A Glance of China's National Oil Companies' Strategies through Game Theory: CNPC, CNOOC, and Sinopec

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Abstract. As a matter of fact, game theory is a field of study that focuses on addressing how people or organizations interact in an attempt to achieve their goals. As mentioned by experts, this theory can be better called as the theory of conflict and cooperation since if there is conflict, a solution is necessary to deal with it and the possible result would always be according to the interest of the parties involved, either having higher payoffs or not. In this regard, oil and gas resources are highly valued assets, which can lead to conflicts due to varying interests among nations, governments, and companies involved in their exploration. Thus, this study utilized a few strategies of game theory to explore its effectiveness in China's energy sectors, particularly with its largest state-owned oil companies (i.e., CNCP, CNOOC, and Sinopec). It is discovered that through prisoners' dilemma or producers' dilemma, and stag hunt games, these three companies created partnership and joint developments to achieve their goals and maximize their payoffs.

Keywords: Game theory; oil and gas; prisoners' dilemma; stag hunt.

1. Introduction

In accordance with the gas and oil discoveries in the middle of the 19th century, the demand for oil continues to this day, and it is increasing remarkably in each nation, leading to the volatility of oil prices. Even more, oil is a limited resource despite being an asset. This fact prompted National Oil Companies' (NOCs') ascent, which is essential to the world oil market, as they generate most of the global supply in gas and oil, and own assets worth at least $3 trillion, according to Manly et al. [1]. In lieu, this study will focus on China's leading entities in this field: China National Petroleum Corporation, China National Offshore Oil Corporation, and China Petrochemical Corporation (now known as Sinopec) [2]. Subsequently, due to their contributions to the growth of the economy and sustainable energy development, the three government-run energy titans are subject to reforms centered around market and industrial strategies, and are recognized as "national champions" [3].

Game theory is known as the science of interactive decision-making, involving individuals who are cognizant of the consequences of their actions on others. Bratvold and Koch state that the interaction between players, each equipped with a spectrum of strategies, each associated with differing probabilities is formalized through game theory. Moreover, since disagreements will inevitably arise in interactions, the game model offers perspectives on how to cooperate or negotiate in certain situations to reach equilibrium solution [4]. Game theory is used to create strategies for market players to get more payoffs or analyze strategies currently used in the oil industry. Numerous researchers have identified how game theory is applied in three categories: competitive bidding, joint venture partnership, and negotiating [5].

Game theory is an ever more prevalent technique in economics. Economists' contributions to game theory come from a broad range of disciplines and areas of interests, and they frequently combine their research on this theory with complementary fields of study [6]. Moreover, Toufighi and Soltani's study provided a systematic literature review and analysis of oil and gas sector scenarios using game theory. They reviewed 2514 papers from Scopus, which they classified under standard oil and gas supply chain fields which they classified further through types of players, making them come up with the final five classification of the papers. They discovered that 'type-of-game' classification has a higher impact on being cited by other researchers. Nonetheless, the review initiated that this theory on strategy is advantageous for the simulation of scenarios in sector of oil and gas [5]. Further, a study

on Russia's gains from strategic behavior by Haita aimed at uncovering the game-theoretic rationale behind the country's goal to expand its oil production and turn into one of the major players in the world oil market [7].

Several researchers have used game theory to analyze OPEC and non-OPEC members' oil and gas industries, and they have even used certain game types to assess how valuable a decision is. With regard, this paper is motivated to apply game theory, mainly that of the prisoners' dilemma and stag hunt to analyze the steps taken by China's oil leaders in making CNPC, CNOOC, and SINOPEC notable global leaders in the petroleum and energy industry with substantial investment and finance activities [2]. Furthermore, as China is one of the key players in the oil market, it is best to understand the strategies it used to attain such standing nationally and internationally. Nevertheless, this paper briefly describes the importance of this strategic approach in the oil industry and why it is being studied deeply. Followed by describing the games used (Sec. 2) with corresponding scenarios (Sec. 3 and Sec. 4). Then, as this research is discussed further, the author will add the limitations of applying the games in the oil industry (Sec. 5). Finally, Sec. 6 concludes the research.

2. Basic Descriptions

According to Dixit & Skeath, equilibrium is the solving of the game in which each player is using the strategy that each think is the best response to the strategies of the other [8]. However, equilibrium does not mean the strategy employed does not change. This definition implies that a strategy constantly evolves to target the other player's moves. Another note is that equilibrium does not mean everything is for the best since a choice can lead to a bad outcome. Nonetheless, Osborne and Rubinstein insisted that determining strategic interactions of agents while assuming a basic level of reason and considering the expectations of other agents when making decisions are the key contributions of game theory approaches [9].

3. Prisoner's Dilemma or Producers' Dilemma

The most frequently employed application of game theory is the Prisoner's Dilemma, a theoretical scenario involving two detained individuals who are presented with the choice of either confessing to their crimes and implicating the other person or remaining silent [10]. This is exemplified in Table 1. Accordingly, Bratvold and Koch utilized this game to illustrate a practical scenario in the oil industry but called it the Oil Producers' Dilemma. Here, two oil-producing countries produce a certain amount that they assume will optimize their profit in oil as exemplified in Table 2 [4, 10].

Table 1. Descriptions of Dixit and Skeath [8].

		Prisoner an Options	
		Stay Silent	Surrender and be treacherous
Prisoner B Options	Stay Silent	Each spends a month incarcerated.	Prisoner A is released. Prisoner B spends a year incarcerated.
	Surrender and be treacherous	Prisoner A spend full year incarcerated. Prisoner B is released.	Each spends a month incarcerated.

This illustration demonstrates that each country is given two choices that they can opt for. Each then chooses to go with the option they think would procure them a higher income, which they can maximize even if there is an agreement for them to have low production to keep the price high. With this choice, both countries can earn $1400 for 10 barrels of oil produced. However, according to Bratvold and Koch, it cannot be expected that both players will commit to restricting their production without additional contractual enforcement processes [4].

Nonetheless, with regard to energy industry of China, particularly CNPC, the foremost producer of crude oil, either by revenue or volume of production, as written by Carpenter, ranked fifth on the

Fortune Global 500 list with $483,019.2 million in revenue in 2023 [11, 12]. However, it should be noted that as of December 2020, CNPC owns 80.25% of PetroChina Company Limited (PetroChina) and is publicly traded company in numerous areas as in Hong Kong, Shanghai, and New York. PetroChina as described by Pearce is a lucrative company with certified performance that can compete with any global oil firm, leading to an assumption that with PetroChina, CNPC is comparable to international oil companies in terms of efficiency [13]. Nevertheless, under CNPC, oil producers provide the State with their revenues in exchange for direct financial contributions from the Central Government [14].

Table 2. Descriptions of Bratvold & Koch [4], Araujo & Leoneti [10]

		Country B	
		Limited Produce (10 oil barrels only)	Maximized Produce (20 oil barrels)
Country A	Limited Produce	$1400; $1400	$750; $1500
	Maximized Produce	$1500; $750	$800; $800

On the other hand, CNPC's rival is the CNOOC, a state-owned company that explores and produces gas and oil in China's offshore waters. Lu & Todeva stated that Compared to CNPC, CNOOC is more commercial and has a stronger financial position because it is the State's representative in joint projects with foreign companies regarding developing offshore and gas reserves [15]. Moreover, approximately 40% of CNOOC's long-term investments are in overseas exploration contracts, and the company exports a large portion of its output.

4. Stag Hunt Game

In this game, two hunters are said to have agreed to pursue a hare or a stag alone [10, 16]. It is explained that hunting a stag is quite tricky. The likelihood of success for both hunters will be quite low if they choose to pursue a stag by themselves. Both players need to hunt a stag, but it takes dedication and trust. Moreover, it should be noted that detrimental consequences and inability to pursue a stag await the person who has adhered to their incipient promise if the other opts to capture a hare. Based on the historical collaboration of companies operating in Japanese petrochemical and oil facilities, Inaba presented a practical implementation of Stag Hunt that tackled issues of energy conservation, environmental protection, maintaining global competitiveness, and production system reorganization [10, 17, 18]. This scenario is illustrated in Table 3.

Table 3. Descriptions of Inaba [17, 18]; Araujo & Leoneti [10].

		Business B	
		Independent Company	Strategic Collaboration
Business	Independent Company	3; 2	3; 0
	Strategic Collaboration	0; 2	7; 4

Two conceivable approaches can be taken by both companies: (i) carrying on with their autonomous operations; and (ii) adhering to commercial cooperation. The primary objective of this game as emphasized by Araujo and Leoneti is to determine the rewards for both organizations by choosing to constantly pursue independent business or cooperative partnership [10]. From Table 3, business coordination strategy has the highest payoffs, hence, when the two businesses collaborate and carry out combined activities, the results will be greater. On another note, considering China’s CNPC and Sinopec as examples for this game, Pearce observed that CNPC and Sinopec possess

complementary skills and engage in symbiotic relationship, fostering both cooperation and competition. This is so since CNPC has more experience in the market of exploration and production as well as resources invested in them, however, it is generally weak in the refining aspects of the industry; hence, more than ten percent of CNPC's profits of refined and crude oil products comes from Sinopec's marketing and distribution [19].

5. Current Limitations

Game theory, while a powerful analytical tool, has several limitations when applied to the intricate and dynamic environment of the oil industry. One of its key limitations is the assumption of rationality inherent in the theory, which posits that all players act in their best interests to maximize their payoffs. However, in the real world, decision-making is often influenced by a multitude of factors that may not align with the model's rationality assumption, such as political pressures, regulatory constraints, and market uncertainties, as seen in the case of China where policies in the industry of oil and gas had been changing due to political issues (especially ruling party), and with the fact that the central government owns most players in China's oil and gas industry.

Another area for improvement is the oversimplification of strategic interactions within the model. Game theory typically involves a small number of players with well-defined strategies, which may not accurately reflect the reality of the oil industry, where numerous players, including multinational corporations, state-owned enterprises, and individual investors, operate with a wide array of strategies and tactics. The complexity of the industry's supply chains, coupled with the global nature of oil markets, makes it challenging to capture all the relevant strategic interactions within a single game-theoretic framework.

6. Conclusion

To sum up, this study provided an overview of game theory and a few of its types. It related them to specific scenarios in the industry of oil and gas, particularly that of China. The paper's discussions demonstrate the usefulness of this theory in the analysis of oil and gas scenarios, and the subject has a lot of promise for using game-theoretic analysis. As this research relied heavily on previous research regarding game theory’s application in the sector of oil and gas, it is significant to dig deeper into how the strategies are utilized in China’s decision-making processes. This is because most of China’s energy companies are state-owned and part of a particular structure organized by the State. Furthermore, game theory often requires a high degree of information symmetry among players, which is rarely true in the oil industry. Having timely and precise data at hand serves as vital in making wise decisions. However, the industry is characterized by information asymmetry, with some players having a significant advantage over others due to their resources, expertise, or connections. Moreover, this scenario is visible within China’s national oil companies, affecting their role in the international market. However, intriguingly, despite political and social issues, China is still ahead of its game in the oil sector.

References

[1] Manley D, Mihalyi D and Heller P. It’s time for more transparency in the management and governance of national oil companies, 2019. Retrieved from: https://www.imf.org/en/Publications/fandd/issues/2019/12/national-oil-companies-need-more-transparency-manley

[2] Guo Y, Poon J, Wang C, Yang Y Y. China’s national oil companies going global and coming home: State–firm nexus, global financial networks, and geopolitical risks, Geoforum, 2023, 146: 103880.

[3] Nolan P. Globalisation and Industrial Policy: The Case of China. The World Economy, 2014, 37, 12197.

[4] Bratvold R B, Koch F. Game Theory in the Oil and Gas Industry. The Way Ahead, 2011, 7(01): 18-20.

[5] Arsenyan B G, Feyzioglu O. Modeling collaboration formation with a game theory approach. Expert Systems with Applications, 2015, 42(4): 2073-2085.

[6] Toufighi S P, Soltani Z. Static and Dynamic Game Theory in Common Oil and Gas Fields: A Literature Review and Bibliometric Analysis. International Journal of Social Science Research and Review, 2022, 5(7): 253-268.

[7] Samuelson L. Game theory in economics and beyond. Voprosy Ekonomiki, 2017: 89-115.

[8] Haita-Falah C. Game Theoretic Modeling of the World Oil Market The Russian Gains from Strategic Behavior. CEU Thesis collection, 2007.

[9] Dixit A, Skeath S. Games of Strategy. Norton, 1999.

[10] Osborne M J, Rubinstein A. A Course in Game Theory. The MIT Press, Cambridge, MA, 1994.

[11] Araújo F C, Leoneti A B. Game Theory And 2x2 Strategic Games Applied For Modeling Oil And Gas Industry Decision-Making Problems. Pesquisa Operacional, 2018.

[12] Carpenter J W. The Five Biggest Chinese Oil Companies, 2023, Retrieved from https://www.investopedia.com/articles/markets/091515/5-biggest-chinese-oil-companies.asp.

[13] Fortune. Global 500. Retrieved from: https://fortune.com/ranking/global500/2023/search/ on April 27, 2024.

[14] Petroineos. Shareholders. Retrieved from: https://www.petroineos.com/about-us/shareholders/petrochina/#:~:text=PetroChina%20is%20the%20publicly%20listed,is%2080.25%25%20controlled%20by%20CNPC on April 27, 2024.

[15] Pearce B. China National Petroleum Corporation (CNPC): A balancing act between enterprise and government, 2011.

[16] Lu L, Todeva E. The Petrochemical Industry in China - Government Regulation and Development Policies. In the proceedings of APROS 2000, Asia-Pacific Research in Organisation Studies Annual, 2020 12: 14-16.

[17] Robinson D, Goforth D. The Topology of the 2x2 Games: A New Periodic Table. Routledge, New York, NY, 2005.

[18] Inaba K. The application of stag hunt game to business cooperation of industrial complexes in Japan. Proceeding of the 12th International Conference on Innovation and Management, IEEE Conference on Computer Science, Wuhan, China, 2015: 1048-1051.

[19] Inaba K. The common integration historical developed form of group operation of petrochem ical complexes in Japan. Enerugih-shi Kenkyu [Research of Energy History), Kyusyu University, 2016: 89-108.