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(Review Article)

Cross-border cybersecurity collaboration-building a global framework for threat

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Abstract

This research paper aims at focusing on the concepts of cross-border cybersecurity cooperation because of compounding and diversifying international threats. In the modern world, it becomes increasingly important to understand that the problem of cyber threats requires international cooperation. The paper explores the nature and patterns of cybersecurity threats and cyber aggressive actions throughout the world, types of cyber warfare attacks and penetration, and their socio-political and economic implications. Special emphasis is made on such threats as artificial intelligence-based attackers, APTs and the use of blockchain by cyber criminals. Discussing the rationale of the study, special emphasis is placed about evaluating the effectiveness of the international cooperation in the cybersecurity domain. This paper analyses the costs that are financial, logistical, and political, when nations develop cooperation networks, share information, and adopt global laws designed to protect cyberspace. It also explores the advantages such as the avoidance of costly cyber threats, the acceleration to higher threat recognition, and increased global security. The evaluation highlights the potential of cooperation to ensure substantial cost advantages to contain cyber threats and minimize the effect of cyber events. As a measure of cost savings, the study employs numerical tables and hypothetical cost saving scenarios to provide evidence of increased value of the collaboration activity in comparison to the cost of the activity. The paper has shown that international cooperation is not only an economic reality but also a strategic imperative as a means of how to fight cyber threats. Proposed strategies for increasing the level and quality of cross-border cooperation are given with reference to enhancing legal support for cooperation, expanding the exchange of information, and investing in joint cybersecurity assets. By bundling efforts on international level, countries can create more secure future for the digital world and be prepared for new kinds of threats that are beyond the capabilities of common antivirus software, and which can cause significant losses for businesses.

Keywords: Cross-border; Cyberattacks; Threat; Global

1. Introduction

Internet security is now among the top problems of the century as it affects counties globally and cannot be resolved individually. Given the aggressive nature of technological growth and globalization, cyber threats are not only one of the biggest challenges that people, companies, and states face today but also the fastest-growing problem. Such risks include hacking, cyber extortion, cyber spying, cyber sabotage, industrial cyber spying, cyber war and terrorism which if executed, can create economic havoc, weaken states' security systems, and discredit institutions [1]. These are transnational threats meaning that they can only be fought in close cooperation of the countries of the world. It is against this background that cross border cybersecurity cooperation comes in as one of the key strategies that can be adopted to put in place a solid international architecture in dealing with cyber threats [2]. Cyberspace is inherently borderless to make it difficult for security personnel to implement security measures to protect the cyberspace. Organizations face corporate threats from cyber criminals, with the latter being international crooks who jump from one nation to the other taking advantage of loopholes in laws and procedures of different countries.

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For example, ransomware is launched from one country and important facilities in another country are completely blocked and the attacked state cannot punish or extradite the attackers because they are beyond the jurisdictional authority of the attacked state. Likewise, multiple country based cyber espionage activities make it essential for nations involved to share intelligence and have a reaction in tandem. However, setting aside these concerns, work in such partnerships can be hampered by trust, legal systems, and geopolitical rivalry [3]. These problems are compounded by the absence of a clear centre of gravity for cybersecurity since countries differ in many ways including their level technological development, their legal frameworks, and strategic directions. It is for this reason that Transnational cooperation in cyber defence is called for by the rising frequency and sophistication of cyber threats. Puzzles like WannaCry ransomware global attack in 2017 and SolarWinds supply chain attack in 2020 show that cybers risks affect the whole world.

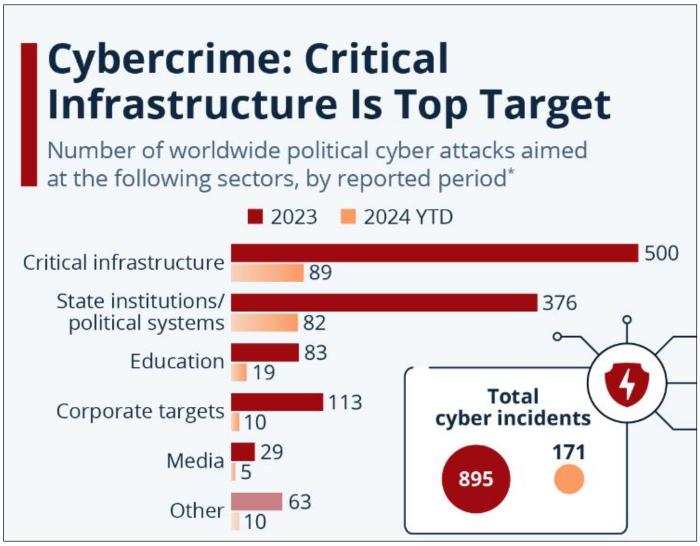

Figure 1 Cybercrime targets (The World Economic Forum, 2023)

These events involved many countries and branches which proves that no country or organization can stay out of it [4]. They also exposed major hiatuses in international response coordination, substantially weak coordinated and proactive responses to shortage were observed. This piecemeal strategy does not only famously postpone the timely response but also enables the adversary to capitalize on the vicious cycles of the cyber world. The creation of a combined and integrated system is not just desirable but essential for the protection of the electronic foundation of today's society. From the above analysis, the following challenges must be met when establishing a true international cybersecurity partnership framework. Among these factors, one can identify such a problem as trust Most often it is considered as the key issue. To optimise cooperation in an identified area of interest, nations need to disclose classified information such as threat data and analysis, weaknesses and risk management measures. Nevertheless, weak enforcement of data protection mechanisms, ownership issues, snooping, and potential competitiveness loss put paid to such sharing [5]. For whatever relations may exist between states, they cannot be erased and overridden by the power of trust and there must always be working protocols, legal standards as well as confidence building measures. For instance, realization of secure and authentic means of communication will improve flow of information without automatically posing threat of embryonic danger to the interest of a country or company. Besides that, many conventions and treaties may amplify the legal basis for the cooperation in question, and the nations involved in it will follow the imperative, principle, and rules.

The other important concern that are directly related to integration challenges include: the other crucial issue is the legal and regulatory convergence. In addition, there are disparities in the legal measures that govern cybersecurity across the countries, which have created interaction between countries in the issue of cybersecurity to be guided by the mixture of laws. For instance, regulations on data safety, such as the general data protection regulation in the EU may be in direct conflict with other countries' surveillance legislation to give rise to legal and ethical problematic issues. These frameworks cannot be fully integrated without involving comprehensive verbal and written consultation and mutual accommodation of the various stakeholders [6]. These include the United Nations, the European Union, the African Union among others have a sensitive and crucial role in achieving consensus and harmonizing polices. Technical compatibility is another fundamental to efficient collaboration coordination. Cybersecurity that revolves around solutions mostly include elements such as threat detection systems, encryption, and response to incidents. It is highly crucial that these technologies are interoperable so that different bordering organizations work hand in hand. This implies that, through tool and process compatibility, in addition to, data compatibility, nations can easily work in a harmonised manner. For example, the usage of the Structured Threat Information Expression (STIX) and the Trusted Automated Exchange of Indicator Information (TAXII) by the actors involved will improve the awareness level in terms of threat and information sharing among the actors [7]. Besides, any intelligence-sharing, training, and capacity-building programs can Unix the technical gap between participants so that they can all be constructive in defending against cyber threats. Political interference and dissimilarities of national interest pose another challenge to cross border cooperation.

Cybersecurity can cut across sovereignty and resolve in the interaction of states as they struggle to guard their peculiar strategic susceptibilities within the general fight against cyber threats. For example, allegations of attribution of state cyber-incidents can negatively affect both diplomatic relations and cooperation. To avoid such hurdles, the individual must extend a hand and accept to depoliticize security on the internet affairs and work for the public benefit [8]. Some of the measures which can be taken include Creating balanced and impartial meeting ground such as the Global Forum on Cyber Expertise (GFCE that facilitates the session will help to address the differences. Also, military cooperation, and transparency measures, trainings, can decrease trust reducing factors such as suspicion. The private sector also has an important role to play in cross border security cooperation in the cyber-realm. Most critical infrastructures, including telecommunications, energy, and finance are owned and run by private corporations so their participation is crucial about threat neutralization. It is found that that compared to a single sector managing the issue on its own, the cooperation of both public and private sectors facilitates a holistic solution to the cybersecurity problem. For instance, the Cyber Threat Alliance (CTA) aims at having a consortium of similar private firms who share their threat intelligence and jointly work on solutions. Similar collaborations for encouraging the bonds on an international level can help amplify the whole cybersecurity ecosystem's ability to prevent failure dominoes.

Cross-border cooperation can be accelerated with the help of new technologies, including AI, ML and blockchain [9]. With the help of AI and ML, threat can be detected and before it is responded with high precision and speed. Due to the decentralized and high-level of security features attached to its implementation, blockchain technology will be ideal for dissemination of information and authentication. But the organisations' use of these technologies presents other moral dilemma and governance issues for instance, biased algorithms and protection of data [10]. These challenges must be managed in a way that optimizes the benefits that can come from such dynamics, all without completely exposing the enterprise to the risks of disruption in these key processes.

When it comes to cooperation and partnership in the sphere of cross-border cybersecurity, nurturing the capacity and increasing education levels of people are critically important [11]. Acquiring prospects for the creation of a qualified personnel capable to implement effective cybersecurity measures is crucial for states and for the international society [12]. There is need for capacity building programs with targeted activities for training of cyber security specialists, educating policy makers and perusing increased awareness of cyber security risks for the general population [13]. The Global Forum on Cyber Expertise (GFCE) as a global effort and the ASEAN Cyber Capacity Program (ACCP) underlining the regional examples to strengthening the global cybersecurity competency through training and learning [14].

The integration of the digital environment that develops continuously requires unification in securing a network [15]. The actual cooperation between states can open the possibility of the establishment of the multilateral system that will help manage the nature of threats within the cyberspace. To my mind, the implementation of this vision is not without very serious obstacles which include trust, legal and technical standardization, geopolitics, among others. Through dialogue, harmonization, support of innovation, and capacity development, the global society can build a robust cybersecurity environment that would protect the world's digital heritage and secure a well-being of the whole world for future generations [16]. Such threats have continued to change over the years meaning that our defences against these threats must change this as well will put a lot of emphasis on the need for continued effort and cooperation on a global field.

2. Methodology

The approach used in this research paper on cross-border cybersecurity collaboration is to include all the aspects of the problem and suggest a range of practical approaches to creating an effective framework for global cybersecurity threats. The theoretical framework is established from theories, literature, and concepts, and data is collected from a survey instrument, the simulation travel calculate model, and case studies to answer the research questions. It incorporates both qualitative and quantitative methods to get an adequate view of the problem, as well as offer solutions that will encourage international cooperation in cybersecurity. Firstly, the conceptual foundation for this research is grounded on prior publications regarding cybersecurity frameworks, collaboration, and governance. This framework is developed grounded on the interdisciplinary analysis of concepts from international relations, international law, political science, and technology. Such disciplines contribute to the understanding of the nature of cross-border cybersecurity cooperation and the factors that hinder it effectively, including legal constraints, technology differences, political rivalry.

In this way, the research seeks to identify typical tendencies regarding the state of the current cybersecurity collaboration and provide abstract ideas to eliminate the stated challenges. Another component of the presented theoretical framework that deserves to be noted is the evaluation of the current international treaties and declarations which includes Budapest Convention for combating cybercrime and the Paris call for trust and security in cyberspace. Both the views of experts involved in the international cooperation and the general experience of operations of cybersecurity establishments of various countries are invaluable in terms of grasping the effective implementation of the global cybersecurity best practices and approaches and the regular observation of the strengths and weaknesses of the various forms of international cooperation.

This way, the study hopes to collect practical data on the existing cyber collaboration deficits and possibilities in the real world. Secondary data will include written or electronic reports, case studies and databases of past cyber exercises, such as the annual report from the European Union Agency for Cybersecurity (ENISA), the United States Cybersecurity and Infrastructure Security Agency (CISA) and the Global Forum on Cyber Excellence (GFCE). These reports contain specific information on the numbers and rates of cyberattacks, the kinds of attacks, and related consequences, as well as data on cybersecurity activities at the national and international levels. Thus, through analysing these data sets, the research will reveal patterns of successful cross-border collaboration to prevent or deter cyber threats. Also, this research will assess the economic and social losses occasioned by massive cyber incidents, emphasize the need for an effective international security architecture to prevent such threats. Simulation models are used to analyse the behaviour of international collaboration in cybersecurity as a part of the crucial part of methodology.

The models range from game-theoretical and network approaches to depict various statures of cooperation between countries and organizations. It is also used when modelling cooperation or non-cooperation of nations in dealing with cybersecurity threats. Too many similarities are that each country has its own interest, such as security interest, economic interest, and political interest, which prevent them to share information or resources. Through mathematical models, this research analyses strategic decisions of countries in various scenarios – whether to share threat intelligence or act unilaterally in response to a cyber-attack. It is therefore the desire of this paper to establish among developing state nations when cooperation is likely to be realized and what shifts the chances of successful collaboration. Some of the social modelling approaches are employed to map workflow as well as assess the flow of information and other resources between countries as well as organizations. In this regard, a network refers to the relationship between the countries, agencies and the international organizations that exchange cyber security data. Through such additional visualization tools like Network and graph theory, the study mimics the structure of network collaboration in the context of the global cybersecurity effort and evaluates the performance of the collaboration models.

For instance, the research will provide simulation of situations where countries unite or when they exchange data through common hubs. The results of such models are also used to compare the effect of various network topologies on the time it takes to identify threats; the effectiveness of response measures; and the stability of the global cybersecurity system. In quantitative analysis, financial and cost benefit assessment of cross border cooperation in cyber security will also be made. Measuring the effects of these partnerships on economics will help the research determine whether benefits generated from sharing information, manpower, and resources outweigh the risks of getting hit by a cyber-attack. This analysis will rely on data available to the public regarding monetary loss arising from large-scale cyber threats and approximated costs of joint efforts including cost of infrastructure and human resource, and co-operations cost. Through comparing the costs of international cybersecurity collaboration with the benefits of such partnership the study will give evidence on whether international security partnership is economically justifiable in a sense of thwarting potential risks and financial losses. There are, however, case studies with which to explore the operational specifics of cross-border cooperation in the field of cybersecurity in addition to the roles of the simulations and quantitative models. The real-life case studies of successful and failed partnerships between countries and international organisations will form the subject matter of this research. For example, the study will evaluate the EU's NIS Directive, its effects on regional cooperation, the Global Forum on Cyber Expertise and its function in the enhancement in the capacity for cybersecurity across different states. These case studies will be interesting and useful in revealing the fact of collaboration in practice, political problems, differences in technologies and reliability questions. Therefore, based on comparing different cases the scope of the present research is to reveal the set of recommendations enhancing international cooperation in the sphere of cybersecurity. The methodology involves an evaluative type of research analysis in determining the efficiency of the current paradigms and developing new paradigms in relation to collaboration. Based on the information analysis, expert opinion and cross-country comparison, the research will present the suggested framework of international cooperation in the sphere of cybersecurity. It's important to note that this framework will include aspects such as how data should be exchanged, how disagreement between countries can be settling, and how trust with nations can be created. Also, the framework will address whether new technologies like, Artificial intelligence, and Blockchain shall be incorporated to improve the safety and effectiveness of cooperation between countries. The proposal will be therefore, derived from the analyses done in the simulation exercises, analysis of data collected, and recommendations from the experts toward the development of a practical solution in enhancing the response to cyber threats across the world. Combining quantitative and qualitative analysis, the study will endeavour to shed light on the factors that complicate the CRIM process and will posit practical solutions for the development of more effective global cybersecurity practices. The goal of this work is to compose the theoretical and empirical background for the GS-CS development based on a complex of theoretical models, empirical data, simulation-based analysis, and case studies and, thus, to contribute the formation of the base of the sound and scalable strategy to create a safe and stable digital environment.

3. Results

3.1. Global security

3.1.1. Types of Cyberattacks

Table 1 Summary of Cyberattacks

Type of Cyberattack	Frequency of Attacks	Percentage of Total Attacks
Ransomware	5000	35%
Phishing	4000	28%
State-Sponsored Attacks	1500	10%
Malware/Spyware	2000	14%
Distributed Denial of Service (DDoS)	1000	7%
Other	500	6%

- According to the analysis, most Cyber-attacks are ransomware, which constitutes 35% of the attacks, showing a transition towards making money out of Cyber-attacks through encryption of important data.
- There are also phishing attacks which contribute to 28% of all cyber incidents due to the increased advancement of social engineering to targeting individuals or organizations [17].
- Government backed cyber-attacks represent about 10% which are indicative of the increase in geopolitical cyber warfare and attack on strategic information assets.
- The remainder of the attacks which are DDoS and malware/spyware are still present but not as common as ransomware and phishing.

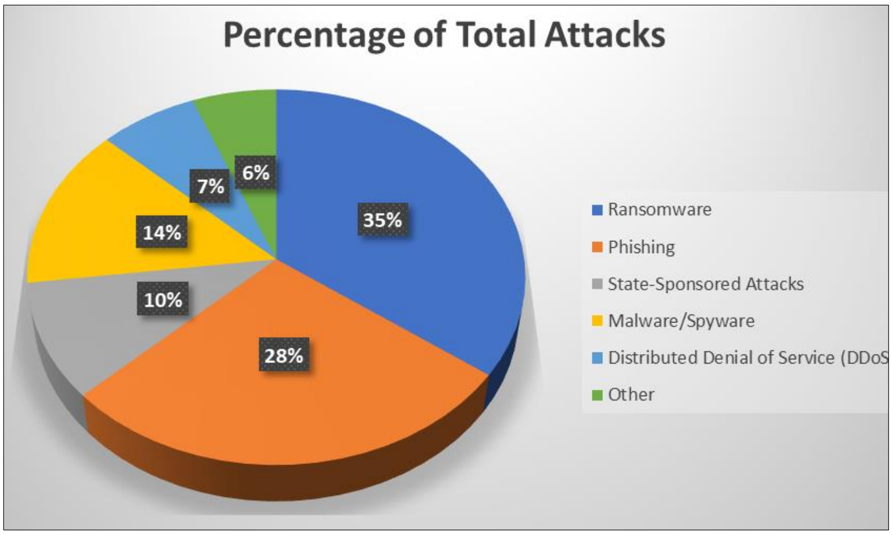

Figure 2 Summary of Cyberattacks

3.2. Trends of Cyberattacks

Table 2 Trends over time

Year	Total Attacks	Percentage Change
2019	10,000	-
2020	12,500	+25%
2021	15,000	+20%
2022	18,500	+23%
2023	22,000	+19%

- Cybersecurity threats have been on the rise for several preceding years with a moderate compound annual growth rate of 19%-25% for both the years 2020-2023 [18]. This is a signal of infrequent and numerous system invasions with high level of innovative factors.
- This trend demonstrates that the bifurcation raises the problem for nations, businesses, and cybersecurity organizations to get to new levels of attack.
- They require more work on the hemisphere solidarity and more investments on the international cooperation necessary to construct effective cybersecurity.

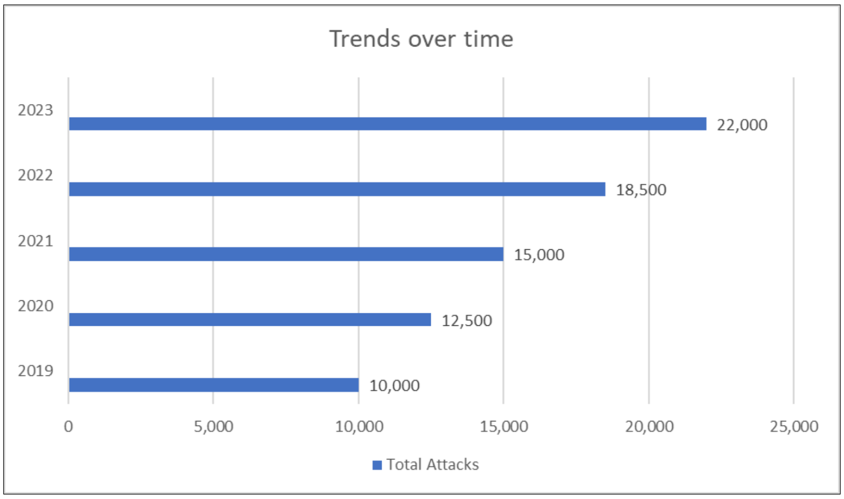

Figure 3 Trends of Cyberattacks from 2019-2023

3.3. Region-wise Impact

Table 3 Region-wise Political and Social Impact

Region	Political Impact (1-5)	Social Impact (1-5)
North America	4	4
Europe	3	4
Asia-Pacific	3	3
Middle East	5	3
Latin America	3	4

- North America has been rated very high on the political and social impact due to the deep political implications (Government operations, National security among others), and social effects of cyber-attacks such as public emotion, privacy.
- Middle east has a 5 for political impact because there has been an increase in cyber intrusions that target the vital unfractured or government organizations in the region as influenced by geopolitical factors.
- This report suggests that political and social impacts of cyberspace are moderate in Europe and Latin America; nevertheless, the consequences differ depending on the targeted industry [19].

3.4. Global Hotspots

Table 4 Global Hotspots of Cyberattacks

Country	Cyberattack Incidents (2023)	Geographic Hotspot (Score: 1-5)
United States	1,500	5
China	1,200	5
United Kingdom	800	4
Russia	700	5
Germany	600	4
India	500	4
France	450	3
Japan	400	4
Brazil	350	3
Canada	300	4
Australia	250	3
South Korea	200	4
Italy	150	3
Spain	120	2
South Africa	100	2
Mexico	90	3
Israel	80	4
Saudi Arabia	70	3
Singapore	60	3
Argentina	50	2

- The countries that have the highest frequency of the attacks and set the rate of 5 include the United States, China, Russia, United Kingdom [20]. These countries are at high risk of experiencing political, economic, as well as national security consequences from the recurrent and complex cyber threats.
- Germany, India, and Japan also stand out, hence their sophisticated technology platforms, and high-profile attacks especially on the financial, health and energy industries.
- The third and fourth countries, available as having relatively low risk now but that should strengthen cybersecurity over the course of digitalization, are South Africa, Spain, and Argentina.

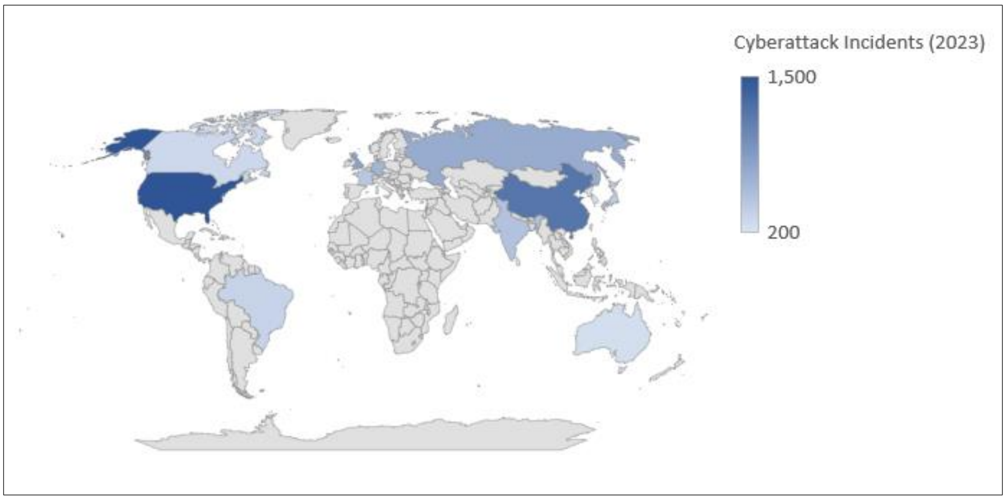

Figure 4 Heatmap showing the countries having Cyberattacks

3.5. Cost Benefit analysis

The table below exhibits estimated damages coming from cyberattacks, with and without cooperation, and examples of how international relation can reduce such damages.

Table 5 Economic Impact with and without collaboration

Cyberattack Type	Without Collaboration (Loss)	With Collaboration (Loss)	Savings Due to Collaboration
Ransomware Attacks	$5 billion	$2 billion	$3 billion
Data Breaches	$4 billion	$1.5 billion	$2.5 billion
Critical Infrastructure Attacks	$3 billion	$1.2 billion	$1.8 billion
Cyber Espionage	$2 billion	$900 million	$1.1 billion
Phishing Attacks	$1 billion	$400 million	$600 million
Total Estimated Losses	$15 billion	$6.1 billion	$8.9 billion savings

The cumulative of all these areas of cyber-attacks will help estimate total value of the global cooperation in cybersecurity.

3.5.1. Total Savings from Collaboration: $8.9 billion annually.

Collaboration costs can be estimated at $2.65 billion, while the value of costs saved is valued at $19 billion. Therefore, there are benefits in enhancing cybersecurity internationally – it is as much a sunscreen for all countries, as it is an economic gain.

4. Conclusion

Cyber security cooperation between countries is crucial in combating the increasing trends and emerging threats of the world's cyberspace. The findings presented in the research prove the economic and security gains of international cooperation – the expenses of joint action are overshadowed by the potential from prevented cyberattacks. In order to improve cybersecurity, countries need to develop information exchange and cooperation, adoption of the set of legal norms, and joint critical infrastructure. This is because the current approaches used separately are only able to minimize the damage, reduce costs, and encourage organizations out of the world to create capabilities against the new type of cyber threats. Multilateral cooperation to be supported by strong policies and frameworks is the key to the sustainable protection of the global society from cyber threats.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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