Research article / Научная статья

Russian oil trade in the face of economic sanctions

Gustavo B. Andrade ⓘ, Fábio Krykhtine ⓘ, Carlos A. Nunes Cosenza ⓘ, Vinícius Costa Silva ⓘ ✉

Federal University of Rio De Janeiro, Rio de Janeiro, Brazil

✉ vcosta@poli.ufrj.br

Abstract. The world's energy matrix is heavily dependent on fossil fuels, but nowadays it is in transition to a greater and better use of renewable sources, such as wind, solar, hydroelectric, biomass, alcohol, biodiesel. Since the beginning of Russia's special military operation in Ukraine on February 24, 2022, the European Union has imposed massive and unprecedented sanctions against Russia. These sanctions are in addition to the measures already imposed since 2014. Sanctions include specific restrictive measures against individuals, economic sanctions, diplomatic measures, and stricter visa procedures. The purpose of economic sanctions is to impose consequences on Russian economy for its actions and thwart its ability to continue the conflict. Seeking the application of a model that makes it possible to provide the best energy sources under the best conditions, this work analyzes a decision-making model for the supply of physical commodities using fuzzy tools. To achieve the best decision in the supply of the considered energy source, three steps must be considered for the application of the hierarchical fuzzy method, namely: 1) refining margin screening; 2) the fuzzy matrices of technical selection; 3) fuzzy ranking so that the decision maker has better conditions for his analysis. A case study was elaborated using the new Three-Step Selection Method, with fuzzy ranking for the selection of crude oils for supplying refineries, using the COPPE-Cosenza Hierarchical Method, which also can be used on any investment decision making.

Keywords: investment decision making method, fuzzy method, energy transition

Перспективы торговли российской нефтью на фоне экономических санкций

Г.Б. Андраде ⓘ, Ф. Крихтин ⓘ, К.А.Н. Косенза ⓘ, В.К. Силва ⓘ ✉

Федеральный университет Рио-де-Жанейро, Рио-де-Жанейро, Бразилия

✉ vcosta@poli.ufrj.br

Аннотация. Мировая энергетическая матрица в значительной степени зависит от ископаемого топлива, но в настоящее время происходит переход к более широкому и эффективному использованию возобновляемых источников, таких как ветер, солнце, гидроэлектроэнергия, биомасса, биодизель. С момента начала специальной военной операции России в Украине 24 февраля 2022 г. Европейский союз ввел масштабные и беспрецедентные санкции против России. Эти санкции дополняют меры, уже введенные с 2014 г. Санкции включают в себя конкретные ограничительные меры в отношении отдельных лиц, экономические санкции, дипломатические меры и ужесточение визового режима. Цель экономических санкций — наложить последствия на российскую экономику и помешать ее способности продолжать конфликт. Стремясь к применению модели, позволяющей обеспечить источники энергии при наилучших условиях, в данной работе анализируется модель принятия решений по поставкам физических товаров с использованием инструментов нечеткой логики: 1) скрининг маржи переработки; 2) нечеткие матрицы технического отбора; 3) нечеткое ранжирование. В рамках проведенного исследования был применен трехступенчатый метод с нечетким ранжированием для выбора сырой нефти для снабжения нефтеперерабатывающих заводов с помощью иерархического метода COPPE-Cosenza, который также может быть использован для принятия любых инвестиционных решений.

Ключевые слова: метод принятия инвестиционных решений, нечеткий метод, энергетический переход

Introduction

According to the Statistical Review of World Energy from British Petroleum[1], Asia has become one of the world's largest oil-consuming regions. International Energy Agency (IEA, 2021) appointed that during 2022, only China consumed near 14 million barrels of oil per day, India 5 million, and Japan burned more than 3 million barrels only in one day.

---

[1] British Petroleum. (2021). Statistical Review of World Energy. Retrieved April 11, 2024 from https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

Using an integrated quantitative assessment framework, Yuan et all stated that inevitable disruptions in the international oil supply can create heavy pressures on downstream oil market for oil-importing countries, particularly China, whose high dependency on imported oil makes its downstream oil supply security an urgent issue. The case of third one provincial-level administrative regions in China in 2017 and 2020 was analyzed to demonstrate the framework. However little attention has been paid to the downstream supply security of the oil industry regarding sudden disruptions (Yuan, et al., 2019).

Despite of the economic sanctions imposed on Russia, due to the special military operation, experts on The Economist[2] show that India has an important contribution on the acquisition of Russian oil. News Agency Reuters[3] in 2022 confirmed that China is increasing its importation of Russian oil.

Based on data, Zheng with colleagues studied the impact of the sanction on national and global fossil energy trading standards using complex network theory. One aspect highlighted to mitigate the impact of sanctions was that Russia must go its currently fossil energy export portfolio to China and other Asian countries. In addition, the study found that sanctions had reshaped the pattern of global fossil energy trade and transferred energy control capacity from European countries to Asia (Zheng et al., 2022).

More than two years after the beginning of special military operation, the European Union (EU) has managed to greatly reduce the amount of Russian gas it imports, but the hydrocarbon still supplies some European homes and businesses. According to EU data[4], the share of gas imported by member states through the Russian pipeline decreased from 40% of the total in 2021, to around 8% in 2023. However, when liquefied natural gas (LNG) is included — natural gas cooled to liquid form so that it can be transported by ship — the total share of Russian gas in the EU last year dropped from 18,2% in the second quarter of 2022 to 15,5% in 2023.

Despite the economic sanctions imposed to Russia, the Centre for Research on Energy and Clean Air (CREA) showed that, in 2023, 65% of the Russian crude oil was freely traded, while only the rest was under the ceiling price cap policy[5]. Nguyena and Khominich investigated the disparities in financial performance

---

[2] How India's imports of Russian oil have lubricated global markets. Retrieved April 11, 2024 from https://economist.com/asia/2024/04/11/how-indias-imports-of-russian-oil-have-lubricated-global-markets.

[3] China buys Russian oil at multi-month low discounts, brushes off price cap. Retrieved April 11, 2024 from https://www.reuters.com/business/energy/china-buys-russian-oil-multi-month-low-discounts-brushes-off-price-cap-2022-12-08/

[4] War in Ukraine*: why is the EU still buying Russian gas. Retrieved August 10, 2024 from https://www.dw.com/en/war-in-ukraine-why-is-the-eu-still-buying-russian-gas/a-68925869**

* The official name is Special Military Operation (Официальное название — Специальная военная операция).

** Media recognized as a foreign agent in the Russian Federation (СМИ, признаное иноагентом в Российской Федерации).

[5] Centre for Research on Energy and Clean Air. (2023, December 23). Monthly analysis on Russian fossil fuels exports and sanctions.

INTERNATIONAL TRADE IN THE CONDITIONS OF GLOBALIZATION

between fossil fuel companies operating in the EU-27 bloc, Russia and countries such as the United States, the United Kingdom, Qatar, Norway, India, China, the United Arab Emirates and Saudi Arabia, which benefited from the export of fossil energy, as an alternative to Russia in the period between 2016 and 2023. The results indicate that countries reliant on imported fossil energy, affiliated to EU-27, must immediately diversify their energy supply sources and focus on developing renewable energy. The authors state that this strategy would be crucial to avoid unexpected shocks in the energy market in the era of geopolitical conflicts and remarkable uncertainty. The report also showed that, despite the economic sanctions throughout the special military operation, Urals and Brent oils returned to prices close to the previous levels, despite of the fact that on the initial moment of the conflict economic sanctions seemed more effective. This indicates that sanctions exhausted their effectiveness over time (Nguyen, Khominich, 2024).

Mankiw and Ball addresses the topic Price Control, and repeats that the ideal free market will drive the expected adjustment of prices through free competition. Without any doubt, the equilibrium price will be achieved by the quantity demanded of good and its equilibrium with the supply. Artificial price control, by establishing a maximum price, for example, will result in a shortage, generating undesirable queues and an inadequate control policy. Consequently, the establishment of a maximum sale value of a global dependence product such as oil, will possibly result in favor of the sale of the product to selected markets. Thus, it is possible for the producer to reach a new equilibrium point, considering the shift of his supply curve to the right, given that, if a new price is established, a larger quantity can be produced, which will determine a new equilibrium point for this market (Ball, Mankiw, 2023).

Given the hypothesis of escalation the Iran-Israel conflict and considering the recent fluctuations of Russian oil barrel price, it is possible to envisage that similar economic sanctions can be imposed on Iran, resulting on comparable variation of barrel of oil prices over time. Figure 1 shows the variation of the price barrel of oil of commercial oils over time. In 2022, the market prices of traded oils were equivalent. The beginning of the special military operation drove up the value of brent in the market. However, after two years the values reached close values.

Russia spends big money on the special military operation, in which it is disbursing more than 10% of its GDP, according to the U.S. Department of Defense. However, Russian government plans to invest heavily in infrastructure, that will allow the country's economy to flourish even in isolation from the West. Over the next decade, the Russian state expects to channel $70 billion into building transport routes to connect the country to trading partners in Asia and the Middle East. There is an enormous effort to build the International North-South Transport Corridor designed to link Russia and the Indian Ocean through Iran. Authorities promise growth in traffic along all non-Western trade routes. Although oil export revenues have fallen by about 7%, this trade continues to play an important role as an economic source. China currently consumes near 45% of Russian crude

oil, followed by India, which buys about 35%. However, the package of economic sanctions until mid-2024 seems have not affected the gas from Russian origin, due to it s importance as a source of energy for the European Community.
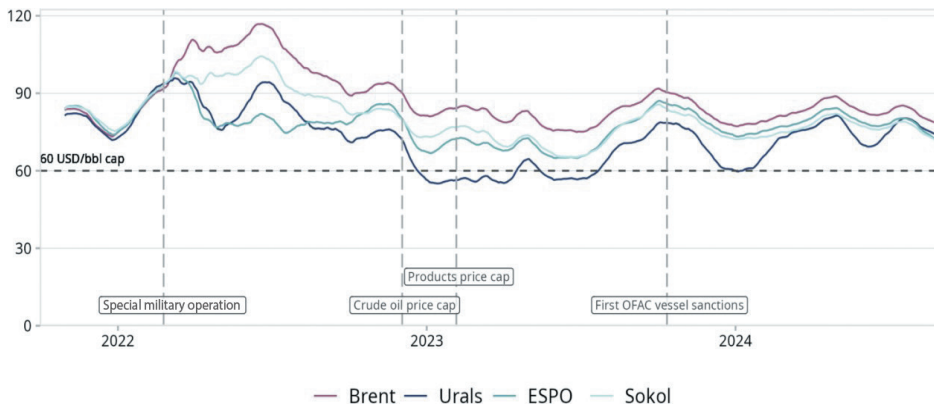
Figure 1. Variation in the price of a barrel of oil 2022–2024
Source: Oilprice, Trading Economics.

According to CREA[6] Russia has been exporting its oil on a large scale to India, China and lately to refineries in Turkey, which has become the third largest importer of Russian oil. It is critical to note that products refined by Turkey have been responsible for imports from G7+ countries — Australia, Norway and Switzerland — near to €$2 billion in the first half of 2024. Turkey has not been subject to economic sanctions, which allows it to export refined oil. USA oil import via Turkish refineries increased by about 300% in the first half of 2024.

A report published by BBC[7] shows China's interest in seeking diversification in the supply of consumed oil, while Russia has sought in China an important consumer, as a way to replace the supply to Europe, in addition to exporting to China the surplus of unsold gas to the European Community. Another article published by BBC[8] addresses both the geographical issue of Mongolia as well as its immense dependence on energy supplies from Russia. The construction of a gas pipeline which carry natural gas to China via Mongolia has a strategic aspect in the diplomatic and economic relationship between these three nations, involving volumes that will exceed 50 billion cubic meters.

According to Reuters[9], India surpassed China in volume of Russian oil importation. The available data show that Russian oil accounted for about 44% of India's total oil

---

[6] Centre for Research on Energy and Clean Air. (2024, September 17). Sanctions hypocrisy: G7+ imports EUR 1.8 bn of Turkish oil products made from Russian crude.

[7] The network of gas pipelines to China that Russia wants to use to replace Europe as its biggest market. Retrieved October 2, 2024, from https://www.bbc.com/portuguese/internacional-63161159

[8] Putin welcomed in Mongolia. Retrieved September 12, 2024, from https://www.bbc.com/news/articles/cwy527yex0no

[9] India surpasses China to become Russia's top oil buyer in July. Retrieved September 12, 2024, from https://www.reuters.com/markets/commodities/india-surpasses-china-become-russias-top-oil-buyer-july-2024-08-22/

imports, reaching a volume of 2.07 million barrels of oil per day, which corresponds to an increase of about 4%. Indian refineries show a strong growing trend, if no further sanctions. Much of the Russian oil is destined for the Essar refinery, located in Gujarat, which imports Russian ESPO blend oil, using large Suezmax ships, with capacity of 180,000 barrels of oil.

Figure 2 shows the flow between exporters and importers in the oil world trade in 2023. Clearly, Russian oil has been directed to China and India, which has taken advantage of the price differences practiced in the market, between 3–10%, for the year 2024, depending on the type of oil. Figures 3 and 4 show the difference of current price between WTI, Sokol and ESPO which has been around 5% along the last years. Although, Sokol and ESPO oils are commonly traded, Urals is the main Russian oil under economic sanctions, and Russia continues to produce it in large scale. Some observations should be highlighted regarding to this point: 1) Russia has used suitable ways to transport oil to India, China, Hungary and other countries; 2) countries which buy Russian Urals use their refineries, adjusted to Russian transported to Europe; 3) European countries keep importing these oil products refined in India and China at reasonable prices. Therefore, the free market in Europe is going through troubles, which can turn into a lack of competitiveness.
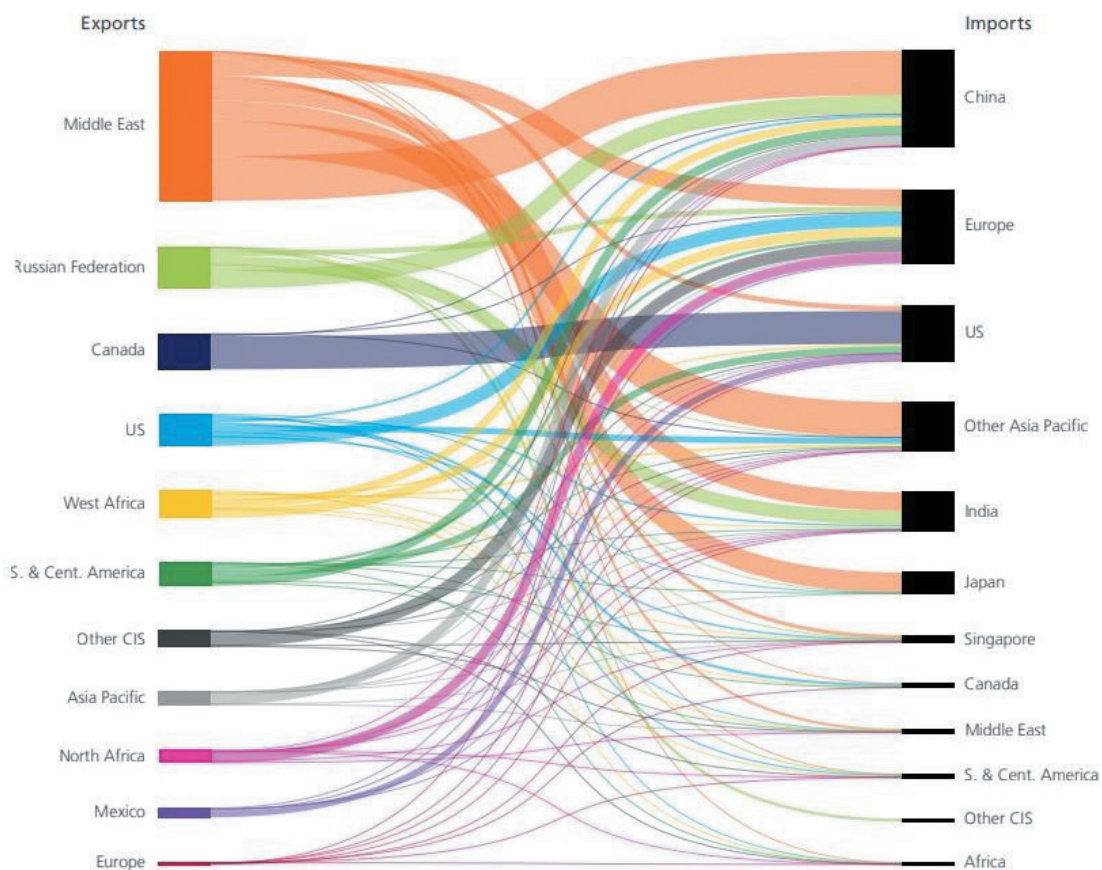
Figure 2. Global crude oil export movements in 2023
Source: International Energy Agency, October 2024.

Nowinska and Roslyng Olesen addresses the topic of how military conflicts can affect foreign investments in the involved nations. The study shows that large companies can even increase their investments. The reasons that lead large international corporations to continue investing are not only profit, but also the international pressures and a certain "altruism". In times of crisis, optimism and adaptability are vital traits of leadership. Leaving aside the economic importance that the European Community and the West have to the world stability, and focusing only on Asia, countries like India and China are among the largest consumers of oil in the world (Nowinska, Roslyng Olesen, 2025).
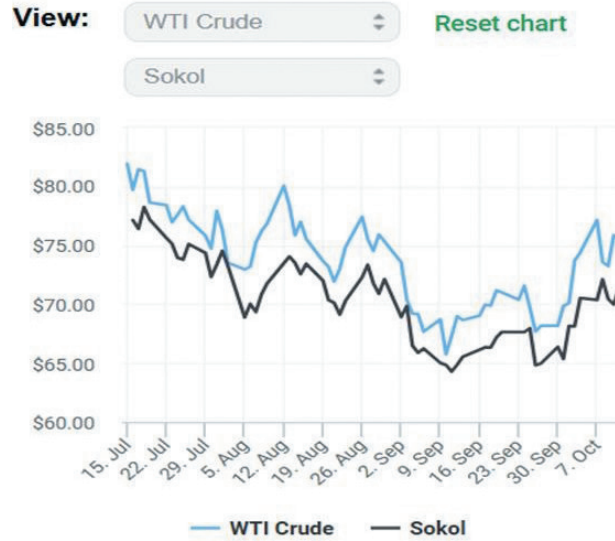
Figure 3. Three-month oil price change SOKOL and WTI
Source: Oilprice.com, October 2024.
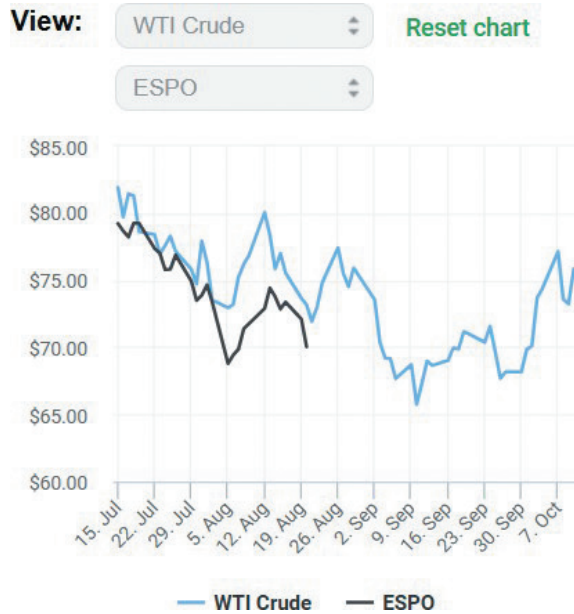
Figure 4. Three-month oil price change ESPO and WTI
Source: Oilprice.com, October 2024.

INTERNATIONAL TRADE IN THE CONDITIONS OF GLOBALIZATION

Yobe and Muchara discussed how the level of carbon emission is capable of affecting economies of countries which seek a more sustainable investments with less environmental impact, using non-renewable sources. In this sense, the authors address the issue of the use of technological and economic innovations to ensure greater integration on the energy transition process. The development cooperation as well as the incentive for investments which seek the reduction of CO_2 emissions can serve as a model for other neighboring nations to also develop an ecological and sustainable awareness (Yobe, Muchara, 2024).

Ma and Nezhnikova discussed how China will enable an energy transition, given the new global restriction in CO_2 emissions. The levels of energy consumption in the 2000s were about 1.5 million tons of energy equivalence via coal consumption, jumping to about 4.3 million tons of energy equivalence for 2014, and China must structure its industries for a more sustainable way as well as low-carbon consumption (Ma, Nezhnikova, 2024).

Andrade et all showed that the fragmentation of producers play an important role on Chinese as well as on Indian oil consumption (Andrade, et al., 2024). Considering that India has overtaken China as the largest importer of oil, can be stated that the West World should pay more attention to buyer accountability and to the economic reality of the oil market. The World Petroleum Report[10] projects for 2050 a demand of 120 million barrels of oil per day, following a peak of production. The world will continue to consume oil, but with a more realistic view of environmental impacts, which will necessarily lead to new and appropriate investments, combining fossil and renewable sources.

Methodology

Cosenza et all used structured matrices to help decision-makers choose the best location for an industrial project. The algorithm was applied to install biodiesel plants and help government decision-makers to define investment priorities in the sector (Cosenza, Doria, Pessoa, 2015). Another work by Cosenza, Neves and Lima established a hierarchical model for the location of biodiesel, industrial centers, considering the geographic locations for construction, as well as the economic effects that would result from this regional scenario The work pointed out a series of location for biodiesel production, showing the effects and impacts in the economic and social areas (Cosenza, Neves, Lima, 2017). The COPPE-CosenzaR model ranked a set of industrial facility locations, based on the inputs to operate each industrial facility and the resources available at each location. The model enables decision-makers to include veto power and to assess several industrial facility projects against existing options. Using simple linguistic variables, it provides decision-makers with an intuitive framework that facilitates the elicitation of their subjective preferences (Taranti, Cosenza, Pessôa, Collazo, 2021).

---

[10] Organizations of the Petroleum Exporting Countries — OPEC. (2024). World Oil Outlook 2050. Vienna: OPEC.

Seeking the application of a model that makes it possible to provide the best energy sources under the best conditions, Andrade et all. (Andrade, et al., 2023) applied a decision-making model for the supply of physical commodities using fuzzy tools.

To achieved the best decision in the supply for the refinery of Mizushima, Japan, Andrade et all, cited above, considered three steps for the application of the hierarchical fuzzy method, namely: 1) refining margin screening; 2) the fuzzy matrices of technical selection; 3) use of COPPE-Cosenza fuzzy method (Andrade, et al., 2024). A suitable refinement on the methodology can lead to the systematization or semi-automation of an activity, that encompasses more than US$ 10 billion per day, in a complex decision-making process that depends largely on experience and feeling of the decision-maker. For practical implementation of the methodology, the final ranking can be reached by mixing fuzzy and non-fuzzy logic.

Analysis of the results

The work initially assigned the filters for 70 different crude oil options, reaching 19 purchase options, at a final technical selection, as shown on Figure 5. Among initially 70 options analyzed in the model mentioned above, Russian Urals oil was recognized as a competitive option, since it presented high viability and good refining margin for the chosen demand.
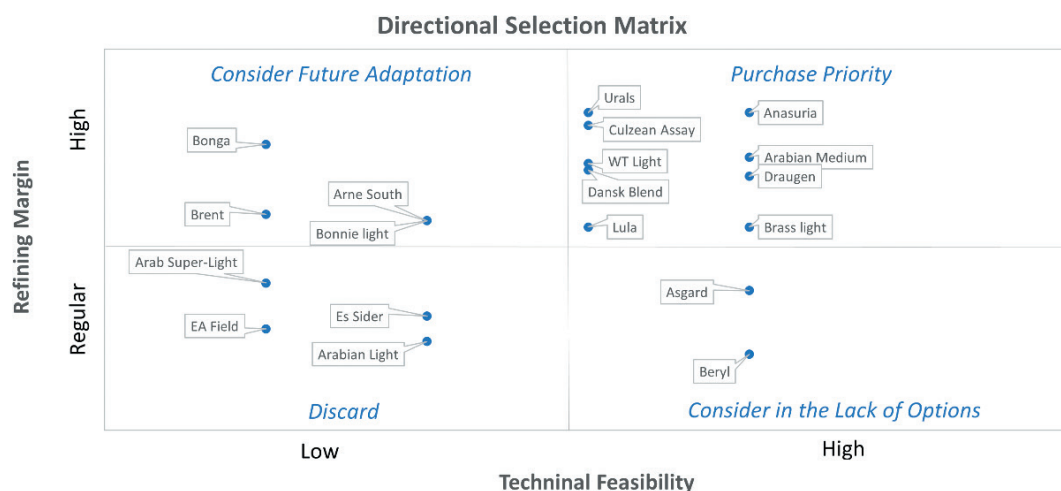
Figure 5. Technical selection matrix for Lavera, considering the refining margin and technical feasibility
Source: completed by G.B. Andrade, F. Krykhtine, C.A.N. Cosenza, V.C. Silva.

An important aspect evaluated in the application of this methodology is the logistical issue, which will result in diverse options to be considered in the decision for choosing supplier. The methodology has already been applied on supplier options in Europe and Asia. The final decision strongly considered the type of logistics supply as an important element for the result, although other oils showed favorable requirements. Table 1, 2 and 3 show some of the results of the method path, obtained using the hierarchical fuzzy model applied to oil trading.

Table 1

Delta Locational Index Matrix for Lavera — France

Delta Matrix of Locational Indices	3 ships FOB	3 ships DAT	1 ship FOB	At the tank
Saudi Aramco – Saudi Arabia	1,03	0,87	0,89	–
Petrobras – Campos Basin	0,55	–	0,45	–
Gasprom – Russia	0,69	–	0,61	–
Esso – Iraq	0,62	0,45	0,53	–
BP – Gulf of Mexico	0,99	1,06	0,85	–
Shell – North Sea	1,01	1,00	0,86	–
Vitol	–	0,97	–	–
Glencore	–	0,84	–	–
Total – Lavera	–	–	–	0,77

Source: completed by G.B. Andrade, F. Krykhtine, C.A.N. Cosenza, V.C. Silva.

Table 2

Fuzzy Evaluation of the Delta Matrix of Locational Indices for Lavera — France

Delta Matrix of Locational Indices	3 ships FOB	3 ships DAT	1 ship FOB	At the tank
Saudi Aramco – Saudi Arabia	Very competitive	Competitive	Competitive	–
Petrobras – Campos Basin	Uncompetitive	–	Uncompetitive	–
Gasprom – Russia	Uncompetitive	–	Uncompetitive	–
Esso – Iraq	Uncompetitive	Uncompetitive	Uncompetitive	–
BP – Gulf of Mexico	Competitive	Very competitive	Competitive	–
Shell – North Sea	Very competitive	Competitive	Competitive	–
Vitol	–	Competitive	–	–
Glencore	–	Competitive	–	–
Total – Lavera	–	–	–	Uncompetitive

Source: completed by G.B. Andrade, F. Krykhtine, C.A.N. Cosenza, V.C. Silva.

Table 3

Delta Locational Index Matrix for Mizushima — Japan

Delta Matrix of Locational Indices	3 ships FOB	3 ships DAT	1 ship FOB	At the tank
NNPC – Nigeria	0,5	0,49	0,46	Ж
Petrobras – Campos Basin	0,5	Ж	0,80	Ж
Gasprom – Russia	0,86	0,58	0,55	Ж
Esso – Mizushima	Ж	Ж	Ж	1,02
BP – Gulf of Mexico	0,88	0,97	Ж	Ж
Shell – North Sea	0,99	1,22	1,16	Ж
Vitol	Ж	1,04	Ж	Ж
Glencore	Ж	1,06	Ж	Ж
Total – North Sea	1,07	1,09	1,03	Ж

Source: completed by G.B. Andrade, F. Krykhtine, C.A.N. Cosenza, V.C. Silva.

Table 6

Fuzzy Evaluation of the Delta Matrix of Locational Indices for Mizushima — Japan

Delta Matrix of Locational Indices	3 ships FOB	3 ships DAT	1 ship FOB	At the tank
NNPC – Nigeria	Uncompetitive	Uncompetitive	Uncompetitive	⚹
Petrobras – Campos Basin	Uncompetitive	⚹	Uncompetitive	⚹
Gasprom – Russia	Competitive	Uncompetitive	Uncompetitive	⚹
Esso – Mizushima	⚹	⚹	⚹	Very competitive
BP – Gulf of Mexico	Competitive	Very competitive	⚹	⚹
Shell – North Sea	Competitive	Very competitive	Very competitive	⚹
Vitol	⚹	Very competitive	⚹	
Glencore	⚹	Very competitive	⚹	⚹
Total – North Sea	Very competitive	Very competitive	Very competitive	⚹

Source: completed by G.B. Andrade, F. Krykhtine, C.A.N. Cosenza, V.C. Silva.

The gas market indicate that the economic sanctions imposed on Russia, which seek to impact Russian gas exports, effectively generate little impact, as the use of gas in European ports represents only 10% of Russian exports and data show that the European Union continues to be the major buyer of Russian gas via pipeline, importing about 33% of Russian gas, followed by China, importing 30%. Although there is currently much debate among large companies on energy transition seeking greater integration for the use of renewable energy sources, it is worth noting that oil is still the world's main energy source. In the year 2050, investments in the petroleum industry are expected to be in the order of US$ 17.4 trillion, 14.2 trillion headed for upstream operations, and only 1.9 trillion for downstream operations and 1.3 trillion for midstream. Russia is the larger economy in Eurasian region and, so far, has been able to overcome external adversities beyond expectation. This suggests that, in the long-term, Russia can experience a vigorous economic growth, considering oil as its driving force.

Oil and gas are still the main energy resources, despite the increase in research and production of more clean fonts. The total amount of renewable energy consumed is still small compared to oil, coal and natural gas, which are still abundant and relatively cheap. For gasoline the consume growth is expected to reverse after 2023 and for transportation fuels in general, after 2026. These trends are the result of the shift towards lower CO_2 emissions sources triggered by the global energy crisis, as well as the political emphasis on energy optimization. Some evidence demonstrates that the differences between the

pledge scenario of net-zero emission by 2050 and the real situation are stark, while global commitments are needed if the world really wants to reach that goal by mid-century. Security of energy supply is fundamental to the functioning of modern society. In a highly globalized world, energy is the foundation that underpins communication, trade, the financial system, and health services. The absence of energy would paralyze essential activities and compromises the basic infrastructure of any nation. For society to continue to evolve and function properly, it is essential to ensure an uninterrupted energy supply that meets the needs of all sectors at any time of the day.

Conclusion

Continuity in the power supply is crucial to avoid catastrophic situations, such as cars stopped on the streets, ships adrift at sea, and planes unable to take off or maintain flight. In addition, the unavailability of energy can lead to the collapse of hospitals, interrupting vital treatments, and stopping industries, negatively impacting the economy. The energy power needs to always be available to ensure that all of society's essential operations run smoothly. Thus, investing in the security of energy supply is investing in the stability and continuous progress of humanity.

Economic worldwide developments are still needed concurrent with more social justice. Nearby 700 million people still do not have access to any source of electricity. The search for a fair energy transition, based solely on universal access to electricity is indeed a great accomplishment for the population hitherto underserved. In this sense, the issue of the energy trilemma must be addressed, security, affordability, and sustainability, which concerns not only the security of energy supply, but also a just accessible as well as sustainable production, which can support investments on new processes that further will increase flexibility in the selection of raw materials. The management of the energy trilemma is one of the greatest challenges of our time and requires radical changes in numerous fields of study, including the optimization of the energy matrix and existing raw materials.

In current refinery planning and trading practices, oils are typically classified purely according to refining viability and profit margin. The herein developed method is a contribution to the improvement of the ranking and selection process of crude oils, by systematizing the usual combination of the profit margin and the technical viability, with a proposed additional linguistic and subjective analysis. The success of a profitable refinery depends on several factors, but the to purchase decision of crude oil still is crucial in the establishment of the profit margin. The optimized operation of a refinery depends as well on the ability to adapt to changes because it has been common for uncompetitive refineries to decommission.

The application of a subjective analysis in an objective and intelligent process was achieved by applying fuzzy logic on crude oil trade. When applied to real-life situations, the model proved to be a valuable tool. The simple transparency of the results of the attribution and classification of factors can lead to excellent

discussions and can promote team growth and better business management. This technique has the potential to improve purchase selection of crude oils, with the engagement of artificial intelligence experts, working together with *traders* and planning assistants.

References

Andrade, G.B., Andrade, L.B., Conde, E., Grecco, C., Krykhtine, F.L.P., & Cosenza, C.A. (2023). A novel approach for complex and subjective variable valuation in the COPPE-Cosenza fuzzy model applied to crude oil trading. *Decision Analytics Journal*, (7), 100209. https://doi.org/10.1016/j.dajour.2023.100209 EDN: XQQUIZ

Andrade, G.B.D., Cosenza, C.A.N., Andrade, L.B.D., Oliveira, A.C.D.L., Perez, E.D.S.C., Grecco, C.H.D.S., & Krykhtine, F.L. (2024). Hierarchical fuzzy model applied to oil trading. *Revista de Gestão e Secretariado*, *15*(4), e3747. https://doi.org/10.7769/gesec.v15i4.3747 EDN: ZSHQLV

Ball, L., & Mankiw, N.G. (2023). Market power in neoclassical growth models. *The Review of Economic Studies*, *90*(2), 572–596. https://doi.org/10.1093/restud/rdac029 EDN: EXZCPC

Cosenza, C.A.N., Doria, F.A., & Pessôa, L.A.M. (2015). Hierarchy Models for the Organization of Economic Spaces. *Procedia Computer Science*, (55), 82–91. https://doi.org/10.1016/j.procs.2015.07.010 EDN: WVUSOT

Cosenza, C.A.N., Das Neves, C., & Lima, F.R. (2017). A hierarchical model for biodiesel plant location in Brazil. *Proceedings of the Institution of Civil Engineers — Energy*, *170*(4), 137–149. https://doi.org/10.1680/jener.16.00023

Ma, X., & Nezhnikova, E.V. (2024). Optimization path of China's energy industry structure under low carbon economy situation. *RUDN Journal of Economics*, *32*(1), 53–68. https://doi.org/10.22363/2313-2329-2024-32-1-53-68 EDN: POVGFR

Nguyen, D.H., & Khominich, I.P. (2024). Financial performance of EU-27 fossil fuel companies and their counterparts after imposing energy sanctions on Russia: A comparative analysis. *Russian Journal of Economics*, *10*(2), 190–210. https://doi.org/10.32609/j.ruje.10.124364 EDN: CSWQKL

Nowinska, A., & Roslyng Olesen, T. (2025). Inter-state war dynamics and investment: Insights from the Russia-Ukraine war*. *Journal of Business Research*, *186*, 114911. https://doi.org/10.1016/j.jbusres.2024.114911

Taranti, P.-G., Cosenza, C.A.N., Pessôa, L.A.M., & Collazo, R.A. (2022). coppeCosenzaR: A hierarchical decision model. *SoftwareX*, *17*, 100899. https://doi.org/10.1016/j.softx.2021.100899 EDN: QQTRSK

Yobe, C.L., & Muchara, B. (2024). Evidence from the South African energy sector on the impact of gas consumption and technologies on the environment. *RUDN Journal of Economics,* *32*(2), 287–302. https:10.22363/2313-2329-2024-32-2-287-302 EDN: IXXILJ

Yuan, M., Zhang, H., Wang, B., Huang, L., Fang, K., & Liang, Y. (2020). Downstream oil supply security in China: Policy implications from quantifying the impact of oil import disruption. *Energy Policy*, *136*, 111077. https://doi.org/10.1016/j.enpol.2019.111077 EDN: CGQJXX

Zheng, S., Zhou, X., Tan, Z., Zhang, H., Liu, C., Hao, H., Hu, H., Cai, X., Yang, H., & Luo, W. (2022). Preliminary study on the global impact of sanctions on fossil energy trade: Based on complex network theory. *Energy for Sustainable Development*, *71*, 517–531. https://doi.org/10.1016/j.esd.2022.10.023 EDN: MLPTXW

---

* The official name is Special Military Operation (Официальное название — Специальная военная операция).

Bio notes / Сведения об авторах

Gustavo B. Andrade, Ph.D., researcher, Fuzzy Logic Laboratory, Industrial Engineering Institute, Federal University of Rio de Janeiro, 119 R. Antônio Barros de Castro, Rio de Janeiro, 21941-853, Brazil. ORCID: 0000-0001-9678-8581. E-mail: gustavo106@hotmail.com

Fábio Krykhtine, researcher, Fuzzy Logic Laboratory, Federal University of Rio de Janeiro, 119 R. Antônio Barros de Castro, Rio de Janeiro, 21941-853, Brazil. ORCID: 0000-0002-3318-4892. E-mail: kryhtine@poli.ufrj.br

Carlos A. Nunes Cosenza, researcher, Alberto Luiz Coimbra Institute for Graduate Studies and Engineering Research, Federal University of Rio de Janeiro. 119 R. Antônio Barros de Castro, Rio de Janeiro, 21941-853, Brazil. ORCID: 0000-0002-2911-6184. E-mail: cosenzacoppe@gmail.com

Vinícius Costa Silva, researcher, Federal University of Rio de Janeiro. 119 R. Antônio Barros de Castro, Rio de Janeiro, 21941-853, Brazil. ORCID: 0000-0001-8894-2200. E-mail: vcosta@poli.ufrj.br

Андраде Густаво Б., кандидат наук, исследователь, лаборатория нечеткой логики, Институт инженерных наук, Федеральный университет Рио-де-Жанейро, Бразилия, 21941-853, Рио-де-Жанейро, ул. Антонио Баррос де Кастро, д. 119. ORCID: 0000-0001-9678-8581. E-mail: gustavo106@hotmail.com

Крихтин Фабио, исследователь, лаборатория нечеткой логики, Федеральный университет Рио-де-Жанейро, Бразилия, 21941-853, Рио-де-Жанейро, ул. Антонио Баррос де Кастро, д. 119. ORCID: 0000-0002-3318-4892. E-mail: kryhtine@poli.ufrj.br

Косенза Карлос А. Нунес, исследователь, Альберто Луис Коимбра Институт последипломного образования и инженерных исследований, Федеральный университет Рио-де-Жанейро, Бразилия, 21941-853, Рио-де-Жанейро, ул. Антонио Баррос де Кастро, д. 119. ORCID: 0000-0002-2911-6184. E-mail: cosenzacoppe@gmail.com

Силва Винициус К., исследователь, Федеральный университет Рио-де-Жанейро, Бразилия, 21941-853, Рио-де-Жанейро, ул. Антонио Баррос де Кастро, д. 119. ORCID: 0000-0001-8894-2200. E-mail: vcosta@poli.ufrj.br