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Optimization and Simulation Modeling of International Relations Interaction Strategies Based on Game Theory

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Abstract Effective games in the interaction of international relations provide a feasible path for maximizing national interests. This paper introduces evolutionary game theory into the study of interactive behavior in international relations, and analyzes the game strategy influencing factors from three aspects: subject assumptions, research methods and research objects, and opponent's certainty. Using Nash equilibrium and Stackelberg equilibrium strategy, the interactive decision-making process of peer-to-peer non- and master-slave non-cooperative games is calculated. Combining the rule of imitating the best player, the rule of replicating dynamics and the rule of Fermi updating, the strategies of the game players are adjusted to optimize the benefits. Taking the US-China energy bilateral trade game as an example, we construct a model of the influencing factors of the game strategies, analyze the current situation of the interests, and propose a method to reach the cooperative equilibrium of the game. The results show that the five influencing factors of the US-China energy game are politics>policy>technology>resources>culture. The score of China's energy trade game strategy is 0.88, higher than that of the U.S. 0.83. During the period of 2018-2023, the energy dependence degree of both China and the U.S. exceeds 40%, which is one of the reasons leading to the choice of competitive game.

Index Terms evolutionary games, international relations interactions, Nash equilibrium, Stackelberg equilibrium, strategy updating rules

I. Introduction

The development process of world history shows that the interaction of international relations determines the development direction of the international community, and also relates to China's international environment [1]. Today, the world is in a situation of great change unprecedented in a hundred years, and China is getting closer to the center of the world stage. In the face of the proposition of “where are international relations going”, the construction of a new type of international relations is an important path to build a community of human destiny, and it is also a transcendence of the traditional western theory of international relations [2], [3].

International economic and trade, territorial disputes and other fields are full of cooperative or non-cooperative national policies and strategic interactions, and game theory, as an important theoretical method, has been proved to be effective in identifying the behavioral patterns of multi-stakeholder interactions, which is suitable for the study of international relations [4]-[7]. Game theory models can provide a theoretical basis for the feasibility and necessity of international cooperation, and the infinitely repeated game model of non-cooperation can prove that international cooperation is the optimal strategic choice in long-term development [8], [9]. Since international conflicts affect important strategic interests between countries, when countries weigh their interests and negotiation positions, conflicts and games inevitably appear, and the strategic choices of participants are dynamic and finite rational [10]-[12]. Based on this, the application of game theory in international cooperation began to focus on long-term evolutionary game research. Through the establishment of evolutionary game simulation model to simulate and analyze the interaction process between the players, so as to put forward targeted international relations interaction strategy is conducive to the construction of good international relations, will certainly be conducive to world peace and stability [13]-[15].

This paper applies evolutionary game theory to analyze interactive behaviors in international relations from multiple perspectives by means of mathematical modeling. The Nash equilibrium strategy is chosen to study the decision-making process of non-cooperative games when the players are in a peer-to-peer position. The Stackelberg equilibrium strategy is chosen to study the decision-making process of non-cooperative games with a hierarchical structure of players containing leaders and followers. According to the commonly used three types of strategy updating rules, the game players' strategies and benefits are updated to get the optimal strategy scheme. Analyze the game influencing factors in the energy bilateral trade relations between China and the United States.

And based on the game perspective, the existing energy interests are modeled and deduced to find the strategy to eliminate the interference in order to obtain a win-win situation for both sides.

II. Evolutionary Game Theoretical Options in International Relations Interaction Strategies

II. A. Game-theoretic analysis of the evolution of international relations

Game theory of international relations is a theory that studies the interactive behavior of parties in international relations. It studies decision-making, strategy selection, and action patterns in international relations through mathematical modeling and theoretical analysis. The game theory of international relations initially focused on the study of winning and losing in chess, bridge, and gambling, but over time, it has evolved into a more complex and refined theoretical framework that can be applied to explain a variety of issues in international relations. In international relations, game theory can be applied to the study of competition, cooperation, conflict and coordination between countries. Prisoner's dilemma is a famous example of game theory in international relations, in addition, game theory in international relations includes other types of game models, such as repeated games can be used to explain long-term cooperation and mutually beneficial relationships between countries, and zero-sum games can be used to explain rivalry and conflict between countries. These models can help people better understand the interactive behavior and decision making in international relations. There are a wide range of applications in international relations, which can help people better understand the interactive behavior and decision making in international relations.

Evolutionary game theory is a theory that combines the analysis of game theory with the analysis of dynamic evolutionary processes. The study of animal conflict behavior marks the birth of evolutionary games. It differs from game theory which focuses on static equilibrium and comparative static equilibrium, emphasizing a dynamic equilibrium. Evolutionary game theory turns the payoff function into a fitness function, and the whole evolutionary process follows the selection mechanism and the compilation mechanism. The selection mechanism is to determine the assignment dynamic equations through the evolutionary game matrix and to find out the included solutions, and the compilation mechanism is used to test whether the evolutionary equilibrium is stable, i.e., to verify whether the solution found by copying the dynamic equations is an evolutionary stable strategy solution.

Evolutionary and traditional games differ in several ways:

(1) Different assumptions about the subject of the game. Evolutionary game that the subject of the game is “limited rationality”, full rationality refers to the decision maker in the decision-making process to seek to maximize their own interests, but this assumption rarely exists in reality, and evolutionary game theory can effectively make up for the shortcomings of the assumptions, it is through the observation of the interests of the subject of the game history, according to the other party's strategy to study what strategy they take to maximize their own interests as far as possible. Study their own strategy to take what strategy, so as to maximize the interests as much as possible.

(2) The research methods and objects of the game are different. Different individuals or groups composed of individuals in taking different decisions will bring different impacts, due to the information in the game process is effective, in a particular situation, a separate decision maker is difficult to choose the decision that is optimal for their own interests, so the game party in the game learning process, need to constantly learn, adjust their own strategies, and then change their own behavior, and ultimately make strategic choices, so the historical information and the surrounding environment also have a great influence on the outcome of the game. The equilibrium point of the game evolution is determined by the game process, in which the external environmental impact and theoretical basis and other factors will be taken into account, so it is more practical in the real research.

(3) The certainty of the research game opponent is different. In the traditional game process, both sides of the game can clarify their game opponent. But in the evolution of the game process, the game player can not confirm a decision of the specific game opponent, also can not understand the whole game system exists in all the game opponent, so can only understand their own a decision on the impact of the local game, but can not fully grasp a decision on the overall impact of the game system. At the same time, it is also impossible to further study the direction and size of the impact of its own decisions on the game system.

In the process of international disputes, due to the diversity of external influencing factors, the game participants are in a complex environment, and can not fully grasp the information of the other parties to the game, so there is no way to make a completely rational decision, its decision-making process may be subject to their own subjective cognitive and external uncertainty of the combined impact of the factors, and can not do to maximize the benefits. Therefore, in the process of the game, the behavior of each game subject is limited rationality, and the basic assumptions of evolutionary game theory are more consistent with this condition, so in this study evolutionary game theory is applicable.

II. B.Analysis of the foundations of game theory

II. B. 1) Peer-to-peer noncooperative games and Nash equilibria

Peer-to-peer architecture noncooperative games are mainly used to study the interactive decision-making process of multiple independent participants who are in equal positions and have equal information. The optimization goals and outcomes of all participants are influenced by each other's strategies and may be in partial or complete conflict. Among them, Nash equilibrium occupies a central position in non-cooperative games, and its mathematical expression is defined as follows:

Definition 1 (Nash Equilibrium) A game $G=\left\{N;\left\{S_i\right\}_{i\in N};\left\{U_i\right\}_{i\in N}\right\}$ of N players is said to have a set of strategies . $\left(s_i^*,s_{-i}^*\right)$. that is a Nash equilibrium of the game, also known as a Pure Strategy Nash Equilibrium (Pure Nash Equilibrium), if and only if the following equation holds:

$$u_i\left(s_i^*,s_{-i}^*\right)\geq u_i\left(s_i,s_{-i}^*\right),\forall s_i\in S_i,\forall i\in N \tag{1}$$

where the strategy of the i st participant in equilibrium is denoted as . $s_i^*,s_{-i}^*=\left(s_1^*,\ldots,s_{i-1}^*,s_{i+1}^*,\ldots,s_N^*\right)$. denotes the strategy of the participants other than the i rd participant in equilibrium, and u_i denotes the utility function of the i th participant. Based on the above definition, it can be seen that under the Nash equilibrium strategy, no participant has an incentive to adjust its own strategy individually and thus obtain a higher utility without affecting the other participants. Therefore, Nash equilibrium is a stable game outcome. Before solving the Nash equilibrium, it is first necessary to analyze and prove the existence of the Nash equilibrium, i.e., the pure strategy game needs to satisfy the following theorem:

Theorem 2 (Sufficient condition for the existence of Nash equilibria) A pure strategy Nash equilibrium exists for a game if for all players . $i\in N$.: 1) the set of strategies S_i is a nonempty tightly convex set in Euclidean space; and 2) the utility function u_i is a continuous fictitious concave function with respect to strategy s_i.

II. B. 2) Master-slave non-cooperative game with Stackelberg equilibrium

Unlike the peer-to-peer non-cooperative game mentioned above, in which all participants have equal status in decision-making, the leader and the followers in the master-slave non-cooperative game have an obvious hierarchical structure. In the master-slave noncooperative game, the leader at the upper level has the decision-making advantage and can occupy a first-mover advantage or a favorable position in the game, while the follower at the lower level needs to respond to the leader's decision-making based on the leader's decision. The definition of Stackelberg game is given below:

Definition 3 (Stackelberg Equilibrium) In a Stack-elberg game G containing a leader and N follower, the set of strategies $\left(s_l^*,s_f^*\right)$ is said to be the Stackelberg equilibrium of the game if and only if the following equation holds:

$$\begin{gathered}u_l\left(s_l^*,s_f^*\right)\geq u_l\left(s_l,s_f^*\right),\forall s_l\in S_l\\ u_{f,i}\left(s_{f,i}^*,s_{f,i}^*\right)\geq u_{f,i}\left(s_{f,i},s_{f,i}^*\right),\forall s_{f,i}\in S_{f,i},\forall i\in N\end{gathered} \tag{2}$$

In the above definition, the utility functions of the leader and the i st follower are denoted as u_l and $u_{f,i}$ respectively, and the strategies of the leader and the i th follower are denoted as s_l and $s_{f,i}$ respectively, and the set of strategies of the leader and the i th follower are denoted as S_l and $S_{f,i}$ respectively. the number of followers is N . It can be seen from the definition of Stackelberg's game in Eq. (2) that, when the game reaches Stackelberg's equilibrium solution, all the game participants are unable to unilaterally adjust their strategies to improve their returns without affecting the other participants. Before solving the Stackelberg equilibrium solution, the following theorem needs to be applied to prove the existence and uniqueness of the equilibrium solution:

Theorem 4 (Existence and Unique Sufficiency Conditions for Stackelberg Equilibrium) In a master-follower non-cooperative game model, a game has a unique Stackelberg equilibrium if the following conditions are simultaneously satisfied:

1) The set of action strategies of all leaders and followers is a non-empty set and is tightly convex;
2) When fixing the leader strategy, each follower has a unique optimal strategy;
3) When fixing the follower strategies, the leader also has a unique optimal strategy.

II. C.Strategy Update Rules

In evolutionary games, unlike one-shot games, individuals play repeated games against each other. This means that individuals need to continuously adjust their strategies to maximize their gains. In this process, strategy updating is involved, which is a key aspect in the study of evolutionary games. Three commonly used strategy updating rules are described in detail next: the imitation of the best player rule, the replication dynamics rule, and the Fermi updating rule.

Imitation of the best man rule (BTO): In real life, imitation of the best man strategy is applied in many scenarios. A typical example is the behavior of firms in competitive markets. In the marketplace, companies often observe and mimic the strategies of competitors who are successful. For example, when a firm introduces a new marketing strategy or product feature, other competitors may, because they see the success it brings, try to mimic a similar strategy in order to gain a higher market share and better revenues. In the field of evolutionary games, the imitation of the best player rule places an individual in a game with all of its neighbors and gains, and at the time of a strategy update, the individual learns the strategy of the highest-returning individual, including itself, as the next moment's strategy, or if there is more than one of the highest-returning individuals, one of them is randomly selected for learning.

Rule of Replication Dynamics (RD): individual i gains a cumulative gain U_i from interacting with its neighbors, and subsequently randomly selects a neighbor j who gains in a similar way U_j. If $U_i > U_j$, then individual i keeps its current strategy unchanged, and otherwise learns with probability W the strategy of neighbor j:

$$W\left(s_i \leftarrow s_j\right) = \frac{U_j - U_i}{D \cdot \max\left(k_i, k_j\right)} \tag{3}$$

where k_i and k_j denote the degrees of nodes i and j, i.e., the number of their neighbors, respectively, and D is the maximum gain difference between individual i and neighbor j. The value of D varies for different social dilemma models. Although the replication dynamics rule is still a linear approach to strategy, an element of randomness has been added.

Fermi Update Rule (FU): in contrast to the replication dynamics rule, the Fermi rule is a nonlinear strategy update rule, where the probability that individual i imitates neighbor j is:

$$W\left(s_i \leftarrow s_j\right) = \frac{1}{1+\exp\left[\left(U_i - U_j\right)/K\right]} \tag{4}$$

U_i and U_j are still the gains of individuals i and j at a given time step, K is a noise parameter characterizing the degree of rationality of the individual, $K \to \infty$, regardless of the size relationship between and U_j, the probability of mimicry is close to 55%, and the individual is randomly choosing a strategy in the set of strategies, with the strongest uncertainty; when $K \to 0$, if the gain of individual i is greater than the gain of j, i.e., $U_i > U_j$, W tends to 0, i.e., it tends to keep its own strategy; Conversely $U_i > U_j$, W tends to 1, i.e., individuals tend to imitate their neighbors with greater probability.

In addition, due to the large number of individuals involved in the network, the strategy update sequence can be categorized into synchronous update and asynchronous update according to the strategy update timing of each individual. Synchronous updating means that in a time step, all individuals accumulate gains after the game and update their strategies at the same time according to the strategy updating rules; asynchronous updating means that in a time step, only a part of the individuals accumulate gains to update their strategies immediately and apply the updated strategies in subsequent time steps, while the strategies of the other individuals remain unchanged.

III. Analysis of the U.S.-China Energy Trade Relationship Based on Game Theory

This chapter establishes a model of factors influencing the bilateral trade game strategy of energy between China and the U.S. and analyzes the energy interests of China and the U.S. in recent years and the way to reach the game cooperation equilibrium based on the game theory perspective.

III. A. Analysis of the bilateral energy trade relationship between China and the United States

Figure 1 analyzes the specifics of energy bilateral trade between China and the United States from 2018-2023. In the energy bilateral trade between China and the U.S., oil energy trade is dominated.During 2018-2023, China's energy export trade to the U.S. fluctuates and increases from $2,216 Million to $5,156 Million, while its import trade from the U.S. steadily increases from $13,244 Million to $31,527 Million. The energy trade deficit between the two countries gradually widened from $11,028 million to $26,371 million. This shows that in the bilateral trade of energy, the trade cooperation between China and the United States has been deepening year by year. But at the same time, the expanding trade deficit also means that the decision-making conflicts between the two countries will gradually intensify in the process of specific trading interactions. It is urgent to model the interaction strategy of energy trade between the two countries by combining international relations game theory to find the optimal interaction strategy.

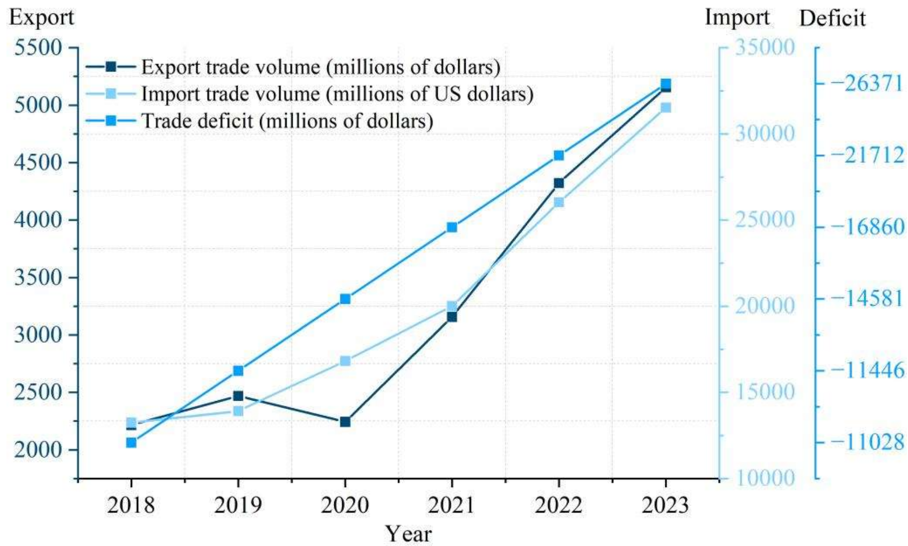

Figure 1: Bilateral energy trade between CN and the US in 2015-2020

III. B. Modeling of factors influencing the bilateral energy trade game strategies of the two countries

III. B. 1) Indicator System for Evaluating the Influencing Factors of the Two Countries' Gaming Strategies

Both sides of the game make energy trade decisions based on the interests of their respective countries. There are five main factors affecting the decision-making of the two sides of the game, namely: political factors, policy factors, technological factors, resource factors, and cultural factors. This paper determines the specific influencing factor indicator system according to the 6 principles of scientific, systematic, consistency, comparability, unity of relevance and independence, and the combination of qualitative and quantitative indicators. Expert questionnaires and quantitative data tables are designed according to the system, and 8 experts in the fields of international relations and energy relations are invited to score. The questionnaire adopts a 7-point system, with the highest score being 7 points and the lowest score being 1 point, accurate to one decimal point. The average of the experts' scores was taken as the basic data for the assessment of the impact factors.

Table 1 summarizes the scoring data of the indicator system of influencing factors for gamers' decision-making. Among the scores of the five influencing factors with a total of 24 indicators, China obtained the highest average score of 6.5 and the lowest average score of 3.2 for each indicator. The United States received the highest average score of 6.6 and the lowest average score of 4.7. The difference between the highest mean scores of the indicators is only 0.1, but the difference between the lowest mean scores is larger, reaching 1.5. In order to model effectively, it is necessary to standardize the scores of the indicators.

III. B. 2) Standardization and analysis of assessment data

The data of each index score under the five influencing factors were subjected to a multi-step standardization process, such as maximization-minimization. Table 2 integrates the results of the standardized processing of the data related to the influencing factors of the gamers. After analyzing the standardized scores of each influencing factor, it is found that in the bilateral trade of energy between China and the United States, the two factors that have the greatest influence on the decision-making of the gamers are politics and policy, with the importance scores of 1, 0.97 and 0.94, 0.93. It shows that in the international energy trade relations, the decision-making is mainly affected by the political stance of the two countries. In terms of the overall score size comparison, China's energy trade decision-making is more balanced by the five influencing factors than that of the United States, which may be due to China's more comprehensive consideration of the full range of impacts that may be brought about by conducting energy trade. Based on the calculation results, the modeling of the influencing factors of the international energy trade game strategy is completed, and the subsequent strategy analysis is carried out by combining the specific energy trade data between the two countries.

Table 1: Score data of indicators influencing factors for players' decision-making

Factor	Indicator	CN	US
Political factor	Government's attitude towards energy trading	6.5	6.3
	Political relations between CN and the United States	6.3	6.2
	Extent to which international relations influence market competition	6.0	4.7
	Extent to which international relations influence market demand	6.1	4.9
	Success rate of cooperation between the governments of CN and the United States in the past five years	5.9	5.6
Policy factor	Extent of the influence of government policies on trade	6.4	5.3
	Influence of the economic conditions of the two countries on trade	5.7	5.6
	Requirements of national strategies for trade	4.5	6.1
	Degree of synergy between economic policies and trade interaction	5.7	5.7
	Scientificity and timeliness of policy adjustments	5.8	5.3
Technical factor	Adaptability of new technologies	5.3	6.6
	Smoothness of energy development	5.4	6.3
	Source of new technologies	4.7	6.1
Resource factor	Proportion of energy practitioners in the two countries	4.9	6.4
	Domestic market share of energy	3.9	5.7
	Market share of energy in foreign markets	3.2	5.9
	Stock of mining equipment at the world's advanced level	4.0	6.4
	Number of senior energy development talents	4.9	6.5
	Total energy quantity	4.7	6.4
	Reliability of the source of development funds	4.6	6.5
	Timeliness of decision-making information transmission	5.5	6.6
	Degree of sharing of innovative information	5.2	6.3
Cultural factor	Degree of recognition of trade by regional culture	4.5	5.1
	Consumption differences of new energy in regional culture	5.1	6.0

Table 2: Data processing results of the influencing factors

Game player	Politics	Policy	Technology	Resources	Culture	Total score	Standardized score
CN	1	0.97	0.85	0.77	0.79	4.38	0.88
US	0.94	0.93	0.90	0.64	0.72	4.13	0.83

III. C. The Current Situation of U.S.-China Energy Interests from the Perspective of Game Theory

III. C. 1) Comparison of Annual Energy Production

Combined with the constructed international energy trade game strategy influencing factors model, we again analyze the change of energy bilateral trade interaction strategy between China and the United States during 2018-2023. Figure 2 demonstrates the annual generation of petroleum energy between China and the United States from 2018-2023. With the development of science and technology and the increase of energy consumption, the contradiction between the supply and demand of petroleum energy has become more and more prominent in recent years. In order to protect its own energy, the United States gradually reduced the development and export of petroleum energy during 2018-2023, with annual production falling from 412.58 million tons to 348.83 million tons, and turned to make the decision to increase oil imports from other countries. And China, as a large energy-consuming country, in response to the U.S. decision, has increased its own petroleum energy extraction since 2018, boosting its oil generation from 181.86 million tons to 211.51 million tons in six years. From the perspective of game theory, the bilateral trade of oil and energy between China and the United States has seen friction in these years, and both sides of the game have made decisions with more consideration for their own interests.

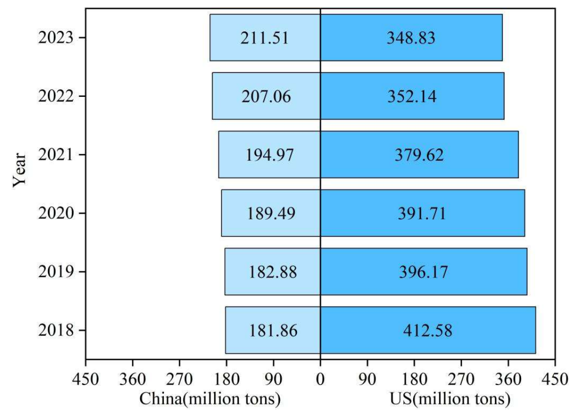

Figure 2: Annual generation of petroleum energy in CN and the US

III. C. 2) Comparison of daily energy import and export volumes

Figure 3 shows the daily oil energy consumption, production, and net imports of China and the United States over the period 2018-2023. China and the U.S. have large shortfalls in their own petroleum energy and are highly dependent on energy imports.During the 2018-2023 period, oil consumption in both countries increases from 695 million barrels per day (bpd) to 2,554 million bpd, but oil production only increases from 648 million bpd to 747 million bpd. The supply and demand relationship between consumption and production led to an increase in net oil imports into the two countries from 0.17 billion barrels per day to 1.677 billion barrels per day. Bilateral trade in energy between the two countries shows a relatively consistent interaction of demand.

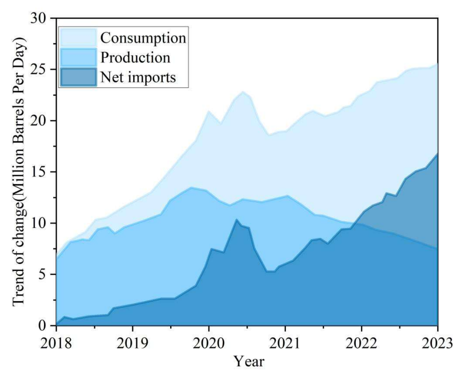

Figure 3: Daily consumption, production and net import of petroleum energy

III. C. 3) Comparison of energy dependence

Both China and the United States are large energy importers, and oil dependence is used to indicate the degree of dependence on oil imports. Oil supply security is inversely proportional to oil dependence. Therefore, oil dependence is also an important indicator for examining the current situation of oil and energy interests of the two countries based on the game theory perspective. When the value of oil dependence is less than or equal to 40%, it is a reasonable range of oil security. China and the United States oil production ranked 3rd and 5th, but the slow growth of production capacity of the two countries can not effectively make up for the momentum of rapid growth in oil consumption, a large amount of oil still need to be imported. In this way, oil price policy, geopolitics and other factors are more disruptive to oil and energy interests. Table 3 analyzes the specific data on oil dependence between China and the United States from 2018-2023. Comparison of the data changes shows that China and the United States have a high degree of oil dependence, both reaching more than 40% from 2018, and reaching 52.98% and 65.28% in 2023, respectively. The high degree of foreign dependence increases the security risk of the economic development of China and the United States, and the similarity of China and the United States for energy dependence is also one of the reasons why the countries carry out the strategy of oil and energy competition and game, and the friction has been continuous so far.

Table 3: The oil dependence between China and the United States

Year	CN	US
2018	42.67%	61.51%
2019	46.93%	62.25%
2020	47.62%	64.34%
2021	48.71%	64.43%
2022	50.66%	64.86%
2023	52.98%	65.28%

III. D. Disturbance and Reinforcement of the Equilibrium Reached in the Sino-US Energy Game Cooperation

III. D. 1) Interfering Factors in the Reaching of the Sino-US Energy Cooperation Settlement

In the process of the game of energy interests between China and the U.S., the most disruptive factor is the skepticism of both sides about their intentions. This is the main reason why the coordination game fails, and China and the United States abandon the pay-to-play equilibrium of cooperation and jointly choose the risk-to-play equilibrium of conflict. The two countries should have a clear understanding of “China's energy threat theory”, “the United States intends to raise oil prices to contain China's economic growth” and other arguments. Oil and other energy sources are not zero-sum supplies. The country's energy demand is also in line with the needs of economic development. China's increased energy demand does not mean that competition for resources will lead to conflict and threaten the global oil and gas supply. Nor is the United States intentionally suppressing China and restricting its rise. The energy politics threat mentality with Cold War thinking is the biggest factor interfering with U.S.-China cooperation, and skepticism about intentions can lead to the two countries not choosing a cooperative strategy.

As China seeks to diversify its energy sources, the United States is greatly concerned about China's cooperation with “problem countries” such as Sudan and Iran. The political effects of energy diplomacy are seen as contributing to regional tensions and conflicts that accompany China's exports of arms and military technology, challenging U.S. global leadership. It should be clear that China does have energy interests in these countries, but the means used to protect its interests are likely to be political, not military. Oil-seeking activities in these countries are aimed at preventing the homogenization of energy sources and minimizing supply-side vulnerabilities.

Also affecting the balance of cooperation are U.S. technology export controls to China. The export and transfer of high-tech products and dual-use technologies are strictly controlled by the Administration and Congress. Restrictive regulations have limited the fruits of U.S.-China cooperation in the field of nuclear energy. In this way, Chinese operating contractors are also worried about huge economic losses in case the imported nuclear power technology is blocked because of the U.S. ready review and control of nuclear power equipment and technology exports. U.S. business people have pointed out that because of the U.S. ban on the sale of nuclear power generation equipment to China, U.S. companies have lost $15 billion worth of nuclear power plant equipment, reducing exports by billions of dollars.

III. D. 2) Ways to Remove Disruptions and Enhance the Balance of U.S.-China Energy Cooperation

Deepen the mechanism of summit diplomacy and high-level strategic dialogues. Expand the influence and communication platforms of the U.S.-China Energy Dialogue, the Clean Energy Forum, and the Oil and Gas Industry Forum in order to minimize the uncertainty of the game. Ensure positive access to information and influence through cheap pre-game negotiations to strengthen communication and enhance mutual trust. In the pre-game cheap talks, geopolitical and ideological factors are minimized, and due to the reduction of uncertainty, the two countries will be more rational in choosing the strategy of payment-advantageous cooperation than the risk-advantageous one due to the uncertainty of the energy game.

The issue of trust between the two countries is also critical to stabilizing cooperation options. China, for its part, regards energy security as a core national interest, and the current energy-related international environment is hardly conducive to a sense of security for China. If the U.S. fails to understand China's basic attitude on energy issues, then the energy game between the two sides will be difficult to converge towards a cooperative equilibrium. At the same time, China also needs to fully understand the United States on the Sino-US energy issues to maintain the sensitivity. From the point of view of the United States, on the energy issue of China's strategy should be: “both based on the overall energy security, due to China's sharing of common interests”. The U.S. should clearly demonstrate to China that it has no strategic intent to use its superior power to weaken and curb China's energy needs, and that it does not oppose China's efforts to acquire overseas energy resources and its go-out strategy. U.S. oil companies should be encouraged, not restricted, from cooperating strategically with Chinese partners. On the other hand, China must demonstrate its willingness to play the role of “responsible stakeholder”, not only on energy security issues, but also on a wide range of major international security and strategic issues. It should try to harmonize its policy positions with those of the United States without compromising its own energy security and economic interests.

IV. Conclusion

This paper uses evolutionary game theory to analyze the decision-making process of interactive strategies in international relations and study the strategy updating methods that can maximize the benefits. China's import and export energy trade volume to the United States in 2023 reached 31,527 million U.S. dollars and 5,156 million U.S. dollars, the energy trade deficit between the two countries reached 26,371 million U.S. dollars, resulting in the game strategy is biased in the negative direction. 5 game strategy influencing factors, the most influential are politics and policy. From the perspective of game theory to see the current situation of energy interests of China and the United States, both countries have a contradiction between supply and demand, highly dependent on imports (oil dependence of more than 40%) of the situation. There is a need to remove interfering factors and actively communicate to strengthen the possibility of realizing the equilibrium goal of game cooperation. In the future, multiple types of international relations research can be introduced to enhance the applicability of the evolutionary game theory model.

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