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Why LNG Can Be a First Step in East Asia's Energy Transition to a Low Carbon Economy: Evaluation of Challenges Using Game Theory

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Abstract: As countries scramble for cleaner energy production and to meet carbon reduction targets, natural gas seems to become an increasingly attractive option with liquified natural gas (LNG) as a popular transportation choice. In this paper, we first conduct a literature review and discuss the various factors affecting the global natural gas market, its recent history, current state, and future. Then we look at the possibility of East Asia becoming an alternative market to Europe for Russian LNG. We also bring in the US both as a political force that employs economic sanctions and as a potential LNG supplier. As a case study, we define a 3-player game between Russia, The United States, and Japan which results in relative market stability. In the case of sanctions against Russia, we conclude that it will lose its foothold in the Japanese market in the long term. Finally, we discuss the potential of LNG trading as the first step for East Asia's energy transition to a low-carbon economy.

Keywords: East Asia; LNG; Russia; United States; game theory; energy transition

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1. Introduction

Globally, natural gas consumption is expected to rise as the transition to low-carbon technologies progresses. Production is likely to keep an upward trajectory fueled by the emergence of new suppliers in the past few years especially as new unconventional sources are becoming viable economic options [1]. The shale gas boom has introduced a new dynamic in the global LNG market. Europe has historically been reliant on Russian natural gas which has undermined its political standing. Russia has repeatedly utilized its natural gas exports as political levers, notably in the Crimean dispute with Ukraine in 2014. The United States has rapidly increased its production of natural gas in the last few years and it is seen as an opportunity for Europe to diversify imports and strengthen its negotiating power [2].

1.1. LNG Market in East Asia

LNG is particularly important to Asia, as geography has created a situation where two Asian industrial powerhouses—Korea and Japan—rely on imports from faraway sources [3]. Japan is the world's largest importer of LNG, accounting for 21.7% of global imports in 2019. Major suppliers to Japan are Australia, Qatar, Indonesia, Malaysia, and more recently, Russia with the U.S. close behind. The import data can be seen in Table 1. The price of LNG available to Japan peaked in the years between 2010 and 2014 but has since fallen, this fall can be attributed to growing supply. A key observation is that Russia only started to hold a meaningful share of the Japanese market in 2008, but in 11 years it has claimed ≈8.2% of Japanese imports. This shows that Russia can compete with other suppliers and has the potential to increase its market share [4].

Table 1. Japanese LNG import data by country, 2020. Data collected from [4].

	Total Proven Natural Gas Reserves (t cm *)	LNG Exports to Japan (b cm †)
Australia	2.4	39.7
Malaysia	0.9	14.8
Qatar	24.7	11.9
Russia	37.4	8.4
United States	12.6	6.4
Iran	32.1	-

* Trillion cubic meters; † Billion cubic meters.

Richman and Ayyılmaz [2] defined a 3-player game between the United States, Russia, and Europe. They analyzed the diversification choice of Europe, economic and political moves from the United States, and a politicization response from Russia. Their study is motivated by the buyer-supplier dynamic between Europe and Russia and the place it has during times of political friction (e.g., the Crimean Crisis). The authors highlighted the importance of infrastructure development for Europe to reduce dependency on one supplier and the potential role that other suppliers (such as Qatar) can play in changing existing relationships. Game theory has also been used in the context of international environmental agreements (IEAs) [5,6]. This is interesting due to the increasing integration of environmental concerns into decisions and policies involving energy and energy use. GHG reduction targets have been set by many countries and entities, such as the EU, have based their energy policy on mitigating GHG emissions. As these agreements become more established, their impact becomes more noticeable, and they should be considered in future research.

Moe [7] studied the vested interests present in the energy industry of Japan. Japan is a country without a meaningful portfolio of fossil fuel reserves and is one of the world's biggest importers with a massive albeit declining need. A well-developed grid also creates problems when new technologies such as renewables emerge, as we see in the case of Japan where established policies are hard to nudge towards a change in the direction of newer alternatives. However, the tragic incident at Fukushima may have just become a catalyst for this change, speeding up the energy transition into a more renewable-friendly energy grid. However, the paper concludes that while this transition is taking place, LNG will be a short-term winner in terms of consumption, filling a role between traditional modes of energy production and emerging ones for Japan's energy transition.

On the other hand, climate change is a big concern for Europe, this can impact everything from food supply chains to habitable areas. The EU has also taken a big step toward renewables by setting ambitious targets and tight regulations [8]. Studies show different energy policies affect energy production, weather patterns, and climate change events. It shows that there is uncertainty in the performance of power systems as time goes on, and therefore new studies are needed to reduce uncertainty and create more robust plans. These studies are important as they illuminate the environmental effects of each policy, allowing a better and more accurate model of said policies to be constructed. An important issue is the forecasting of supply and demand. This is important to suppliers as they decide which market to invest in, and it is critical in current policy decisions both by suppliers and by the demand.

Choi and Heo [4] focused on modeling LNG price premiums available to Korea and Japan. The study looks at LNG originating from the Middle East (Qatar, Oman) and inside Asia (Malaysia, Indonesia) and finds that the appearance of a new supplier may not necessarily lead to a decrease in premiums. This study also discusses the policy implications resulting from this dynamic, and advocates for market cooperation especially among Asian countries, and a diversification of supply routes. The paper also advances the notion that the LNG markets of Asia and Europe are mutually influencing each other, in part due to the multitude of suppliers active in both markets. This influence should be paid attention to as

markets ebb and flow. The study also discusses events of note that have affected prices in Korea and Japan.

Söderbergh et al. [9] looked at the relationship between the EU and Russia with respect to the geographical positions of Russia's existing natural gas fields. The article notes that due to the proximity of fields in Eastern Siberia, the natural gas produced from them would most likely be sent to the Asia Pacific markets. Therefore, as a result of these complications, resource constraints may become an issue for Europe. This paper also mentions some of the agreements between Russia and countries in the Far East such as South Korea and China. It then goes on to calculate that Russia's export capacity to Europe may start to shrink as early as 2030 due to declines in Russia's western natural gas fields. The article's message seems to be that there needs to be discussions on whether Russia even has the capacity to keep up with European demand.

Kim and Blank [10] noted several interesting figures; Asia imports 60% of all LNG globally and is the fastest-growing market, moreover natural gas has the potential to supply 30% of the world's primary energy needs by 2025 and 35% by 2035 (although it should be noted that the recent COVID-19 outbreak may affect demand that was not expected previously, natural gas' share of primary energy use was 24.2% in 2019 with a growth rate of 2% [4]). Russia generates a significant amount of revenue from natural gas export to Europe (from $42 billion to $60 billion annually) which if were to decline would have a negative impact on the Russian economy. Therefore, Moscow should devise strategies to keep Russian natural gas competitive on an international scale if it wants to avoid losing its market share to emerging players such as the United States. The article also analyses actions that need to come from Washington in order to assist the EU in procuring its much-needed natural gas; The EU and the US should take more affirmative actions regarding bilateral cooperation in LNG trade, and the US should more firmly pursue developments in LNG infrastructure (in both continents) to facilitate trade. The EU has to perhaps put political pressure on Russia regarding pipelines.

Qatar is a country that exports considerable LNG to the Asian market. Therefore, it is useful to look at how the Qatari LNG was able to break into this market and how the market reacted. Table 1 shows that Qatar exports a large quantity of natural gas to Japan, and it also holds significant proven natural gas reserves. It should be noted that, in the Middle East region, Iran also is a large-scale producer and may very well be a key future player in the LNG industry if an opening presents itself (Table 2).

Table 2. Statistics of select countries in the Middle East region, Source: Data collected from [4], all quantities are in Billion cubic meters.

Country	Natural Gas Consumption	Production	LNG Exports
Iran	223.6	244.2	-
Saudi Arabia	113.6	113.6	-
UAE	76.0	62.5	7.7
Qatar	41.1	178.1	107.1
Oman	25.0	36.3	14.1

Meza and Koç [11] explored the impact of Qatari natural gas on the Asia Pacific market. It concludes that Qatar was instrumental in creating the current buyer's market dynamic which is important in understanding current and future market trends. The three most important factors that have impacted and helped transform the global natural gas trade are

- Advances in technology rendering previously uneconomic fields feasible
- New emerging suppliers
- Unconventional sources such as shale gas.

Understanding them is beneficial to any study involving natural gas. One key take-away from this article is that this market is everchanging and evolving, so, any player needs to constantly innovate and push for better margins to stay competitive.

Medlock et al. [12] looked at the shale gas boom and subsequent upheavals that the US experienced in its natural gas dynamics, going from a net importer to a net exporter in a short amount of time. Again, we see the highly complex and entangled nature of the natural gas market, as the article notes, it was increased production from within Asia that allowed Qatar to divert more of its natural gas to Europe. From the perspective of the American policymaker, aggressive LNG investment is seen as the key to deterring Sino-Russian cooperation and thus strengthening the geopolitical power of the United States. More LNG from the US would also mean more supply and subsequently lower prices which slows the flow of cash to the fossil fuel-dependent Russia, again helping elevate the US against Russia. The article concludes that stronger networks of trade between the US and its strategic allies can enhance energy security and help advance their geopolitical goals.

Guo and Hawkes [13] explored market equilibrium scenarios that may arise in the global natural gas scene. It specifically looks at various exportation strategies the United States may employ and their effects on prices. It reaches an interesting conclusion; if the United States keeps its reservations and does not pursue an aggressive export policy, it will result in continued European dependence on Russian natural gas. On the opposite side of the coin, if the US actively and aggressively invests in creating more export capacity, it will lead to revenue loss by the Middle East and Australia and a willingness to diversify from Europe. It is clear that whatever strategy the United States decides to follow will heavily impact not just regional natural gas markets, but also fossil fuel consumption trends and as a result, climate change mitigation strategies.

Len and Nian [14] addressed one of the most important events in recent Japanese history and its effects on the energy policy of Japan; the 2011 Fukushima Daiichi nuclear incident. This event triggered a rapid shift in public opinion in Japan against nuclear power and caused an increase in natural gas use. This article talks about the uncertainties facing Japan in determining its energy policy. The country needs to examine its energy security and reliance on fossil fuels and carbon-intensive industry and consider its relationship with its allies and neighbors. In another study, Wakamatsu and Aruga [15] explored the effects of the US shale gas revolution on the energy usage of Japan. It attempts to investigate and establish a causal link between the two markets to determine mutual influences. The article also investigates the possibility of methane hydrate extraction as a nonconventional natural gas source.

The significance of methane hydrate for Japan is its apparent abundance off the coasts of this otherwise fossil fuel-lacking nation (Figure 1). Commercial extraction of methane hydrate is not yet achieved by currently available technologies, but it is sought after due to the potential revenue and increase in energy security. This might become an impactful development in the future if we are able to extract methane hydrate at an affordable cost, and it has the potential to alter the entire landscape of the global LNG trade. This might trigger another upheaval in the markets akin to the shale gas revolution of the United States, LNG would be especially affected as Japan currently imports a large amount of LNG and might be able to substitute a great amount of it by domestically producing natural gas from extracted methane hydrate.

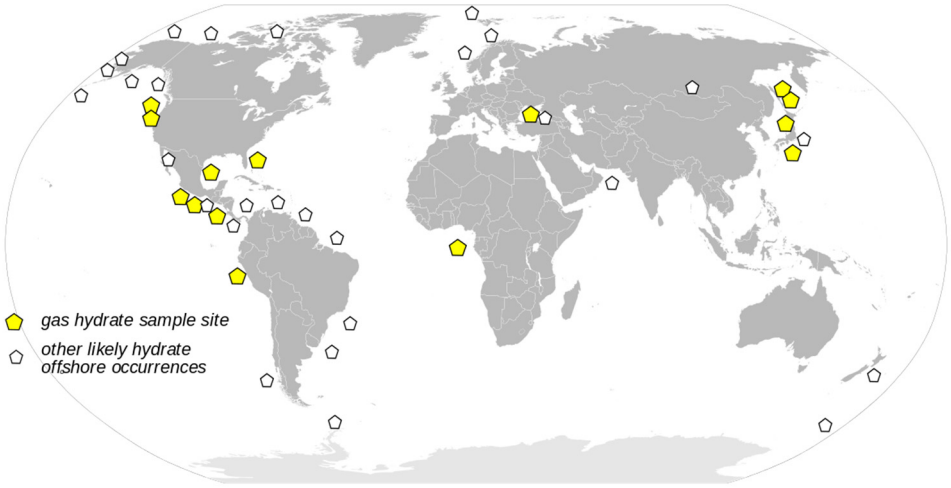

Figure 1. Location of methane hydrate reserves, natural gas hydrate deposits may become an important unconventional natural gas source similar to shale gas. Image from U.S. Geological Survey [16].

Kutcherov et al. [17] examined the natural gas market from the perspective of Russia. The article looks at three markets; it concludes that the US market is closed to Russia, and it is important that Russia—despite current difficulties—maintain its shares in the European market. Finally, the paper expresses the need for Russia to look to the Asian market's big importers such as China, South Korea, and Japan for its future exports and should try to secure footholds in this market. Bilgili et al. [18] studied the effects of the US shale gas boom on the United States industry. It reaches the conclusion that the natural gas boom in the US has had considerable positive effects on the US economy. Another interesting point is that this boom influences other countries such as China to follow the same path and start investing in their shale gas exploration and infrastructure. Saussay's study [19] is connected to the previous paper, it specifically explores the possibility of a replication of the American shale gas revolution in Europe. Several countries such as France and Denmark have considerable deposits which they might be able to utilize. The study, however, finds that due to the high breakeven point of production it is currently unprofitable to implement large scale shale gas extraction. So, this pathway of European natural gas independence seems infeasible.

1.2. China's Reliance on Coal

China is the world's largest consumer of coal by a staggering margin. China burned 81.67 exajoules (EJ) of coal in 2019—more than four times what India consumed, the second largest user of coal—this represents a significant amount of carbon production that needs to be mitigated to help facilitate the transition into a cleaner paradigm of energy generation [4]. Coal in China is utilized for electricity generation in coal power plants (and in fact, China tops the world in financing new coal plants) and for domestic use for heating and cooking. This heavy reliance on coal has been a double-edged sword for China; while it is one of the driving forces behind the rapid rise in Chinese quality of life it is also one of the principal contributors to the air pollution that takes more than a million lives annually. This is brought about not just because of massive coal power plants, but also household use of coal which produces much more pollutants per ton compared to concentrated, large-scale use. It follows that a shift in domestic use is an important and effective measure in reducing coal consumption [20].

An important obstacle in the path of coal reduction can be modeled as vested interests; since coal is widely used in China it employs a significant number of people and is a source of revenue for the government in the form of taxes. In terms of macroeconomic indicators, coal is also an important contributor to GDP which discourages policies that

cause it to drop. In Shanxi for example, coal and coal-affiliated industries contributed 29% to its GDP and made up 46% of its tax revenues in 2018 [20]. The choice to cut coal use can be seen as politically undesirable due to the short-term effects it has on employment and GDP. This creates an unwillingness to transition away from coal use, therefore, vested political and economic interests can affect and hinder this transition. However, this is where natural gas (and LNG) come into play. By moving towards natural gas use, China can shift into a market that cannot be easily influenced by opposing political forces (due to the buyer-friendly nature of this market) and gain both greener and more secure energy.

Coal is important right now as it is employing workers that do not have the skill to work in other areas, provides the electricity that an emerging market demands in order to function and foster economic growth, provides the government with tax streams, and is a long-term investment for its financers. However, also important right now is mitigating environmental impacts (which China has publicly shown to be concerned with, consider for example China's INDC document [21]), lowering pollution levels and modernizing the energy infrastructure in preparation for a changed world after the recent COVID-19 pandemic. Natural gas fits every criterion that China demands:

- Availability through LNG imports and Russian pipelines.
- Buyer's market dynamic ensures stable prices and supply.
- Cleaner alternative to coal, helping the infrastructure adjust itself in the energy transition period.

The COVID-19 pandemic has brought about a unique situation. Due to the pandemic, economies around the world slowed, and so did China's. This can help in overcoming the "finance inertia" around the energy sector. With investors looking to recommit their assets post-pandemic for a rebound effort, effective policy measures can influence new capital to redirect towards natural gas instead of traditional coal, helping the energy transition efforts.

There are several contributing factors to the pricing of natural gas. In this paper, we will first discuss the various factors that influence the highly convoluted international natural gas trade and then we will attempt to model the interactions between Russia, the United States, and Japan as a 3-player game. After creating an outline of the game, we will use the method of backward induction to methodically reason our way through different scenarios. Finally, we will conclude with the results of our model and discuss the potential of LNG trading as the first step for East Asia's energy transition to a low-carbon economy.

This paper seeks to add to the existing literature through a systematic analysis of the current situation that leads to a deeper understanding of future dynamics. As the wide array of studies related to this field suggests, understanding the energy market and its policymaking is a complex task. We systematically identify what factors influence the market, how they affect decision-making, and how we can integrate outside influences.

2. Factors of Interest

In this paper, we intend to understand how the natural gas market is influenced by political and economic decisions. To this end, we first introduce several factors that have a bearing on the issue and then discuss the political and economic options at the disposal of each market participant. We use the information discussed in this section to determine the outcome of decisions made during the game. Then, we discuss the outcome of the choices determined as "optimal" for each player. Using this information, we can gain an overall understanding of the current market.

2.1. East Asia-Europe Energy Dynamics

Since the Ukraine crisis, Russia has heightened tensions with Europe. This has prompted attempts at diversification of energy sources in Europe with a shift towards the United States and the Middle East. Following this, Russia has begun a shift of its own, pivoting towards the Far East, and growing exports to Japan and China [22]. However, of concern to the U.S. is the fact that if Russia is successful at taking a foothold in the

Japanese energy markets, it can create a powerful bargaining tool in its negotiations with Europe, further tipping the balance in its favor. Moreover, Japan's position as a strategic ally of the U.S. further complicates matters; this can lead to a situation where both major markets allied with the United States may be susceptible to Russian politicization, thus, in turn, weakening global American influence.

So, it can be seen that any change in Euro-Russian relations can affect Japan and vice-versa. Europe cannot overlook the potential of Japan—and the Asia Pacific region as a whole—as a substitute market for Russia's natural gas and Japan, in turn, has to consider its diplomatic ties when browsing the market.

The LNG market from China's perspective is simpler than Japan's. For the Chinese, the suppliers are the same while also having a warm relationship with Russia and less political pressure from the US. Therefore, they too can benefit from the buyers' market dynamic and have a stable supply of LNG. This establishment of the "security of supply" is paramount for China. They require energy to fuel their economy and they must ensure they have a safe supply. LNG is thus seen as a logical choice that satisfies this requirement. There is also a possibility for a synergic combination of natural gas pipelines within a hydrogen economy. If the use of natural gas is promoted through LNG and pipelines are constructed, these can be later repurposed to supply hydrogen in a near-to-transition economy [23].

2.2. Infrastructure

One of the key factors in global LNG trade is the underlying infrastructure available in each region. Qatar has invested heavily in new LNG trains as it is looking to ease the exporting of its natural gas to Europe and Asia [24]. Australia has also ramped up production, reaching Qatar in 2018 [25]. The development level of available infrastructure determines exporting power and price flexibility.

After the Coronavirus pandemic struck the entire globe in 2020, it was evident that the world economy was headed for a recession. As recessions are often followed by drops in primary energy usage this could be bad news for suppliers. Another way that this downturn manifested itself is in a drop in infrastructure funding for new LNG regasification plants. If these planned terminals fail to be financed, we could see a significant drop in LNG consumption growth, even as much as half [26].

2.3. Geography

Another factor of importance is geography; Russia is much closer to Japan than other suppliers, lowering transportation costs and offering increased safety. It operates the Sakhalin–Khabarovsk–Vladivostok pipeline which currently has a capacity of 5.5 Bcm (Billion cubic meters) with plans for future expansion [27]. In 2014 Russia and China signed a 400-billion-dollar contract for the construction of a pipeline carrying Russian natural gas into mainland China [27], furthering Russia's geographical advantage. Geographical distance can impact factors including insurance fees and fuel costs. This factor becomes key in the scenario of a price war; Russia has the advantage of lower transportation costs and therefore a stronger ability to offer lower prices than other suppliers can afford.

2.4. Supply vs. Demand

The Asia Pacific natural gas market is projected to grow well into 2030 with a secure and diverse supply [28]. This abundance means that no individual country can create a monopoly in the region, this is in contrast to the European market which is mainly dominated by Russia.

From this buyer's market dynamic follows that neither Russia nor the U.S. can hold Japan's attention if they decide to raise their prices above the established market trend. This competition will both make it harder for U.S. shale gas to break further into the Asian market and will demand Russian price concessions if they decide to shift further towards the East. This factor will become apparent when we discuss the U.S.—Russia pricing subgame. Figure 2 shows the overall consumption of oil and natural gas in Japan. One key

observation here is that while total consumption and oil use have fallen in the previous decade, natural gas use has seen a slight increase in demand. This is consistent with global trends of pivots towards cleaner natural gas.

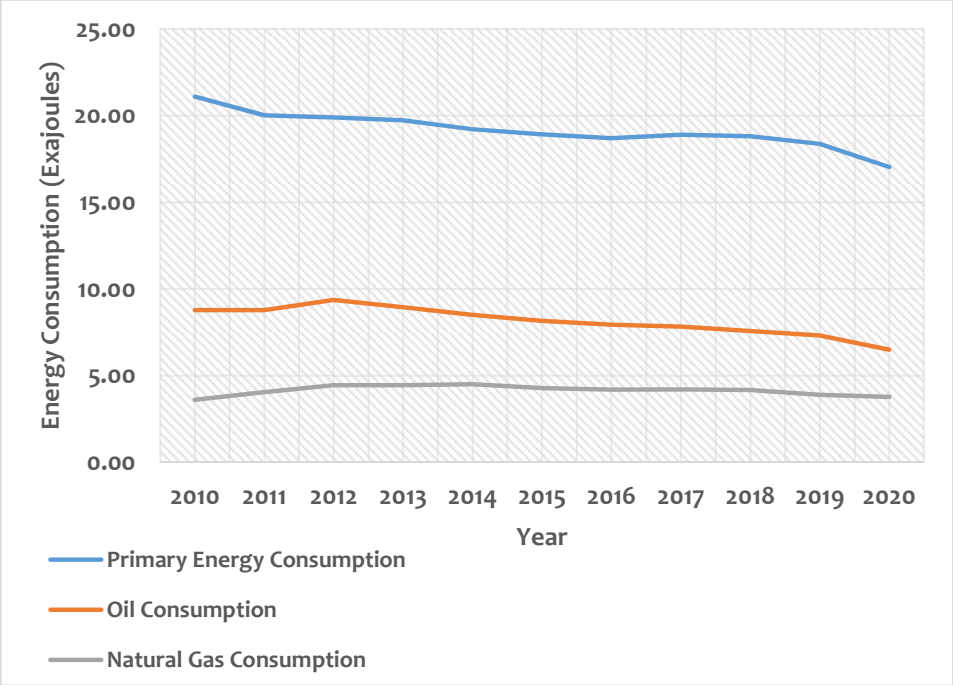

Figure 2. Japanese energy consumption based on data from [4].

There have been recommendations for the promotion of natural gas in China such as [29]. The article highlights the importance of LNG as a means of progress for China, both by allowing a more stable and environmentally friendly power grid and as a means of technological advancement. The authors also warn that the problem of competitiveness—and a lack thereof—with coal should be addressed before natural gas can be introduced. In another study [30], the authors also note the importance of supply security for the development of LNG in China. China's southeastern and eastern regions are very developed and densely populated but have no energy supply fields situated in or close to them. That is why LNG can be a good fit as it can be shipped using ships and offloaded directly into major coastal areas such as Shanghai. Moreover, the LNG market has a diverse number of suppliers which are positioned to provide LNG to East Asia and the market dynamic ensures a stable supply. Thus, LNG can help overcome the hurdle of energy security which China is very concerned with and supply its energy-poor regions with cheap, cleaner fuel.

3. Game Theoretic Model

To better analyze the challenges of natural gas supply for East Asia's economies for a successful energy transition, a game-theoretic model has been developed for analyzing the USA-Russia rivalry in Japan's Natural Gas Market as a major East Asian natural gas market. We can model the geopolitical interactions between the United States, Russia, and Japan as a 3-player game as a case study. This game is considered in the context of Richman and Ayyılmaz [2]; Russia's urge to shift towards the East and the United States' ability and willingness to compete in the Asia Pacific natural gas market relies heavily on the Euro-Russian political climate.

The United States has both political and economic options on the table. It can sanction imports from Russia and/or ramp up investments in LNG exports to Japan to counter the Russian presence. The end goal of the U.S. is to support its strategic allies while also generating revenue through its export of natural gas. Russia's end target is to maintain a dominant position against Europe so it can more effectively exercise its influence. Russia

can counter the effect of diversifying Europe by lowering the price of its exports to Japan, in this way supplementing the losses incurred by Europe replacing it with the United States, and also strengthening its ability to price out the United States in trade.

The full game has $2 \times 3 \times 3 \times 2 = 36$ outcomes, we will use the method of backward induction to solve for the resulting equilibrium. The full game tree is shown in Figure 3.

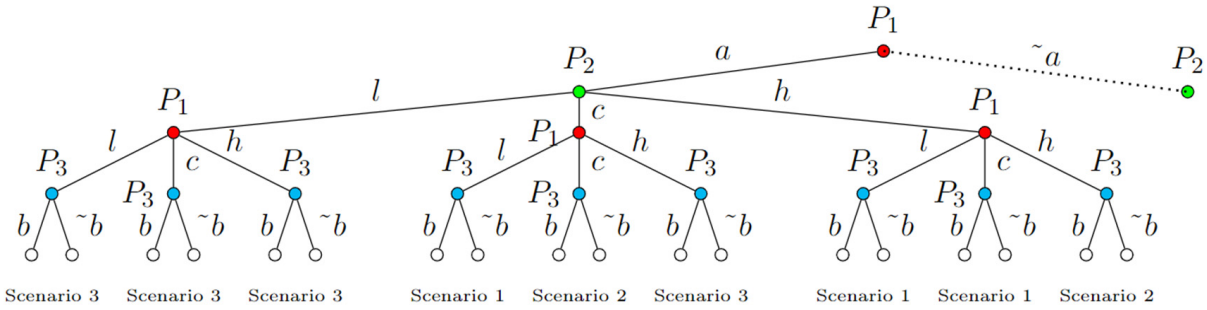

Figure 3. Full game tree, P_1: United States, P_2: Russia, P_3: Japan, a: sanction, l: set price lower than the market average, c: competitive prices relative to the market, h: set prices higher than the market average, b: diversify. The dotted line represents a duplicate tree not drawn due to space limitations. $\frown$ indicates reverse moves ($\frown a$: not sanction).

3.1. The Sanction Dynamic

In Richman and Ayyılmaz [2], the U.S. has the option to sanction Russia, as this study is linked closely with the aforementioned paper, one might wonder if sanctioning Russian natural gas exclusively for Europe and/or Japan might yield different results. We will show that for the U.S. a uniform policy strictly dominates other options.

Let us consider the four options that the U.S. has at its disposal. The full game tree is illustrated in Figure 4. If the United States sanctions European imports but does not do the same for the Japanese, it will make it easy for Russia to substitute its export market and effectively remove bargaining power from Europe. If the situation does not merit a sanction of European imports a Japanese sanction is moot, achieving nothing but political backlash from Tokyo and Moscow. However, as we will discuss further in this paper, a coordinated, unified policy from the U.S. may be the key to deterring Russian influence. So, we can say the payoffs b and c are strictly less than a and d, regardless of the relationship between each pair. Therefore, a unified economic policy strictly dominates other options and when we talk about U.S. sanctions, we need not clarify which imports we are talking about, the policy will be the same for both.

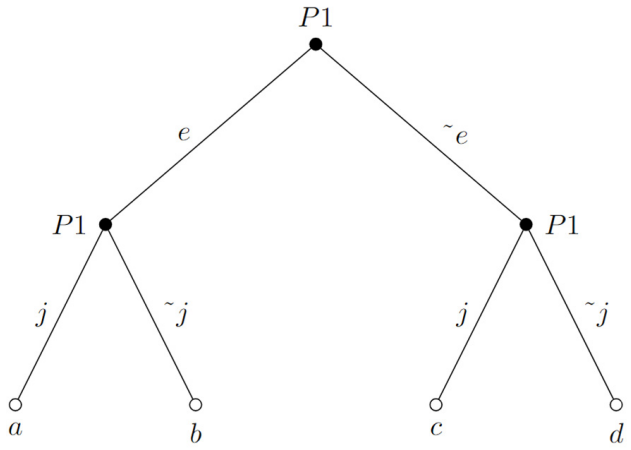

Figure 4. Full game tree of U.S. sanction choices, $P1$: the United States, e: sanction of European natural gas imports, j: sanction of Japanese natural gas imports, $\frown$ indicates reverse moves.

Furthermore, from a geopolitical point of view, it can be argued that as Qatar and Australia are strategic allies of the United States with significant shares in the Japanese market and they stand to lose revenue if Russia gets to break further into the market, it is necessary for United States policymakers to take action against Russian exports to Japan.

3.2. Price Scenarios

The first subgame we consider is the choice of Japan. We group the various outcomes of the U.S.—Russia pricing game into three categories, illustrated in Table 3.

Table 3. Price scenarios arising from the Russia-United States subgame.

Scenario 1	$P_{Ru} > P_{US}$
Scenario 2	$P_{Ru} \approx P_{US}$
Scenario 3	$P_{Ru} < P_{US}$

P_{Ru}: the price of Russian LNG available to Japan, P_{US}: the price of U.S. LNG available to Japan.

The overall payoff matrix of the U.S.—Japan subgame is shown in Table 4. First, we will derive the table for an unsanctioned Russia. In this scenario, Russia has the pricing advantage due to being unrestricted in trade and the factors discussed in Section 1. Therefore, the United States must beat Russia on prices if it wants to persuade a diversification move from Japan. We will then get Table 5 which indicates a mixed strategy Nash equilibrium of periodic United States price dips which are needed to sustain Japanese interest. This is compliant with the current market trends of competing suppliers. The next scenario is a sanctioned Russia, shown in Table 6. Here the advantage shifts to the U.S., which is reflected in the fact that the diversification strategy strictly dominates not diversifying ($\beta \succ \delta \succ \zeta$). However, if the U.S. decides to mark up its prices and go above market value, Japan would be less inclined to purchase U.S. natural gas. It would still not prefer Russian natural gas due to the imposed sanctions but would pursue deals with other suppliers. This means that the United States would fare better if it stuck to market averages ($c \succ e$). Additionally, a sanctioned Russia is more likely to politicize against Europe which would mean more U.S. resources are diverted towards the West and consequently a smaller capacity for going below the market average ($c \succ a \succ e$). The outcome of this game is a pure strategy Nash equilibrium of a diversifying Japan and competitive prices from the United States ($\langle$Scenario 2, Diversify$\rangle$).

Table 4. Overall payoff matrix for the Japan-U.S. subgame.

		Japan	
		Diversify	**Don't Diversify**
United States	Scenario 1	a, α	b, β
	Scenario 2	c, γ	d, δ
	Scenario 3	e, ε	f, ζ

Table 5. Payoff matrix for sanction scenario 1 (Unsanctioned Russia).

		Japan	
		Diversify	**Don't Diversify**
United States	Scenario 1	4, 6	3, 5
	Scenario 2	6, 3	2, 4
	Scenario 3	5, 1	1, 2

Table 6. Payoff matrix for sanction scenario 2 (Sanctioned Russia).

		Japan	
		Diversify	**Don't Diversify**
United States	Scenario 1	4, 6	3, 5
	Scenario 2	6, 4	2, 3
	Scenario 3	5, 2	1, 1

The conclusion we can draw from these results is that due to the abundance of supply from countries such as Qatar and Australia, Japan will not accept a price hike from the U.S. in any case, regardless of its political relationship with the Russian Federation.

3.3. Russia-United States Subgame

In this section of the study, we will consider the different pricing combinations and their payoffs for each player. First, we will discuss what options each country has. Russia has the option of setting prices lower than other suppliers (l), competitively (c), or higher than other suppliers (h). Due to Russian natural gas mainly being controlled by the State, Russia has tight control over how it prices its exports. The U.S. on the other hand has to employ other methods, such as economic incentives in the form of tax breaks or federal funding for technological research, and it has done so in the past [31].

The overall payoff matrix of this subgame is shown in Table 7. For the sake of simplicity, red letters correspond to U.S. payoffs and green letters are Russia's. We will first discuss pricing combinations when Russia is not sanctioned.

Table 7. Payoff matrix for Russia-U.S. subgame, unsanctioned Russia.

		Russia		
		l	c	h
United States	l	a, a	b, b	c, c
	c	d, d	e, e	f, f
	h	g, g	h, h	i, i

When Russia is not sanctioned, it enjoys the freedom of trade, it also has an easier time dealing with Europe. Therefore, there is little incentive for it to price its LNG higher than other competitors, to save its market share and by extension, its bargaining chips against Europe. It would be content with keeping current market shares as it continues to fund pipelines and LNG trains, while simultaneously benefiting if other suppliers decided to place prices higher than its competitive values ($h \succ e \succ b \succ g \succ d \succ a \succ i \succ f \succ c$). The payoff matrix is illustrated in Table 8.

Table 8. Payoff matrix for Russia-U.S. subgame, unsanctioned Russia.

		Russia		
		l	c	h
U.S.	l	6, 4	7, 7	4, 1
	c	5, 5	8, 8	9, 2
	h	1, 6	2, 9	3, 3

The United States on the other hand when seeing Russia's position knows it must commit to periodic drops in its asking price if it wants to convince Japan to diversify, but in the absence of political motivation

$$f \succ e \succ b \succ a \succ d \succ c \succ i \succ h \succ g$$

All in all, we see a pure strategy Nash equilibrium ($\langle c, c \rangle$) of keeping it as it is, both players sticking to market prices as the demand in Asia continues to grow. This scenario is shown in Table 9.

Table 9. Payoff matrix for Russia-U.S. subgame sanctioned Russia.

		Russia		
		l	c	h
U.S.	l	5, 6	8, 2	9, 1
	c	3, 7	6, 5	7, 3
	h	1, 8	2, 9	4, 4

When Russia is sanctioned, it has a greater need for the Asian market. While Russia on the other hand has Japan to keep trading it needs to lower its prices, and considering it has a greater ability to drive prices down we get ($h \succ g \succ d \succ a$). Other options are unlikely to be intriguing for Japan as the U.S. is at least matching at price and it follows that Japan would definitely sideline Russian natural gas ($e \succ i \succ f \succ b \succ c$). If Russia fails to respond adequately to political pressure, the issue for the U.S. then becomes competing with other major suppliers, trying to expand in the market as much as possible by setting the most competitive prices. Therefore, going higher than the market is out of the question, and the payoffs going increasingly higher as the U.S. offers cheaper natural gas. If an all-out price war emerges, the winner is likely to be Russia, however, this would also likely lead to a softer stance against Europe as Russia struggles to compete for its market share, therefore $a \succ i \succ d \succ h \succ g$ and overall $c \succ b \succ f \succ e \succ a \succ i \succ d \succ h \succ g$.

The overall solution of this variation is a pure strategy Nash equilibrium corresponding to $\langle l, l \rangle$. This indicates that the best response for Russia is to counter with lower prices against U.S. economic sanctions. This can be explained as Russia needing to keep the Asia Pacific market when it is already struggling with Europe, losing a foothold in both markets at the same time can hurt the Russian economy.

In the rest of the article, we intend to bring a new perspective on this market when considering the overarching energy transition and the effect of other outside players. First, we look at China as an emerging market for energy, and how it can influence the dynamics discussed in this paper. Next, we look at the ongoing energy transition as a force that affects the dynamics of the markets, and how economies can take full advantage of this transition in the realm of natural gas trading and liquified natural gas.

4. China: A Growing Energy Market

As mentioned before, Russia and China have begun a close partnership in the fossil fuel industry, and this pairing seems as if a match made in heaven; China has a fuel-hungry industry and Russia is conveniently placed to supply it. A recent trade deal between the two nations is set to provide a fifth of China's current natural gas consumption [32].

In Figure 5, we see the rapid rise of Chinese energy use in a decade. This dramatic increase (amounting to 44.18 exajoules, or rather, more than twice the energy consumption of Japan) is projected to continue and so, the Chinese energy market may become a replacement for Europe.

Figure 6 tells a different side of the story; Japanese LNG imports are still higher than China's, and despite a slight decline in energy use over the past decade LNG imports have seen a rise. It seems that while Japan is stable (and slightly on the decline) in its energy use, rising Chinese consumption may challenge the central position of Japan as a global trendsetter in the business of liquified natural gas.

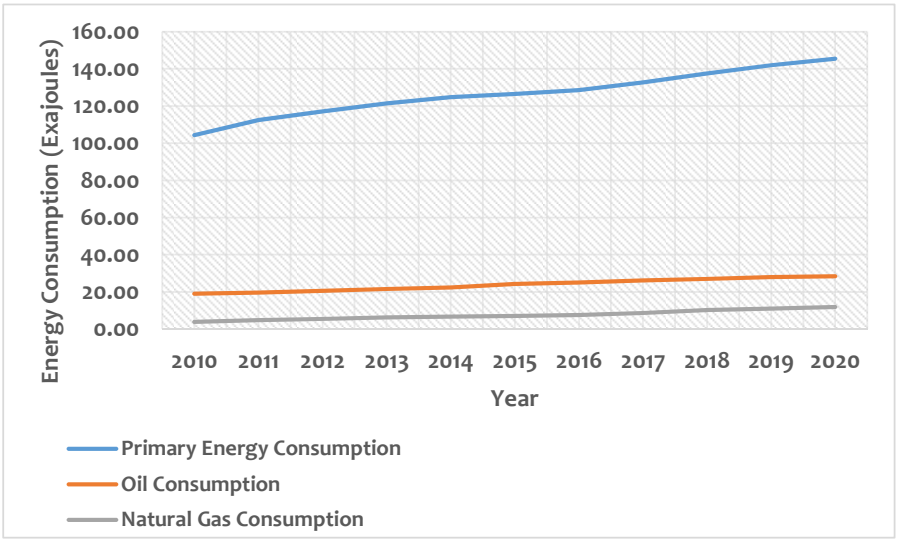

Figure 5. Chinese energy consumption based on data from [4].

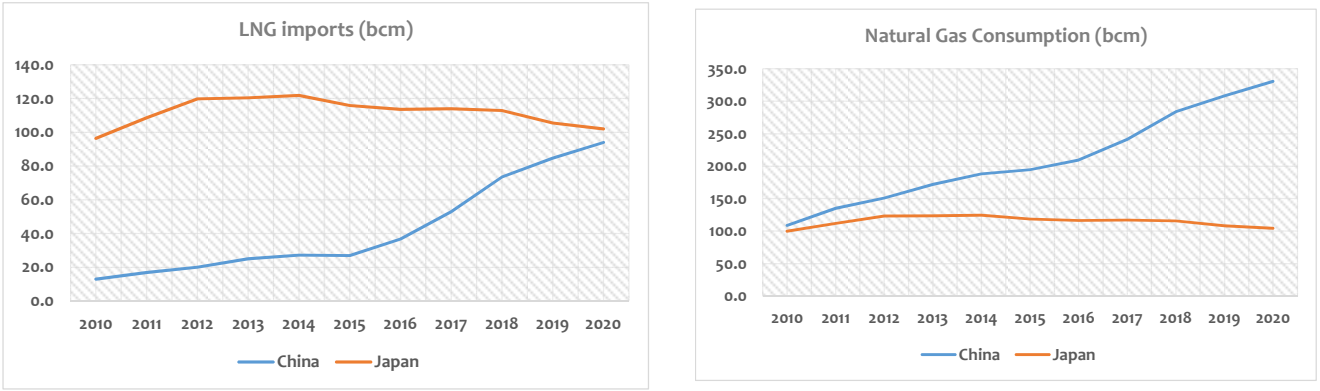

Figure 6. Based on data from [4].

All signs point to a meteoric rise in the Chinese economy and energy use [33], and an expected peak of 550 billion cubic meters consumed annually around the year 2040 [34]. This increase in consumption is not simply changing market sizes, it is also paramount—especially for the EU and the United States—to understand the relationship between rising imports in Asia and LNG export destinations. As previously mentioned in [9], it might be due to geographical considerations that Russia may send the natural gas from its western natural gas fields to Asia and put Europe in a bind, at the very least raising prices.

5. LNG Trading as a First Step in East Asia's Energy Transition

Overall, LNG can be a logical first step toward a full energy transition for China. It addresses many of its concerns such as energy security and environmental impact, while also not needing an immediate overhaul of energy infrastructure. The role of LNG can also be seen in the recent announcement of a 20-year deal between South Korea and Qatar which is set to supply 2 million tons of LNG to Korea annually, showing the connection between Middle Eastern suppliers and East Asia is growing [35].

There is also a discussion on how "green gas" can be integrated with hydrogen production to reduce the carbon dioxide load of natural gas burning. The future of natural gas and its role in the energy transition depends on how policymakers approach this issue and how technology advances. There is also a political aspect as natural gas producers and consumers move forward, this can be seen in the cooperation of Russia and Saudi Arabia—two producers of natural gas—in researching hydrogen production [36].

In Total, Asian LNG importers accounted for 72% of the global LNG trade volume in 2017 and it is forecasted that their reliance on imports will grow significantly. China has also experienced a 55% annual growth in imports up until 2017. South Korea has also seen a much smaller but still noteworthy 4.8% growth rate. As with Japan and China, South Korea also imports from a wide variety of sources; Those in the middle east, such as Qatar, within Asia, such as Malaysia, Australia, Russia and the United States. This means that its security of supply is less tied to regional fluctuations. Natural gas is seen as a viable alternative to coal within the entirety of Asia, not just in Japan [37]. This fact can be used to support a hydrogen economy as the final goal in the energy transition. By employing natural gas as a cleaner alternative to coal, countries can keep their economic momentum while reducing emissions and planning for a change in infrastructure.

There have previously been studies conducted regarding the role of natural gas in aiding the construction of a future hydrogen economy. Although there is speculation about the large-scale feasibility of repurposing natural gas infrastructure for hydrogen use, there have been proposals regarding the transport of hydrogen in the form of a blend with natural gas inside pipelines [38]. While the energy mix is still dominated by fossil fuels, most investments into future infrastructure are made by entities linked to fossil fuels, and natural gas can be an avenue of transition; hydrogen production is integrated and introduced into natural gas production pathways and this can enable a transition from decision-making through fossil fuel entities to decision-making by entities linked with hydrogen production, which will promote further development of a hydrogen economy [39].

The natural gas industry has mature technologies, this matureness means that it can support renewable sources by providing a reliable and affordable source of energy in the short and mid-term. Without a mature alternative to act as a transition fuel, the transformation of energy systems into renewable technologies might be infeasible and delayed. However, care should be taken by policymakers to not overinvest in natural gas and cause an overcrowding effect amongst emerging renewable technologies [40]. As we have discussed, energy security is a large concern for Asia's developing economies, even more so after the Fukushima disaster. The diversity of the LNG market seems to hold an answer to these concerns. Natural gas is also cleaner compared to coal and can help reduce the emissions from coal-intensive Asian nations which is another positive point. It is also effective in dealing with vested interests that may hinder the decision to begin the transition. Therefore, natural gas—LNG in particular—can be integral in realizing the energy transition in East Asia.

6. Conclusions

This paper intends to bring a new logical paradigm to the study of the natural gas market. We first discussed factors that can have an impact on the LNG trade, such as geographical, technological, and political forces that are contributing to this ever evolving and complex market. In the concluding section, we will first discuss the results gained from the game theory analysis, and then we will look at lessons learned when considering the larger dynamic induced by the ongoing energy transition and emerging energy markets.

6.1. Game Theoretic Analysis

We explored the need for the United States policymakers to adopt a unified political stance against Russia and why that is essential for the success of their economic sanctions. Regardless of the market conditions, if Russia is politicizing its exports to Europe, the United States stands to benefit from restricting Russian trade in the Asian market wherever it can. The political reach of the United States may fail when it comes to power such as China but restricting access to a large market such as Japan would put incredible pressure on Moscow.

Then we looked at different pricing scenarios that may arise within our game, and how Japan will react to each one. We also explored the instruments through which the United States and Russia can internally adjust the price of their products. The United States as a

liberal economy needs to resort to federal research grants (to improve shale gas extraction technology) or tax cuts to incentivize private investments. While on the other hand, natural gas in Russia is mostly state-owned and the Russian government has more direct control over prices, so, the methods by which these two powers can change their prices are also fundamentally different and may be illuminating if investigated and compared.

In the case of the United States sanctioning Russia, the most probable outcome is a drop in Russian market shares, followed by the lowering of the prices by Russia to counter and stay in the market. Japan would diversify towards other suppliers, in particular the U.S., and due to an abundance of supply, the natural gas flow to Japan would most likely not see significant disruption.

In case of no action from the United States, the most likely scenario is the continuation of current market trends. The Asia Pacific market would continue to grow in size and attract more investment from suppliers. Japan's LNG imports will increase in volume as consumption rises and coming out on top requires a great amount of investment in infrastructure.

In the context of LNG markets, a country suitable for future research is Iran; Iran holds one of the largest reserves of natural gas in the world and it also possesses an established fossil fuel industry that is well known. Comprehensive studies should be conducted to determine the potential of Iran as an LNG supplier. For example, the level of infrastructure development needed, and the potential market impact must be determined.

6.2. Understanding the Larger Picture

In this paper, we discussed the dynamics surrounding Japan and the overall importance of the East Asia market for Russia as an alternative market. What we found was that, for the most part, gaining a foothold in the Japanese LNG market would be very tough for Russia, but a viable alternative candidate for replacing the EU might be found in China. Japan is expected to keep the same levels of primary energy consumption through to 2050 and see a slight decline in natural gas use, down to around 85 billion cubic meters per year in 2050 from 108 BCM in 2019 [40]. Several developments should be watched closely in the coming years: the bounce back from COVID-19, the methane hydrate evolution, geopolitical considerations, and LNG infrastructure investments.

It seems that Russia cannot make a big move regarding Japan and market shares should stay the same throughout. China seems to be a more inviting candidate and the Sino-Russian partnership should be an important one. The United States will want to further pressure Russia. It seems that owing to existing difficulties for the export of Russian oil and natural gas, if the United States can stay committed to developing its LNG trains and use its political levers against Moscow, it can get the edge in the natural gas market.

The concept of vested interests is an important issue. This concept can be generalized to the entire fossil fuel industry along with regulators and policymakers. As long as there is not sufficient gain in transitioning to hydrogen –through lost investments or future revenue– there will not be interest in transitioning. Thus, through stepwise programs that focus on eliminating this source of attachment to fossil fuels, we can aid the development of hydrogen, and natural gas can play an important part in this effort. In the case of Germany, these vested interests (referred to as lock-in mechanisms) are outlined by [41] and are a mix of political and economic motivations. It can thus be seen that these vested interests are already influencing environmental and political decisions. Through a well-thought-out policy that plays into eliminating these mechanisms, we can accelerate the adoption of hydrogen over other fuel choices. However, if we simply seek to ignore these mechanisms and try to force a transition this would likely fail due to an absence of political, institutional, and economic motivations. Therefore, we must understand these vested interests and use transition technologies regarding natural gas to systematically address and remove obstacles in the way of a hydrogen economy. On a global scale, LNG can be important in the energy transition as it functions as a crutch, helping countries shift their energy mix from oil and coal toward natural gas and eventually fully renewable sources. This

"intermediate step" can be a motivating factor in ensuring more and more countries start their shift.

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