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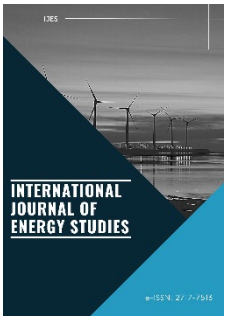

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Energy outlook of Japan: A economic and econometric analysis

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Highlights

- Due to the increase in energy needs of states such as China and India in the last 10-15 years, Japan's energy consumption in the Asian continent is around 60%.
- After the increase in oil prices since 2002, Japan's interest in Central Asia started to increase gradually.
- The fact that Japan is a country in the "intensive energy consumption areas" indicates a further increase in hydrogen and oil consumption and imports.
- The North America, Asia Pacific, Middle East region is also in a considerable position in Japan's hydrogen and natural gas imports.

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ABSTRACT

Japan is a country that started its industrial movements in the beginning of the 20th century. Thanks to its existing coal resources, this country met the energy it needed and took a certain distance on the path of development by improving its industry before 1950. However, Japan's coal resources were not sufficient to make rapid strides towards industrialization. In this case, the large amount of cheap oil that was injected into the world markets after 1950 allowed Japan to make a great leap forward in industrialization. It has found the opportunity to develop its industries with oil imported from the Middle East and Indonesia with tankers with a carrying capacity of 500 million tons, and thus, it has taken its place among the countries of the world. In this study, causality analysis proposed by Toda and Yamamoto (1995) was used to examine the relationship between Japan's real import level and oil consumption. After the econometric analysis, a bidirectional causality relationship was determined. Japan's oil demand, import and consumption have moved in direct proportion. In addition, in the axis of the study, Japan's energy policy, energy supply security, liquefied natural gas (LNG) demand, energy infrastructure investments, transportation of energy resources within the country, the logistics and the effect of pipelines, the functions of sea routes and unloading ports in oil demand will be examined. This study clarifies the transformation of Japan's renewable energy transformation strategy around the axis of hydrogen economy. The bidirectional causality relationship between energy consumption and import is also consistent with the hydrogen economy. For the first time, the study contributed to the literature by addressing Japan's energy consumption and imports from an interdisciplinary perspective such as transportation, logistics, economy, energy geopolitics, foreign policy, hydrogen economy, energy economics, and econometrics.

Keywords: Japan, Energy, Import, Logistics, Economics

1. INTRODUCTION

Japan is one of the states and powers that best keeps up with the developing technology and globalizing world. Showcasing the blessings of its advanced technology in the best way in the world markets, Japan has become an important actor in the world by further consolidating and enriching its vision. 6 different approaches that shape the new energy diplomacy announced in April 2004 in Japan are the main determinants of energy policy. While these approaches especially emphasize the principle of ensuring energy security, they believe that if this security is ensured, the security of energy demand supply will be in safer hands. These six approaches can be briefly listed as [1]

- Development of care and emergency response measures
- Establishing friendly relations with other energy-producing countries, especially the Middle East countries, and countries in the directions of energy transportation.
- Diversification of energy supply sources
- Diversification of energy sources
- Energy saving, effective energy use, development of alternative energy use and sensitivity to environmental factors
- Creating an environment along with the public and other countries in order to ensure and improve global energy security [2];

Japan is a poor country in terms of energy resources. For this reason, it imports a large part of its energy supply from abroad. In this case, it brings with it many troubles and uneasiness. In particular, the oil crises experienced in the 1970s can be among the first to come to mind as the periods when the most visible problems were experienced for Japan, whose energy consumption was based on oil superiority in those years. [3];

Japan's particular focus on energy is the issue of "energy security". After the troubled times in the energy supply issue in the 1970s, the most prominent priorities in Japanese energy policy were to reduce the dependence on foreign resources, especially Middle East oil, which is highly dependent on energy imports, and, in parallel, to diversify energy supply sources.

The aim of this study is to reveal the importance of logistics infrastructure, which comes to the fore in meeting and supplying energy needs, by measuring the link between Japan's energy needs, imports and consumption with an econometric model. In the study, Granger Causality Tests and

Toda and Yamamoto econometric model were used to examine the relationship between energy imports and energy consumption in Japan.

In this study, "The relationship between Japan's energy import and consumption was investigated, and a bidirectional causality relationship was found between the variables." The increase in imports prompted Japan to consume more, and the increase in energy consumption led Japan to import more energy. Thus, there will be energy supply diversity, difference in energy supply, expansion of logistics infrastructure, and diversification of liquefied natural gas strategy. In the study, Japan's Hydrogen Basic Strategy, announced in 2017 and revised in 2023, is discussed. The revised Hydrogen Basic Strategy reveals Japan's future hydrogen strategy. The bidirectional causality relationship obtained as a result of the econometric analysis is also meaningful within the framework of the hydrogen economy policy. It is anticipated that hydrogen imports will increase consumption by reducing prices. In this context, Japan's transformation from non-renewable energy sources to renewable energy sources is explained with the concept of "hydrogen economy" in the study. This study has brought an interdisciplinary perspective covering issues such as energy, energy supply security, logistics, and economy to the literature for the first time with a multi-perspective.

2. LOGISTICS AND STRATEGIC AREAS IN JAPAN'S ENERGY OUTLOOK

Middle East oil is so important for Japan. Because Japan imports approximately 80-90% of its oil from the states in this region. Nonetheless, the Middle East region is also in a considerable position in Japan's natural gas imports. While Japan imports 75% of its natural gas imports (as LNG) from Asia-Pacific countries, it also imports approximately 23% from Middle Eastern countries. As can be seen from the dependency ratios stated, it is possible to easily understand the reasons for Japan's resource diversification policy on natural gas, especially oil [4]

In search of alternatives to the Middle East energy resources to which it is dependent, Japan has turned its route to hydrocarbon-rich Russia, Iran, North Africa and Central Asian states, whose energy resources can be considered as untouched yet. In this process, studies have been carried out between Japan and Russia, Iran and Libya on various projects that could potentially provide energy security and alternative destinations for Japan. The first of these projects is the Tayshet-Nakhodka Oil Pipeline planned to be built between Japan and Russia, and the second is the

Azadegan Project between Japan and Iran. We can add to these the activities of Japanese companies in Libya.

2.1. Tayshet - Nakhodka Oil Pipeline

Tayshet-Nakhodka Oil Pipeline is an oil transportation line planned by Russia. With this pipeline, Russian oil is transported from Eastern Siberia to the north of Lake Baikal from Russian territory, Buor from Angarsk to Skovorodino as originally planned, and from there to Nakhodka, the Russian port in the Pacific Ocean, and from Nakhodka port to Japan by tankers. The pipeline is estimated to be approximately 4000-4130 km long. The fact that the pipeline will be shortened and its economic cost will decrease as China wants it to pass through its own territory has stood out as an important topic. The cost of the project is estimated to be approximately 15 billion dollars. Apart from this line, Japan also cooperates with Russia in the Shakalin Project [5]

2.2. Azadegan Project

The project that Japan focuses on and is seriously interested in is the Azadegan Project with Iran. This Azadegan field, in which Japan operates, is among the largest oil fields in the world. The crude oil reserves in the Azadegan oil field are estimated at 33 billion barrels. The Japanese government looks at this project with high sensitivity and considers the Azadegan project as a national project. The importance of this project for Japan is not only economic but also strategic. The aim of the project is the desire to bring Iranian and Japanese companies closer to each other and thus lay the groundwork for Japanese entrepreneurs in future energy projects in the region. The project was taken over by the Japanese company INPEX. After the company received this project and during the development process, it has been subject to serious pressure from the USA due to Iran's nuclear endeavors. However, INPEX company gave priority to such a profitable project because many foreign companies were waiting in line to enter the region in case of a possible withdrawal. Especially when these companies were Chinese and Indian companies, the Japanese did not want to lose such a profitable project to these two states, which are their biggest rivals in energy imports. However, when INPEX stopped its investments in this country in 2010 due to the US sanctions against Iran, the Tehran administration transferred the projects in Azadegan to the State Oil Company of China (CNPC) in 2010. The cost of the project is approximately 2 billion dollars. During this project, 50,000 barrels of oil were produced daily until July 2007, and 150,000 barrels until July 2008 [6]

2.3. Japan-Libya

Apart from relations and projects on energy with Russia and Iran, another important region for Japan in terms of energy supply is Libya, a North African country. But Japan is by no means alone in this region. It is in serious competition with two giant rivals such as China and India, whose energy needs are increasing in parallel with their increasing populations every passing day. However, in this competitive environment, Japan wanted to make good use of Libya's entry into the world energy market and showed that despite the fact that its rivals are giants, it is not an easy bite to swallow Japan [7]

Especially after Libya got rid of the chain of embargoes in 2003, there was a great war between the big states for energy over the natural resources of this country. The struggle over the Libyan reserves after the embargoes were lifted attracted the attention of Japan as well as the United States of America and European countries. Japan's attention towards Libya also had important consequences. In 2005, one of the visible successes on the Libyan fields was realized by Japanese companies. In particular, in the tenders in which approximately 60 companies participated in the 26 largest oil fields of Libya, the results of which were announced in October 2005, Japanese companies won the tenders for the 6 largest fields. This success created a serious splash in the world public opinion and the Japanese were accepted as a serious threat to their rivals. The reasons behind this great success in Libya are the name Kakizawa Koji, in addition to their attention to the region and being aware of what they want. Kakizawa Koji is the former foreign minister of Japan, and in 2003, before the United Nations embargoes over Libya were lifted, he suggested the development of relations with Libya and carried out serious studies in this framework. When we look at Koji's thoughts and works, we can say that he predicted what would happen and played a major role in taking the necessary precautions [8]

2.4. New Target: Central Asia

When it comes to the energy issue in the Asian continent, Japan has always made a name for itself. However, in recent years, there have been noticeable changes in energy supply and demand, especially in Asia. The main reasons behind this are as follows; [9]

- Increasing energy consumption in Asia,
- Increasing energy needs of fast-developing states such as China and India,
- The effect of the decrease in the energy consumption rate of Japan as a result of the rapid increase in the energy needs of the countries in the region, especially China and India,
- The emergence of tight competition between the states of the region with the increase in the energy need in the Asian continent.

In parallel with the emergence of China and India as global powers, the United States of America's becoming an energy exporting country from an energy importing country and the instability in the regions that have the main energy resources in the world upset the balances in the international energy market.

3. NEW STRATEGIES IN JAPAN'S ENERGY POLICY

Due to the increase in energy needs of states such as China and India in the last 10-15 years, Japan's energy consumption in the Asian continent is around 60%. However, the progress of these two states towards becoming a global power step by step has caused serious changes in Japan's rate.

After these events, energy is no longer just a product or a useful item for Japan, and it has become a national issue for the country, that is, a national strategic interest. As a result of the energy crisis in the 1970s and the rise in oil prices in recent years, some new strategies have emerged in Japan's energy policy. These are called the international approach and the statist approach. According to the first approach, the international approach, Japan would support international trade and investment in the energy issue, however, state intervention would be limited and the economy would be shaped according to free market principles. In the emergence of this approach, the large amount of money that Japan paid for oil in the 1990s draws attention. The second approach, the statist approach, emphasizes that the state should undoubtedly have control in ensuring energy security. Advocates of this approach adopted the logic of zero-sum in the competition in the energy market and supported the idea that while one side wins, the other side loses. Because, according to them, since the energy market is a sensitive one, it should not be left to free market conditions and should be under state control. [10]

After the increase in oil prices since 2002, Japan's interest in Central Asia started to increase gradually. Before 1991, there were no relations and ties between Japan and the countries in the region. The most important reason for the increase in Japan's interest in the region is undoubtedly the underground wealth of the newly independent states there, especially oil reserves. Japan sees this region as an alternative to the Middle East, on which it is dependent on oil. For this reason, Japan has a very important project called the Southern Route. According to this project of the Japanese, the pipelines that will start from Central Asia will bypass these countries without entering China and Russia and proceed to the Indian Ocean through Afghanistan and Pakistan [10]

For these reasons, Japan is developing its political and economic relations with Central Asian countries. The country that was the primary focus of attention of the Japanese in the region was Kazakhstan. In addition to oil and natural gas, Kazakhstan is at the top of the world rankings in this field with its rich uranium deposits. In August 2006, JBIC (Japan Bank for International Cooperation) signed a loan agreement regarding the uranium project with Kazakhstan's Kazataoprom company, which has the world's fourth largest uranium reserves. Yet, Japan is not alone in this area and has many rivals [11].

After the collapse of the Soviet Union, Central Asia witnessed the struggles of the great powers with each other. Especially after Russia and the United States of America, China, India, Pakistan and Iran, which are rapidly catching up with them and wanting to have a say in this competition, as well as Japan, are seeking to increase their influence in this region from all fields, especially in energy. When we look at the activities of Japan in Uzbekistan and Kazakhstan in recent years, it is not difficult to conclude this. [11]

4. LEADER IN GLOBAL LIQUEFIED NATURAL GAS (LNG) IMPORTS: JAPAN

Japan is the largest LNG importer in the world. The amount of LNG imports in 2035 is expected to be 112 billion m3. The Fukushima accident is one of the most important developments that triggered Japan's increase in LNG imports. This makes Japan more attractive for countries that will export LNG in the global market. There are 21 LNG Discharge Facilities in Japan. (Figure 1.)

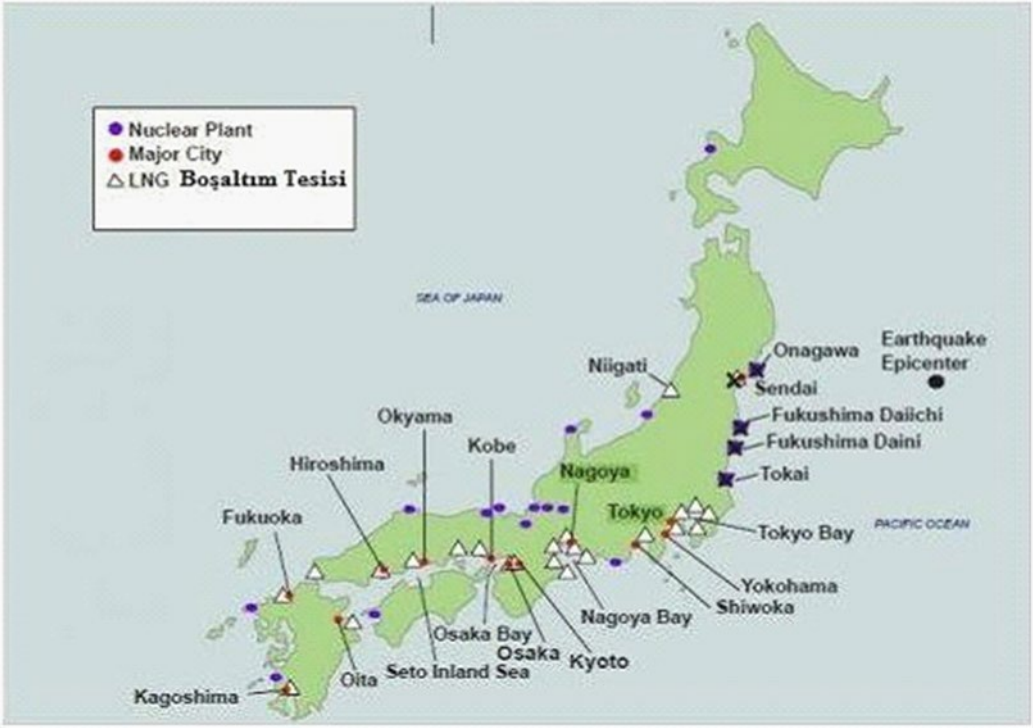

Figure 1. Japan's LNG Discharge Facilities [12]

Japan is trying to better control LNG prices by diversifying the source country in LNG imports. As of 2011, Japan, which has given more weight to its LNG import strategy, imports LNG from Malaysia, Qatar, Australia, Indonesia and Russia. Russia's share of 9% went up with the increase in the production capacity of the Sakhalin II LNG terminal and the commissioning of the Vladivostok terminal in 2017 [12]

Russia had increased this rate by 4% as of 2009 and reached 9%. The effects of geographical proximity advantage in Japan's LNG imports are clearly visible. For this reason, Indonesia, Malaysia and Australia took advantage of their geographical proximity and had a 49% share in the Japanese gas market. Japan, the world's largest LNG importer, also changes the amount it pays for LNG due to fluctuations in the Japanese Yen. When the Japanese Yen depreciates against the dollar, the amount increases further. Japan increased its LNG consumption after the Fukushima Power Plant accident in March 2011. LNG is also used in power plants in Japan [13]

The burden that LNG brings to the Japanese economy leads Japan to find cheaper LNG. At this very point, with the USA's permission to export LNG, Japan brings with it the cheap US gas that will come to it.

Japan's TEPCO Trading Corporation and Chubu Electric Power Company negotiated gas imports from the United States of America. The United States of America has enough gas for the next 100 years. Therefore, the amount of gas does not put pressure on exports. The number of LNG loading terminals in the United States of America is increasing day by day. New terminals on the Gulf coast have been put into operation since the beginning of 2015. These terminals draw gas from the world's largest gas producing areas Barnett, Haynesville, Eagle Ford and Marcellus. With the opening of the Panama Canal to LNG ships in 2014, the Far East route was shortened and this region, where the world's LNG demand was highest, was reached more quickly. The most distinctive and advantageous aspect of the US LNG economy is that natural gas prices are not determined based on crude oil prices. In this case, if the calculation is made for Japanese LNG exports, the following cost items and amounts appear [14]

• Transmission cost up to the liquefaction terminal: $0.32/MMBtu for a transmission distance of 300 miles
• Liquefaction cost: For this cost, the costs at various terminals are examined and $1.58/MMBtu is taken into account.
• LNG transportation unit cost: Here, $0.89/Mcf2, which is the cost of transportation from the far east of Russia to the west coast of North America, is taken for long-distance transportation.
• Gasification and storage cost: In a report of the International Energy Agency, this cost is taken as $0.30/MMBtu3, while ICF International gives this cost as $0.38/Mcf .
• Total cost: Including the cost of regasification of LNG in Japan, the total cost is assumed to be $7.17/MMBtu.

However, this value was above the $5.55/MMBtu calculated by PFC Energy, which exports gas to Japan, including $0.38/MMBtu as gasification cost. The estimation of PFC Energy is based on the calculation that the oil price will be $60-80 per barrel in Japan's crude oil index. However, the price that Japan buys from the gulf for crude oil imports in the next 5 years is $105-110 a barrel of crude oil. Research by NYMEX WTI also confirms these expectations for future crude oil prices. In this case, the LNG Free On Board price of $7.17/MMBtu (before gasification) offers LNG exporters a meaningful level. These days, many long-term LNG contracts charge a unit MMBtu price of 14-15% of the dollar price per barrel [15]

The fact that the LNG price is not indexed to the Japanese crude oil price may be harmful for United States gas exporters. Despite the short-term impact of western spot markets, prices in medium-term and long-term LNG agreements are expected to remain indexed to oil prices. Small adjustments can also be made according to the amount of gas to be extracted. Since Japan is a net LNG importer and the demand for LNG is increasing rapidly, it is seen that energy source country is diversified. In this context, it is possible for the USA to play an important role in the Far East market in a short period of time with the LNG sector. However, considering that Russia is also very eager for the same market, it can be said that the struggle for this market will be very difficult. Japan has stated that public and private sector companies will invest over $10 billion in liquefied natural gas (LNG) projects worldwide to strengthen the global LNG market and energy supply security. In 2017, the move, doubling Japan's commitment to support energy supply chains, aims to reduce the world's largest buyer of LNG's reliance on energy from the Middle East as it jeopardizes the growing oil shortage in the region. Isshu Sugawara, Japan's Minister of Economy, Trade and Industry, said at the annual LNG Producer-Consumer Conference, “In addition to Japan's commitment from two years ago to invest and finance more than $10 billion in energy supply chains, we are committing to additional and collective funding of 10 billion dollars from both public and private sector” and added, “As part of Japan's effort to expand the use of supercooled fuel, the country also plans to train 500 experts in LNG technology.” [16]

According to the compilation made from the "LNG 2020 Report" of the International Gas Association, global LNG trade increased by 13% last year compared to the previous year and reached 354.7 million tons. In the global market, the highest LNG demand came from Asian countries last year. Japan ranked first in LNG imports with 76.9 million tons (22%). Japan was the country that imported the most LNG in 2018. Japan's LNG stocks fell to the lowest in 7 months, as cold weather increased demand and a significant portion of LNG tankers turned their routes to Europe. According to the Japanese Ministry of Commerce data, LNG stocks at power plants decreased by 6.9% to 2 million tons in the week of January 16, 2022 compared to the previous week. This was recorded as the lowest stock amount since May. In the last 4 years, LNG stocks in Japan have decreased by 2% between late December and late January, but this year stocks have decreased by 14% since late December. Due to the high prices offered by Europe in the LNG spot market, Japan was able to supply 10 percent less LNG in the month ended on January 17, compared to the previous year. [17]

While the coldest winter of recent years is experienced in Asian countries, a seasonal energy crisis is experienced due to the higher-than-expected energy demand and the problems in resource supply. Especially in Japan, the demand for liquefied natural gas (LNG) increased as a result of the insufficient nuclear capacity to meet the increasing electricity consumption and low gas stock, while spot LNG prices in Asia reached the highest level in history this month with an increase of approximately 16 times due to the problems in supply. While the situation in Japan is considered to be the biggest crisis after the Fukushima nuclear accident in 2011, it is predicted that the share of oil-fired power plants in production may increase in order to meet the country's rising electricity demand. [3,18]

Extreme cold weather in Asia caused a very rapid increase in gas and electricity demand. After Japan closed most of its nuclear power plants after the Fukushima accident, natural gas power plants began to play a critical role in electricity generation in the country, and the rising energy demand also increased the demand for spot LNG. Asian spot LNG prices increased more than 16 times this month, reaching a record level of $32.5 per million BTU, as a result of delays in cargo originating from the Panama Canal, insufficient spot LNG cargoes, and record transportation costs. Japan Korea Marker spot LNG price and the increase in demand also stimulated the global LNG markets. [19]

It is seen that energy and trade companies that want to benefit from the record prices in Asia direct their LNG cargo from the USA, Nigeria and Qatar to or from Europe to Asia. With the increase in temperature in the region, a relaxation and a decrease in spot LNG prices for March delivery will be expected. It is observed that electricity prices in Japan have increased too much due to the increasing demand and there are some structural problems in the electricity market of the country. With the inadequacy of the electricity grid in Japan and the economic recovery in China, it is observed that the electricity demand has increased and spot LNG prices have increased [20]

5. ECONOMETRICAL MODELLING

In this part of the study, the relationship between the Japanese real import level (IMPORT) and oil consumption (OIL) has been empirically examined. In the study, annual data covering the period 1980-2023 were used depending on the availability of the data. Data were obtained from the British Petroleum world energy statistics report. In the empirical analysis, the logarithm of the variables was taken conclusively.

In this study, causality analysis proposed by Toda and Yamamoto (1995) was used to examine the relationship between the level of real imports and oil consumption. The advantage of this method, developed by Toda and Yamamoto (1995), is that it allows causality findings over the VAR model, independent of the cointegrated relationship between the series [21]

In the Toda-Yamamoto causality test, a VAR model is created by using the level values regardless of the order in which the time series is stationary. In this test consisting of two stages, firstly, the optimal lag length and the maximum degree of integration (dmax) are determined for the series subject to the application. The determination of the appropriate lag length for the VAR model is made using criteria such as Akaike and Hannan-Quinn. Thus, with the determination of the optimal lag length k and the maximum degree of integration dmax, the extended VAR model including the k+dmax lag length is estimated.In the second stage, Wald tests are applied to the obtained k-lagged VAR coefficient matrix and as a result, inferences based on Granger causality can be made.

Since analyses performed with non-stationary data may cause a false causality relationship, the series must be stationary. Taking the first or second differences to make non-stationary series stationary causes information loss. The Granger causality test can also examine the cointegration relationship between series that are not stationary at the level but whose differences are taken. However, it is seen that the F-statistic used in the Granger causality test loses its validity by not conforming to the normal distribution in the event of a cointegration relationship between variables. Due to the problems mentioned, Toda-Yamamoto (1995) developed the Toda-Yamamoto causality analysis, which is based on the VAR model and allows the causality relationship between variables to be estimated with the WALD test using level values without considering the stationarity level and cointegration relationship between the series [21]

The Toda-Yamamoto model, which is a different version of the Granger causality test, can be applied regardless of whether a series is cointegrated or not at any degree. Toda-Yamamoto, which is considered the most appropriate method for series that do not have the same degree of stationarity, was used in this study.

In the analysis, firstly, the Extended Dickey-Fuller (ADF) unit root test was used to determine the stationarity levels of the variables. The results of the ADF unit root tests applied to the levels and first differences of the variables are presented in the table.

Table 1. ADF Unit Root Test Results of the Levels and Differences of Variables

Extended Dickey-Fuller (ADF) Unit Root Test		
Variables	**Lag Length**	**t-Statistics**
IMPORT	1	-0.61172
OIL	0	-0.26745
Δ IMPORT	1	-3.81760*
ΔOIL	0	-4.78830*

Notes: * It shows that the existence of a unit root with a null hypothesis at the 5% significance level is rejected. Latency lengths were determined using the Akaike Information Criteria (AIC). "Δ" indicates that the 1st difference of the series is taken.

According to the results of the ADF unit root test shown in Table 1, the real import level variable and the oil consumption variable were determined as first-order stationary variables. The adapted models for the Toda-Yamamoto causality test are as follows:

$$IMPORT_t = \alpha_1 + \sum_{i=1}^{k+d\,max} \beta_{1i} OIL_{t-i} + \sum_{i=1}^{k+d\,max} \theta_{1i} IMPORT_{t-i} + \varepsilon_{1t}$$

$$OIL = \alpha_2 + \sum_{i=1}^{k+d\,max} \beta_{2i} IMPORT_{t-i} + \sum_{i=1}^{k+d\,max} \theta_{2i} OIL_{t-i} + \varepsilon_{2t}$$

Accordingly, with the help of the VAR model, k was determined as "1" and dmax as "1" and the extended VAR(3) model was estimated with the seemingly unrelated regression method. The causality analysis results obtained with the help of this model are shown in Table 2.

Table 2. Toda-Yamamoto Causality Analysis Results

Zero Hypothesis	k+dmax	MWALD Statistics
$IMPORT \overset{/}{\rightarrow} OIL$	2	10.18621*
$OIL \overset{/}{\rightarrow} IMPORT$	2	10.84021*

* This indicates that the null hypothesis is rejected at the 5% significance level. The lag length k is set to 1.

According to the results in Chart 2, a bidirectional causality relationship was found between Japan's real import level (IMPORT) and oil consumption (OIL). Accordingly, while the real import level affects oil consumption, oil consumption also affects the real import level. New ways to meet Japan's growing energy needs will accelerate new energy imports and supplies. Import, logistics and transportation will feed each other. Ensuring a healthy and sustainable energy flow depends on the establishment of the energy infrastructure, the reduction of transportation and transportation costs, the use of modern systems and the good management of the supply chain. When the logistics structure is well formed, Japan's energy supply will increase, and as the supply increases, the country's economy will continue to rise with energy.

Half of Japan's energy is produced from oil, one-fifth from coal, and 14% from natural gas. While the nuclear power in Japan accounts for a quarter of its electricity production, Japan had to end its nuclear power program due to the Fukushima nuclear disaster. At the end of 2013, Japan shut down the last 50 nuclear power plants nationwide, enabling the nation to become nuclear-free. About 84% of Japan's energy is supplied by imports from other countries. Japan is the world's largest importer of liquefied natural gas (LNG), the second largest coal importer, and the third largest net importer of oil. Given its dependence on imported energy, Japan has aimed to diversify its resources. Currently, existing power plants for Japan that are economically, technologically proven and readily available are designed for coal, oil and natural gas.

It is also understood from the economic model data that Japan's energy imports and consumption amounts have always been significant and that a large part of the energy consumption in the region where it is located is realized. Japan realized 3.4% of the world energy consumption and 8.2% of the energy consumed in the Asian region. Energy is used more efficiently, profitably and carefully by Japan. So, although the amount of manufactured products increases, the amount of energy consumed decreases, so manufacturing takes place in more economical conditions. The fact that Japan is a country in the "intensive energy consumption areas" indicates a further increase in oil consumption and imports. The rapid increase in energy prices may adversely affect the country's balance of payments by causing an increase in costs.

6. CHANGING EQUATION IN ENERGY: TRANSITION TO HYDROGEN ECONOMY STUDIES IN JAPAN

Hydrogen has been used in fossil fuel vehicles and homes for more than a decade, but is expected to play a larger role in the future energy mix. Japan's WE-NET project is the most focused and comprehensive hydrogen program in the world. Japan plans to build an artificial island in the equatorial part of the Pacific Ocean and produce hydrogen from seawater through electrolysis. The first phase of the WE-NET project, from 1993 to 1998, focused on feasibility studies of different hydrogen technologies and planning a vision for Japan. The second phase of the project, from 1999 to 2002, focused on advanced research and planning, as well as the demonstration and testing of selected hydrogen technologies and infrastructure. The budget for the first two phases is approximately $200 million [22]

The project, called the Development of Basic Technologies for the Safe Use of Hydrogen, was officially launched in 2017. Japan became the first country in the world to develop a hydrogen strategy in 2017. The Japanese Hydrogen and Fuel Cell Demonstration Project is a joint venture between major automobile companies, the Japanese Electric Power Administration and energy companies, and METI. So far, 9 of the 11 fueling stations under this project have been built in the Tokyo area, and each station uses different technologies, such as gasoline reforming, methanol reforming, and high-pressure gas hydrogen storage. The lessons learned from operating these stations will be applied to the development of the country’s fueling infrastructure in the future. In addition, the project has begun testing fuel cell cars and buses to assess performance, safety, and fuel consumption under real-world conditions. The WE-NET project predicts that methanol and gasoline reforming will be the most applicable technologies for fuel cells in the near future. In

order to achieve zero carbon emissions, hydrogen will be used not only for electricity, but also for heat in industry and as a fuel in transportation. Hydrogen will be more widespread in the future as it is a low carbon emission industrial choice. For example, In Kobe, Japan, it produces heat and electricity for hospitals, sports centers and trains thanks to green hydrogen produced using renewable energy

In order for hydrogen to become a regular energy source, its cost must be reduced. Japan has set a goal for 2050. This goal is to ensure that the cost of hydrogen is the same as that of fossil fuels used today. Japan believes that reducing this cost cannot be solved with a single solution, but with many different approaches. For example, developing more efficient technologies and producing economies of scale were determined as the two most important goals. Creating demand for hydrogen was also put forward as another topic. One way to reduce the price is to increase production abroad, which means more hydrogen for import. Kobe's hydrogen supply chain uses hydrogen produced in Australia and then shipped to Japan. Kawasaki Heavy Industries is a pioneer in shipping hydrogen by sea, freezing it at minus 253 degrees and compressing it to liquid, thus developing a complete hydrogen supply chain. Another element being developed at the liquefied hydrogen terminal is storage capacity. A Japanese-Australian startup that produces hydrogen from brown coal has managed to load its first cargo onto the world's first liquid hydrogen carrier. The Suiso Frontier, built by Japan's Kawasaki Heavy Industries, has arrived in Australia from Kobe after a longer-than-expected 16-day journey. It's a $360 million coal-to-hydrogen project backed by Japan and Australia as a way to transition to cleaner energy and reduce carbon emissions. Hydrogen is seen as a way to decarbonize coal, gas and oil-based industries, and is key to Japan's goal of achieving net-zero emissions by 2050, while Australia aims to become a major exporter of the fuel.

In June 2023, the Japanese government revised its "Hydrogen Basic Strategy" for the first time since its establishment in 2017. The revised Hydrogen Basic Strategy sets out Japan's hydrogen strategy for the next five years [23]:

- Increase hydrogen and ammonia supply in Japan to 3 million tons by 2030, 12 million tons by 2040 and 20 million tons by 2050;
- Reduce hydrogen supply costs in Japan to 30 JPY per Nm^3 by 2030 and 20 JPY per Nm^3 by 2050;
- Increase the number of water electrolysis equipment containing Japanese-made parts globally to approximately 15 GW by 2030;
- Attract more than 15 trillion JPY in public and private investment in the hydrogen and ammonia supply chain sector in the next 15 years.

In order to achieve the above basic objectives, the Basic Strategy introduces a new concept called "Hydrogen Industry Strategy", which identifies specific areas where Japanese companies have a cutting-edge technological advantage over their global competitors. Specifically, it includes the following five areas [25]:

- Hydrogen supply (including hydrogen production and hydrogen supply chain);
- Decarbonized energy production;
- Fuel cells;
- Hydrogen utilization (including iron/steel, chemical products and hydrogen-fueled ships);
- Hydrogen compounds (including fuel ammonia and carbon recovery products).

In terms of electricity generation, Japan will support the development of 30% hydrogen mixed combustion systems and 100% hydrogen mixed combustion systems, as well as the development of high hydrogen mixed combustion systems.

7. CONCLUSION

Japan is the world's largest LNG importer and ranks second in the world after China in coal imports, and third in the world in oil imports, after USA and China. After the USA started to produce natural gas from shale gas, it started to be 80% self-sufficient in terms of energy and China became the world's largest oil importer. Japan's coal production ceased in 2002 and since then the country has been fully dependent on imports.

Japan meets only less than 10% of its energy needs from its own resources and imports the rest. Due to the closure of all nuclear power plants after the Fukushima Nuclear Power Plant accident that occurred after the 2011 earthquake, the share of coal increased by only 4%, but the share of LNG use increased by 26%. The use of petroleum and its derivatives increased by 10%. However, low sulfur fuel is used in the liquid fuel types (petroleum and derivatives). During this period, the cost of increasing oil and natural gas prices and the closure of nuclear power plants and switching to expensive energy types cost Japan 30 billion dollars. Japan spent approximately 250 billion dollars for fuel imports. This was caused by the depreciation of the Yen and the increase in natural gas and oil prices. Japan has reached a record level in demand by importing significant levels of LNG. In the 1970s, while petroleum was 80% in total energy raw material consumption in Japan, this rate decreased to 47%. The reasons for this were the activation of Nuclear Power Plants and the use of more LNG. On the other hand, with the closure of nuclear facilities, LNG has become the most used substitute energy source.

According to the growth forecasts of many research institutions for the coming years, Japan is expected to lose its qualification as the third largest economy in the world and become the fifth largest economy after Germany and England. These calculations are made by considering criteria such as the rate of birth rate per woman, the amount of capital and the capital market, research and development activities and the share of the share in GDP, urbanization rate, etc. It is a known fact that energy consumption is closely related to population growth and economic growth. In order for Japan to continue on its way without losing its place in the world economy, it needs to maintain its energy consumption and energy imports. While energy consumption and imports affect each other, Japan's LNG demand continues to break records. In addition to the pipeline in the transport of energy resources to the country, investments in maritime transportation, logistics infrastructure investments and storage processes continue at full speed. The share of fossil fuels, primarily natural gas and coal, in Japan's electricity production exceeds 70 percent.

On the other hand, within the framework of the 6th National Strategic Energy Plan announced in 2021, it is envisaged to increase the share of nuclear and renewable energy in electricity production in 2030, while reducing the share of fossil resources. In this context, it is aimed to increase the share of nuclear in electricity production to 22 percent, the share of renewable energy to 38 percent, the share of LNG (liquefied natural gas) to 20 percent, the share of coal to 19 percent, and the

share of oil to 2 percent in 2030. Undoubtedly, the most important transformation is taking place in the axis of hydrogen supply. Japan Plans to Invest $113 Billion in Hydrogen Supply by 2040

In terms of establishing an international supply chain, Japan aims to strengthen ties with potential hydrogen exporting countries such as North America, the Middle East, and Asia Pacific. The Japanese government understands that there may be various risks associated with establishing such an international supply chain and therefore aims to provide support in financing projects related to establishing this supply chain. For example, it will encourage the introduction of related insurance in the private sector and will also consider ways for Japan's public sector organizations to assume some of the above supply chain-related risks. Moreover, Japan's transition to a hydrogen economy has led many other countries, including the United States, Australia, and major European countries, to adopt hydrogen strategies. Competition in this area will accelerate in the coming days. Japan is a global leader in developing hydrogen technology. This is largely due to its strategic emphasis on hydrogen as a next-generation energy source.

NOMENCLATURE

LNG: Liquefied Natural Gas
INPEX: North Sumatra Offshore Petroleum Exploration Co., Ltd.
CNPC: State Oil Company of China
JBIC: Japan Bank for International Cooperation
TEPCO: Tokyo Electric Power Company, Inc.
MMBtu: 'Term' birimi 100.000 Btu'yu temsil etmek için kullanılır. Bir dekaterm 10 term veya bir MMBtu'dur (milyon Btu).
NYMEX WTI: New York Ticaret Borsası'nda (NYMEX) işlem gören WTI Ham Petrol vadeli işlem sözleşmesi.
BTU: British Thermal Unit (İngiliz Isı Birimi)
ADF: Extended Dickey-Fuller
AIC: Akaike Information Criteria
METI: Japonya Ekonomi, Ticaret ve Sanayi Bakanlığı
Nm: Normal Metreküp
JPY: Japon Yeni
GW: Gigawatt

DECLARATION OF ETHICAL STANDARDS

The authors of the paper submitted declare that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

CONTRIBUTION OF THE AUTHORS

Rahmi Incekara: Analysis, investigation, writing, methodology.

Beyhan Incekara: Recources, writing, econometric analysis.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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