МОРСКОЕ ПРАВО

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Арбия Хлали,
Факультет экономики, Университет Сфакса, Тунис

Чеботарев Владимир Евгеньевич,
Российский университет транспорта (МИИТ)

Аль Али Насер Абдель Рахим,
Российский университет транспорта (МИИТ)

Проблема автономного судоходства: баланс между устойчивой рентабельностью и риском кибербезопасности

Аннотация. Интеграция автономного судоходства приводит к ряду преобразований в морском секторе, в основном в сфере устойчивой рентабельности. Однако внедрение подобных изменений вызывает ряд проблем. Целью данного исследования является изучение сложного баланса между двумя важнейшими аспектами автономного судоходства, такими как устойчивое создание рентабельности и рисками кибербезопасности. Кроме того, в данной работе рассматривается, как автономное судоходство создает устойчивую рентабельность и в то же время создает надежную систему кибербезопасности. В исследовании рассматриваются различные преимущества, создаваемые автономным судном, подчеркиваются угрозы кибербезопасности, а также отмечаются решение различных проблемы. Результаты подчеркивают важность создания устойчивой рентабельности автономного судоходства и необходимость коррекции действующих правил.

Ключевые слова: автономное судоходство; риски кибербезопасности; робототехника на морском транспорте; искусственный интеллект на морском транспорте; системы автоматизации на морском транспорте.

Hlali Arbia,
Department of Economics, University of Sfax, Tunisia

Vladimir Ev. Chebotarev,
Russian University of Transport (MIIT)

Naser Abdel Raheem Al Ali,
Russian University of Transport (MIIT)

Autonomous Shipping challenge between Sustainable Value Creation and Cybersecurity Risk

Abstract. The integration of autonomous shipping introduces several transformations in the maritime sector, mainly the sustainable value creation. However, this technology adoption provokes some challenges. The purpose of the current paper was to study the complicated balance between two critical aspects of autonomous shipping, such as sustainable value creation and cybersecurity risks. In addition, there has been considered how autonomous shipping creates sustainable value while at the same time establishes a robust cybersecurity system. There have been also studied various advantages created by autonomous ships and underlined the cybersecurity threats, also stated the solution of different challenges. The conclusions have highlighted the importance of autonomous shipping value creation and the necessity of current regulations' correction.

Keywords: autonomous shipping; cybersecurity risks; robotics in marine transport; artificial intelligence in marine transport; automation systems in marine transport.

Introduction

The advancements in technology such as digital tools and automation reformed the traditional seaport operations with efficiency optimization, sustainability, and improve of the overall performance of maritime ports in the modern era. Thus, it also reported the challenges, benefits, and potential strategies for successful digital transformation in seaport management (Hlali, 2021).

In addition, the maritime industry has several transformations, driven by the development of autonomous ships. These vessels are one of the main reforms in maritime transportation, as well as autonomous ships are vessels that operate without direct human intervention. The autonomous ships are relied to the advanced technologies, robotics, artificial intelligence, and automation systems. The transformation from traditional crewed vessels to autonomous is supported by several features such as advanced sensor technology, artificial intelligence, connectivity, safety protocols (Ahn et al., 2019).

The digitalization of ships is a continue creation and dynamic process, with new technologies and innovations. The maritime industry holds digitalization as all sectors, it also associated the challenges about safety, security, and environmental. The evolution of ships in the digitalization promises to reform the industry, and to make it more efficient, sustainable, and more connected

(International Maritime Organization, 2020). Figure 1 describes the evolution of ship due to the digitalization and summaries the difference between smart ship and autonomous ship.

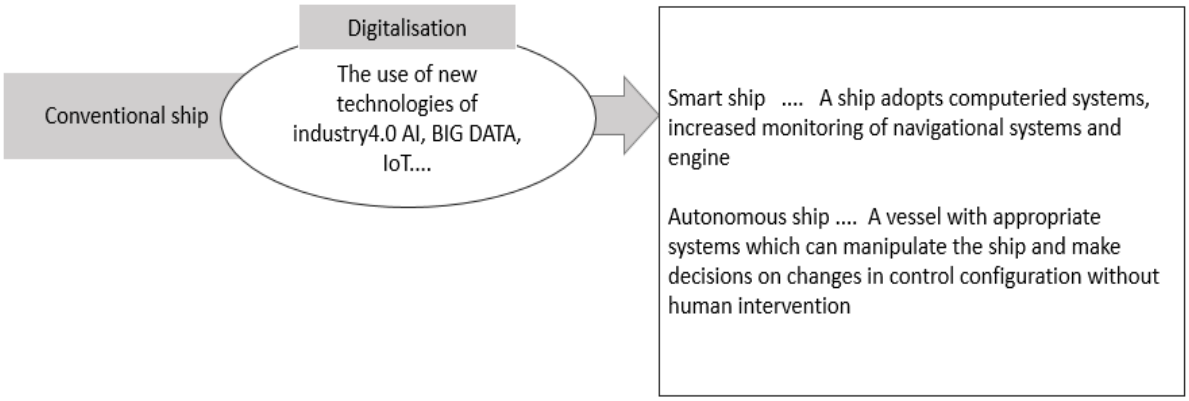

Fig. 1. **Evolution of ships due to digitalization**

Source: created by (Ichimura, 2022)

The international maritime organization (IMO) has classified the levels of autonomy into four levels. Level 1 is the low degree of autonomy with advanced decision support systems on board. Level 2 is semi-autonomous vessel controlled by a remote-control center (RCC) with a reduced crew. Level 3 is a semi-autonomous vessel controlled by a remote-control center (RCC) without any crew on board. Level 4 is fully autonomous ships capable of making decisions themselves. Figure 2 represents the degrees of autonomy which are classified up to four levels in last years.

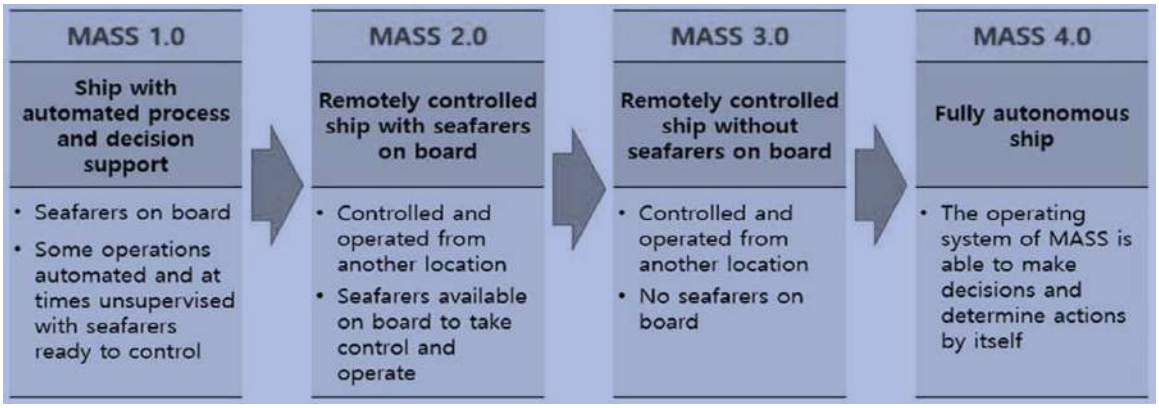

Fig. 2. **Degrees of autonomy**

Source according to IMO

The autonomous ships are innovative vessels without human crews, have the potential to change the maritime transportation. This research paper analysis the emergence of autonomous shipping, from its appearance as a technological tool for sustainable value creation to the complicated challenges to cybersecurity risks. The paper is organized as follows: the first section

represents an introduction that underlines the impact of the digitalization of ships and cites the different levels of shipping autonomy according to the international maritime organization. The second section defines the value creation of autonomous ship in the sustainable context. The third section explores the meaning of cybersecurity for autonomous ship and defines the critical threats in cybersecurity, the fourth section analysis the variety of challenges, the legal and regulatory challenges. The end section synthesizes the findings of the study.

Sustainable value creation of autonomous ships

Sustainable autonomous ships are eco-friendly vessels transformed the maritime industry by the benefits of the combination of the autonomy with environmental practices. The challenges of the sustainable autonomous ships emphasizing the critical importance of ecological considerations in shaping the future of maritime transportation [https://doi.org/10.1057/s41278-022-00216-y]. Thus, the sustainable autonomous ships are at the forefront of adopting eco-friendly propulsion technologies, including electric and hybrid systems, wind-assisted propulsion, and hydrogen fuel cells. These advancements reduce emissions and dependency on traditional fossil fuels. Sustainable autonomous ships leverage advanced algorithms to make data-driven decisions that lower their carbon footprint. Autonomous ship could also connect solar and wind energy on sustainable autonomous ships is becoming increasingly common, further, to reduce their reliance on conventional energy sources (Olabi, et al., 2023). These systems contribute to the vessels sustainability and energy efficiency. Further, the most crucial aspect of sustainability is understanding the environmental impact of autonomous shipping. To promote sustainability in maritime transportation, a comprehensive regulatory framework is needed (Boviatsis and Vlachos, 2022). International organizations and governments are working on standards for sustainable autonomous shipping, addressing emission limits and environmentally responsible practices (IMO, 2021). In addition, the transition to sustainable autonomous shipping is not without challenges, including the need for advanced energy storage solutions, power management systems, and infrastructure at ports to support green technologies.

Sustainable autonomous ships offer a promising solution to reduce the environmental impact of maritime transportation while embracing the benefits of autonomy. These vessels not only provide economic advantages but also contribute to global efforts to combat climate change. The innovations, regulations, and challenges are a vital to the potential of sustainable autonomous shipping in the future.

In addition, the economic value added of autonomous ships is a topic of significant interest in the maritime industry. These vessels offer the potential for substantial cost savings through increased operational efficiency and reduced fuel consumption. The integration of advanced navigation systems and real-time data analytics allows autonomous ships to optimize routes and cargo management, resulting in improved profitability and sustainability. Additionally,

the economic value added is enhanced through the predictive maintenance capabilities of autonomous ships, reducing downtime and maintenance costs. As the maritime industry continues to embrace digitalization, the economic benefits of autonomous ships are becoming increasingly evident, making them a focal point of economic analysis and investment.

Autonomous ship and Cybersecurity risk

Kevin Jones analyzed the various threats and their impacts on cybersecurity in the maritime industry and delivered a vision into the specific challenges and vulnerabilities faced by maritime cybersecurity, as well as the potential consequences of cyber threats in this context. It may also explore strategies and solutions to mitigate these threats and enhance the overall cybersecurity posture within the maritime sector [https://10.1049/etr.2015.0123].

Cybersecurity has various threats for autonomous ships. In the realm of navigation and control systems, there is a growing vulnerability to cyberattacks that could disrupt critical operations and endanger vessel safety. Similarly, in cargo management, the potential for cyber intrusions threatens not only the security of the cargo itself but also the economic value of the shipment. The communication networks that reinforce autonomous ships are another factor for cybersecurity risks, as gaps in these networks could compromise data integrity and vessel to shore connectivity. Furthermore, the increase of reliance on remote monitoring and the data exchange exposes the maritime sector to potential gaps and data theft. Thus, the cybersecurity threats become paramount to ensure the safe and secure operation of the advanced vessels.

Autonomous ships become popular in the shipping industry, but they also pose significant cybersecurity risks. As these systems become more complex and interconnected, the potential for cyberattacks and data cracks increases. It is essential to integrate cybersecurity best practices into the design and development of autonomous ship systems to ensure the safety and security of the vessel and its passengers. Table 1 represents some cybersecurity risks and some practices that can protect the ship.

Table 1

Cybersecurity risks and best practices for autonomous ship

Cybersecurity Risks	Cybersecurity Best Practices
• Malware and viruses can be introduced into the system through vulnerabilities in the software or hardware. • Hackers can gain access to the system through unsecured networks or weak passwords. • Insider threats, such as employees or contractors with access to the system, can intentionally or unintentionally cause damage or steal data.	• Regularly update and patch software and hardware to address known vulnerabilities. • Implement strong access controls, such as multi-factor authentication and role-based access, to limit the potential for unauthorized access. • Regularly monitor the system for suspicious activity and implement incident response plans to quickly respond to any security incidents.

Sources elaborated by authors

Challenges

The challenges associated with autonomous ships are not developed in the current literature, however some studied focus on and try to analyze the impact of the new technology on maritime transport and maritime industry. In this context (Chougrani et al., 2021), discussed the regulatory framework and legal considerations that are essential to ensure the safe operation of autonomous ships to minimize the environmental impact. Also (Hlali, 2022) examined the specific challenges and issues related to data protection within the shipping industry. The study aims to explore how data privacy and security are addressed, the vulnerabilities and risks associated with data in maritime transport, and potential solutions or best practices to protect sensitive information and resolve the compliance with data protection regulations in the context of shipping. The International Maritime Organization (IMO, 2020) analyzed the complex task of developing comprehensive international regulations for autonomous ships. The stability between the technological innovation and the safety/security of maritime operations is a central challenge, so the crucial challenge to minimize the environmental impact of autonomous ships, includes emissions reduction and prevention the release of harmful substances into the sea requires for current ethical and legal issues. In addition, the responsibility and liability for accidents involved by autonomous ships represent another obstacle in the autonomous shipping industry. In general, there many challenges facing the adoption of autonomous ships such as:

Liability and Responsibility: As autonomous ships operate without human intervention, establishing liability in case of accidents or incidents becomes a multifaceted issue. Traditional maritime law frameworks are not assisted to address these scenarios (IMO, 2020). The International Maritime Organization is working on the legal implications of autonomous shipping, including liability concerns to provide a global regulatory framework (IMO, 2020).

Cybersecurity: Autonomous ships rely on digital systems and connectivity, making them susceptible to cyber threats. Khan conducted comprehensive studies on the cybersecurity risks faced by autonomous ships, shedding light on the challenges and potential solutions (khan et al., 2023).

International Harmonization: The global nature of maritime trade demands harmonized regulations. Achieving consensus among various nations on regulatory matters is essential to ensure smooth international operations (IMO, 2020). The IMO is at the forefront of these efforts, striving to establish uniform international regulations for autonomous ships (IMO, 2020).

Environmental Regulations: Autonomous ships need to comply with environmental standards, such as reduction of emissions and adopting eco-friendly technologies examined the environmental impacts and challenges of digitalization in maritime transport for sustainable practices [https://doi.org/10.1016/j.oceaneng.2023.114420].

Recognition and Acceptance: Autonomous systems on ships need to be recognized and accepted by port authorities and other vessels. Also, the integration into existing maritime protocols is vital for the industry's progress (IMO, 2020). Kim explored the impact of autonomous shipping on regulations, technologies, and industries.

There are numerous challenges associated with the use of autonomous ships such as technology, safety, regulation, ethics, and the environment. These challenges require collaborative efforts, international cooperation, and innovation to ensure the successful integration of autonomous ships into the maritime industry.

Conclusion

The current paper has explored the benefits of autonomous ships to sustainability within the innovative value creation added to the dimensions of sustainability such as economic, social, environment, and technological. In addition, the paper has analyzed the cybersecurity risks of autonomous ships and detected the main challenges.

The main findings of the study highlighted the importance of both sustainability and cybersecurity in the era of autonomous shipping. Autonomous ships hold significant potential for sustainable value creation in the maritime industry. It offers the opportunity to optimize routes, reduce fuel consumption, and minimize emissions. These advancements align with global efforts to combat climate change and reduce the environmental footprint of the shipping sector. In addition, the economic benefits and efficiency improvements are reinvested in sustainable initiatives. However, cybersecurity challenges defined by the rise of cyber threats present a significant concern. The complexity of autonomous systems, the reliance on communication networks, and the potential vulnerabilities make autonomous ships susceptible to cyberattacks. Also, the security and resilience of these vessels to avoid operational disruptions, safety hazards, and environmental disasters.

The study has concluded that the matching sustainability and cybersecurity is the key to a successful future for autonomous ships. In conclusion, the autonomous shipping era holds immense promise in terms of sustainability and economic efficiency. The industry’s stakeholders, from shipbuilders to regulatory bodies, need to make an equilibrium between benefits and cybersecurity risks.