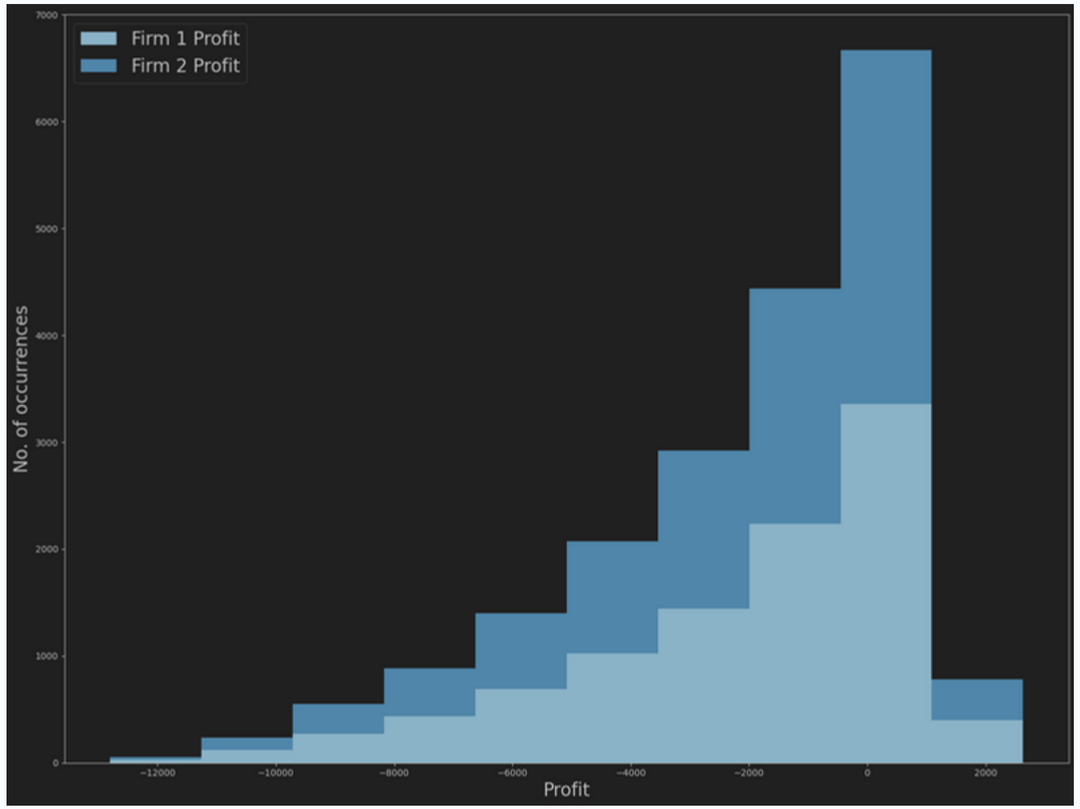
SIMULATION 2

FIRM 1 AND FIRM 2 HAVE LOWER COSTS OF PRODUCTION

Simulation 2 portrays a scenario to figure out whether the cost of production is a significant factor in causing loss.

Mean Profit for Firm 1: -2057.9147
Mean Profit for Firm 2: -2104.552

Out of 10000 iterations, Firm 1 made a profit 27.04% of the time, Firm 2 made a profit 25.06% of the time, and both firms profited simultaneously 24.4% of the time.



F1 VS F2 PROFIT

CONCLUSION

In a truly random scenario with a cheaper cost of production, both firms again undertake heavy losses for a majority of iterations. Although curbing the loss by a small margin, cutting costs is not optimal and it can be safely concluded that the cost of production isn't a significant factor when it comes to making a profit.

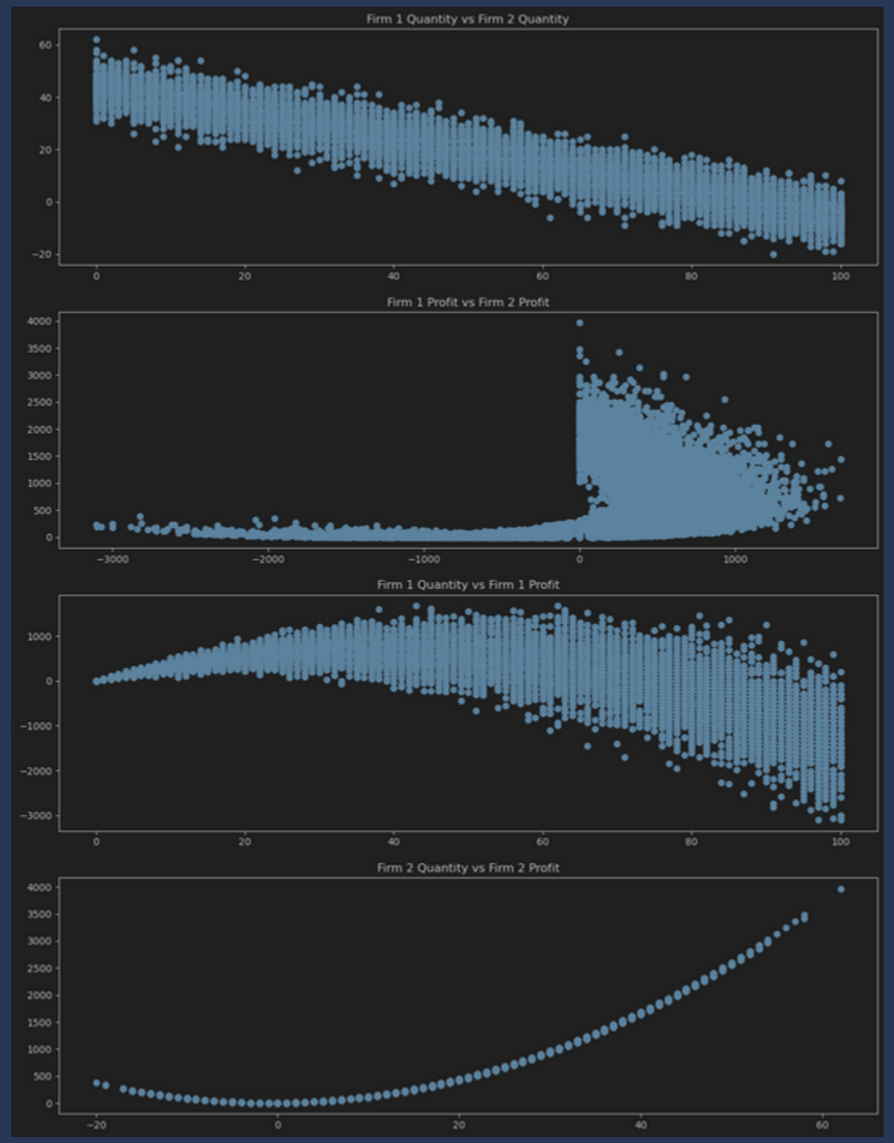
SIMULATION 3

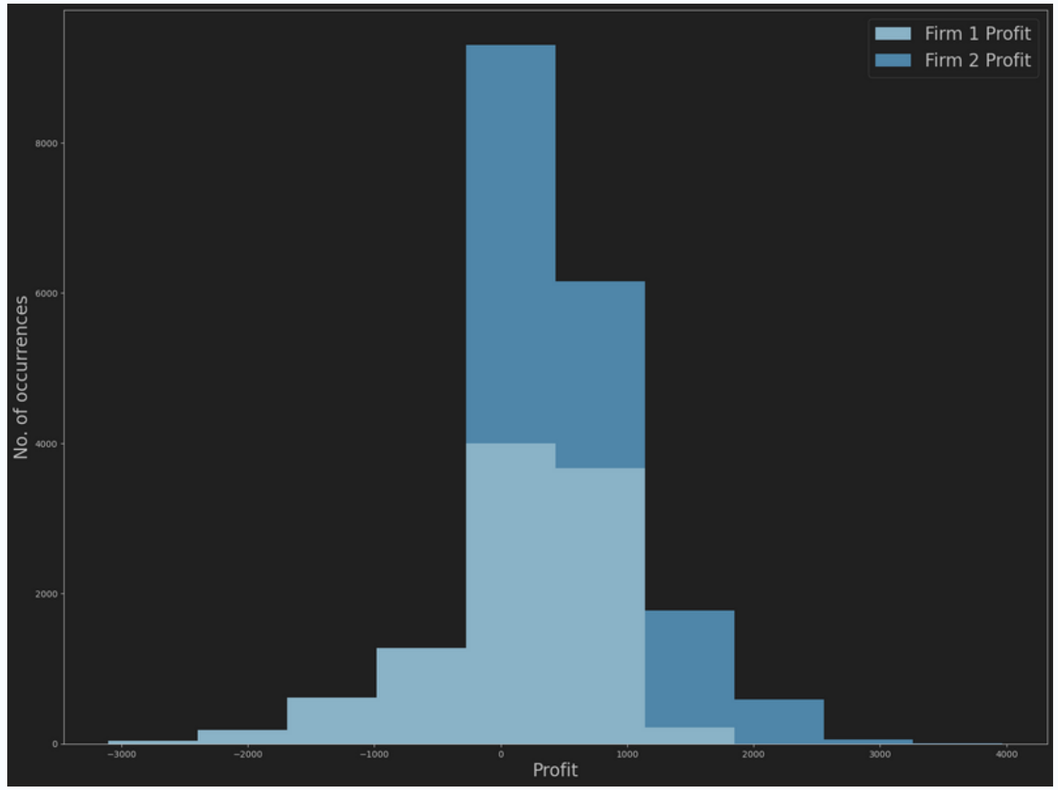
FIRM 2 HAS OPTIMIZED QUANTITY OF PRODUCTION

Simulation 3 portrays a different scenario wherein we try to optimize the quantity of firm 2 based on the quantity firm 1 produces. This is possible as quantities are simultaneously chosen and not concurrently.

Mean Profit for Firm 1: 141.1328
Mean Profit for Firm 2: 617.8894

Out of 10000 iterations, Firm 1 made a profit 69.56% of the time, Firm 2 made a profit 95.52% of the time, and both firms profited simultaneously 69.25% of the time.





F1 VS F2 PROFIT

CONCLUSION

Finally, it is observed that profits start trickling in. This is a very clear indication that optimizing the quantity of production will lead to higher profits. However, there are still 30% scenarios, where both firms don't profit.

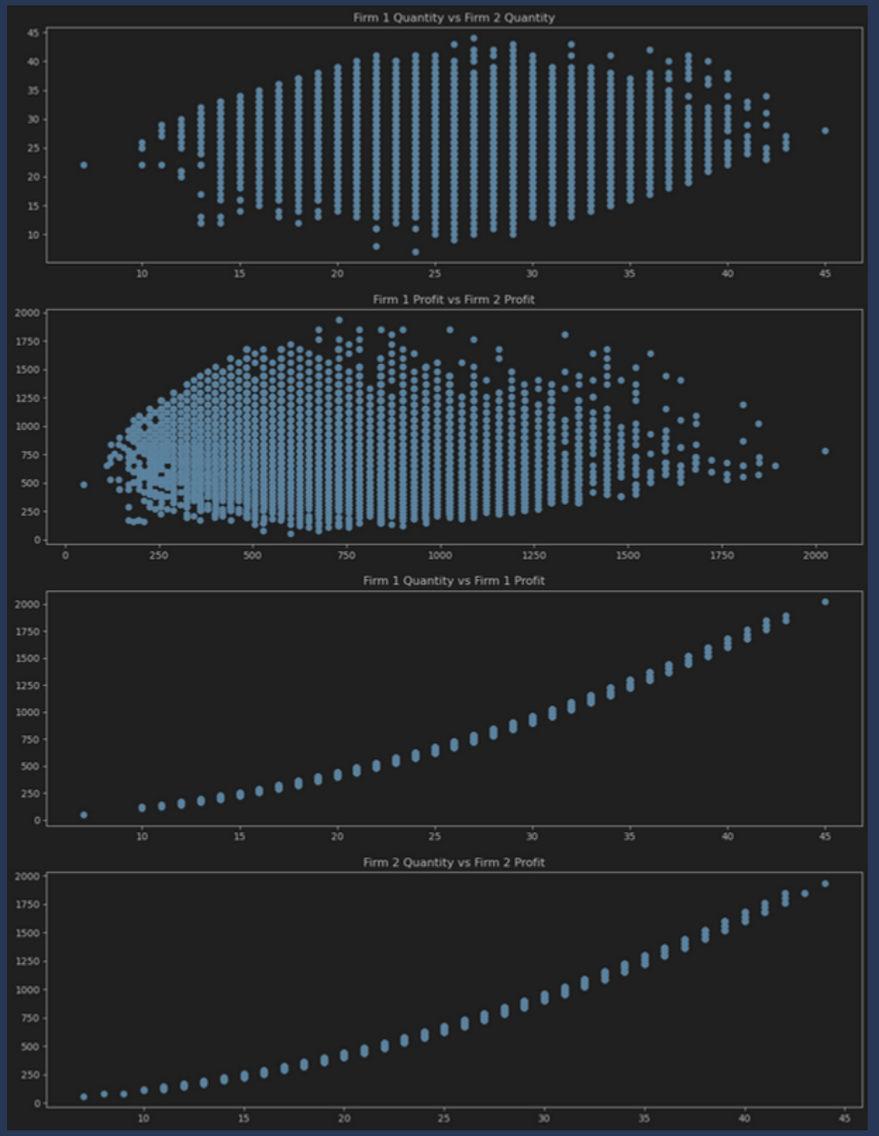
SIMULATION 4

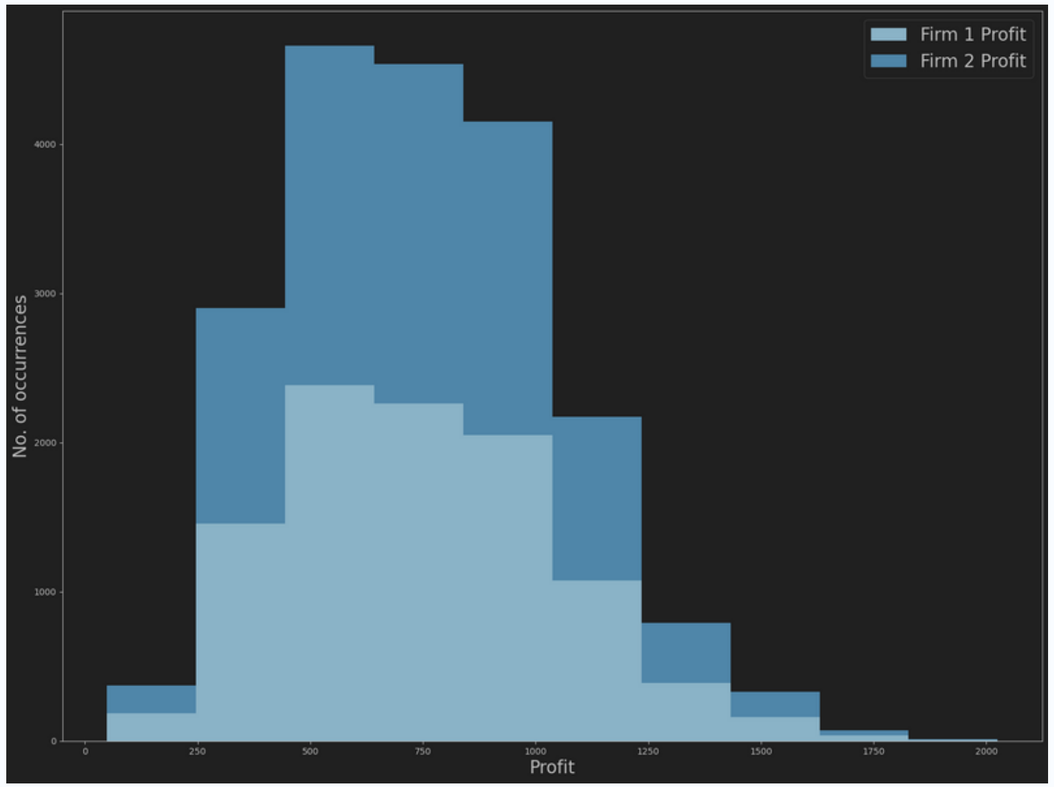
NASH EQUILIBRIUM

The Nash equilibrium is achieved when each firm chooses a quantity that satisfies the profit-maximizing condition, considering the quantities chosen by all other firms. At the Nash equilibrium, no firm has an incentive to change its quantity unilaterally.

Mean Profit for Firm 1: 748.3632
Mean Profit for Firm 2: 753.2239

Out of 10000 iterations, Firm 1 made a profit 100.00% of the time, Firm 2 made a profit 100.00% of the time, and both firms profited simultaneously 100.00% of the time.





F1 VS F2 PROFIT

CONCLUSION

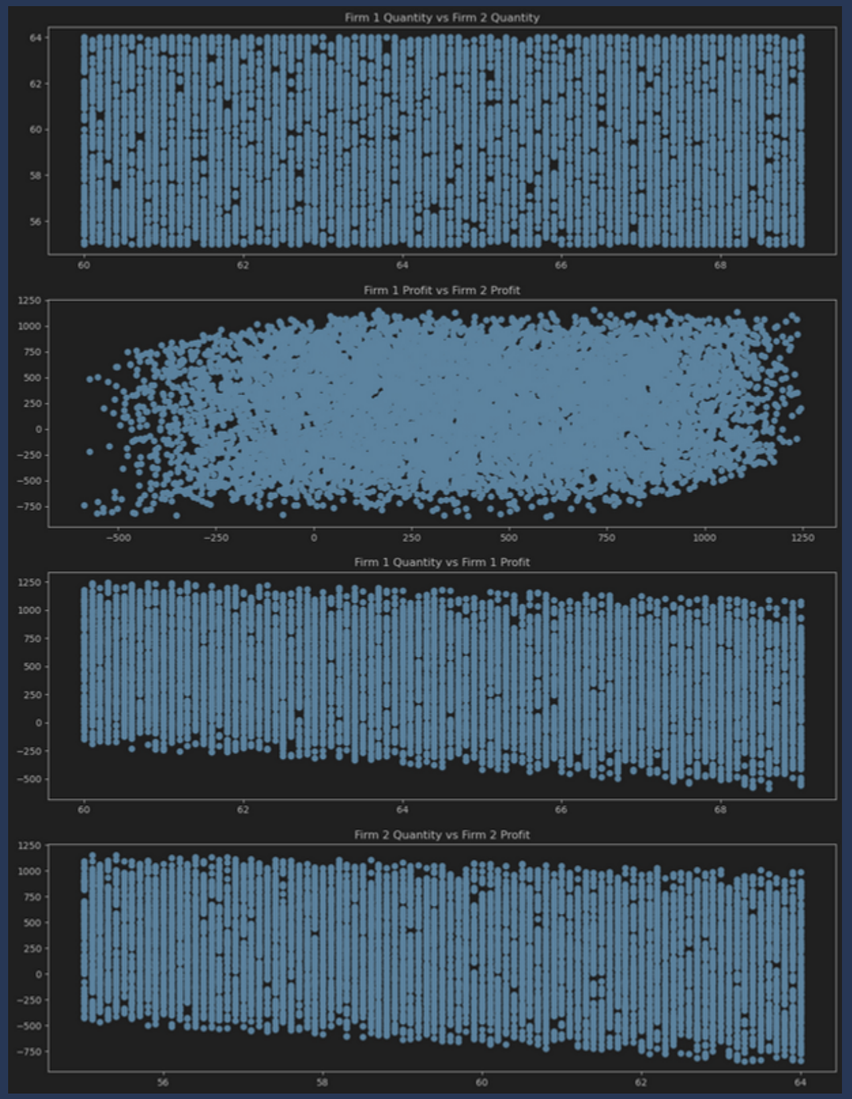
For the very first time, we observe that the profits are graphed in the first quadrant which indicates that both the firms profit for all the iterations in the simulation.

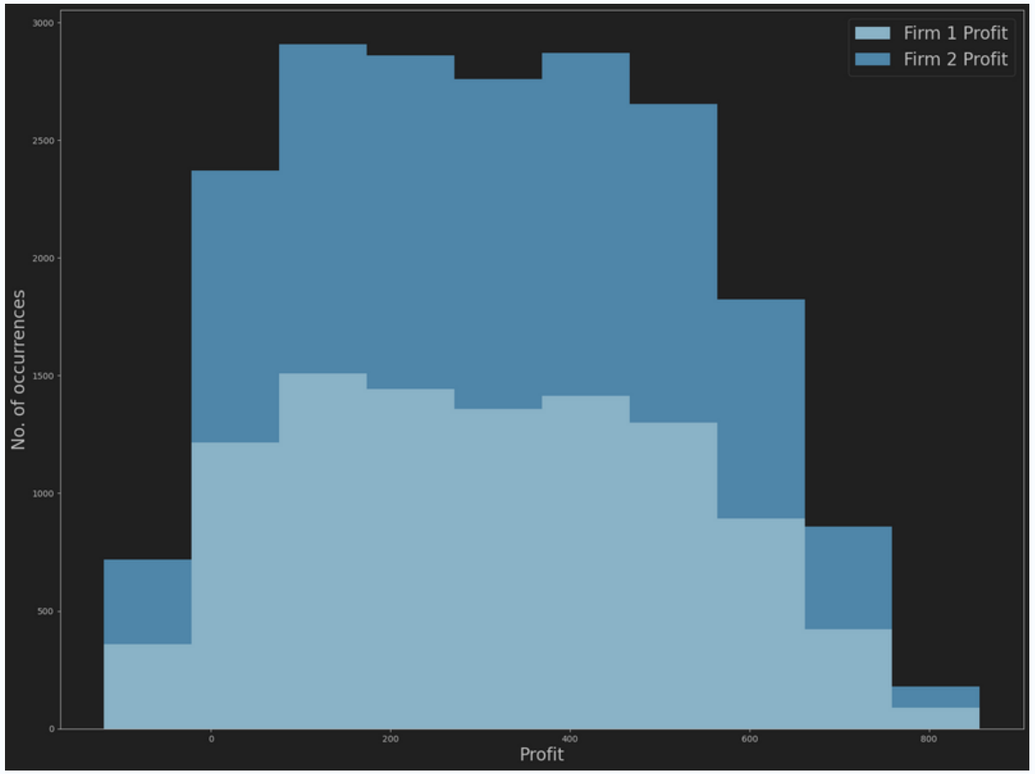
SIMULATION 5

INTRODUCING ELASTIC DEMAND TO THE COURNOT MODEL

Elastic demand refers to a situation in which the quantity demanded of a good or service is highly responsive to changes in price. In other words, when the price of a product changes, the percentage change in the quantity demanded is relatively larger.

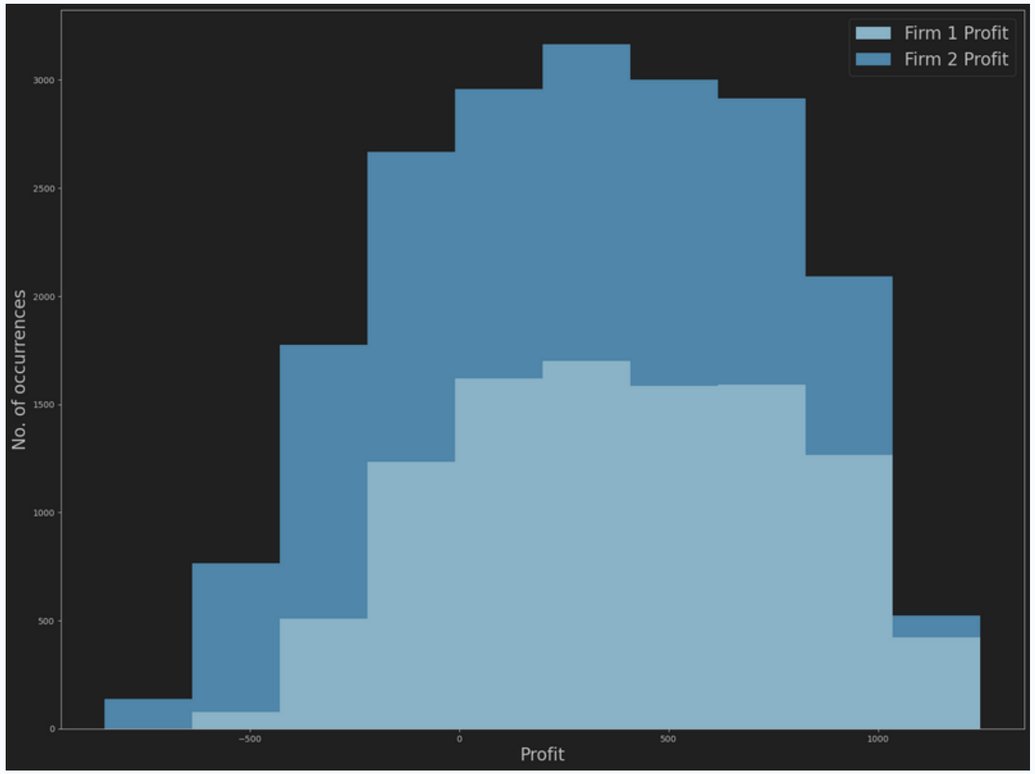
Mean Profit for Firm 1: 312.6217
Mean Profit for Firm 2: 320.3259144





ELASTIC DEMAND

OUT OF 10000 ITERATIONS, FIRM 1 MADE A PROFIT 94.1% OF THE TIME, FIRM 2 MADE A PROFIT 94.3% OF THE TIME, AND BOTH FIRMS PROFITED SIMULTANEOUSLY 89.14% OF THE TIME.



INELASTIC DEMAND

OUT OF 10000 ITERATIONS, FIRM 1 MADE A PROFIT 80.9% OF THE TIME, FIRM 2 MADE A PROFIT 64.07% OF THE TIME, AND BOTH FIRMS PROFITED SIMULTANEOUSLY 52.77% OF THE TIME.

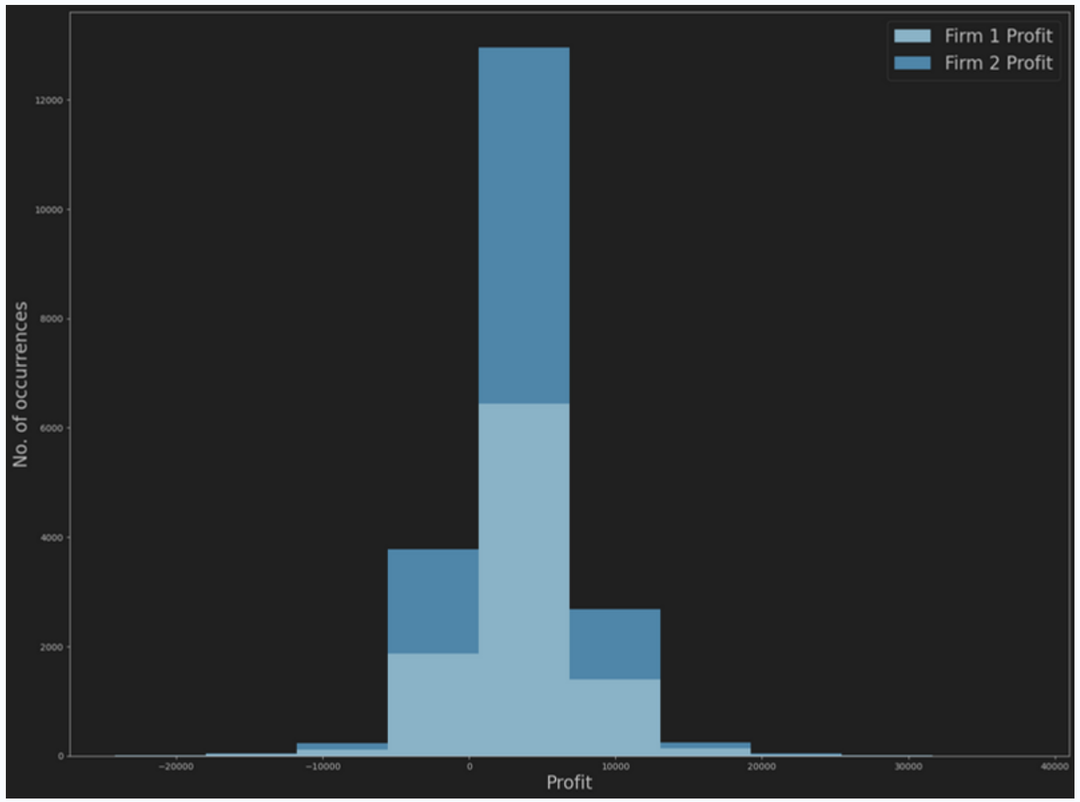
SIMULATION 6

MIMICKING REAL-WORLD SCENARIOS

Saving the best for the last, Simulation 6 shows how a Cournot Duopoly model would perform under real-world scenarios. For this particular simulation, various other variables have been taken into account.

- Demand Shock
- Supply Shock
- Inventory
- Disease Outbreak (p=0.1)
- Inflation (p=0.7)

Mean Profit for Firm 1: 3290.1129091671087
Mean Profit for Firm 2: 3174.7060421412148



F1 VS F2 PROFIT

CONCLUSION

Out of 10000 iterations, Firm 1 made a profit 85.19% of the time, Firm 2 made a profit 85.84% of the time, and both firms profited simultaneously 72.13% of the time

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THANK YOU