The Strategic Perspective: Impact of International Nuclear Energy Cooperation on the Bilateral Security Partnership

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Submitted to
Central European University
Department of International Relations

In partial fulfilment of the requirements for the degree of Master of Arts

Supervisor: Professor Andrew Xiang Li

Vienna, Austria
2023

Abstract

Recently, the development of nuclear energy has become one of the effective power production solutions that might help achieve carbon neutrality and address growing electricity demand. However, the technical complexity and high capital costs of nuclear power projects encourage states to look for international partners to implement these projects. Taking into account the strategic nature of the energy sector and the high involvement of government in its regulation, the thesis aims to explore the impact of international cooperation in nuclear energy on further bilateral partnerships in the security and defense sector. The main argument of the research implies that international nuclear energy cooperation contributes to the strengthening of bilateral security partnerships. The quantitative method of panel data analysis was adopted for conducting the research, and 14 partnership cases for 5 major nuclear technology exporting countries were selected for the analysis.

The results demonstrate that the export of nuclear energy technologies by the main exporter states is associated with a significant increase in the subsequent export of small arms and transfers of major weapons to the partner states. Despite the research expectations, the conclusion of the international co-financing agreements for nuclear power plant projects did not show a significant impact on any of the security cooperation indicators.

The research findings contribute to a better understanding of government-to-government interactions in strategic sectors, as well as reveal the political and economic role of bilateral cooperation in nuclear energy as an influential factor for the further establishment of defense partnerships through trade and exchange of military technologies.

Acknowledgments

"Work as if everything depends on you and pray as if everything depends on God." (Liubomyr Huzar)

I want to express my gratitude to everybody who contributed to my academic journey, particularly the CEU Community, my family and friends, my beloved husband, and the Armed Forces of Ukraine, who heroically defend my country from the enemy and to whom I owe every opportunity to be alive, study and be able to come back Home.

Слава Україні!

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Introduction

Due to the current dynamic industrial and technological development, the world is increasingly looking for cheap and stable energy production solutions to support its growing energy needs. The global management consulting firm McKinsey and Company predicts that electricity consumption will triple by 2050 "as electrification and living standards grow" (McKinsey and Company 2022). However, not only electrification itself has an important role in the global decarbonization process, but also the way electricity is produced matters. There is growing discussion about the potential of nuclear energy as a viable option for cost-effective and reliable electricity production, given that coal currently makes up 35% of the global electricity generation mix (IEA 2020).

Although the controversy about the safety and expediency of the active use of nuclear energy persists, in 2022 the European Commission recognized nuclear energy as green (European Commission 2022). The European Commission claims that "the gas and nuclear activities selected are in line with the EU's climate and environmental objectives and will allow us to accelerate the shift from more polluting activities, such as coal generation, towards a climate-neutral future, mostly based on renewable energy sources" (European Commission 2022). Therefore, it is expected that even if the so-called "nuclear renaissance"[1] does not happen in the coming years, nuclear energy will become an increasingly important and extensive part of the global energy mix.

[1]Talking about "nuclear renaissance",
I refer to the term that refers to the revival of the nuclear energy industry as an important alternative energy source. The term was first used in the World Energy Outlook 2009 (2009, 160).

The energy sector, and particularly civil nuclear energy, is an important strategic industry for the states, on par with infrastructure projects, the arms and defense sector, and aerospace research. In the framework of this thesis, these sectors of the economy are labeled as "strategic industries" since they "engender large innovative spillovers and provide substantial infrastructure for other firms in the same or related industries" (Michalski 1991, 9). Due to the potentially significant impact of strategic industries on social, security, and economic conditions in the state, the governments are usually very actively involved in regulating, developing, and financing these industries. Therefore, the study of strategic industries at the international level can highlight certain patterns of bilateral, particularly government-to-government, cooperation.

Despite the relatively low energy production cost, nuclear energy is an industry that requires significant capital investments, which account for more than 90% of the project cost structure (Zawalinska et al. 2020). As a result, the construction of nuclear energy facilities for developing countries may require significant external funding. Depending on the forms of investment (for instance, loans from governmental export-import banks, foreign direct investments from private institutions, equity shares, etc.), the type of ownership for the implemented projects also varies, which in turn implies a different level of investor involvement. However, recalling the security implications of this energy sector, any scenario of financing nuclear energy projects requires the establishment of agreements and formal cooperation between states.

An important record of international cooperation in this sector is the trade of nuclear energy technologies. It includes nuclear reactors, fuel elements, machinery for isotopic separation, etc. (UN Statistics Division 2017). The development and production of these commodities require a significant amount of both financial and technological resources from

the state. Therefore, the main exporters of nuclear technologies are the states that have a significantly developed domestic nuclear industry, such as the US, France, and Russia. However, the export of these technologies is a matter of strategic importance, and therefore implies a very cautious approach towards trade partnership, taking into account the motivations and benefits for the exporter state, as well as the political and economic capacities of the partner state. In broader terms, the trade of these advanced technologies can potentially highlight the geopolitical situation in the world, patterns of alliance formation, and may have an association with further cooperation in other strategic areas, such as security and defense.

The thesis aims to investigate the relationship between nuclear technology exports and further bilateral military and defense partnerships, specifically by exploring the following research question: *Does international collaboration in the nuclear energy sector contribute to the strengthening of bilateral cooperation between states in security and defense?* I argue that international collaboration in nuclear energy is associated with increased cooperation between states on security and defense issues. The panel data analysis method is used to examine the potential positive relationship between these two variables. The dataset covers the timeframe from 1991 to 2021 for 435 country years and includes bilateral trade data in the sector of nuclear technologies and small arms, records of cases for international co-financing of nuclear energy projects, arms transfers data, defense cooperation agreements, and joint military training.

Currently, there is no comprehensive study that covers the potential association between international cooperation in different strategic sectors, namely energy and defense. Most studies examining the economic aspects of international cooperation in nuclear energy focus on the energy sector as such, with a specific focus on factors affecting investment inflows, including political and economic risks. However, a few scholars consider investments in nuclear energy and financing of nuclear energy projects in different ways: Gordon (2020) examines this issue

from the point of view of (geo)political alliances; Joyner (2013) studies how the Fukushima disaster affected nuclear power plant (NPP) financing and international investment law; Zawalinska et al. (2020) and Mirrlees-Black (2011) explore the part of economic benefits and investment risks in nuclear energy.

In the field of interstate interactions in strategic sectors, Kang's (2011) study examines the relationship between the regional trade agreements and the subsequent change in the dynamics of Jordan's export capacity in strategic industries. Another example is the research by Rabe and Gippner (2017), which highlights the change in perception of China in European host countries that received Chinese foreign direct investment in strategic industries. Although there is an extensive amount of literature covering the factors for increased international security cooperation, no studies that focus on the relationship between two strategic industries at the international level, particularly the energy and defense sectors, have not been done so far.

The thesis places nuclear energy as a strategic industry that plays a crucial role in international security. This implies that states are highly involved in the trade process, as well as in establishing partnerships and agreements related to nuclear energy. However, the civil nuclear energy sector has not been studied thoroughly in terms of its strategic importance for international security and connection with the military and defense realm. Hence, this study holds significance in the realm of international political economy as it aims to provide insights into the association between bilateral cooperation in different strategic sectors, thus contributing to a deeper understanding of this complex relationship. Moreover, it provides a new perspective for examining international trade, security dependencies, and patterns of alliance formations through the lens of nuclear energy technology promotion.

The thesis will consist of four main parts. The first section is dedicated to outlining the theoretical model of this research, as well as a review of the relevant literature in three main

thematic dimensions: the economic and political aspects of the nuclear energy sector; the concept of the strategic industry; and the intersection of the concept of energy security and defense. The second section describes the research design and provides extensive information on research methods, operationalization, data processing approaches, and tools used for the analysis. The next, third section will present the results of the data analysis together with the visualizations and model diagnostics. The thesis concludes with the fourth section which focuses on a deeper analysis and interpretation of the research findings, its placement, and its role in relevant scholarship, as well as outlining possible directions for further research.

1. Literature Review & Theoretical Implications

This study aims to answer the research question of whether international cooperation in the nuclear energy sector contributes to the strengthening of bilateral cooperation in security and defense. Despite the narrow research scope, the study opens up space for examining not only the intersections between energy and security but also touches upon the topic of strategic industries, economic tools for achieving political goals, as well as global political and economic dependencies. Therefore, this thesis section aims to reveal and analyze the state-of-art in the context of this study and localize it within the theoretical framework of international relations scholarship. The section consists of two main parts. The first sub-section is dedicated to the review of relevant literature in three thematic dimensions related to the scope of the study, followed by the sub-section which provides a comprehensive description and justification of the theoretical model for this study.

1.1. Literature Review

As mentioned before, this sub-section is dedicated to examining the relevant literature in three thematic dimensions as follows: (1) the economic and political aspects of the nuclear energy sector, (2) the concept of the strategic industry, and (3) the intersection of the concept of energy security and defense.

a. Economic and political aspects of the nuclear energy sector

Even ten to fifteen years ago, nuclear energy was cautiously perceived as a very controversial solution for electricity production, in particular, due to the tragic accidents at the Chornobyl and Fukushima nuclear power plants. However, with the rise of concern about global warming, the development of nuclear power infrastructure more often becomes a part of state strategies on climate change (Hickey et al. 2021). Considering the fact that in 2022 the

European Commission identified nuclear energy as one of the options for replacing coal-fired electricity generation facilities on a par with other renewable energy sources (European Commission 2022), it can be expected that the number of NPP projects may increase in the coming years. At the same time, besides the aspect of the carbon neutrality agenda, nuclear power serves as a stable and cheap solution for electricity production, which often has key importance for countries that need to cover their growing electricity demands. However, the cost-effectiveness of nuclear power plants can be considered only in long-term electricity generation (IEA 2020). So, first, it is crucial to outline the precise details of the nuclear energy industry's economic and financial aspects and identify the role of international cooperation in the functioning and development of this sector.

Due to its complexity in terms of operation and safety, this industry has specific nuances related to capital investment and a relatively wide range of risks that need to be considered. Hickey, Malkawi, and Khalil (2021, 1) emphasize that "nuclear power plants are capital-intensive assets, which means the fixed price of the project is perilously high, although there could be price stability for the electricity generated by NPPs with long-term power purchase agreements". The analysis of the typical cost structure for nuclear energy projects shows that 91.8% of project expenditures fall on capital costs (Zawalinska et al. 2020, 6). This, in turn, implies that the states need to allocate a significant share of the budget for such infrastructure projects or look for opportunities for co-financing.

In addition, based on the abovementioned studies, it is necessary to consider two economic and financial aspects associated with an investment in the civil nuclear energy sector: the inability of low- and middle-income countries to finance the construction of NPP, as well as the number and nature of risks borne by financing parties. Hickey et al. (2021) emphasize that low- and middle-income states often cannot fully commit to the climate change agenda

involving nuclear power development since they do not have enough resources to finance the building and proper maintenance of NPP. At this point, the space and need for international cooperation in civil nuclear energy emerge. International economic cooperation in the field of nuclear energy can take various forms, including both the export of nuclear technologies and the co-financing of nuclear energy projects. In the context of the latter, international involvement is present both at the level of private companies and at the intergovernmental level in the form of providing loans, or different models of ownership in implemented projects. Hickey et al. (2021), and Gordon (2020) consider the financial aspect of the nuclear power industry precisely at the level of states. When adding Bowen and Apostoaei (2022) to this discussion, it can be observed that the common point in these papers is the emphasis on the political role of EXIM banks and the provision of loans for nuclear energy projects. Gordon (2020), as well as Bowen and Apostoaei (2022), agree that the suspension of loans for nuclear power projects by the US EXIM Bank reduces its competitive advantage in the nuclear energy market and opens room for growth for other major nuclear technology exporters, such as China and Russia. Therefore, the investment patterns, as well as nuclear technology trade flows become a matter not only of a specific market but also a political issue due to the strategic and security nature of the nuclear power industry.

States have been practicing the export of nuclear energy technologies for a long time. However, due to the key importance of nuclear energy in the context of energy security as such, as well as the strategic nature of nuclear energy technologies, any interactions between countries related to investment in this sector acquire the character of indirect influence on the political and potentially security realm. Feng Sun (2014) explains that foreign direct investments in the non-primary sector, which particularly includes electricity generation, also have political importance since the non-primary sectors have “a broad variety of linkage-

intensive activities" (Sun 2014, 110). The author claims that in the political context, investments in the non-primary sector can serve as a tool for democracy promotion. However, Sun (2014) argues that developed democratic countries usually invest in the non-primary sector, while authoritarian states invest in the primary sector because they can "take advantage of the large revenues from taxes, licenses, and profit-sharing arrangements generated by foreign companies through the exploitation of natural resources to buttress their elite political position" (Sun 2014, 110). I find this argument quite controversial since the cases of international involvement in nuclear energy projects include examples of Russia and China, which are states with authoritarian rule. Regardless of this, they still have been actively involved in nuclear technology exports, as well as in various forms of NPP project co-financing. Therefore, it can be assumed that investments in non-primary and, particularly, the energy sector, as well as nuclear technology exports, are not only a matter of democracy promotion but also reflect the struggle for political influence and the creation of multi-level dependency.

However, it is also necessary to consider not only the state-centric approach to the development of the nuclear energy industry. It is particularly important in the context of dependence on the investor-state. Daniel H. Joyner (2014) suggests that countries may try to avoid direct dependence on investor states by switching to other forms of ownership in civil nuclear energy. As an example, he considers the transition from government financing, which is currently the most common approach, to project financing, which in turn can involve primarily private companies. Jonathan Mirrlees-Black (2011) to some extent confirms this assumption, adding that against the background of economic crises, countries will diversify investment sources, focusing not only on bilateral agreements with other states but on private investors as well.

The point of transition in funding trends is an important detail to consider in the context of this research. However, I still see it more efficient to study the nuclear power industry precisely at the intergovernmental level for two reasons. First, due to the particularities of nuclear power plants' cost structure, I do not see opportunities where the private sector will take the associated political and financial risks, especially in middle- and low-income countries. Secondly, due to the strategic and security importance of the nuclear power industry to the states, the sector is usually highly regulated, making the participation of private actors very difficult.

b. The concept of the strategic sector

It is important to note that in the context of this thesis, not only international cooperation in nuclear energy as such is considered, but also its influence on bilateral relations in the field of security and defense. The rationale behind the choice of these two sectors for the analysis is explained by the common security nature of these industries and their strategic importance for the state. However, at this point, it is important to outline the concept of a strategic industry, and how cooperation in one such industry impacts the others.

The relevant scholarship provides a few perspectives on the definition of the strategic sector. Michalski (1991, 9) argues that certain industries can have strategic importance for the state if they "engender large innovative spillovers and provide substantial infrastructure for other firms in the same or related industries". At the same time, Kang (2011), in his study of the impact of regional trade agreements on strategic sectors of the Jordanian economy, considers "strategic" precisely those industries that have the competitive ability, traced through certain patterns of trade flows. Kang (2011, 78) refers to the "traditional theory of international economics", when arguing that states tend to export exactly those goods and technologies which they can efficiently produce. Therefore, the focus on the state's ability to export certain goods,

according to Kang, determines the strategic importance of industry for the state. Considering the scope of this thesis, the above-mentioned argument makes sense, since states, which are the main nuclear energy technology exporters, have a highly developed domestic nuclear energy sector. Therefore, the export of such advanced technology plays an important role in the economy of exporting states.

However, defining strategic sectors exclusively through the prism of economic indicators, such as export capacity, in this case, does not reveal the complexity of these industries. The security aspect of the strategic sectors also needs to be properly addressed. Any transformations and cooperation in strategic sectors not only directly affect the economic condition of the state, but are also related to the defense capacity, political stability, and the level of sovereignty that the states have conceded in exchange for the benefits of this cooperation. In addition, the strategic nature of the nuclear energy industry is relevant not only for the states which are exporting nuclear technologies intending to improve their competitive advantage. For countries that are developing and increasing their industrial capacity, the import of energy technologies is also a key security issue, which pushes them to search for international cooperation solutions since the states can bear more risks and provide more guarantees than the private actors. Boubakri, Cosset, and Guedhami (2008) also confirm the abovementioned statement by emphasizing the fact that strategic industries, especially in developing countries, are often placed under extensive governmental control and regulation. Therefore, cooperation in strategic sectors is often realized in a government-to-government format.

There is not enough literature coverage in terms of analysis of connections between strategic industries and the role of international cooperation in this context. Kang (2011), which I mentioned earlier in this section, has a more economic focus and addresses the topic of the trade agreements' effect on a subsequent export growth rate in strategic sectors of the Jordanian

economy. At the same time, Rabe and Gippner (2017) explore the political effect of foreign direct investment in large infrastructure projects and strategic industries of European countries using the case of China's involvement. Although this study is indirectly related to the scope of this thesis, since it is focused more on interactions between businesses, Rabe and Gippner (2017) examine the case of the Hinkley Point C NPP project, in which a Chinese state-owned company was involved. The authors note that China's engagement in such a strategically important project was perceived as controversial due to concerns about China's potential intentions to build up even greater industrial capacity in the international market through big infrastructural projects. This observation provides an additional political spectrum for the understanding of international collaboration in strategic sectors of the economy.

Following the discussion about the concept of strategic sectors, this thesis closes a significant research gap in the study of the relationship between various strategic industries at the international level and reveals the concept of strategic industries from a security perspective, complementing a rather traditional economic approach.

c. Intersections between Energy and Security

It is important to emphasize that the key methodological implication of this thesis lies in the fact that it examines the relationship between nuclear energy and the security and defense sectors. For this reason, one of the central thematic dimensions of this research section is dedicated to outlining the other factors affecting bilateral security cooperation and showing how the concept of energy security and security in the military and defense sense are related.

Despite the nuclear energy cooperation factor that is in the scope of the research interest, other aspects influence international security cooperation as well. It is clear that the state's involvement in armed conflicts increases its need to purchase weapons and find political allies who can support it. This, in turn, directly affects the volume of interstate arms trade, as well as

patterns of security cooperation. However, it is also important to consider the motivations of the arms exporting country since it can have some political aspects. Ali (2020), using the case of the arms trade between China and Pakistan as an example, claims that Pakistan's participation in the armed conflict primarily allows China to test weapons of its production and deepen ties with Pakistan in the security sector, creating an informal alliance in the region.

On the other hand, Law (2007), as well as Bailes and Cottey (2006) consider how the participation of states in international and regional organizations contributes to changes in the security dimension of international relations. Bailes and Cottey (2006) argue that regional international organizations serve as an important support mechanism for global organizations in the context of post-conflict relations, the fight against terrorism, and the advocacy of regionally important security issues at the international level. At the same time, Law (2007) is focused more on the role of international organizations as actors in the process of security sector reform. The author makes an interesting argument that "...the IGOs do generally not see themselves as being part of the security sector. But it is clear that they are, especially when one considers that IGOs perform many of the functions of government as in a post-conflict environment such as Kosovo" (Law 2007, 20). This argument leads to the assumption that through the platform provided by international organizations, states to some extent shape the security climate in the world. Therefore, in the context of this thesis, it makes sense to assume that joint participation in international organizations can influence the patterns of security cooperation between the Actor and Partner states.

Finally, Aggarwal and Govella (2013) consider an economic factor influencing bilateral security cooperation, namely international trade patterns. The authors provide a comprehensive analysis of various levels of international trade agreements and conclude that in the modern context, using the example of the Asia-Pacific region, international trade acts as a balancing

mechanism through "the creation of the most favorable arrangement for economic, political, and security reasons, rather than simple aggregate economic gains" (Aggarwal and Govella 2013, 19). Therefore, the established trade relations between the states are also likely to have an impact on further bilateral defense cooperation.

In the context of the intersection between energy security and defense concepts, Samaras, Nuttall, and Bazilian (2019) try to reveal the relationship of the energy sector towards other industries, which in one way or another are related to the state's security dimension: environment, economy, and defense. However, there is a noticeable focus on the topic of the connection between the military and the energy sectors, mostly in the context of fuel. The authors note that often military needs and challenges related to energy result in further innovations in the civilian energy sector as well. Although the paper is largely limited to the domestic level of analysis and the role of oil and fuel for the defense sector, it still provides a good basis for understanding the intersections between energy and security-related industries.

Thomas (1986) is focused more on nuclear energy in the context of security and defense. In his study, the author examines the nuclear energy and the aerospace industries in the case of India. An extensive part of the paper is dedicated to the exploration of the two-fold nature of nuclear energy, which, according to the author, has the potential not only for civilian uses but also for the gradual (and clandestine) development of weapons of mass destruction. Although Thomas (1986) emphasizes that the domestic development of the nuclear energy industry not always means the intention to develop nuclear weapons, he nevertheless examines the industry through the dichotomy of development and defense. However, this approach oversimplifies the complex nature of the nuclear energy sector and its contribution to the state's security. Therefore, identifying the relation of nuclear energy to the defense sector through the prism of the potential for the development of weapons of mass destruction is not comprehensive enough.

Finally, Kerigan-Kyrou (2013) examines the relationship between the energy sector and defense through the prism of considering electricity production facilities as critical infrastructure, which in turn plays a key role in national security. The author analyzes how NATO addresses security challenges in relation to critical infrastructure, which includes strengthening resilience against various forms of attacks: both armed and cyber-attacks. In fact, examining the nuclear energy industry as a critical infrastructure of high importance to the civilian population, economy, and security situation in the country once again emphasizes the industry's strategic importance and its connection to security issues.

To summarize, this thesis fits into the relevant literature, continuing the exploration of the interconnections between energy and other security-related industries. At the same time, this research adds value to the existing scholarship through an in-depth analysis of nuclear energy security in the context of its association with further bilateral partnerships in the field of military and defense, which has not been explored yet. As a result, this thesis provides an additional ground for a broader understanding of the economic and political aspects of international cooperation in strategic sectors and offers a new lens for examining the role of energy in international politics.

1.2. Theoretical Implications

From the perspective of the theoretical framework, I have developed a conceptual model that describes the ideational background of the research. In this model, I narrow down from the traditional approach to understanding the international political economy as such to more specific theories that will help to better examine the energy and security focus of the research. The visualization of the model is presented in Figure 1:

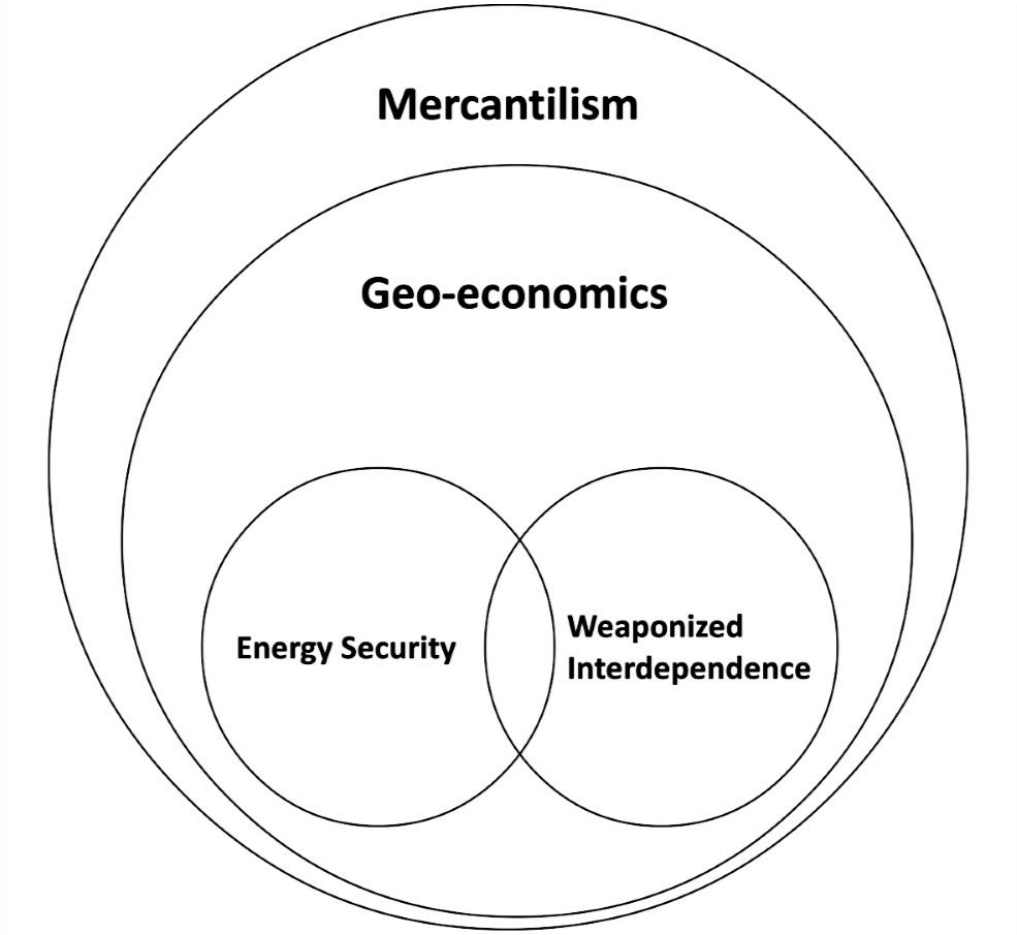

Figure 1. Theoretical model

The theoretical basis for the research is the concept of mercantilism, which is one of the traditional approaches to the understanding of international political economy. The classical mercantilist approach provides a strong ideological basis for substantiating the relevance of this topic when exploring international cooperation in strategic sectors of the economy, and, more specifically, analyzing the motives behind the export of nuclear technologies, A good fit of this theoretical perspective is explained by several following reasons. First, classical mercantilism claims that national power and wealth are connected, and wealth, in turn, is necessary to strengthen and assert power (Oatley 2018). Extrapolating this statement to a modern condition, it can be assumed that in the context of international relations, politics, and economics are inseparable. The mercantilist approach provides a state-centric theoretical foundation, which in

practice is revealed in observing the interactions of states in the nuclear energy sector precisely through the establishment of bilateral trade, as well as the provision of EXIM loans for NPP projects. In addition, mercantilism emphasizes the need to develop sectors of the economy with higher added value, which in turn resonates with the principle of the importance of a positive trade balance (Oatley 2018). In the context of exploring the cases of nuclear technology exporting countries, which are few, these statements can contribute to the explanation of the root cause for the export of advanced and strategically important technologies and, in particular, the development of bilateral cooperation in the nuclear energy sector.

As Figure 1 demonstrates, the theoretical framework of the study further narrows down to the concept of geoeconomics. This term was first outlined by Edward Luttwak as "the admixture of the logic of conflict with the methods of commerce - or, as Clausewitz[2] would have written, the logic of war in the grammar of commerce" (Luttwak 1990, 19). It is worth taking into account that Luttwak conceptualized the idea of geoeconomics in the post-Cold War international environment, where different political approaches towards international competition and confrontation were discussed. If this idea is "stretched" to fit the modern context, the concept of geoeconomics can be characterized as the state's use of economic tools to achieve (not necessarily economic) strategic goals. Although, in his work, Luttwak tries to distance the concept of geoeconomics from the theoretical implications of mercantilism, in particular through the argument that the "methods of mercantilism could always be dominated by the methods of war, (however) in the new "geo-economic" era not only the causes but also the instruments of conflict must be economic" (Luttwak 1990, 21). However, in this research, I would like to outline the idea of geoeconomics as a conceptual complement to a broader

[2] In this case Edward Luttwak is referring to the book “On War” by Carl von Clausewitz (1892).

mercantilist approach. Thus, the prism of geoeconomics adds a new layer to the understanding of international cooperation in the nuclear energy industry as a tool of (geo)political influence to preserve or undermine the status quo, form alliances, and increase competitive advantage in the defense and security sector.

Finally, as Figure 1 shows, the theoretical framework narrows down to more specific concepts, the combination of which helps to explore the nuances of the research scope. These two "pillars" include the concept of energy security (Cherp and Jewell, 2014), as well as the theory of weaponized interdependence (Farrell and Newman, 2019). As it was mentioned before, the scope of the research implies a precise analysis of the relationship between international investments in nuclear energy and defense cooperation. Therefore, these two narrow concepts create a foundation for delineating the security component of the energy sector as such, as well as provide ideological tools for analyzing motives of international cooperation in strategic fields of economy. In particular, Cherp and Jewell (2014) attempt to redefine the concept of energy security by challenging its "four As" framework. The authors claim that defining the concept of energy security according to four clear criteria - availability, affordability, accessibility, and acceptability - does not fully reveal the complexity of the modern energy sector with its large number of stakeholders and intersections with other economic and political dimensions. This argument to some extent emphasizes the purpose of this thesis, namely, to conduct a more in-depth study of the complex interrelationships of energy in international politics.

In contrast to the four A's, Cherp and Jewell (2014, 417) offer to answer "three fundamental security questions: Security for whom? Security for which values? and Security from what threats?". Although the authors themselves do not answer this question, they create a framework for discussion and interpretation, which in turn allows us to outline the concept of

energy security more precisely in the context of this study. Therefore, in this thesis, the concept of energy security is limited only to the level of nations. In addition, special attention is paid to the statement that energy is related to social values, and therefore the protection of the values of other states includes the protection of their energy systems (Cherp and Jewell 2014). This approach offers another non-standard lens for understanding the patterns of partner selection for cooperation in nuclear energy, and further security partnership.

Due to the key importance of capital investment for the nuclear energy industry and to a large extent the oligopoly in the civil nuclear technology market, the concept of weaponized interdependence (Farrell and Newman 2019) opens another dimension to the analysis of the establishment of international cooperation in this energy sector. Farrell and Newman explain the phenomenon of interdependence through the concept of networks, which consist of objects and relations between them. The authors claim that the vast majority of states are connected in a global network and therefore are dependent on each other. At the same time, the unequal distribution of information, resources, and technologies serves as a root cause for the formation of "power relations" in these networks. In this case, the power states use this advantage of unequal distribution to influence so-called "target states", using it as a tool of political pressure to increase dependence (Farrell and Newman 2019). The authors touch upon the topic of the energy sector, but only in the context of oil, arguing that in such a diversified market, partnerships and trade relations are difficult to weaponize.

However, extrapolating the concept of weaponized interdependence to the nuclear energy sector, it can be observed that only a few countries in the world are the main exporters of nuclear technologies. Therefore, it implies that only a few players in a global market can offer technological solutions in the civil nuclear energy sector. Against the background of the growing need for stable and accessible electricity for the population, cooperation with nuclear

technology exporting states can potentially be weaponized and used as one of the levers of political influence.

To conclude, the described literature and theoretical framework create a foundation for exploring and testing the main hypothesis of this thesis, which implies that bilateral cooperation in the nuclear energy sector contributes to the strengthening of strategic cooperation in the field of security and defense.

2. Research Design

A quantitative data analysis approach was adopted to test the hypothesis of the thesis. This section provides a comprehensive overview of the thesis research design and the data analysis techniques used in the study in order to ensure the reliability and reproducibility of the research findings[3]. The section starts with the outlining conceptual approach to the research design and provides general information on the research method and analysis tools. This sub-section is followed by a detailed description of the study operationalization including a complete overview of the data and its sources. The third sub-section describes the conditions and rationale for the selection of the partnership cases. Following the description of the research design, the last part of the section reports on the aspects of data processing, as this condition directly affects the results of the study.

2.1. General Implications

The research design is based on a pragmatic philosophical approach. Considering the novelty of the research scope and the nature of international political and economic cooperation that is being explored, a pragmatic approach allows us to interpret quantitative results more effectively and place them in the relevant international relations scholarship. In logical terms of research design, this study builds on deductive reasoning. Therefore, the research is based on broad assumptions about international cooperation in strategic sectors and aims to identify and verify specific patterns of bilateral cooperation specifically for the nuclear energy and defense sectors. The dataset created for the analysis includes 435 observations for 14 country

[3] The research design of the thesis partially intersects with the research design for the Term Paper in the framework of the course "Research Design Methods in International Relations: Quantitative Methods" as per instructor's permission.

pairs during the 30-year time frame from 1991 to 2021. The data was analyzed using the R programming language within the integrated development environment RStudio.

2.2. Operationalization and Data

Data analysis within the framework of this study aims to confirm or reject the main hypothesis that international collaboration in nuclear energy contributes to the strengthening of bilateral cooperation on security and defense issues. Therefore, the indicators of collaboration in the nuclear energy sector serve as independent variables, while the dependent variable is explained by the indicators of bilateral defense cooperation. The selection of control variables is based on the literature reviewed in the previous section, describing other factors that influence the establishment and deepening of international security and defense cooperation. The control variables include the trade flows between the partners, joint membership in international organizations with security functions, and the factor of states' participation in armed conflict. The list of variables, their indicators, and data sources is presented in Table 1:

Variable	Indicator	Data	Source
1. Independent Variable: collaboration in the nuclear energy sector	**a).** Exports of nuclear energy technologies	Trade value of nuclear energy technology exports (HS 8401) in US dollars[4]	UN Comtrade
	b). Co-financing of nuclear power plant projects	Dummy variable, created to document the fact of concluding the agreement between Actor and Partner states on the form and amount of co-financing of an NPP project	Media materials and governmental web resources (for the sources see sub-section 2.3. and List of References)
2. Dependent Variable: bilateral defense cooperation	**a).** Small arms and ammunition exports from Actor state to Partner state	Trade value of arms and ammunition exports (HS 93) in US dollars	UN Comtrade
	b). Small arms and ammunition imports from Partner state to Actor state	Trade value of arms and ammunition imports (HS 93) in US dollars	UN Comtrade
	c). Arms transfers	Trend-indicator value (TIV) of arms transfers from the Actor state to the Partner state. This data covers major conventional weapons (aircraft, air defense systems, artillery, missiles, etc.) and does not cover small arms	SIPRI Arms Transfers Database

[4] HS stands for Harmonized System, which is "a standardized numerical method of classifying traded products" (International Trade Administration). In this case HS 8401 code covers the following goods: nuclear reactors; fuel elements (cartridges), non-irradiated, for nuclear reactors, machinery and apparatus for isotopic separation (UN Statistic Division 2017).

		and light weapons (SALW)[56].	
	d). Joint military exercises	Cases of bilateral joint military training	Bernhardt, 2021 - Joint Military Exercises Dataset - Harvard Dataverse
	e). Defense cooperation agreements	Cases of bilateral defense cooperation agreements	Kinne, 2020 - The Defense Cooperation Agreement Dataset - Correlates of War
3.1. Control Variable: armed conflicts	**a).** Participation of Partner state in an armed conflict	Cases where the Partner state is a side of an armed conflict	Sarkees, Reid, Wayman, 2010 - War Data - Correlates of War
3.2. Control Variable: joint membership in international organizations with security functions	**a).** The number of international organizations with security functions in which a country pair has joint membership	Cases of bilateral joint membership in international organizations	Pevehouse, Nordstron, McManus, Jamison, 2020 - Tracking Organizations in the World: The Correlates of War IGO Version 3.0 datasets - Correlates of War
3.3. Control Variable: trade between Actor and Partner state	**a).** Trade flows from the Actor state to the Partner state	Trade flows from Actor state to Partner state in US dollars	Barbieri, Keshk, 2016 Correlates of War Project Trade Data Set Codebook, Version 4.0 - Correlates of War

[5] This indicator was included for the purpose of a comprehensive exploration of trade patterns and arms transfers between countries, since the TIV of arms transfers in this case complements the SALW export indicator, and also covers other types of international arms transfer besides the trade - gifts, lease and manufacturing licenses. This, in turn, allows us to see the full picture of security cooperation in the context of arms supply.

	b). Trade flows from the Partner state to the Actor state	Trade flows from Partner state to Actor state in US dollars	Barbieri, Keshk, 2016 Correlates of War Project Trade Data Set Codebook, Version 4.0 - Correlates of War

Table 1. Research operationalization

The data was collected from open sources and processed in accordance with the research objectives. More details about the procedure and approaches to data processing are covered in sub-section 2.4.

2.3. Case Selection

As mentioned earlier, the research dataset consists of data for 14 country pairs over 30 years. A country pair consists of an Actor state and a Partner state. As for the Actor states, five major nuclear technology exporting states were selected for the study: the US, France, China, Russia, and the Republic of Korea. The selection of Partner states was mainly based on the policy paper by Bowen and Apostoaei (2022) and on the compliance of the partnership case with two conditions: (1) a documented case of government-to-government cooperation regarding one or more NPP projects, (2) the NPP project is already in operation, or under construction.

It is important to emphasize that the US has not provided any government-to-government or EXIM loans for NPP projects for the past twenty years (Bowen and Apostoaei, 2022. Nonetheless, the country is not excluded from the analysis, as it is still one of the world's largest exporters of nuclear technologies. The Partner states for the US were selected based on two criteria: (1) membership in 123 Civil Nuclear Agreement, and (2) receiving of loans from US EXIM Bank for constructing nuclear reactors in the period from 1960 to 1980, based on the

data provided in policy paper by Bowen and Apostoaei (2022). European countries are excluded from the scope since the current cooperation with the US in the nuclear energy sector is regulated through a joint organization Euratom, a member of the 123 Civil Nuclear Agreement.

The full list of country pairs selected for analysis is provided in Table 2:

Country pair	Actor state	Partner state
1	**USA**	Japan
2	USA	Republic of Korea
3	USA	Brazil
4	USA	Mexico
5	**France**	China
6	France	Finland
7	France	United Kingdom
8	**China**	Pakistan
9	**Russian Federation**	Bangladesh
10	Russian Federation	Belarus
11	Russian Federation	China
12	Russian Federation	India
13	Russian Federation	Turkey
14	**Republic of Korea**	United Arab Emirates

Table 2. Case selection

This specific approach to the case selection makes it possible to specifically investigate the role of government-to-government interactions both in the nuclear energy and defense sectors.

2.4. Data Processing

Following the collection and creation of the research data frame, the data for all the variables was filtered by year and countries of interest. The indicators for arms transfers, nuclear energy technology export, small arms and ammunition export/import, as well as trade flows, have not undergone significant modifications, however, the data mostly needed to be transformed into a long format.

The predictor variable for the co-financing of nuclear power plant projects was created as a dummy to document the agreement between the Actor state and Partner state in a certain year. Part of the information was obtained from the policy paper by Bowen and Apostoaei (2022). However, to confirm the case and year of the co-financing agreement conclusion, additional data was collected mainly from media materials - reports, articles, and press releases. When searching for sources, priority was given to government web resources. Nevertheless, when the data from the government was not available, materials from credible media platforms were used. These online media resources particularly include Nikkei Asia, EnergyWorld by Economic Times, and World Nuclear News. In addition, some observations relied on data from the World Nuclear Association and AidData's Global Chinese Development Finance Dataset. For a complete and detailed list of the sources used to form this variable, see the List of References section.

Data for the joint military exercise was filtered only to bilateral cases with the participation of country pairs of interest. The number of bilateral military exercises in a certain year for the same country pair was omitted since only the recording of the fact but not the level of its manifestation is important for the analysis. Thus, the data was included in the final dataset as a dummy variable, where "1" means the case of a joint military exercise in a certain year, and "0" indicates its absence. A similar approach was applied to the control variable that covers the participation of the Partner state in an armed conflict.

The bilateral defense cooperation agreements indicator records not only the conclusion of an agreement but also the level at which the collaboration is established. The original dataset differentiates between general and sector types of agreements. Therefore, for the effectiveness of analysis, the abovementioned types of agreements were coded as “1” and “2” respectively, while “0” indicates that no such agreement was concluded in a given year.

An extensive dyadic dataset (Pevehouse et al. 2020), which contains data on the participation of states in more than 500 international organizations (IO), was used as a basis to form the control variable for joint membership in IO with security functions. Of course, not all international organizations are relevant for this study, but only those that have security functions. Therefore, based on studies by Bailes and Cottey (2006) and Law (2007) on the role of regional organizations in security cooperation and the role of international organizations in shaping the security sector, the original dataset was filtered to 24 relevant organizations. According to the Codebook original data source (Pevehouse et al. 2019), "1" indicates joint full membership for a country-pair. So, for better representativeness of the variable, observations of joint membership were added together, and the numbers within this variable in the final dataset represent the actual number of country pairs' joint membership in international organizations with security functions in a given year.

The data was processed and analyzed in RStudio (R Core Team 2022) using the following packages: "dplyr" (François et al. 2022), "tidyr" (Wickham and Girlich 2022), "ggplot2" (Wickham 2016), "lmtest" (Zeileis and Hothorn 2002), "sandwich" (Zeileis et al. 2020), "countrycode" (Arel-Bundock et al. 2018), "oddsratio" (Schratz 2017), and "arm" (Gelman and Su 2022). The regression tables were exported using the "stargazer" package (Hlavac 2022).

3. Results

This section presents a comprehensive overview of the data analysis results. First, a brief description of summary statistics will provide a resume of the dataset, as well as information about how the data was modified during the analysis process. This part is followed by the main sub-section which demonstrates the results of the linear and logistic regression analysis and describes the process for creation and selection of regression models. Finally, the last sub-section covers the diagnostic analysis of the regression models to ensure the robustness of the results.

3.1. Summary Statistics

The table below presents the summary statistics of the research dataset, including all dependent, independent, and control variables. The time variable, as well as country variables, are excluded from the final tables since the fixed effects coefficients in the Ordinary Least-Squares (OLS) models should not be interpreted.

Statistic	N	Mean	St. Dev.	Min	Max
Exports of nuclear energy technologies	268	39,555,530	60,243,795	550	463,398,180
Co-financing of nuclear power plant projects	435	0.025	0.157	0	1
Small arms and ammunition (exp)	326	75,347,137	142,154,668	130	722,491,259
Small arms and ammunition (imp)	288	30,775,570	47,043,319	33	247,410,375
Arms transfers	313	511.607	698.438	3	3,853
Defense cooperation agreements	435	0.108	0.401	0	2
Joint military exercises	435	0.225	0.418	0	1
Armed conflicts	435	0.186	0.390	0	1
Joint membership in IO with security functions	168	5.179	1.591	1	8

Trade flows from Actor State	222	27,559,441,036	48,256,141,348	1,410,000	218,086,000
Trade flows from Partner State	227	20,878,503,656	33,090,172,862	17,190,000	166,468,000

Table 3. Summary statistics

Table 3 shows that the number of observations for the variables differs from the total number of dataset observations, which counts for 435 units. This outcome is mainly caused by the regular presence of missing data (NAs). However, in some cases, the research dataset was affected by the incomplete availability of data for the selected time frame. The reason for this is explained by the fact that some variables were built on data from datasets created by scientists, and not on the data published and regularly updated by international organizations or think tanks.

It can also be observed that very large numbers are present for the mean, standard deviation, as well as for the minimum and maximum values. It is because some indicators of interest are measured in the amounts of US dollars per year. Since the values mostly reflect real trade activity between the states, the data is quite spread out and usually has a high standard deviation. A vast majority of variables did not undergo transformations that would affect the values in the summary statistics, other than those mentioned in the previous section. At the same time, it is important to note that the numbers for the Trade flow variables were scaled to match the values of the independent and dependent variables, and therefore to be more convenient for logarithmic transformations. Also, during the initial exploration of the data using descriptive analysis methods, a few atypical minimum and negative values were detected. These observations were most likely errors since they did not have a practical meaning in the context of the data, and therefore were recoded to NA values.

3.2. Linear and Logistic regression Results

Five linear regression models were developed for the analysis, one for each dependent variable, to comprehensively observe the impact of international cooperation in nuclear energy on collaboration patterns in the security and defense sector. In the analysis process, the models were gradually becoming more complex, moving from simple linear regression to multiple linear regression with one fixed effect, and then, accordingly, with two fixed effects. It is important to emphasize that fixing the effect of time is a key feature of panel data analysis. This approach helps to prevent biased research outcomes that may arise due to the effects of time dependencies.

Statistical significance was observed for the models with a fixed effect of time, while fixing the effect of Partner state and Actor state resulted in statistical non-significance for almost all models, except for Model 4, which should not be interpreted since requires an additional logistic regression analysis. Non-significant results for more complex two-way fixed effects (2FE) models might be caused by the effect of adding new factor variables for fixed effects, which most likely took over significance from the other variables.

Based on the results for one-way fixed effects (1FE) models, it can be assumed that the relationship between the variables exists yet requires additional analysis. The results of the 1FE linear regression analysis are presented in Table 4. For the outcomes of the 1FE models analysis, the model diagnostics, as well as further interpretation are provided in this and the next section. The results of the 2FE linear regression analysis are reported in Table 5.

In addition, for Models 1, 2, and 3, the predictor and response variables, excluding the binary and factor ones, were log-transformed. This transformation allowed to facilitate the analysis and interpretation of large values, as well as to improve the overall model performance and residual distribution. For Models 4 and 5, only x-variables were log-transformed. Also, in

the process of exporting the final tables from RStudio, the factor variables of fixed effects were omitted.

It is necessary to mention that during the regression analysis, the independent variable for co-financing of nuclear power plant projects consistently returned NA-values when used in multiple regression models. However, the results were available in simple regression models. Since this independent variable is a dummy, it was assumed that NA results are caused by possible collinearity with another predictor variable. Using a test method of dropping variables, it was discovered that this independent variable most likely has a collinear relationship with the control variable for joint membership in international organizations (IO) with security functions. In the case of dropping this control variable in the regression model, the independent variable started to return the result correctly. However, when running the corrected models, the indicator for the co-financing NPP projects did not show statistically significant results in any case and therefore is not going to be interpreted.

	Dependent variable:				
	Small arms and ammunition (exp)	Small arms and ammunition (imp)	Arms transfers	Joint military exercises	Defense cooperation agreements
	(1)	(2)	(3)	(4)	(5)
Exports of nuclear energy technologies	0.581***	-0.852***	0.802***	0.109***	0.016
	(0.106)	(0.115)	(0.110)	(0.027)	(0.026)
Co-financing of nuclear power plant projects					
Armed conflicts	-4.457***		-0.925	0.625***	0.143
	(0.903)		(0.856)	(0.224)	(0.216)
Joint membership in IO with security functions	-0.657***	-1.450***	-0.230	-0.228***	-0.009
	(0.238)	(0.281)	(0.261)	(0.062)	(0.060)
Trade flows from Actor State	1.173***	3.144***	-0.172	0.375***	-0.229***
	(0.326)	(0.372)	(0.291)	(0.075)	(0.073)
Trade flows from Partner State	-0.359	-0.666	-0.023	-0.227**	0.188*
	(0.447)	(0.667)	(0.429)	(0.108)	(0.104)
Constant	-8.523**	-24.070***	-1.120	-3.840***	0.818
	(4.201)	(7.362)	(4.315)	(1.096)	(1.056)
Observations	75	68	76	82	82
R^2	0.802	0.884	0.617	0.574	0.403
Adjusted R^2	0.712	0.828	0.448	0.405	0.166
Residual Std. Error	1.362 (df = 51)	1.280 (df = 45)	1.380 (df = 52)	0.365 (df = 58)	0.352 (df = 58)
F Statistic	8.965*** (df = 23; 51)	15.637*** (df = 22; 45)	3.645*** (df = 23; 52)	3.393*** (df = 23; 58)	1.702* (df = 23; 58)
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 4. Linear regression results for 1FE models

	Dependent variable:				
	Small arms and ammunition (exp)	Small arms and ammunition (imp)	Arms transfers	Joint military exercises	Defense cooperation agreements
	(1)	(2)	(3)	(4)	(5)
Exports of nuclear energy technologies	0.049	-0.177	-0.034	-0.080**	-0.032
	(0.133)	(0.131)	(0.102)	(0.034)	(0.044)
Co-financing of nuclear power plant projects					
Armed conflicts	-6.356***		-2.075**	0.112	-0.107
	(1.149)		(0.861)	(0.292)	(0.376)
Joint membership in IO with security functions	0.225	-0.712***	0.377	-0.102	0.008
	(0.298)	(0.236)	(0.239)	(0.083)	(0.106)
Trade flows from Actor State	-1.171**	2.873***	-0.644*	0.134	-0.414***
	(0.511)	(0.378)	(0.321)	(0.111)	(0.143)
Trade flows from Partner State	1.440*	-0.202	1.716***	0.297	0.360
	(0.749)	(0.687)	(0.552)	(0.180)	(0.232)
Constant	7.671	-42.742***	-16.279**	-7.075***	1.780
	(9.922)	(9.625)	(7.369)	(2.432)	(3.130)
Observations	75	68	76	82	82
R^2	0.912	0.970	0.893	0.782	0.455
Adjusted R^2	0.862	0.951	0.832	0.673	0.183
Residual Std. Error	0.945 (df = 47)	0.684 (df = 41)	0.760 (df = 48)	0.271 (df = 54)	0.348 (df = 54)
F Statistic	18.072*** (df = 27; 47)	50.876*** (df = 26; 41)	14.799*** (df = 27; 48)	7.164*** (df = 27; 54)	1.670* (df = 27; 54)
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 5. Linear regression results for 2FE models

Multiple regression analysis results demonstrate that the exports of nuclear energy technologies have a statistically significant effect on four out of five dependent variables. At the same time, the fact of co-financing of nuclear energy projects, as mentioned earlier, showed no statistical significance in all models. Considering that Models 1, 2, and 3 are log-log transformed, the coefficients should be interpreted in a way that a 1% increase in the independent variable is associated with a percentage change in the dependent variable. Therefore, according to the analysis results, a 1% increase in the exports of nuclear energy technologies by the Actor state is associated with a 0.58% increase in the export of small arms and ammunition and a 0.80% increase in arms transfers to the Partner state. In contrast, the increase in the independent variable is associated with a decrease of 0.85% in the import of small arms and ammunition from the Partner state. Both independent variables did not have a statistically significant influence on the conclusion of bilateral defense cooperation agreements in the Model 5.

The control variables systematically presented statistically significant results and were often found to be negatively associated with the dependent variables. In this case, the results in some way contradict the literature, as they show a negative impact on bilateral cooperation in the security and defense sector. However, the control variable for the Trade flows from the Actor state consistently showed a positive relationship with the dependent variables in all cases of statistical significance, following the assumptions given in the relevant literature.

Finally, special attention should be paid to the results of Model 4, which demonstrates a statistically significant influence of the predictor variables on conducting joint military exercises. Although after receiving the results, I found it difficult to interpret the coefficients due to the binary nature of the response variable. Therefore, I found out that the method of logistic regression analysis is much more representative in discovering the effects on the binary

response variable. So, as mentioned earlier, it was decided to conduct an additional logistic regression analysis for Model 4, the results of which are shown in Table 6.

	Dependent variable:
	Joint military exercises
Exports of nuclear energy technologies	1.166***
	(0.381)
Co-financing of nuclear power plant projects	
Armed conflicts	-2.354***
	(0.818)
Joint membership in IO with security functions	6.037***
	(2.137)
Trade flows from Actor State	4.177***
	(1.290)
Trade flows from Partner State	-2.785*
	(1.555)
Constant	-42.561***
	(15.721)
Observations	82
Log Likelihood	-19.235
Akaike Inf. Crit.	86.470
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 6. Logistic regression results for Model 4

The predictor variable of the nuclear energy technologies exports maintained the significance in the results of logistic regression. Also, the results for the model with the omitted control variable for joint membership in international organizations showed no significance for the co-financing independent variable. In order to interpret the results of logistic regression for statistically significant variables, odds ratios for predictor variables were calculated using the "oddsratio" R-package. The result for the indicator of nuclear energy technologies exports was 3.208. The interpretation of odds ratios for logistic regression results is based on the principle

that an indicator of 1 demonstrates the absence of an effect for the predictor variable, while indicators greater than 1 and less than 1 demonstrate an increase and decrease (respectively) in the probability that the phenomenon of the response variable will occur. Therefore, it can be assumed that an increase in the export of nuclear energy technologies results in higher odds of conducting joint military exercises.

3.3. Model Diagnostics

All model variations were also analyzed in the format of residual plots. This sub-section covers the process and outcomes of 1FE models diagnostic, as well as the results of regressions with robust standard errors. Notably, this part of the section includes the diagnostic results for the models which showed statistical significance for the independent variable and are presented earlier in Table 4.

Analysis of residual plots for Models 1 and 2 showed a rather uneven distribution of residuals. As can be observed from Figure 2 and Figure 3, both Models are characterized by a clustering of residuals in the right part of the scale and the presence of several outliers significantly distant from the center. This provides grounds for assuming heteroskedasticity for these models. Therefore, the regression analysis with robust standard errors was performed.

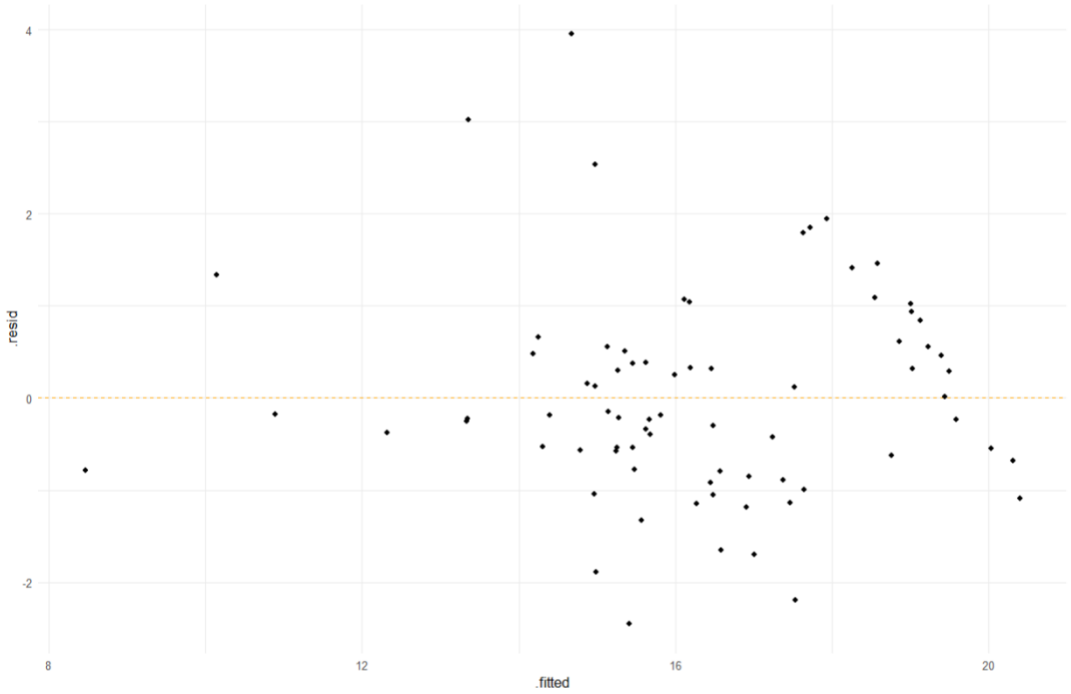

Figure 2. Residual plot for Model 1 (dependent variable: Small arms and ammunition (exp))

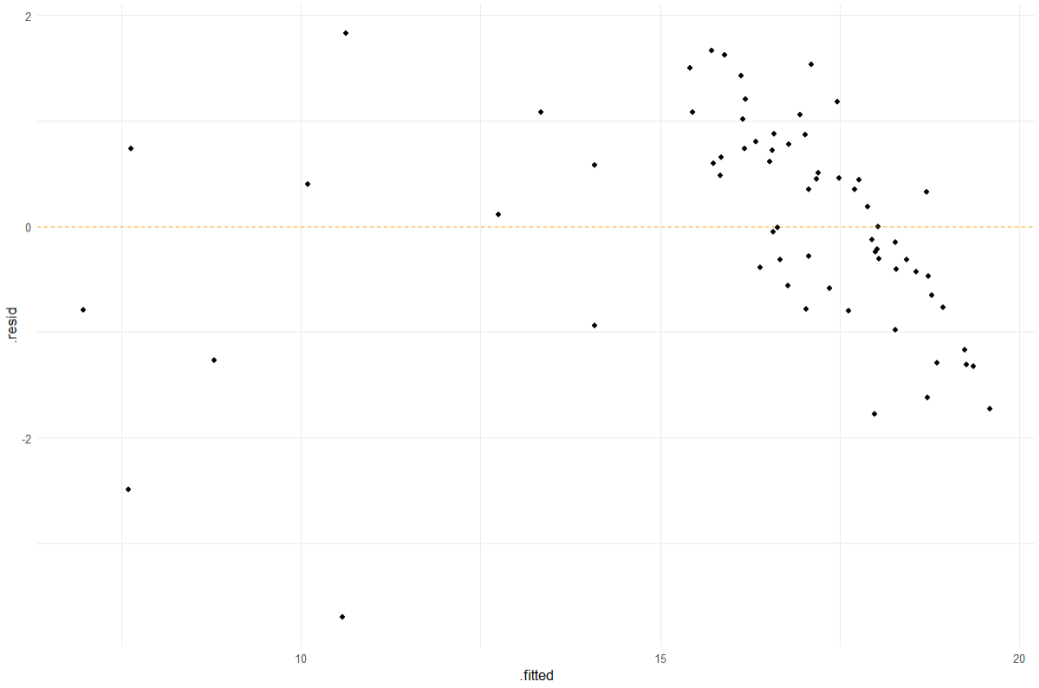

Figure 3. Residual plot for Model 2 (dependent variable: Small arms and ammunition (imp))

As the analysis results in Table 7 and Table 8 show, the OLS model overestimated the standard error for arms exports and underestimated the indicator for arms imports from the Partner State. Nevertheless, the independent variable for the export of nuclear energy technologies maintains statistical significance at all variations of heteroskedasticity-consistent (HC) standard errors in both models. Therefore, it can be concluded that the results of the analysis for these models are most likely reliable.

	Regression With Robust Standard Errors				
	HC0	HC1	HC2	HC3	HC4
	(1)	(2)	(3)	(4)	(5)
Exports of nuclear energy technologies	0.581***	0.581***	0.581***	0.581***	0.581***
	(0.058)	(0.070)	(0.070)	(0.085)	(0.071)
Armed conflicts	-4.457***	-4.457***	-4.457***	-4.457***	-4.457***
	(0.769)	(0.933)	(0.963)	(1.210)	(1.004)
Joint membership in IO with security functions	-0.657***	-0.657***	-0.657***	-0.657***	-0.657***
	(0.165)	(0.200)	(0.198)	(0.239)	(0.198)
Trade flows from Actor State	1.173**	1.173**	1.173**	1.173*	1.173**
	(0.457)	(0.554)	(0.562)	(0.693)	(0.571)
Trade flows from Partner State	-0.359	-0.359	-0.359	-0.359	-0.359
	(0.524)	(0.635)	(0.643)	(0.791)	(0.652)
Constant	-8.523**	-8.523*	-8.523**	-8.523*	-8.523**
	(3.514)	(4.262)	(4.218)	(5.069)	(4.196)
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 7. Results of regression with robust standard errors for Model 1 (dependent variable: Small arms and ammunition (exp))

	Regression With Robust Standard Errors				
	HC0	HC1	HC2	HC3	HC4
	(1)	(2)	(3)	(4)	(5)
Exports of nuclear energy technologies	-0.852***	-0.852***	-0.852***	-0.852***	-0.852***
	(0.096)	(0.118)	(0.120)	(0.151)	(0.123)
Joint membership in IO with security functions	-1.450***	-1.450***	-1.450***	-1.450***	-1.450***
	(0.280)	(0.345)	(0.356)	(0.453)	(0.369)
Trade flows from Actor State	3.144***	3.144***	3.144***	3.144***	3.144***
	(0.401)	(0.493)	(0.507)	(0.643)	(0.523)
Trade flows from Partner State	-0.666	-0.666	-0.666	-0.666	-0.666
	(0.827)	(1.017)	(1.054)	(1.345)	(1.094)
Constant	-24.070**	-24.070**	-24.070*	-24.070	-24.070*
	(9.614)	(11.818)	(12.221)	(15.556)	(12.640)
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 8. Results of regression with robust standard errors for Model 2 (dependent variable: Small arms and ammunition (imp))

As can be observed from Figure 4, the residual plot for Model 3, which analyzes the effect on the indicator of arms transfers, demonstrated a fairly homoskedastic distribution of the data. However, additional regression analysis with robust standard errors shows results only for HC0 and HC1, because other variations of heteroskedasticity-consistent standard errors returned "NaN" results. Most likely, the reason for this is the collinear relationship one of the other predictor variables. However, it was decided to accept the results for HC0 and HC1, and not to drop the variables from the model, as they are justified by the literature. As the outcome in Table 9 shows, the OLS model underestimated the standard error for the indicator of arms

transfers, but for HC0 and H1 the statistical significance of the independent variable is maintained.

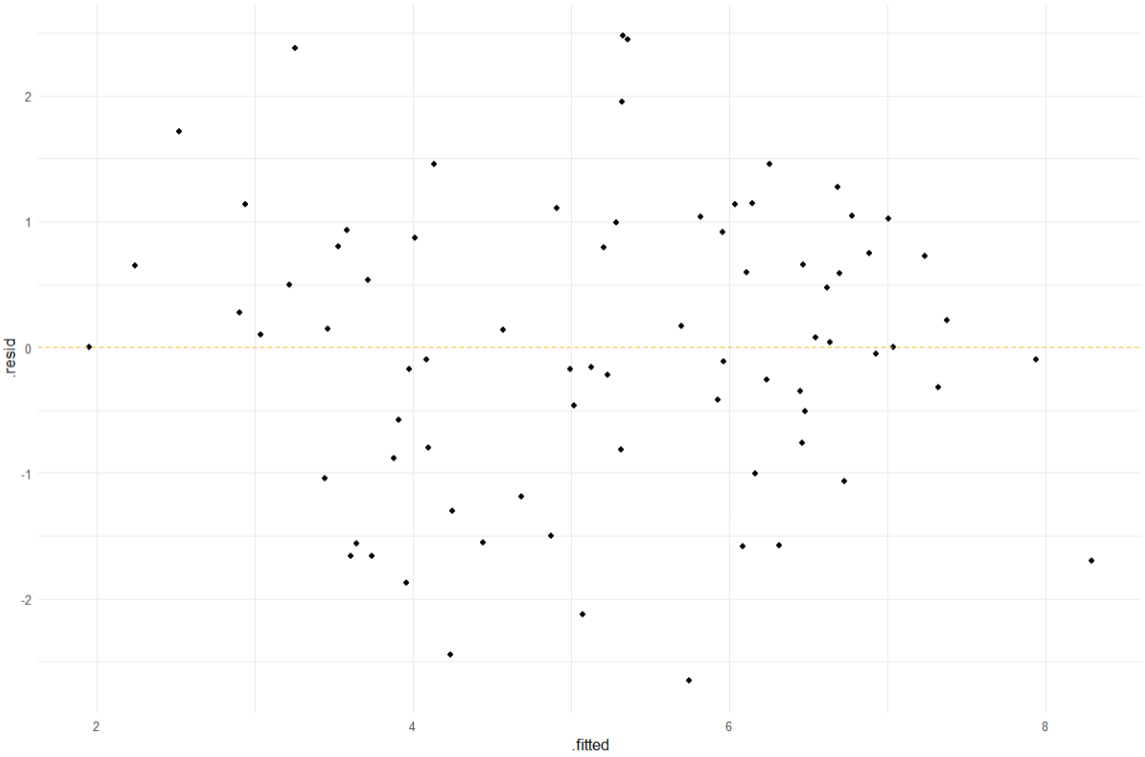

Figure 4. Residual plot for Model 3 (dependent variable: Arms transfers)

	Regression With Robust Standard Errors	
	HC0	HC1
	(1)	(2)
Exports of nuclear energy technologies	0.802***	0.802***
	(0.085)	(0.103)
Joint membership in IO with security functions	-0.925*	-0.925
	(0.499)	(0.604)
Armed Conflicts	-0.230	-0.230
	(0.233)	(0.282)
Trade flows from Actor State	-0.172	-0.172
	(0.231)	(0.279)
Trade flows from Partner State	-0.023	-0.023
	(0.381)	(0.461)
Constant	-1.120	-1.120
	(3.862)	(4.669)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 9. Results of regression with robust standard errors for Model 3 (dependent variable: Arms transfers)

For the binary dependent variable of joint military exercises, only the logistic regression diagnostic will be demonstrated since these results are more representative. The binned residual plot in Figure 5 demonstrated that, among a generally small fraction of residuals, several observations fall outside the standard error bands, and several points cluster at the intercept. Therefore, the model apparently does not perform best in explaining the response variable.

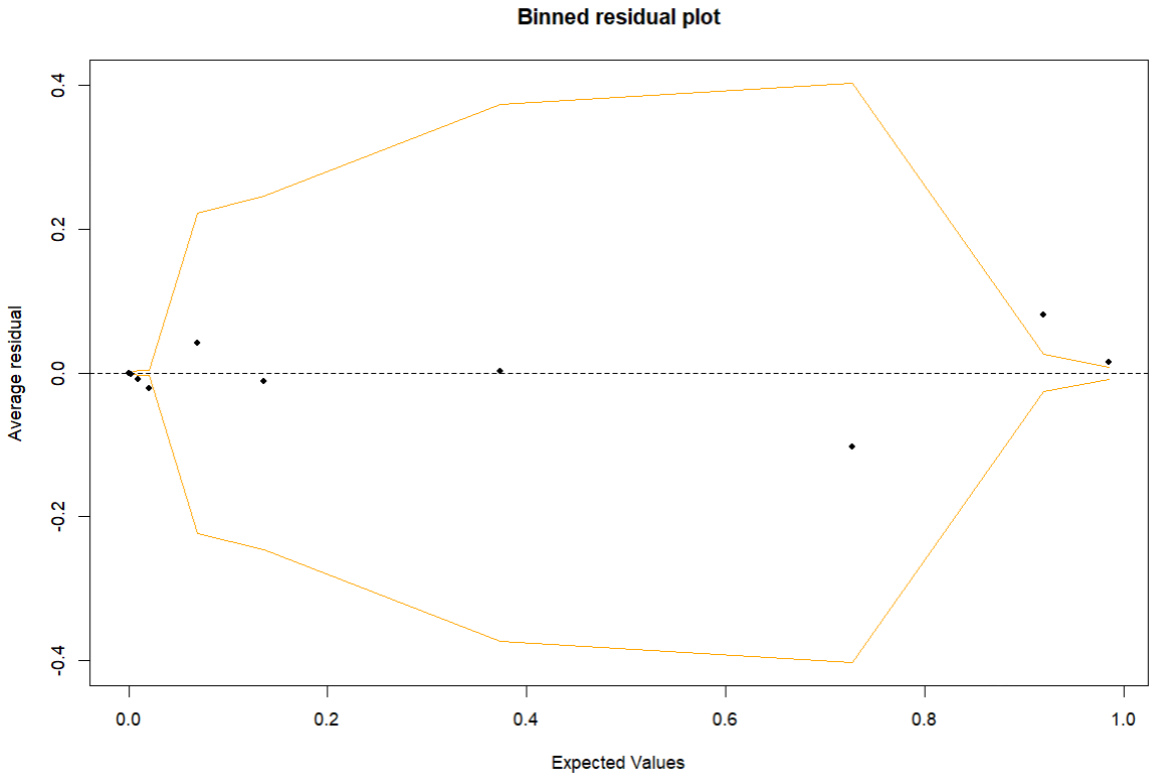

Figure 5. Residual plot for Model 4 (dependent variable: Joint military exercises)

	Regression With Robust Standard Errors				
	HC0	HC1	HC2	HC3	HC4
	(1)	(2)	(3)	(4)	(5)
Exports of nuclear energy technologies	1.166***	1.166***	1.166**	1.166	1.166
	(0.376)	(0.447)	(0.529)	(0.761)	(0.731)
Joint membership in IO with security functions	-2.354***	-2.354***	-2.354***	-2.354**	-2.354**
	(0.584)	(0.695)	(0.796)	(1.121)	(1.071)
Armed Conflicts	6.037**	6.037**	6.037*	6.037	6.037
	(2.422)	(2.879)	(3.231)	(4.409)	(4.050)
Trade flows from Actor State	4.177***	4.177***	4.177***	4.177**	4.177***
	(0.832)	(0.990)	(1.172)	(1.674)	(1.575)
Trade flows from Partner State	-2.785**	-2.785*	-2.785*	-2.785	-2.785
	(1.216)	(1.446)	(1.634)	(2.245)	(2.078)
Constant	-42.561***	-42.561**	-42.561**	-42.561*	-42.561*
	(15.951)	(18.966)	(19.664)	(25.218)	(23.302)
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 10. Results of regression with robust standard errors for Model 4 (dependent variable: Joint military exercises)

In addition, the results of the regression analysis with robust standard errors showed that starting with HC3, the independent variable loses its statistical significance. These results may indicate that the export of nuclear energy technologies may have a certain influence on the chances of conducting joint military exercises, but this relationship should be further investigated, possibly using other approaches to model building.

4. Discussion of Findings

The results of the analysis for 14 country pairs within the 30 years' time frame demonstrate a correlation between the export of nuclear technologies by the Actor states and arms trade and transfers with the Partner states, as well as indicate the potential impact of nuclear energy cooperation on joint military exercises. At the same time, the case of concluding an NPP project co-financing agreement did not show a significant impact on any of the aspects of international cooperation in security and defense within the scope of this study. Thus, this section is dedicated to the interpretation of the obtained quantitative results, determining their theoretical implications, placing the main findings in a relevant scholarship framework, and outlining directions for future research.

4.1. Interpretation of Results

This thesis aimed to find an answer to the main research question of whether bilateral cooperation in the nuclear energy sector contributes to the strengthening of collaboration in the field of security and defense. Considering that interstate relations in the security dimension are measured by five indicators that combine economic, political, and military aspects, the answer to this question is also quite complex.

First, an observed strong connection between the indicators of nuclear technology exports and the export/import of small arms and ammunition may indicate the predominant importance of the economic aspect of cooperation in strategic industries. While more political indicators in the form of joint military exercises and the cases of the conclusion of defense cooperation agreements do not show a clear association with international nuclear energy cooperation, presumably due to the strong influence of other political factors.

Considering the recorded significant relationships between the variables of interest, it is first necessary to analyze how nuclear energy technologies export by the Actor state is associated with the indicators of small arms and ammunition trade with the Partner state. It was expected that establishing cooperation in the strategic energy sector would lead to an increase in both export and import trends for the arms trade. However, the presumed association was confirmed only for the indicator of arms exports from the Actor state. At the same time, an increase in the independent variable results in a decrease in the indicators of arms imports from the Partner state. Considering the pool of country pairs analyzed, it can be assumed that the negative association between the variables might be influenced by the fact that Actor states often invest in the nuclear energy sector of developing countries. These states are more likely to have a less developed arms industry and have less capacity to export arms to the partners. Nevertheless, the positive relationship between the predictor variable and the indicator of arms exports may confirm the assumption that economic cooperation in certain strategic industries can create prerequisites for expanding trade partnerships in another strategic sector. This statement is also supported by the observation that the export of nuclear energy technology is the only factor that has a significant influence on arms transfers. Taking into account that the indicator of arms transfers covers precisely major weapons, which are complex strategic technologies, it can be assumed that bilateral partnership in technologically advanced industries increases the probability of further exchange and sharing of technologies in other sectors.

The results of the data analysis also recorded that cooperation in the nuclear energy sector does not have a particular impact on the conclusion of defense cooperation agreements. This can be explained by the fact that the conclusion of such formal agreements can be better explained by other factors, such as participation in joint military and economic alliances, the establishment of bilateral trade relations, or which was not considered in the scope of this study,

the geographical factor. That is why, even if cooperation in the nuclear energy sector may have some relevance to the conclusion of defense cooperation agreements, this aspect is most likely to be integrated into a set of other economic and political factors.

Finally, it is also important to explore the impact of the export of nuclear energy technologies on the conduction of joint military exercises. Logistic regression analysis showed that there is a relationship between the predictor and the response variable. However, further diagnostics using regression analysis with robust standard errors showed that this model, although it may hint at a connection between the variables, is not reliable enough to draw conclusions about the influence of cooperation in nuclear energy on this aspect of the security dimension partnerships. Therefore, these results leave room for further analysis.

4.2. Discussion of Results

In broader terms, the results of this study provide meaningful insight into understanding the interconnections in different strategic sectors. The thesis complements the existing literature by Michalski (1991) and Kang (2011) by synthesizing the concept of a strategic sector at the level of international relations and demonstrating that government-to-government interaction in these sectors has a cumulative effect and strengthens the cooperation between states in other areas related to the security and stability. Also, the research offers a new perspective on the economic and political role of civil nuclear energy on a global scale, especially considering its potentially significant impact on the international security dimension discovered in the result of the analysis.

In line with the theoretical framework of this study, the results fit well with the conceptual principles of mercantilism and geoeconomics, particularly by demonstrating that the export of nuclear energy technologies is a significant economic tool for paving the way to bilateral military cooperation, and, as a possible potential outcome, influencing the balance of

power in the international arena. Therefore, in this theoretical context, the results contribute to establishing the niche in an understanding of the economic aspect of security influence by specifying that it is not just general economic relations but precisely the economic cooperation in key sectors which can be used as a tool for achieving strategic goals. However, for a deeper understanding of the political motives of investments and trade in the nuclear energy sector, as well as to confirm the tendency to "weaponize" such cooperation in strategic sectors, it is necessary to conduct additional research.

4.3. Limitations and Recommendations for further research

In the context of the research design, as mentioned earlier, this study aims to identify and analyze the impact of international collaboration in the field of nuclear energy on strengthening partnerships in the security and defense sector. At the same time, it is necessary to acknowledge a possible round-wise effect between these two phenomena. However, in the framework of this study, this effect is not investigated and remains as a subject for further research.

The limitations of the data analysis include incomplete data availability for the timeframe in scope. Often this issue arose due to the use of databases created by scientists, and not provided by governments or think tanks. As a result, this aspect affected the number of observations that were finally analyzed in linear regression models.

In the context of research outcomes, this study is narrowly focused on the impact of international cooperation in the nuclear energy sector, and therefore the results of the analysis should not be generalized to the effects of the partnership in the energy sector as such, or other energy sources. For that reason, the effect of cooperation in oil, gas, or renewable sources sectors must be further investigated.

In addition, although this research demonstrates the potential connection between the nuclear energy industry and the bilateral defense partnership, it does not fully reveal the in-depth aspects of this partnership for pairs of countries. This limitation results from the choice of the quantitative method for the analysis. Although the quantitative analysis approach is justified, considering the novelty of the research scope, it does not allow fully reveal political dependencies for each case.

Therefore, the main recommendation for further research is to explore the patterns of cooperation and the formation of dependencies between partners to better assess the political context of the relationship between the two sectors. A particularly beneficial approach for this can be a case study, as it will allow capturing the political nuances that were limited by this research. For example, potential cases for exploration could include the relatively recent partnership between South Korea and the UAE, the effects of which are currently difficult to assess due to time and data constraints, as well as changes in the trends of partnerships with Russia against the background of a full-scale Russian-Ukrainian war, which also was not considered in this study due to the limited timeframe.

Conclusions

The thesis aimed to answer the following research question: *Does international collaboration in the nuclear energy sector contribute to the increase of bilateral cooperation between states in security and defense?*

A quantitative analysis of 14 partnership cases for 5 major nuclear energy technology exporters confirmed the assumptions arising from the research question. The main takeaway of this research lies in the evidence that the economic aspect of security cooperation is significantly associated with trade relations in the nuclear energy sector. The results of the study showed that the increase in the export of nuclear energy technologies is positively related to the export of small arms and ammunition, as well as transfers of major weapons to the Partner state. Following the theoretical implications that explain the nature of strategic sectors and the high involvement of the state in their regulation, it can be concluded that the establishment of trade partnerships for nuclear energy technology may serve as a tool for the Actor state to integrate its other technologies into the defense system of the Partner state, thereby creating the prerequisites for further military-technical partnership. On the other hand, additional analysis may be required to confirm or deny the influence of nuclear energy cooperation on the political dimension of security partnerships.

The thesis brings a novel approach to the understanding of the political and economic role of bilateral cooperation in the nuclear energy sector, outlining it as one of the formative factors for the international security partnership. This creates a foundation for further research into the relationship between energy and security, especially in the context of the current rapid development of carbon-neutral energy sources.

As the scope of this study is quite new, the quantitative approach to the research analysis made it possible to identify the potential connections, as well as the new political and economic role

that international cooperation in nuclear energy can have in the security context. At the same time, the results of this study should not be generalized to the energy sector as such, or to other energy sources, as this topic requires additional research. Moreover, to better explore and confirm the political aspects of the international nuclear energy partnership, it is recommended to conduct an in-depth case analysis of the cooperation for individual country pairs.

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