

Central Asia Oil and Gas Transfer to China, Cooperative Game Theory Approach

Touraj. Dehghani¹ 

¹ Assistant Professor, Energy Economics Department, Institute for International Energy Studies (IIES), Tehran, Iran

* Corresponding author email address: dehghani576@yahoo.com

Article Info

Article type:

Original Research

How to cite this article:

Dehghani, T., (2027). Central Asia Oil and Gas Transfer to China, Cooperative Game Theory Approach. *Journal of Resource Management and Decision Engineering*, 6(2), 1-16.
<https://doi.org/10.61838/kman.jrmde.397>



© 2027 the authors. Published by KMAN Publication Inc. (KMANPUB). This is an open access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) License.

ABSTRACT

International institutions project a substantial increase in China's demand for oil and gas in the coming years. To secure its energy supply, China has pursued a strategy of diversifying import sources. Landlocked Central Asian nations and energy-rich Iran aim to capitalize on this demand by expanding their export capabilities. This study employs cooperative game theory to analyze the bargaining power of countries in potential oil and gas transmission scenarios from Central Asia and Iran to China through pipeline. By developing future scenarios and evaluating their economic feasibility, we assess the bargaining power of each country using the Shapley value. Our findings indicate that a country's geographic location and production capacity are key determinants of its bargaining power in energy geopolitics. Additionally, if Iran significantly increases its production and export capacity, and its pipeline network connects with Turkmenistan's, it could economically justify joining the coalition for natural gas exports through the Central Asia-China pipeline by supplying approximately 12 billion cubic meters of natural gas annually.

Keywords: Oil, Natural Gas, Cooperative games, Bargaining Power, Central Asia

1. Introduction

In the third millennium, the economy is the focal point of national power for countries (Beckley, 2018). Therefore China's plan to become the first major power in the 21st century needs significant sources of production factors. The gross domestic production (GDP) as the most important indicator of an economy, is the main factor of national power and production factors abundance is a significant factor for continuous economic growth (Rauch, 2017). Energy, as one of the essential factors in the production function, has unique

importance for China's energy intensive economy, which has abundant labor and capital sources and is progressively promoting in technology and human and social capital (Piketty et al., 2019). Since China's economy is energy intensive, (Iea) energy resources are the most important economic growth factors for China, and the domestic conventional energy resources of China are not sufficient for this purpose. In the early nineteenth, oil demand surpassed domestic supply, and China became a net oil importer, and in 2006, it became a net natural gas importer.

Therefore, the energy security of china depends on the abroad resources of energy, and energy security plays an essential role in the future of china's economy. Over 70% of China's oil and LNG imports transit through the Strait of Malacca, making it a vital chokepoint for its energy security (Feng, 2023). Any disruption to the Strait of Malacca, whether due to natural disasters or geopolitical tensions, could significantly impact China's energy supply. Therefore, China has implemented various strategies to mitigate these risks such as diversifying import sources and building alternative routes. One of the main strategies to reduce its vulnerability and enhance its energy resilience is developing oil and gas pipelines. China imports a significant portion of its oil and gas from two regions, gas from Central Asia, and oil from Persian Gulf neighborhood (Wu, 2014). The Central Asia is known for its strategic importance, which lies in its abundance of oil and gas resources. This region contains large volumes of oil and natural gas reserves. One of Persian Gulf neighbors which plays a significant role in china's energy security is Iran. Iran exports most of its oil to china in recent years (bp, 2022), after USA withdraws JCPOA. In the next decades, emerging powers will demand a significant part of world oil and gas supply and central Asia countries that have no border with seas, and oceans are looking for oil and gas export benefits to foster economic development.

The economic development is considered remarkably crucial for the support of social and political stability in China (Zhang et al., 2022). Its financial security depends on the equilibrium of three variables: economic growth, energy security, and environmental protection. In these circumstances, energy security has become an issue of the "high politics" of national security (Lee & Wang, 2022).

There is an energy transfer network among central Asia countries and china, which transfer thousand tons of oil and gas. The Turkmenistan–China gas pipeline (Central Asia–China gas pipeline) has designed and developed to transfer gas from Turkmenistan to Xinjiang in China. By connecting Turkmenistan to China, this project makes the possibility of gas transportation about 7000 km from central Asia to China. The pipeline starts in Saman-Depe, carrying natural gas from the Bagtyyarlyk gas fields on the right bank of the Amu Darya in Turkmenistan. It is mainly supplied from Iolotan and Sag Kenar fields. The pipeline enters Uzbekistan to southern Kazakhstan (Xie, 2021).

The Kazakhstan–China oil pipeline is the first project which enables China to import oil directly through the pipeline from central Asia. It starts from Kazakhstan's Caspian shore to Xinjiang in China. The 2,228 kilometers

long pipeline runs from Atyrau in Kazakhstan to Alashankou in China's Xinjiang. The Kenkiyak–Atyrau section of the pipeline is 449 kilometers long and has a capacity of 120 thousand barrels per day. The capacity of the pipeline may be upgraded to 180 thousand barrels per day in the future (Tang & Joldybayeva, 2023).

The main question we seek to answer is which scenarios on the oil and gas trade between middle Asia and china are most probable to occur and what economic consequences they might have? How much is the net present value (NPV) of each scenario, and how does the bargaining power be distributed among the countries if they decide to make coalitions? These questions are critical for the future of china's energy security, which plays a significant role in the speed of china's development. On the other hand it is important for energy exporting countries in Central Asia and Middle East.

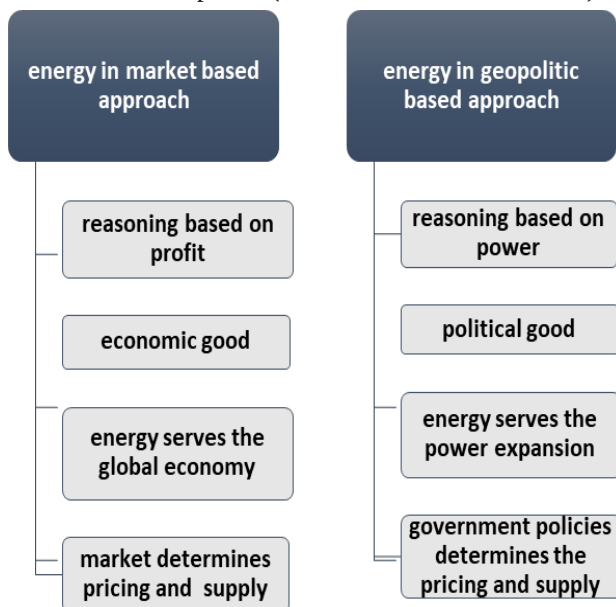
2. Theoretical Framework

Gas pipelines serve as networks that facilitate international energy trade. Their design significantly influences not only the flow of energy but also the bargaining power of involved countries. Countries strive to shape these networks to maximize their benefits and leverage. The concept of control over critical infrastructure and trade routes as a source of power was first theorized by Hirschman in 1969 (Hirschman, 1980). Cooperative game theory, particularly the Shapley value, provides a robust framework for analyzing power dynamics within such networks. Myerson 1977 pioneered the application of cooperative game theory to transmission structure analysis (Myerson, 1977). Jackson in 2008 further extended this approach to public networks, introducing a two-level framework: a non-cooperative level for network architecture decisions and a cooperative level for determining payoffs based on the existing network (Jackson, 2008).

Gas transmission lines typically operate under comprehensive contracts that govern capacity utilization and transfer tariffs. The distribution of benefits among participants is determined through negotiations within the network. The cooperative game theory approach enables the identification of optimal decisions and outcomes for each party. Hubert and Ikonnikova in 2011 initially proposed this approach for analyzing natural gas networks. Subsequent studies have successfully applied this framework to various case studies (Hubert & Ikonnikova, 2011).

2.1. Methodology of the research

Using cooperative game theory, this research intends to survey the more likely future scenarios on the oil and gas transmission from central Asia and Iran to the China through the pipeline. This research methodology consisted of mathematical methods in economic evaluation and cooperative game theory. Profit is the core of market approaches. However, national power is the core of the geopolitics approach toward energy topics. In this research we consider energy in a geopolitical based approach. In other words, we consider energy as a political good that serves national interest and power (Pascual & Zambetakis, 2010).



First of all, we have made an economic evaluation on the current projects and most probable scenarios. Then we have calculated the bargaining power of each player (country) in potential scenarios. In the cooperative game theory, Shapely value is a useful index that shows us the players' bargaining power. The bargaining power can be used as a criterion for sharing the benefits of cooperation among the coalition's members. At the last step, we interpret the model outcomes from a geopolitical based approach.

2.2. Game theory

Game theory studies situations of interaction (competition or cooperation) among involved parties using mathematical methods. In other words, Game theory analyzing what happens when self-interested agents interact. This is a broad definition. However, it is consistent with a broad range of purposes. These applications range from strategic issues in a conflict or a war to understanding

economic or financial competition. Game theory was given its first mathematical formulation by John von Neuman and Oskar Morgenstern (1944). Game theory is an established mathematical system, but it has progressed and implemented often by economists (Tadelis, 2013).

2.3. Cooperative game theory

Cooperative games, model situations in which players tend to cooperate in order to achieve their objectives. In a cooperative game, the focus is on payoffs and coalitions, rather than on strategies. The prevailing analyses have an axiomatic flavor, in contrast to the equilibrium analysis of none-cooperative theory. The implicit assumption is that players are able to make restrictive contracts. The primary assumption is that groups of players can form and enter coalitions, engage in a binding agreement that returns them a certain amount of profit. The maximal value that a coalition generates through the partnership is named the worth of the coalition (Chakravarty et al., 2014). In cooperative game theory, the question is which coalitions may form, and how each coalition divides it worth if the players are partitioned into a collection of coalitions. A single-valued solution is a function that allocates to each coalitional game a vector in RN indicating the payoff each player obtains. A set solution is a function that allocates each coalitional game a set of vectors in RN . Single-valued solution concepts model a referee who recommend to the members the way of the division of the worth of the coalition among its cooperators. A set solution concept indicates which divisions are more probable than others (Chakravarty et al., 2014).

Distinction between cooperative and none-cooperative game theory is the possibility of binding agreement among the players and the modelling technique in use. In none-cooperative games, players have specific strategies, whereas, in cooperative games, the characterization is based on the outcomes and payoffs that players and coalitions can reach. The implicit assumption in a cooperative game is that player's ability to establish coalitions and make restrictive agreements about the way that how to distribute the profits of the coalitions. In cooperative games, the utility assumed to be transferable, there is a quantity of utility, and the implicit assumption is, it is possible to transfer this utility among the participants in the coalition.

In this research, we are using cooperative game to analyze the situation. Cooperative games model situations in which the players may conclude binding agreements that impose a

distinct action or series of actions on other players. In cooperative game theory as in none-cooperative, players may be a person, company, government, and so on. The only requirement is that players be capable of arriving at decisions and committing to those decisions (Chakravarty et al., 2014).

2.4. Shapely Value

The Shapley value first introduced by Shapley (1953), is a single-valued solution concept for cooperative games. Answering the question, how much would a player be willing to pay for cooperating in a game was Shapley's basic idea. The answer of this question relies on how much a player foresees to get when he wants to cooperate in the game. How will the value $V(N)$ be divided among the participants of the coalition if the grand coalition N will be formed? If we may expect that player i will get the sum ϕ_i , that sum will be called player i 's value in the game. We can also explain ϕ_i as the amount that it is fair for the player i to get if the N as the grand coalition is formed. Shapley suggested a solution concept that advantage is satisfying several characteristics, which is called the Shapley axioms. These axioms may also be appropriate for a fair judgment about the way the players dividing the value getting through cooperation among themselves if the grand coalition could be formed. A single-valued solution concept is an infinite sequence of functions, one for each set of players N . Let ϕ be a single-valued solution concept, let $(N; v)$ be a coalitional game, and let $i \in N$ be a player. Then $\phi_i(N; v)$ is called the value of player i in $(N; v)$ according to ϕ (Curiel, 2013).

$$\phi(V) = (\phi_1(V), \phi_2(V), \dots, \phi_n(V))$$

Let's introduce the axioms. The efficiency property is the first property we introduce, which claims that the sum total all the players expect to get equals $V(N)$, the worth of the grand coalition N . A solution concept ϕ satisfies efficiency if for every coalitional game.

$$\sum_{i \in N} \phi_i(V) = V(N)$$

If we take the coalition that will form is the grand coalition N , then the total payoff that the players foresee to receive is $V(N)$, the total amount available to them, and it is logical to expect that rational members of coalition without wasting, will distribute the entire sum total.

Symmetry axiom asserts that two members of the coalition with the same status in the game should expect the same amount. Therefore, this axiom is a non-discrimination

axiom. If $(N; v)$ be a cooperative game, and $i, j \in N$, then players i and j are symmetric players if for every coalition $S \subseteq N / i, j$ (which contains neither i nor j as members),

$$V(S \cup \{i\}) = V(S \cup \{j\}) \rightarrow \phi_i(V) = \phi_j(V)$$

A solution concept ϕ fulfil the condition of symmetry if for every cooperative game $(N; v)$ and every pair of symmetric players i and j in the game: $\phi_i(N; v) = \phi_j(N; v)$.

The symmetry property requires that the solution concept having independence from the names of the players if their contributions to every coalition are equal. Two such players should get the same portion of $V(N)$, and therefore should have incentive to pay the same quantity for cooperating in the game (Curiel, 2013).

The null property states that a player should not expect to obtain a positive amount for cooperating in the game if he is contributing nothing to any coalition he is in as a member. For every coalition $S \subseteq N$, including the empty coalition, if $v(S) = V(S \cup \{i\})$ the player i is called a null player in the game $(N; v)$.

$$V(S \cup \{i\}) = V(S) = \phi_i(V) = 0$$

The null player presents zero value to any coalition he decides to be a member of it, if i is a null player, then $V(i) = 0$. A solution concept ϕ satisfies the null player property if for every coalitional game $(N; v)$ and every null player i in the game, $\phi_i(N; v) = 0$

The additivity axiom studies a couple of cooperative games with an equal set of members and attaches the solution of those two games to the solution of their sum.

If for every pair of cooperative games $(N; v)$ and $(N; w)$, $\phi(N; v + w) = \phi(N; v) + \phi(N; w)$, then solution concept ϕ satisfies additivity. If the same set of players participate in the two cooperative games $(N; v)$ and $(N; w)$. The value that player i foresees to get in $(N; v)$ is $\phi_i(N; v)$, and the value that player i foresees to get in $(N; w)$ is $\phi_i(N; w)$. Shapley claimed that there is a unique solution concept which providing efficiency, additivity, the null player property, and symmetry. Shapley presented a specific formula for calculating this solution concept. The Shapley value is the only single-valued solution concept which satisfying efficiency, additivity, the null player property, and symmetry. The following equation gives the Shapley value (Curiel, 2013):

$$\phi_i(\mathbf{v}) = \sum_{i \in S} \frac{(|S| - 1)! (n - |S|)!}{n!} (\mathbf{v}(S) - \mathbf{v}(S - \{i\}))$$

3. Research Background

Thus far, most studies and research in this field have concentrated on energy geopolitics and its influence on the broader Central Asian or Caspian Basin international relations landscape. However, less attention has been given to quantitative models designed to calculate the bargaining power of countries based on economic evaluations of potential projects. This part of the research reviews studies on oil and gas transmission and economic cooperation between China and Central Asia countries.

Krey and Minullin 2010 modeled the competition among natural gas pipeline projects in China using a two-step non-cooperative game theory model. Several potential pipelines from Russia and CIS countries to China have investigated in this research and results indicate that four out of five pipelines are economically feasible and among these four Irkutsk pipeline and Sakhalin to northern China would be competitive in the next years, and operation from Kazakhstan requires a deeper and efficient market. The authors state that China will be closer to energy sustainability if it uses pipelines from Russia and Kazakhstan in addition to domestic resources (Krey & Minullin, 2010).

Cobanli 2014 studied the central Asia gas impact on the Eurasian power game using a quantitative model based on cooperative game theory. To calculate the player's bargaining power via Shapley value, the author economically evaluated the pipeline projects. In the transition route, Turkey, because of its unique geographical position, holds the maximum bargaining power and collects a large portion of benefits driven from Caspian Basin-Europe gas trade. The author mentions four primary pipeline options compete for diversification of the central Asia gas transfer to export markets, and for Turkmenistan, the route via the Caspian Sea is the most beneficial west bound option. Bringing larger gains than the western options, the Turkmenistan-China pipeline is the best diversification option for the Central Asian countries (Cobanli, 2014).

In another study, Fatima and Zafar 2014 explored the new great game in central Asia from geopolitical, geo-economics, and geostrategic aspects. The authors argue that the centrality of this region did not diminish though changed its dimensions and the main reasons of the importance of this

region are geographical location, closeness to major powers like Russia and China, and richness of energy resources such as oil and natural gas and these factors have initiated the new great game in the region. The authors believe that major players in this region are China, the USA, Russia, Iran, Turkey, and Pakistan. Each player is pursuing its policies to achieve its goals, and the most crucial goal for major powers is to control the energy resources and corridors. Central Asia states aim to extract maximum benefit from their geographical position (Fatima & Zafar, 2020).

Hu Bin 2014 investigates oil and gas cooperation between China and Central Asia in the competitive environment to propose measures for improving cooperation in oil and gas. The author states that central Asia has a prominent geopolitical situation and major powers have competition on energy resources and transition routes. CNPC succeeded in completing centers for producing 50 million tons of oil and gas yearly. This cooperation faced challenges like political risks of central Asia countries and frequently occurring violence in the region. Hu Bin suggests that for improving cooperation, China should develop an acquisition strategy, assign an ambassador for regional energy, establish regional multinational subsidiaries, and improving risk prevention systems (Hu, 2014).

Gulinaer Yusufu 2017 studied oil and gas cooperation between China and Central Asia. The author argues that because of the shortage of domestic oil and gas production and rapid economic development and growing domestic demand, China's dependence on imports will continue to grow. On the other hand, as one of the resource-rich areas of the world the importance of central Asia increases continuously and due to fostering the development process, they are looking for markets for their energy. Central Asian countries and China both developed energy strategies which have strong complementarities and the Shanghai Cooperation Organization provided an excellent platform for the implementation of the energy strategy. Therefore, the development of energy cooperation is feasible both in theory and practice (Gulinaer, 2017).

In another study, Orazgaliyev and Eduardo 2019 considered the conflict and cooperation in the Caspian Sea. They model the case as a prisoner's dilemma involving five claimant countries and interests of major power (US, European Union, and China) with two different outcomes. In the northern region of the Caspian Sea neighbors got an agreement to cooperate and solve their problems on ownership of oil fields. In the southern parts of the Caspian Sea, neighbors failed to get an agreement and cooperate

despite decades of effort. However, governance regimes are not static and are changeable over time due to the interplay of geopolitical and economic factors. Authors conclude that in the case of the Caspian seas northern part, geopolitical and economic considerations are the main factor of cooperation. The study does not provide universal implications because the oil and gas resources and pipelines in the Caspian region make its calculations unique (Orazgaliyev & Araral, 2019).

Jafarzadeh 2021 studied the energy transfer from Azerbaijan and Turkmenistan, and Iran through the Nabokov pipeline to the European gas market using a cooperative game theory model. After calculating each country's bargaining power in each probable scenario, the authors argue that the Nabokov pipeline is economically feasible if Iran increases its gas production and contributes to the coalition for exporting gas from the Caspian basin to Europe. Turkey has the highest bargaining power among the countries because none of the projects is feasible if turkey do not allow the pipelines to go through its soil, and every member of the coalition requires turkey contribution (Jafarzadeh et al., 2021).

Baghdadi 2021 researched Caspian basin oil and gas transfer to Europe through the pipeline using an interdisciplinary approach based on cooperative game theory and international political economy. After exploring the Caspian region transfer network and Caspian Sea neighbors' oil and gas reserves, the authors calculated each probable scenario's net present value in a 30 year-long vision and then calculated each country's bargaining power using shapely value. The authors claim that the best probable scenario for Europe gas importing diversification is the formation of a great coalition among Iran, Azerbaijan, Turkmenistan, and Kazakhstan to export gas to Europe through the Turkey and Iran route has an advantage over the proposed trans-Caspian pipeline. The authors argue that each country's geo-economics and energy resources is the primary factor of national power using the neorealism school of the international political economy, and the cooperative game theory model ratifies it (Baghdadi, 2022).

4. Natural Gas Transfer Scenarios

This section delineates the game-theoretic framework employed to analyze the economic viability and bargaining power dynamics of oil and gas pipeline projects from Central Asia to China. The primary objective is to evaluate the potential scenarios and assess the relative influence of each participating country.

Firstly, the game is defined, identifying the key players, their strategic options, and the associated payoffs. Subsequently, a cooperative game-theoretic approach, specifically the Shapley value, is utilized to analyze coalition formation and power distribution among the players. By applying this methodology, we aim to address the following research questions:

- What are the most economically viable pipeline routes?
- How does the geographic location of countries influence their bargaining power?
- What is the impact of production capacity on a country's bargaining position?

The analysis will provide insights into the potential benefits and risks associated with various pipeline projects, as well as the geopolitical implications of these energy infrastructure developments.

4.1. Game Definition

The players of the game are indicated by $N = \{i, \dots, n\}$, where N is the number of players. The network $N = \{IR, AZ, TN, KA, UZ\}$ includes Iran, Kazakhstan, Azerbaijan, Turkmenistan and Uzbekistan. The players form coalitions and the set of final coalitions is called the characteristic function. Kazakhstan and Uzbekistan are being considered as the most important players in the transfer process, because without the participation of these countries in the game, the occurrence of scenario which is the gas transfer to china market is impossible. Therefore, the revenue that Kazakhstan and Uzbekistan earn from gas transmission can be considered a part of the country's payoff in this game. In addition to Uzbekistan and Kazakhstan, it is possible for each country to enter the game in mathematical order, but the research model has limitations to show the possible scenarios. In this game, Turkmenistan, Kazakhstan, Azerbaijan, Iran and Uzbekistan are competing and cooperating to form an oil and gas alliance with China. Russia, for political and economic reasons, is unlikely to join any of the alliances, as it has made every effort in recent years to maximize the amount of energy transferred from its route to the Chinese market. Russia's main goal is to make China's energy security more dependent on itself. Russia has also designed and built gas pipelines to China in recent years. As a result, we ignore Russia's participation in this game because of the possibility of opposition.

4.2. Characteristic Functions Definition

In cooperative games, to in order to quantify the payoff of the game for the players, characteristic functions should be defined first. For Iran, Azerbaijan, Turkmenistan, Kazakhstan and Uzbekistan, the characteristic function is the profit function of gas supply to China. The net present value of gas supply can be calculated according to the income and cost of the pipeline projects and considered as their benefit or payoff. The minimum number of players required to form an oil or gas coalition is 1 because one can be producer and transmitter as the same time.

To calculate the total profit of gas exports of the mentioned countries to China, the net present value is calculated. Characteristic functions are defined as the gas supply profit function, as follow (Baghdadi, 2022):

$$NPV = \sum_{i=1}^t \frac{NPV}{(1 + pr.r)^t}$$

$$NPV_t = Income - (Capex + Opex)$$

$$Capex = lc + d$$

$$Opex = 0.08 * Capex$$

$$Income = P * Q$$

$l = l =$ Length of pipeline (km)

$c = c =$ Cost of the pipeline per km

$d = d =$ Upstream design cost

$Q = Q =$ Capacity (1000m³)

$P = P =$ Natural gas price (1000 m³)

$PR =$ political risk

Political risk is incorporated into the model as a factor influencing the interest rate. The highest political risk among the countries along the pipeline route is assigned to the entire route. This risk premium, which is greater than one, is multiplied by the base interest rate, effectively increasing the borrowing cost and reducing the net present value of the project. For instance, in the Uzbekistan-Turkmenistan cooperation scenario, the higher political risk of 0.52 results in a risk-adjusted interest rate of 1.52 times the base rate. Consequently, higher political risk correlates with lower net present values, reflecting the increased uncertainty and associated financial costs (Baghdadi, 2022).

The assumptions of the following table are used in the calculations of the net present value function. The quantitative assumptions in the table below are taken from the source (Oil & Gas, 2022)

Table 1

quantitative assumptions for gas transmission scenarios

Title	Unit of measurement	Quantity
Pipeline capacity	Billion cubic meter	55
Downstream part design	Million dollar	400
Onshore pipeline cost per kilometer(CAPEX)	million dollar	4.75
Annual operational cost(OPEX)	percent of total capital cost	8

The natural gas price used in this study is based on the average export price of Iranian gas to Iraq and the average import price of gas for Turkey and China over the decade ending in 2018. This average price is estimated at \$7.56 per million British thermal units (MMBtu) or \$270 per thousand cubic meters (m³). Gas transmission costs vary widely across regions and pipeline systems, influenced by factors such as pipeline infrastructure, operating costs, and contractual arrangements. Some countries, such as Russia and Ukraine, have historically charged transit fees per unit of gas per distance traveled. For instance, Russia charged approximately \$1.09 per thousand cubic meters per 100 kilometers for transporting Turkmen gas to Ukraine in 2014. Considering these factors, a conservative estimate of \$3.1 per million cubic meters per 100 kilometers is adopted for

gas transmission costs in this study, reflecting the historical costs of transporting Turkmen gas through Ukraine.

To account for geopolitical factors, the research incorporates a political risk index into the economic analysis. Given the intergovernmental nature of such large-scale infrastructure projects, political stability is a critical determinant of project viability. The Middle East and Central Asia region, characterized by geopolitical tensions and historical conflicts, presents significant political risks. To quantify these risks, a 10-year average of political risk indices for the countries involved in each coalition is utilized. This approach allows for a more nuanced assessment of the potential challenges and uncertainties associated with each scenario.

The International Country Risk Guide (ICRG), published since 1979, considers the political, economic and financial risk of more than 140 countries (The Prs Group, 2021). This index is a function of factors such as ethnic tensions, internal tensions and conflicts, external tensions and conflicts, the quality of the institutions, corruption control, militarist intervention in politics and the economy, the state of investment and the rule of law. The index is calculated annually, and organizations such as Transparency International have been using the data and information in their reports for 20 years. Also, the only methodology accepted by the courts for trade disputes over countries' political risk is the methodology used by the ICRG (Baghdadi, 2022).

4.3. Results of calculations

This section presents the net present value (NPV) analysis of various gas transmission projects. The NPV, representing the present value of future cash flows, serves as the primary metric for evaluating project viability and determining the bargaining power of participating countries. Gross project revenues are estimated based on realistic assumptions regarding gas prices, transmission volumes, and operating costs. The NPV is calculated using a discount rate of 10% over a 30-year project horizon, with a 5-year construction phase and a 25-year operational phase. Excel software is utilized for NPV calculations, while R software is employed for analyzing bargaining power dynamics.

4.4. Current Situation Scenario

In the current situation scenario, without considering future scenarios and creating new capacities and other countries' cooperation, characteristic functions and bargaining power are analyzed according to the existing infrastructure. Turkmenistan currently exports gas to China. Kazakhstan and Uzbekistan also export gas to China. In 2023, Uzbekistan exported about 1.2 bcm, Kazakhstan exported 4.6 bcm and Turkmenistan exported 30.5 bcm of natural gas to China through the Central Asia-China gas pipeline with a capacity of 55 billion cubic meters (Bp, 2019). Considering the unused capacities of transmission lines, it is possible to examine countries' ability to export gas to China and examine the bargaining power of each. In the current situation and with the existing infrastructure, Turkmenistan, Uzbekistan and Kazakhstan export gas to China via the Central Asia-China pipeline (Line A, B and

C). Currently, Iran does not export natural gas to China, and its main exports are to Turkey and Iraq.

$$1 - V(KA) = -5.5$$

$$2 - V(TN) = 0$$

$$3 - V(UZ) = 0$$

$$4 - V(KA, UZ) = -3.3$$

$$5 - V(KA, TN) = 0$$

$$6 - V(TN, UZ) = 0$$

$$7 - V(KA, TN, UZ) = 20.4$$

In the baseline scenario, the analysis focuses on existing infrastructure and current export capacities. Turkmenistan, Kazakhstan, and Uzbekistan are the primary exporters of natural gas to China via the Central Asia-China pipeline. Iran, while possessing significant gas reserves, is currently not connected to the Chinese gas market.

Given the limited pipeline capacity and the absence of direct connections, Iran is excluded from the initial analysis. The Shapley value is calculated for the three Central Asian countries based on their individual and cooperative NPVs. The results indicate that a coalition among these countries is economically viable and offers the highest collective payoff. The Shapley value, derived from these calculations, provides insights into the relative bargaining power of each country within the coalition.

$$\{KA, UZ, TN\} = \{9.2, 6.4, 4.7\}$$

Kazakhstan emerges as the country with the highest bargaining power within the coalition. This dominance can be attributed to its critical role as a transit country for gas exports to China. The dependence of other countries on Kazakhstan's soil provides it with significant leverage in negotiations. Uzbekistan, with its substantial gas reserves and strategic location, holds the second-highest bargaining power. However, its reliance on the same export pipeline as Kazakhstan limits its influence. Despite being the largest gas exporter in the region, Turkmenistan exhibits the lowest bargaining power. This is primarily due to the absence of direct pipeline connections to China and the availability of alternative supply sources for Chinese buyers.

4.5. Iran adjoining to Kazakhstan, Turkmenistan and Uzbekistan Scenario

Iran has the potential to join the regional gas export network by constructing a new pipeline connecting its extensive gas reserves in the South Pars field to the Turkmen gas pipeline system. This pipeline, with a projected capacity

of 12 billion cubic meters per year and a length of approximately 1,087 kilometers, could significantly enhance Iran's export capabilities within the region.

$$\begin{aligned}
 1 - V(KA) &= -5.5 \\
 2 - V(UZ) &= 0 \\
 3 - V(TN) &= 0 \\
 4 - V(IR) &= 0 \\
 5 - V(KA, UZ) &= -3.02 \\
 6 - V(KA, TN) &= 0 \\
 7 - V(KA, IR) &= 0 \\
 8 - V(UZ, TN) &= 0 \\
 9 - V(UZ, IR) &= 0 \\
 10 - V(IR, TN) &= 0 \\
 11 - V(KA, UZ, TN) &= 20.4 \\
 12 - V(KA, UZ, IR) &= 0 \\
 13 - V(KA, TN, IR) &= 0 \\
 14 - V(UZ, TN, IR) &= 0 \\
 15 - V(KA, UZ, TN, IR) &= 28.6
 \end{aligned}$$

The provided functions represent the net present value (NPV) of various coalition scenarios for natural gas exports to China. Only Kazakhstan can export gas independently, but this scenario is economically infeasible due to a negative NPV of -\$5.5 billion. Other countries lack direct pipeline connections to China and thus have zero NPV. While several bilateral combinations are theoretically possible, only the Kazakhstan-Uzbekistan partnership is practically feasible, albeit with a negative NPV of -\$3.2 billion. The coalition of Turkmenistan, Uzbekistan, and Kazakhstan yields a positive NPV of \$20.4 billion, indicating significant economic benefits. The optimal scenario (grand coalition) involves the cooperation of all four countries (Kazakhstan, Uzbekistan, Turkmenistan, and Iran). This grand coalition offers the highest NPV of \$28.6 billion. The Shapley value, derived from these NPV calculations, provides insights into the relative bargaining power of each country within the coalition:

$$\{KA, UZ, TN, IR\} = \{10.5, 8.6, 8.1, 1.3\}$$

The Shapley value analysis reveals that Kazakhstan possesses the highest bargaining power, primarily due to its strategic geographic location as a transit country for Central Asian gas exports to China. Uzbekistan, Turkmenistan, and Iran follow in terms of bargaining power, with their

respective positions influenced by factors such as production capacity and proximity to the Chinese market.

Generally, countries with higher production capacity and favorable geographic locations tend to have greater bargaining power. However, it's important to note that other factors, such as geopolitical considerations and specific contractual arrangements, can also significantly impact the distribution of bargaining power among the participating countries.

4.6. Line D of Central Asia-China pipeline operation scenario

In 2018, construction commenced on Line D of the Central Asia-China gas pipeline, a 1,000-kilometer pipeline designed to transport an additional 30 billion cubic meters of natural gas per year from Turkmenistan's gas fields to China, traversing Uzbekistan, Tajikistan, and Kyrgyzstan. The project was spearheaded by Trans-Asia Gas Pipeline Company Ltd., a subsidiary of CNPC, in partnership with Tojiktransgaz. However, in early 2020, the project was temporarily suspended. As of late 2023, there has been renewed interest in the construction of Line D of the Central Asia-China Gas Pipeline. PetroChina, the Chinese state-owned energy giant, is actively working towards resuming construction in 2024, pending the finalization of a long-term gas supply contract with Turkmenistan (Bp, 2019).

$$\begin{aligned}
 1 - V(KA) &= -21.8 \\
 2 - V(UZ) &= 0 \\
 3 - V(TN) &= 0 \\
 4 - V(TA) &= 0 \\
 5 - V(KY) &= 0 \\
 6 - V(KA, UZ) &= 0 \\
 7 - V(KA, TN) &= 0 \\
 8 - V(KA, TA) &= 0 \\
 9 - V(KA, KY) &= 0 \\
 10 - V(UZ, TN) &= 0 \\
 11 - V(UZ, TA) &= 0 \\
 12 - V(UZ, KY) &= 0 \\
 13 - V(TN, TA) &= 0 \\
 14 - V(TN, KY) &= 0 \\
 15 - V(TA, KY) &= 0 \\
 16 - V(KA, UZ, TN) &= 0 \\
 17 - V(KA, UZ, TA) &= 0 \\
 18 - V(KA, UZ, KY) &= 0
 \end{aligned}$$

$$\begin{aligned}
 19 - V(KA, TN, TA) &= 0 \\
 20 - V(KA, TN, KY) &= 0 \\
 21 - V(KA, TA, KY) &= 0 \\
 22 - V(UZ, TN, TA) &= 0 \\
 23 - V(UZ, TA, KY) &= -10.4 \\
 24 - V(TN, TA, KY) &= 0 \\
 25 - V(KA, KY, TN) &= 0 \\
 26 - V(KA, UZ, TN, TA) &= 0 \\
 27 - V(KA, UZ, TN, KY) &= 0 \\
 29 - V(KA, UZ, TA, KY) &= 0 \\
 28 - V(KA, TN, TA, KY) &= 0 \\
 30 - V(UZ, TN, TA, KY) &= 0 \\
 31 - V(KA, UZ, TN, TA, KY) &= 17.5
 \end{aligned}$$

The provided functions represent the net present value (NPV) of various coalition scenarios for natural gas exports to China. Single-Country Scenarios: Only Kazakhstan can export gas independently, but this scenario is economically infeasible due to a negative NPV of -\$21.8 billion. Other countries lack direct pipeline connections to China and thus have zero NPV.

Several bilateral combinations are possible, but most are economically unviable due to limited infrastructure and market access. The coalition of Turkmenistan, Uzbekistan, and Kazakhstan yields a negative NPV of -\$10.4 billion, indicating limited economic benefits. Grand coalition involves the cooperation of all five countries (Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, and Iran). This grand coalition offers a positive NPV of \$17.5 billion, signifying the potential for significant economic gains through regional cooperation.

The Shapley value, derived from these NPV calculations, provides insights into the relative bargaining power of each country within the coalition.

$$\{KA, UZ, TA, KY, TN\} = \{7.3, 2.7, 2.7, 2.7, 1.8\}$$

According to the above results, Kazakhstan has the most bargaining power due to its geographical location and the dependence of other countries on it. After Kazakhstan, Uzbekistan and Turkmenistan have the highest bargaining power, respectively, due to geographical location and production capacity. Turkmenistan has the least bargaining power due to the essential need for other countries' soil for export natural gas through a pipeline to China.

4.7. Iran adjoining and operation of Line D scenario (same time)

In this scenario, we assume that Iran has joined the coalition and Line D of the Central Asia-China pipeline is operational. Iran aims to export 12 billion cubic meters of natural gas annually through a new pipeline connecting its gas fields to the Central Asia-China pipeline system.

This expanded coalition includes six countries, resulting in a large number of potential coalition formations. However, only a few of these combinations are practically feasible due to geographic constraints, economic considerations, and political factors. Therefore, we focus on the most relevant scenarios.

$$\begin{aligned}
 1 - V(KA) &= -21.8 \\
 2 - V(UZ, TA, KY) &= -4.6 \\
 3 - V(KA, UZ, TN, TA, KY) &= 17.2 \\
 4 - V(KA, UZ, TN, IR, TA, KY) &= 20.8
 \end{aligned}$$

The provided functions represent the net present value (NPV) of various coalition scenarios for natural gas exports to China. Only Kazakhstan can export gas independently, but this scenario is economically infeasible due to a negative NPV of -\$21.8 billion. The coalition of Uzbekistan, Tajikistan, and Kyrgyzstan yields a negative NPV of -\$4.6 billion, indicating limited economic benefits. The coalition of Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, and Kyrgyzstan offers a positive NPV of \$17.2 billion, demonstrating the potential for significant economic gains through regional cooperation. The optimal scenario involves the cooperation of all five countries, resulting in a higher NPV of \$20.8 billion. The Shapley value, derived from these NPV calculations, provides insights into the relative bargaining power of each country within the coalition:

$$\{KA, UZ, TA, KY, TN, IR\} = \{7.6, 3.3, 3.3, 3.3, 3.2, 2\}$$

Similar to previous scenarios, Kazakhstan maintains the highest bargaining power due to its strategic geographic location and the dependence of other countries on its transit infrastructure. Uzbekistan, Turkmenistan, and Kyrgyzstan also possess significant bargaining power, influenced by factors such as production capacity and proximity to the Chinese market. Iran, while possessing substantial gas reserves, has the lowest bargaining power due to its reliance on transit routes through other countries to reach the Chinese market.

5. Oil Transfer Scenarios

This section explores potential scenarios for oil pipeline projects in the Caspian Basin region. To quantify the economic benefits and bargaining power of participating countries, a cooperative game-theoretic approach is employed. Characteristic functions are defined to represent the net present value (NPV) of oil exports to China for each coalition.

In this context, the minimum coalition size is one, as a country can both produce and transport oil independently. The NPV of oil exports is calculated based on factors such as production capacity, transportation costs, and market prices.

The following characteristic functions define the potential payoffs for different coalition structures:

$$NPV = \sum_{i=1}^t \frac{NPV}{(1 + pr.r)^t}$$

Table 2

quantitative assumptions for oil transmission scenarios

Title	Unit of measurement	Quantity
Pipeline capacity	Barrels per year	360000000
Downstream part design	Million dollar	400
Onshore pipeline cost per inch(CAPEX)	thousand dollar	161000
Annual operational cost(OPEX)	percent of total capital cost	8

Oil prices are assumed based on the average oil price in the Dubai market from 2009 to 2019(before covid shock). The average price of Dubai oil in the last ten years is \$ 77. Also, the oil transfer tariff is set at \$ 4 per barrel, the Turkish tariff for the transfer of Azerbaijani oil.

Since contracts for this type of project are considered intergovernmental contracts and governments are responsible for their commitments, the political risk index can be used in the equations. The quantitative assumptions in the table below are taken from the source (Oil & Gas, 2022).

5.1. Current Situation Scenario

In the current situation, Kazakhstan supplies about 120,000 barrels of oil per day to China markets through the 2228-kilometer Kazakhstan–China oil pipeline the capacity of this pipeline is 120000 barrels per day. In 2022, Kazakhstan produced 1,931,000 barrels per day, and about 120,000 barrels exported to China through the Kazakhstan–China oil pipeline (Bp, 2019)

$$NPV_t = Income - (Capex + Opex)$$

$$Capex = lc + d$$

$$Opex = 0.08 * Capex$$

$$Income = P * Q$$

$$l = l = \text{Length of pipeline (km)}$$

$$c = c = \text{Cost of the pipeline per km}$$

$$d = d = \text{Upstream design cost}$$

$$Q = Q = \text{Capacity (1000m}^3\text{)}$$

$$P = P = \text{Oil price (per barrel)}$$

$$PR = \text{political risk}$$

The assumptions of the following table are used in the calculations of the net present value function.

$$1 - V(KA) = 2.7$$

The value of Shapley obtained from the above data is as follows:

$$\{KA\} = \{2.7\}$$

5.2. Iran and Turkmenistan adjoining to Kazakhstan scenario

Iran and Turkmenistan have the possibility to form a coalition with Kazakhstan by constructing a new Oil transmission pipeline. In this scenario, we assume that Iran and Turkmenistan intend to export oil through a pipeline to China and the pipeline's capacity will be about 280000 barrels per day. Its length will be about 2015 km from southern oil fields in Iran's Khuzestan province to Atyrau in Kazakhstan.

$$1 - V(KA) = 13.2$$

$$2 - V(TN) = 0$$

$$3 - V(IR) = 0$$

$$4 - V(KA, IR) = 0$$

$$5 - V(KA, TN) = -1.4$$

$$6 - V(TN, IR) = 0$$

$$7 - V(KA, TN, IR) = 19.7$$

The provided functions represent the net present value (NPV) of various coalition scenarios for oil exports to China. Single-Country Scenario: Only Kazakhstan can export oil independently, with a positive NPV of \$13.2 billion. While several bilateral combinations are possible, only the Kazakhstan-Turkmenistan partnership is practically feasible, albeit with a negative NPV of -\$1.4 billion. The coalition of Turkmenistan, Iran, and Kazakhstan yields a positive NPV of \$19.7 billion, demonstrating the potential for significant economic gains through regional cooperation.

The Shapley value, derived from these NPV calculations, provides insights into the relative bargaining power of each country within the coalition:

$$\{KA, TN, IR\} = \{11.2, 4.6, 3.8\}$$

Kazakhstan maintains the highest bargaining power due to its strategic geographic location and the dependence of other countries on its transit infrastructure. Turkmenistan and Iran, with their significant oil reserves, also hold considerable bargaining power. However, Iran's reliance on transit routes through other countries limits its bargaining power compared to the other two countries.

5.3. Kazakhstan new project scenario

Kazakhstan made a tremendous effort to absorb foreign investment during recent years. Tengiz oil field, which is one of the world's deepest oilfields in production, is being developed to further increase its oil production. Kazakhstan has plans to increase its oil production. The country aims to reach an oil production level of 100 million tons per year (around 730 million barrels) by 2030. Projects like the expansion of the Tengiz and Kashagan fields are expected to contribute significantly to increased production.

Kazakhstan continues to invest in exploration activities to discover new oil reserves.

In this scenario, we assume that the Kazakhstan oil export will increase by about 250000 barrels per day.

$$1 - V(KA) = 32.7$$

The value of Shapley obtained from the above data is as follows:

$$\{KA\} = \{3.2\}$$

5.4. Adjoining of Iran and Turkmenistan and Kazakhstan new project scenario

A potential scenario involves Iran and Turkmenistan forming a coalition with Kazakhstan by constructing a new oil pipeline. This pipeline, with a capacity of 280,000 barrels per day and a length of 2,015 kilometers, would connect Iran's Khuzestan oil fields to Atyrau in Kazakhstan. The following characteristic functions represent the net present value (NPV) of various coalition scenarios for oil exports to China:

$$1 - V(KA) = 26$$

$$2 - V(KA, TN) = 27.7$$

$$3 - V(KA, TN, IR) = 49.2$$

Only Kazakhstan can export oil independently, but this scenario is economically infeasible due to a negative NPV of -\$26 billion. The Kazakhstan-Turkmenistan coalition yields a positive NPV of \$27.7 billion, demonstrating the potential for significant economic gains. The coalition of all three countries (Kazakhstan, Iran, and Turkmenistan) offers the highest NPV of \$49.2 billion, highlighting the benefits of regional cooperation. Shapely value obtained from the above data is as follows:

$$\{KA, TN, IR\} = \{2.9, 1.6, 2.8\}$$

Like the previous scenarios, Kazakhstan has the most bargaining power over other countries due to its geopolitical energy position. Turkmenistan has the least bargaining power due to the very low oil export to china.

6. Research Findings

This study employs a game-theoretic approach to assess the bargaining power of countries within the Central Asian energy corridor. By analyzing various scenarios and calculating the net present value (NPV) of oil and gas

exports, the relative influence of each country is determined. The following table summarizes the key findings:

6.1. Research Findings on Gas Transmission Projects

Table 3

Shapely value of countries in gas transmission scenarios

Scenario Title	Shapely Value					
	Kazakhstan	Uzbekistan	Turkmenistan	Iran	Tajikistan	Kyrgyzstan
Current Situation	9.2	6.4	4.7	0	0	0
Iran adjoining	10.5	8.6	8.1	1.3	0	0
Line D operation	7.3	2.7	1.8	0	2.7	2.7
IR adjoining and Line D operation	7.6	3.3	3.2	2	3.3	3.3

Table 4

Shapely value of countries in gas transmission scenarios (percentage)

Scenario Title	Shapely Value(percentage)					
	Kazakhstan	Uzbekistan	Turkmenistan	Iran	Tajikistan	Kyrgyzstan
Current Situation	45%	31%	24%	0%	0%	0%
Iran adjoining	37%	30%	28%	5%	0%	0%
Line D operation	42%	13%	0%	0%	13%	13%
IR adjoining and Line D operation	33%	14%	13%	10%	15%	15%

6.2. Research Findings on oil Transmission Projects

Table 5

Shapely value of countries in oil transmission scenarios

Scenario Title	Shapely Value		
	Kazakhstan	Turkmenistan	Iran
Current Situation	2.7	0	0
Iran and Turkmenistan adjoining	11.2	4.6	3.8
Kazakhstan new project scenario	3.2	0	0
Adjoining of Iran and Turkmenistan and Kazakhstan new project scenario	2.9	1.6	2.8

Table 6

Shapely value of countries in oil transmission scenarios (percentage)

Scenario Title	Shapely Value(percentage)		
	Kazakhstan	Turkmenistan	Iran
Current Situation	100 %	0 %	0 %
Iran and Turkmenistan adjoining	57 %	24 %	19 %
Kazakhstan new project scenario	100 %	0 %	0 %
Adjoining of Iran and Turkmenistan and Kazakhstan new project scenario	40 %	22 %	38 %

This research aims to address the following key questions:

- What are the most likely scenarios for oil and gas trade between Central Asia and China?

- What are the potential economic and political implications of these scenarios?

- How does the Shapley value analysis reveal the distribution of bargaining power among the countries involved?

The findings of this research are crucial for understanding of China's energy security and the geopolitical dynamics of the Central Asian region. By analyzing the factors that influence bargaining power, policymakers can make informed decisions to optimize energy trade and promote regional cooperation.

The research findings indicate that two primary factors shape a country's bargaining power within the Central Asian energy corridor:

- 1- **Geopolitical Significance:** Countries with strategic geographic locations, such as Kazakhstan, possess significant bargaining power due to their control over critical transit routes. This geopolitical advantage enables them to influence the terms of energy trade and extract favorable deals.
- 2- **Production Capacity:** Countries with substantial oil and gas reserves have greater bargaining power, as their resources are essential for meeting regional and global energy demand.

Kazakhstan's dominant position in the region stems from its strategic location and well-developed infrastructure. Its control over key transit routes enables it to shape the flow of energy resources and exert influence over other countries. Iran, Turkmenistan, and Uzbekistan, with their significant hydrocarbon reserves, can significantly impact regional energy dynamics. However, their ability to leverage their resources depends on the development of adequate infrastructure and secure transit routes.

The implementation of various pipeline projects, such as Line D, can reshape the landscape and alter the distribution of bargaining power among countries. Increased connectivity and diversified export routes can enhance the bargaining power of countries with significant gas reserves, such as Turkmenistan and Iran.

7. Conclusion

Hydrocarbon energy sources, particularly oil and gas, are strategic commodities that significantly influence international relations and economic dynamics. Price volatility and supply disruptions can have profound geopolitical implications. For instance, the missile attack on Saudi Arabian oil facilities in 2019 led to a significant spike in global oil prices, highlighting the vulnerability of the global energy market. As the world transitions towards

cleaner energy sources, natural gas is gaining prominence as a bridge fuel. Its increasing demand, coupled with the complexity of regional gas markets and long-term contractual arrangements, makes it a strategic commodity. The Caspian Basin and Central Asia are rich in hydrocarbon resources, making them a focal point of geopolitical competition. China's growing energy demand necessitates secure and diversified energy supplies. The region's abundant resources offer a strategic opportunity to enhance China's energy security. Energy consumers seek to diversify their energy sources. Central Asia and the Caspian Basin offer potential alternatives. The competition for energy resources and transit routes can intensify geopolitical tensions between major powers, including Russia, the United States, and China. To maximize their leverage, Central Asian countries and Iran must prioritize regional cooperation and strategic partnerships. By investing in infrastructure, diversifying export routes, and fostering strong diplomatic ties, these countries can enhance their bargaining power and secure favorable deals. The emerging geopolitical landscape is characterized by shifting power dynamics, increased competition, and complex alliances. To navigate this complex environment, countries in the region must adopt a strategic approach that balances national interests with regional cooperation. By leveraging their geographic advantages and natural resources, Central Asian countries and Iran can position themselves as key players in the global energy market. However, they must also be mindful of the geopolitical risks and challenges that accompany their strategic aspirations.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

References

- Baghdadi, S. (2022). Caspian Basin Natural Gas Transfer: A Cooperative Game Theory Approach. *Journal of Energy and Economic Development*, 1(2), 50-66. <https://doi.org/10.30503/jeedev.2023.363025.1022>
- Beckley, M. (2018). The Power of Nations: Measuring What Matters. *International Security*, 43(2), 7-44. https://doi.org/10.1162/isec_a_00328
- Bp. (2019). Statistical Review of World Energy. <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energyeconomics/statistical-review/bp-stats-review-2019-full-report.pdf>
- bp. (2022). Statistical Review of World Energy 2022 (71st edition). <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf>
- Chakravarty, S. R., Mitra, M., & Sarkar, P. (2014). *A Course on Cooperative Game Theory*. Cambridge University Press. <https://doi.org/10.1017/CBO9781107415997>
- Cobanli, O. (2014). Central Asian gas in Eurasian power game. *Energy Policy*, 68, 348-370. <https://doi.org/10.1016/j.enpol.2013.12.027>
- Curiel, I. (2013). *Cooperative game theory and applications: cooperative games arising from combinatorial optimization problems* (Vol. 16). Springer Science & Business Media. [https://books.google.com/books?hl=en&lr=&id=BoXdBwAAQBAJ&oi=fnd&pg=PR7&dq=Curiel,+I.+\(2013\).+Cooperative+game+theory+and+applications:+cooperative+games+arising+from+combinatorial+optimization+problems,+Springer+Science+%26+Business+Media,+%09&ots=bmhQrc_W1w&sig=oAyPVnjF35T9K15CmJmuvdTN-BI](https://books.google.com/books?hl=en&lr=&id=BoXdBwAAQBAJ&oi=fnd&pg=PR7&dq=Curiel,+I.+(2013).+Cooperative+game+theory+and+applications:+cooperative+games+arising+from+combinatorial+optimization+problems,+Springer+Science+%26+Business+Media,+%09&ots=bmhQrc_W1w&sig=oAyPVnjF35T9K15CmJmuvdTN-BI)
- Fatima, Q., & Zafar, S. (2020). New Great Game: Players, Interests, Strategies and Central Asia. *South Asian Studies*, 29(2). <https://journals.pu.edu.pk/journals/index.php/IJSAS/article/view/2972>
- Feng, R. (2023). China's energy security and geopolitical imperatives: Implications for formulating national climate policy. *Next Energy*, 2, 100034. <https://doi.org/10.1016/j.nxener.2023.100034>
- Gulinaer, Y. (2017). Oil and Gas Cooperation between China and Central Asia. 2017 3rd International Conference on Economics, Social Science, Arts, Education and Management Engineering (ESSAEME 2017).
- Hirschman, A. O. (1980). *National power and the structure of foreign trade* (Vol. 105). University of California Press. [https://books.google.com/books?hl=en&lr=&id=BezqxPq50dwC&oi=fnd&pg=PA3&dq=Hirschman,+A.+O.+\(1980\).+National+power+and+the+structure+of+foreign+trade,+University+of+California+Press.+%09&ots=9cCVltSMFQ&sig=-BXN2YMFUUoEEF7R5V-ncxnTCHg](https://books.google.com/books?hl=en&lr=&id=BezqxPq50dwC&oi=fnd&pg=PA3&dq=Hirschman,+A.+O.+(1980).+National+power+and+the+structure+of+foreign+trade,+University+of+California+Press.+%09&ots=9cCVltSMFQ&sig=-BXN2YMFUUoEEF7R5V-ncxnTCHg)
- Hu, B. (2014). Oil and gas cooperation between China and Central Asia in an environment of political and resource competition. *Petroleum Science*, 11, 596-605. <https://doi.org/10.1007/s12182-014-0377-7>
- Hubert, F., & Ikonnikova, S. (2011). INVESTMENT OPTIONS AND BARGAINING POWER: THE EURASIAN SUPPLY CHAIN FOR NATURAL GAS. *Journal of Industrial Economics*, 59(1), 85-116. <https://doi.org/10.1111/j.1467-6451.2011.00447.x>
- Iea. China - Countries & Regions - IEA. (n.d.). <https://www.iea.org/countries/china/efficiency-demand>
- Jackson, M. O. (2008). *Social and economic networks*. Princeton University Press. <https://doi.org/10.1515/9781400833993>
- Jafarzadeh, A., Shakeri, A., Ghasemi, A., & Javan, A. (2021). Possibility of potential coalitions in gas exports from the Southern Corridor to Europe: a cooperative game theory framework. *OPEC Energy Review*, 45(2), 217-239. <https://doi.org/10.1111/opec.12196>
- Krey, V., & Minullin, Y. (2010). Modelling competition between natural gas pipeline projects to China. *International Journal of Global Environmental Issues*, 10(1-2), 143-171. <https://doi.org/10.1504/IJGENVI.2010.030571>
- Lee, C.-C., & Wang, C.-s. (2022). Financial development, technological innovation and energy security: Evidence from Chinese provincial experience. *Energy Economics*, 112, 106161. <https://doi.org/10.1016/j.eneco.2022.106161>
- Myerson, R. B. (1977). Graphs and cooperation in games. *Mathematics of Operations Research*, 2, 225-229. <https://doi.org/10.1287/moor.2.3.225>
- Oil, & Gas, J. (2022). Land pipeline construction costs hit record \$10.7 million/mile. <https://www.oil.com/pipelines-transportation/pipelines/article/55233450/cheaper-labor-helps-reduce-pipeline-construction-costs>
- Orazgaliyev, S., & Araral, E. (2019). Conflict and Cooperation in Global Commons. *International Journal of the Commons*, 13(2), 962-976. <https://doi.org/10.5334/ijc.914>
- Pascual, C., & Zambetakis, E. (2010). The geopolitics of energy. In *Energy security: Economics, politics, strategies, and implications* (pp. 9-35). https://www.brookings.edu/wp-content/uploads/2016/07/energysecurity_chapter.pdf
- Piketty, T., Yang, L., & Zucman, G. (2019). Capital Accumulation, Private Property, and Rising Inequality in China, 1978-2015. *American Economic Review*, 109(7), 2469-2496. <https://doi.org/10.1257/aer.20170973>
- Rauch, C. (2017). Challenging the Power Consensus: GDP, CINC, and Power Transition Theory. *Security Studies*, 26(4), 642-664. <https://doi.org/10.1080/09636412.2017.1336389>
- Tadelis, S. (2013). *Game Theory: An Introduction*. Princeton University Press. [https://books.google.com/books?hl=en&lr=&id=_4OqAaITAWMC&oi=fnd&pg=PP1&dq=Tadelis,+S.+\(2013\).+Game+Theory:+An+Introduction,+Princeton+University+Press.+%09&ots=oMZ7V4SpUn&sig=_STMs3XnxoLns5-32U9Afdk97-I](https://books.google.com/books?hl=en&lr=&id=_4OqAaITAWMC&oi=fnd&pg=PP1&dq=Tadelis,+S.+(2013).+Game+Theory:+An+Introduction,+Princeton+University+Press.+%09&ots=oMZ7V4SpUn&sig=_STMs3XnxoLns5-32U9Afdk97-I)
- Tang, W., & Joldybayeva, E. (2023). Pipelines and power lines: China, infrastructure and the geopolitical (re)construction of Central Asia. *Geopolitics*, 28(4), 1506-1534. <https://doi.org/10.1080/14650045.2022.2062325>
- The Prs Group, I. (2021). The International Country Risk Guide (ICRG). <https://www.prsgroup.com/explore-our-products/international-country-risk-guide/>

- Wu, K. (2014). China's energy security: Oil and gas. *Energy Policy*, 73, 4-11. <https://doi.org/10.1016/j.enpol.2014.05.040>
- Xie, Z. (2021). China's energy infrastructure development in Central Asia and its impact on regional energy supply and geopolitics. *Journal of Inter-Regional Studies: Regional and Global Perspectives (JIRS)*, 4. https://waseda.repo.nii.ac.jp/record/58952/files/JIRS_4_2.pdf
- Zhang, R., Worden, S., Xu, J., & et al. (2022). Social stability risk assessment and economic competitiveness in China. *Humanities and Social Sciences Communications*, 9, 309. <https://doi.org/10.1057/s41599-022-01329-8>