# GAME THEORY AND 2 x 2 STRATEGIC GAMES APPLIED FOR MODELING OIL AND GAS INDUSTRY DECISION-MAKING PROBLEMS

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Problem :
To examine relevant realistic and real-world cases of the oil and gas industry in the form of 2 x 2 strategic games, aiming to improve decision-making processes by providing an adequate visualization of the strategic interactions of several situations.

Motivation:
Oil and Gas are valuable natural resources and its supply and demand is greatly affected by conflicts or coordination between agents involved such as consuming and producing nations, governments and companies. We can use classical games such as prisoners dilemma, stag hunt, battle of sexes to analyze players motivation and numerically express payoffs to facilitate decision making process.

Modelling Iran-Qatar conflict over the fields of South Pars and North Dome as **Prisoner's Dilemma Game**:

- Actions are LER or HER, clearly if both nations do LER the payoffs would be high(Pareto optimal), but Nash equilibrium is (HER, HER).
- Currently, Qatar implements HER while Iran implements LER, thus Qatar has more payoff. But It can change as soon as Iran changes its strategy, similar to prisoner's dilemma.

| Iran | Qatar | |
|---|---|---|
| | Low Extraction rate | High Extraction rate |
| Low Extraction rate | 2,2 | 0,3 |
| High Extraction rate | 3,0 | 1,1 |

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Modelling Cooperation dilemma faced by Japanese oil and petrochemical plants as **Stag Hunt Game**:

- Companies can generate higher profits if they coordinate, even if the payoffs are unequal.
- But if any one company breaks the deal and starts operating independently, then the other company can incur huge losses.
- The payoffs are similar to stag hunt game, and players can achieve higher payoffs if they coordinate.

| Company A | Company B | |
|---|---|---|
| | Independent business | Business Cooperation |
| Independent business | 3,2 | 3,0 |
| Business Cooperation | 0,2 | 7,4 |

Modelling Iran-Iraq conflict over the Fakka oil field region as **Chicken Game**:

- The classical game is dangerous form of destructive competition, where two teenagers drive at high-speed towards each other to see who will deviate first.
- Fakka is a common region on the border of Iraq and Iran. If both nations start exploring the region, conflict would occur, which will result in losses.
- If both countries stay away from the region, the resources can be used in the future thus giving higher payoffs.
- If any one nation explores then it generates higher payoff.

| Iran | Iraq | |
|---|---|---|
| | Abandon the region | Stay in the region |
| Abandon the region | 3,3 | 2,4 |
| Stay in the region | 4,2 | 1,1 |

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Modelling Market dominance of OPEC countries and Seven Sisters in the 1960s and 1970s as **Battle of sexes**:

- Here the governments and 7 big oil companies try to control the market.
- High payoffs are generated only if one dominates and other follows, with dominant agent achieving greater payoff.
- But these payoffs are better than payoffs if both agents' strategy conflict with each other.
- The structure is similar to battle of sexes game.

| OPEC Countries | Seven Sisters | |
|---|---|---|
| | Dominate | Acquiesce |
| Full production | A;B | C;D |
| Prorate | D;C | B;A |

B > A > C > D

## Conclusion

- In energy markets or industries such as the oil and gas, these games demonstrated to be useful for modeling and solving potential conflicts in the decision-making processes.
- This paper evaluates realistic and real-world situations faced by the oil and gas industry that used a game theory approach for aiding in the understanding of the strategic interactions and the estimation of the agents' payoffs.
- The topologies of 2 x 2 strategic games have a simplified framework. These topologies were applied to capture the essence of the strategic interaction of realistic interactions, for example conflict between two nations, coordination between companies and governments, cooperation between two companies.

## Gaps and Future Scope

- Several conflicts of interests among the players involved in the oil and gas industry were still not properly addressed by formal methodologies or techniques. The formalization of these potential issues can provide a better understanding and evaluation of real-world situations, consequently improving the decision-making processes.
- A deeper analysis of the oil and gas applications without a more formal and standard form is recommended.