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SWOT Analysis for Assessing Autonomous Shipping's Viability using Literature: A Review Study

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Abstract

This study evaluates the feasibility of autonomous shipping by employing a SWOT analysis, drawing insights from reviews of relevant literature from 2018 to the present. The field of autonomous shipping necessitates critically examining its potential, and this study seeks to contribute to this discourse. The study uses the SWOT analysis framework to assess this transformative technology's intrinsic strengths, weaknesses, opportunities, and threats. As discerned through our analysis, the strengths of autonomous shipping are manifold. They include the promise of heightened cost-efficiency and improved safety and security measures. These positive attributes stem from optimizing operational processes, streamlining crew requirements, and integrating advanced collision avoidance capabilities. However, the viability of autonomous shipping is contingent upon addressing several technological challenges. Notably, issues surrounding the development of robust automation systems, establishing reliable communication infrastructure, and formulating comprehensive navigation protocols emerge as prominent areas for improvement. Moreover, the analysis underscores the significance of overcoming substantial upfront costs to address financial feasibility and market adoption concerns. Despite these challenges, the study identifies compelling opportunities for autonomous shipping, driven by the escalating volumes of global trade and a growing acceptance of automation. The potential for further expansion is contingent upon regulatory alignments and the establishment of robust international protocols. Simultaneously, the study recognizes critical threats to adopting autonomous shipping, encompassing vulnerabilities to cyberattacks, piracy, societal anxieties about job displacement and ethical considerations. To contextualize and enrich these findings, we conduct a bibliometric analysis of pertinent literature published from 2018 to the present, providing valuable insights into research trends and thematic focal points.

Keywords
Autonomous shipping, Unmanned vessels, SWOT analysis, Review, Maritime innovation

1. Introduction
The maritime sector is the engine powering the vital flow of global commerce across continents. Its paramount importance is underscored by its responsibility for transporting 90% of the world's goods by volume. In 2020 alone,

the monetary worth of maritime trade reached an extraordinary US$15 trillion, serving as a testament to the industry's pivotal function in facilitating the exchange of resources and finished goods among nations. The immense volume of commodities conveyed via maritime routes vividly portrays the sector's magnitude. In 2020, global maritime trade reached 11.1 billion tons, exhibiting a consistent upward trajectory over the preceding years. This translates to a substantial per capita tonnage of 1.44 tons, illustrating maritime activities' indispensable role in connecting various stakeholders across continents (Ghaderi, 2019).

The maritime transport industry has witnessed transformative changes in the past two decades, with a pronounced inclination towards embracing technology in various facets (Pinto et al., 2015). Factors such as heightened competition, evolving customer expectations, safety and operational standards compliance, and integration with interfacing systems have driven this evolution. As intelligent vehicles, including autonomous cars and flying drones, increasingly permeate commercial and societal scenarios, marine agents capable of autonomous navigation have been a research focus for the past 50 years (Bibuli et al., 2018). Initially driven by military goals, the application of intelligent marine agents has shifted towards civilian use, particularly in environmental sampling, data-gathering operations, and intervention scenarios. The maritime industry is now at the cusp of a digital age, poised to undergo transformative changes by adopting autonomous systems (Chan et al., 2023; Bibuli et al., 2020). The International Maritime Organization (IMO) is actively involved in regulatory scoping exercises and the establishment of the Maritime Autonomous Surface Ships (MASS) working group, reflecting the industry's preparation for the integration of autonomy. Meanwhile, "Yara Birkeland", the world's inaugural fully electric and autonomous ship, is operational in Norway, revolutionizing maritime transportation by fully automated fertilizer delivery between ports (Rødseth et al., 2023).

MASS refer to vessels capable of operating independently to varying degrees without direct human interaction, as defined by the IMO in 2018. The IMO presents four degrees of autonomy:

1. Crewed ships with automated processes and decision support systems (DSS)
2. Remotely controlled ships with seafarers on board
3. Remotely controlled ships without seafarers on board
4. Fully autonomous ships

As vessels with any level of autonomy can fall under the MASS category, and MASS may transition between different degrees of autonomy during a single voyage, it is beneficial to distinguish two primary facets of autonomous shipping development: the level of onboard manning and the degree of autonomy or independence from human operation (Tsvetkova & Hellström, 2022). Figure 1 (Source: Ringbom, 2019) shows the distinction between where a MASS can be placed according to its operation and the level of human interaction in the operation process.

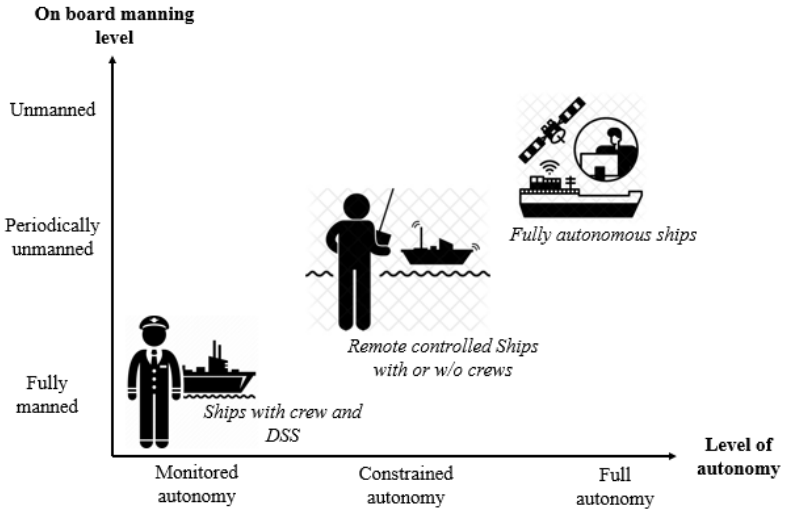

Figure 1. Levels of autonomy and onboard manning for MASS

1.1 SWOT Analysis

Developed by Albert Humphrey in the 1960s, the SWOT analysis framework is a robust tool for strategic planning within organizational contexts. This methodology systematically examines both internal and external factors, facilitating the evaluation of an entity's Strengths (S) and Weaknesses (W) in conjunction with Opportunities (O) and Threats (T). By engaging in this methodical assessment, practitioners gain a nuanced perspective on their internal capabilities and the external environment they navigate (Raouf et al., 2021). The essence of SWOT analysis lies in its ability to promote a comprehensive approach to strategic planning, advocating for a balanced and fact-based perspective on an organization's standing. This approach guides entities in optimizing their strengths, addressing weaknesses, capitalizing on available opportunities, and proactively managing potential threats. The resulting holistic understanding serves as a foundation for informed decision-making, enhancing agility within the dynamic landscape of strategic planning.

1.2 Objectives of the Study

The objectives of this study are to employ a combined approach of SWOT analysis and bibliometrics analysis to systematically evaluate the viability of autonomous shipping. It will evaluate the internal strengths and weaknesses, as well as external opportunities and threats of autonomous shipping. Additionally, the study will map research trends and identify knowledge gaps in the field from 2018 onwards. This multifaceted approach aims to offer insights into the current landscape of autonomous shipping, enabling informed decision-making and strategic planning within the maritime industry.

This section provides an overview of the study's structure. Section 2 explains the methodological foundations of the literature review, including search parameters and data extraction procedures. Section 3 presents the combined findings of the bibliometric and SWOT analyses. The bibliometric analysis quantitatively evaluates research trends and knowledge themes in relevant publications, while the SWOT analysis synthesizes insights from the literature, highlighting strengths, weaknesses, opportunities, and threats in autonomous shipping. Finally, Section 4 offers a conclusion, summarizing key findings and identifying research gaps, providing insights for future scholarly inquiry.

2. Research Methodology

This study employed a research methodology to explore the dynamic domain of autonomous shipping and associated technologies. A diverse set of keywords, such as "autonomous shipping," "unmanned vessels," "Maritime Autonomous Surface Ships (MASS)," "underwater automated vessels," "automated marine vehicles," "marine drone," and "Naval UAV," was meticulously chosen to capture relevant publications spanning from 2018 to the present. The study, focusing exclusively on English-language papers, utilized the visual capabilities of VOSviewer and Biblioshiny software. These tools facilitated the exploration of latent structures within the field by generating co-occurrence networks, thematic maps, and temporal maps. This approach revealed prominent research trends and potential knowledge themes. In conjunction with this quantitative analysis, a qualitative SWOT approach was adopted to dissect the content of identified publications. Systematically, this study discerned inherent strengths, weaknesses, opportunities, and threats related to autonomous shipping. This dual-method strategy, integrating quantitative and qualitative insights, yielded a comprehensive and nuanced understanding of the research landscape and pivotal factors influencing the trajectory of this transformative technology within the maritime sector. Table 1 shows the keywords used and inclusion and exclusion criteria in the literature search.

Table 1. Search query, inclusion & exclusion criteria

	Search Query
Keywords	"autonomous shipping" OR "unmanned vessels" OR "Maritime Autonomous Surface Ships" OR
	"underwater automated vessels" OR "automated marine vehicles" OR
	"marine drone" OR "Naval UAV"
Time period	2018 to present
Language	English

3. Results and Analysis

This section delves into the results of the bibliometric analysis, presenting thematic clusters, knowledge gaps, and research trends extracted from the reviewed publications. It then proceeds to synthesize insights gleaned through the SWOT analysis from the surveyed publications.

3.1 Bibliometric Analysis

This keyword co-occurrence network (Figure 2) visualization provides an insightful overview of the contemporary research landscape in autonomous shipping, a field poised for substantial transformation. Through analyzing keyword co-occurrence within pertinent publications, this approach identifies central thematic clusters, prevailing research trends, and potential knowledge gaps warranting further investigation.

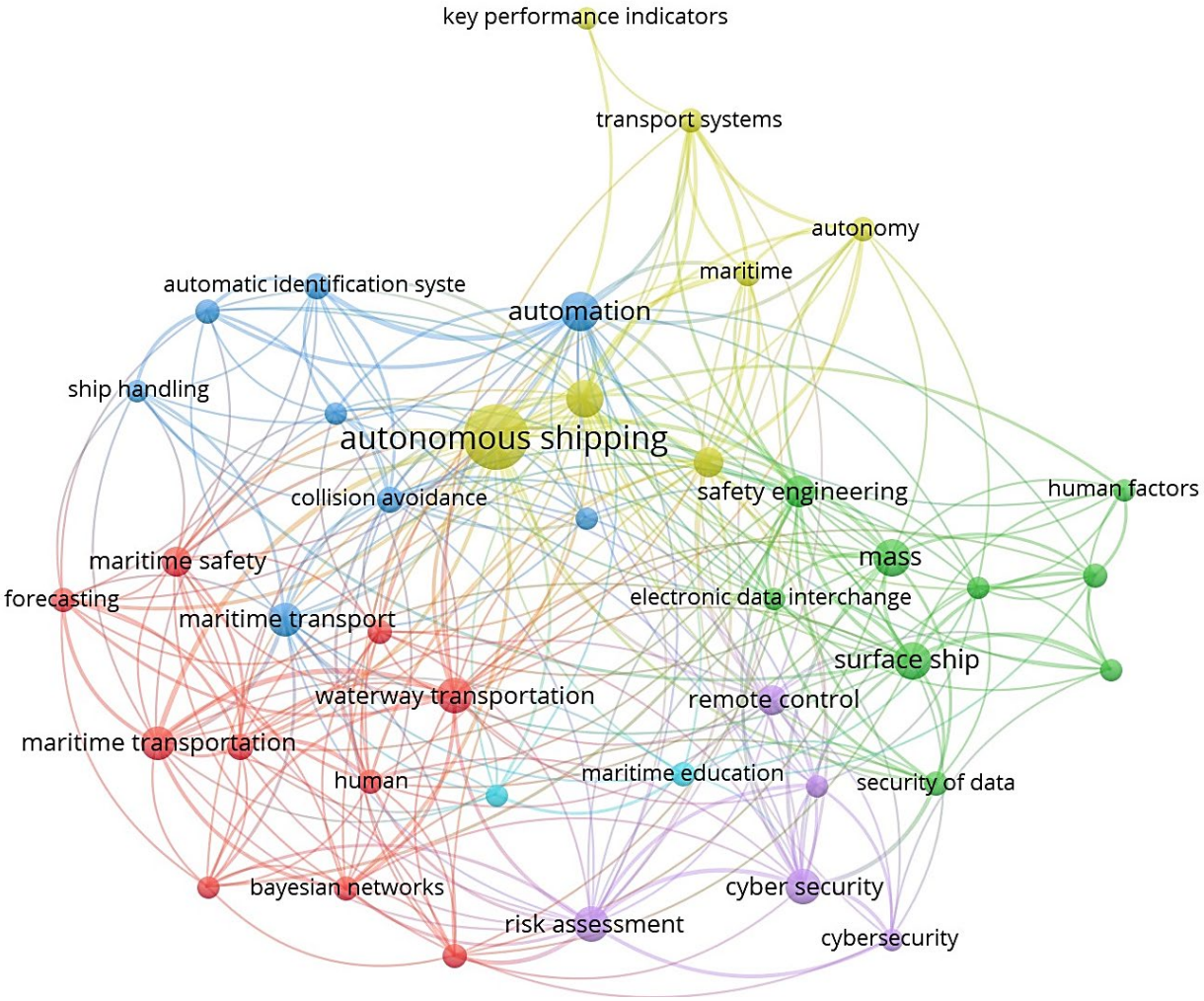

Figure 2. Co-occurrence network for surveyed publications

Five discernible clusters, characterized by distinct thematic concentrations, have emerged from this analysis: yellow, green, purple, blue, and red. The yellow cluster, occupying a central position, interconnects with multiple thematic areas, suggesting a pivotal role as a bridging entity. Within the green cluster, a noteworthy interplay exists with the purple cluster, unveiling intersections between human factors, safety engineering, and cybersecurity. Simultaneously, the red cluster establishes connections with the blue and purple clusters, delineating maritime safety, waterway transportation, automation, and risk assessment interdependencies. This co-occurrence network intricately portrays the interdisciplinary essence of the field, underscoring the necessity of a comprehensive approach that incorporates technological advancements, safety considerations, and human factors in the deployment of autonomous shipping systems.

Central Clusters:

At the network's nucleus, pivotal clusters emerge, encapsulating themes critical to the progression of autonomous shipping. These encompass:

I. Technology and Systems: Noteworthy keywords such as "collision avoidance," "automatic identification system," and "safety engineering" underscore the emphasis on developing resilient, automated systems and intelligent navigation protocols.
II. Safety and Security: Keywords including "cybersecurity," "risk assessment," and "maritime education" underscore the paramount importance of ensuring the safety and security of operations within this emerging domain.
III. Economic and Societal Impact: The co-occurrence of terms such as "key performance indicators," "forecasting," and "human factors" reveals ongoing deliberations regarding the economic and societal ramifications associated with the widespread adoption of autonomous shipping.

Bridging Clusters:
The intricate web of connections within the network highlights the interconnected nature of diverse research areas. For instance, the connection between "collision avoidance" and "electronic data interchange" emphasizes the critical reliance of effective collision prevention systems on accurate and comprehensive sensor data. Similarly, the linkage between "maritime education" and "risk assessment" underscores the imperative for robust legal frameworks to address liability concerns and facilitate the seamless economic integration of autonomous vessels.

Figure 3 presents a Sankey diagram developed to depict the thematic evolution observed in the surveyed publications, with arrow thickness reflecting the relative volume of research within each domain. The diagram captures the evolving research landscape in autonomous shipping. Notably, a pronounced shift is observed from a focus on navigation and collision avoidance in 2017-2018 to an intensified emphasis on shipping automation and risk assessment in the subsequent period of 2023-2024. The breakdown reveals that initial research centred on fundamental technologies, including navigation and collision avoidance, expanding to encompass safety, automation, risk assessment, and numerical modelling in the later years.

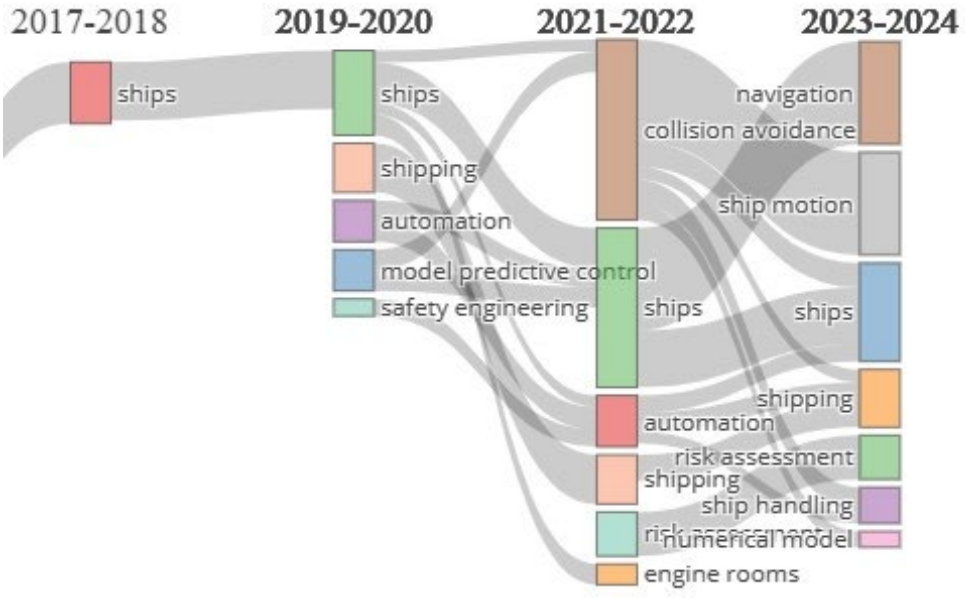

Figure 3. Sankey diagram illustrating thematic shifts in surveyed publications on autonomous shipping (2018-present)

Figure 4 shows the thematic map of surveyed autonomous shipping publications, revealing vital research themes and their significance. The map visually represents themes through circle size (density) and position (centrality). A larger circle means that there has been more research on that theme. Centrality is shown by the position of the circle on the map. Circles closer to the map's centre are more significant to the field of autonomous shipping. The map employs a nuanced representation with four quadrants defined by relevance degree along the x-axis and development degree along the y-axis.

The first quadrant delineates emerging or declining themes, including keywords such as maritime traffic, maritime education, personnel training, IoT, and maritime communication. IoT and marine communication keywords positioned higher in the quadrant show their evolving importance or waning emphasis within the field. The second quadrant, housing basic themes, incorporates keywords like ships, surface ships, and risk assessment, reflecting foundational concepts that persist as cornerstones of autonomous shipping research. The third quadrant, dedicated to motor themes, prominently features keywords like automation, unmanned surface vehicles, collision avoidance, and trajectories, underscoring the discipline's dynamic and active areas of exploration. Meanwhile, the fourth quadrant, reserved for niche themes, accommodates keywords such as data security, blockchain, and electronic data interchange, indicating specialized and cutting-edge aspects of research.

Noteworthy is the central positioning of specific keywords—maritime autonomous surface ships, benchmarking, and key performance indicators—indicating their overarching relevance across all thematic dimensions. This spatial arrangement underscores the interdisciplinary nature of these central themes, serving as focal points in the autonomous shipping research landscape. The larger circle sizes of these central themes denote a higher density of research attention, emphasizing their significance in the field. The emergence of themes such as blockchain, risk assessment, and social/ethical issues, juxtaposed with declining emphasis on personnel training and regulation, further illuminates the dynamic shifts within autonomous shipping research. Beyond being a descriptive visualization, this bibliometric analysis tool offers a strategic perspective, guiding future research trajectories by identifying key themes and discerning trends within the autonomous shipping domain. Researchers and practitioners can leverage this information to prioritize areas of development and align their efforts with the evolving landscape of autonomous shipping research.

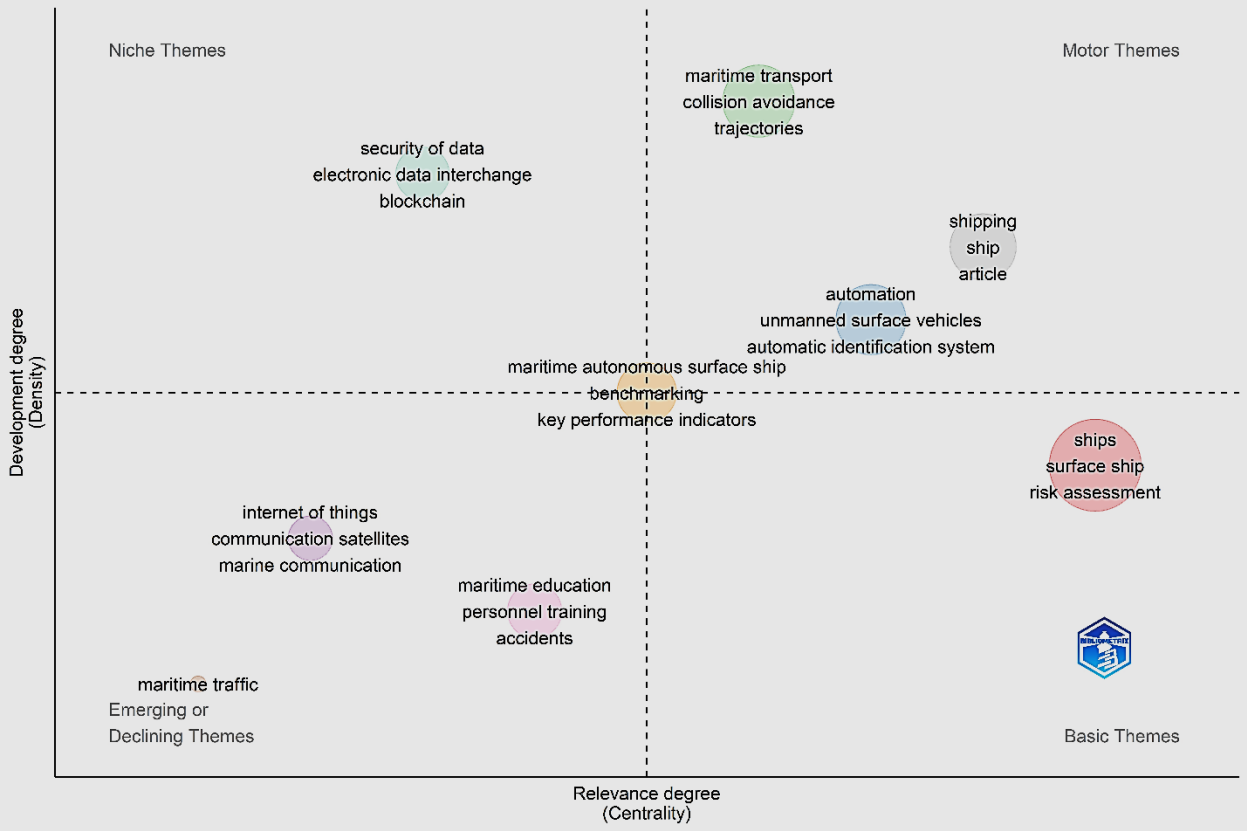

Figure 4. Thematic Map of Autonomous Shipping Research studies (2018 - present)

3.2 SWOT Analysis of Autonomous Shipping: Insights from Surveyed Publications

This section presents an analysis of autonomous shipping based on a survey of relevant publications utilizing a SWOT framework. Figure 5 provides a visual summary of these factors, offering a high-level overview of the current technological landscape. However, a more detailed examination of the literature reveals a nuanced and multifaceted

perspective, encompassing the intricate interplay between technological advantages, operational challenges, market potential, and societal concerns.

A. Strengths

1. Cost minimization

Autonomous shipping presents a distinctive advantage in cost optimization, primarily attributable to the absence of human crew members. The mitigation of crew-related expenses, notably crew wages, often the most substantial constituent of voyage expenditure, constitutes a pivotal factor in achieving cost minimization (Ghaderi et al., 2019). Eliminating on-board personnel obviates the necessity for infrastructure such as the bridge, crew accommodations, and crew utility facilities. This absence further precludes associated costs related to heating, freshwater provisioning, and storage for perishable goods (Tsvetkova & Hellström, 2022).

Additionally, cost reduction is realized through diminished maintenance expenses incurred by autonomous vessels. The real-time monitoring capabilities and the implementation of predictive maintenance protocols inherent to autonomous ships contribute to a notable decrease in overall maintenance costs (Le Diagon et al., 2019). Furthermore, reducing susceptibility to collisions (Bačkalov et al., 2023) and eliminating human hostage scenarios during pirate attacks may result in a commensurate reduction in insurance expenditures. This collective suite of cost-saving mechanisms underscores the economic efficacy of autonomous shipping within the maritime domain.

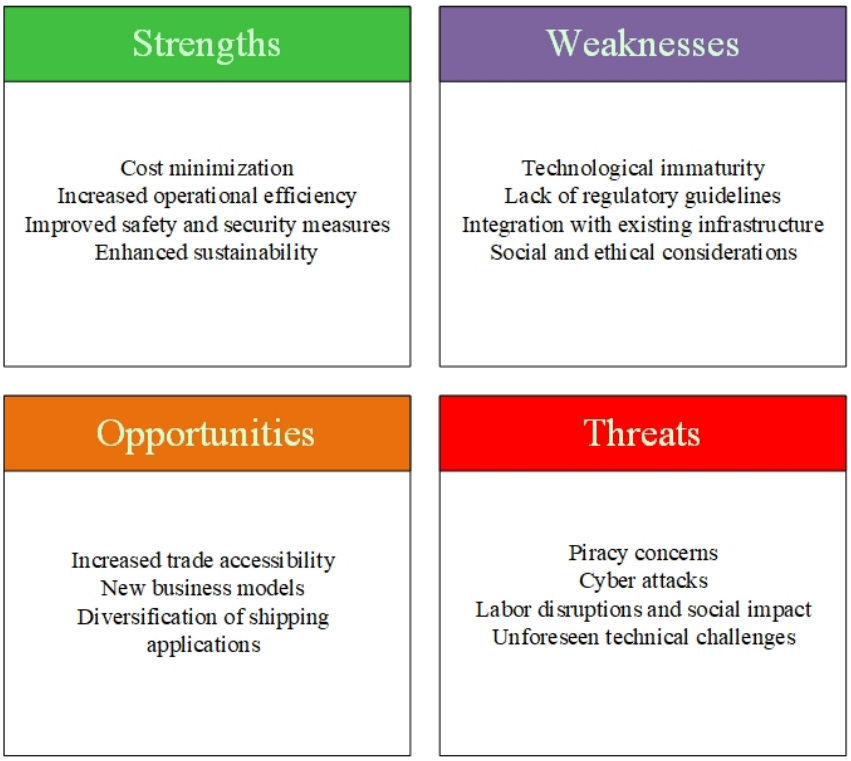

Figure 5. An overview of SWOT analysis of autonomous shipping

2. Increased operational efficiency

Operational efficiency within autonomous shipping is realized through multifaceted mechanisms. Prominent contributors to heightened efficiency encompass voyage optimization, optimized cargo storage strategies, and augmented navigation capabilities. Voyage optimization manifests in formulating optimal route plans, culminating in improved fuel efficiency and diminished turnaround durations (Hu et al., 2023). Concurrently, optimized cargo storage plans facilitate the maximized utilization of cargo hatch spaces, thereby mitigating unit carrying costs.

The augmented navigational capabilities inherent in autonomous vessels empower seamless engagement in loading, unloading, anchoring, and berthing activities with heightened efficiency within compressed time frames (Herremans et al., 2023; Zhang et al., 2023). This confluence of voyage optimization, cargo storage optimization, and advanced navigation functionalities establishes a comprehensive framework for achieving operational efficiency in autonomous shipping.

3. Improved safety and security measures
Enhancements in the safety and security paradigm of autonomous shipping are substantiated through diverse mechanisms. Integrating in-built safety engineering systems and sensor fusion technologies imparts a heightened resilience against collisions and accidents (Jovanović et al., 2023). The reduced reliance on human intervention in navigational operations further diminishes the likelihood of accidents (Bačkalov et al., 2023) .

The absence or reduction of onboard crew contributes significantly to overall crew safety, particularly in perilous contexts such as bulk carriers for oil, crude tankers, and gas tankers. This is attributed to mitigating potential risks associated with human presence in hazardous operational environments. Additionally, implementing predictive maintenance protocols is a proactive measure, substantially minimizing the probability of onboard equipment failures during voyages. Collectively, these strategies converge to establish a robust framework for ensuring the improved safety and security of both autonomous ships and their crew (Tsvetkova & Hellström, 2022).

4. Enhanced sustainability
The attainment of sustainability objectives in maritime transportation is contingent upon advancements in fuel consumption efficiency. The prevailing marine fuel, characterized by high pollutant emissions encompassing CO2, greenhouse gases (GHG), and particulate matter, ranks among the least environmentally friendly combustion technologies in the transportation sector (Liu et al., 2022; Liu et al., 2021). Enhancements in fuel consumption efficiency are pivotal for mitigating emissions, thereby ameliorating the environmental impact. Furthermore, autonomous shipping exhibits adept capabilities in averting environmental hazards, exemplified by its capacity to prevent incidents such as oil spills while concurrently exerting control over noise pollution (Marine, 2018).

Autonomous shipping technologies play a crucial role in this context by facilitating the recording and monitoring of emissions. This capability aligns with the International Maritime Organization's (IMO) endeavours to implement a pollutant pay tax. The systematic measurement and documentation of emissions contribute to environmental stewardship and provide a tangible means to address and regulate pollutant outputs within the maritime domain (Falari et al., 2022). Consequently, integrating autonomous shipping technologies is a strategic enabler for achieving sustainability goals by concurrently optimizing fuel consumption and aligning with international regulatory frameworks.

B. Weaknesses
1. Technological immaturity and Integration with existing infrastructure
A primary obstacle to the widespread adoption of autonomous shipping is the technological immaturity observed in current developments. Notably, the existing technological framework must still attain the requisite maturity to support the seamless integration of fully automated vessels into operational contexts. Moreover, uncertainties persist regarding how extant shipbuilding entities and dockyards intend to assimilate their technologies with those inherent to autonomous ships (Kurt & Aymelek, 2022)). Integrating autonomous shipping technologies with established shipbuilding practices poses a substantial challenge, necessitating further elucidation.

Similarly, integrating automated ships with port operations introduces a host of unresolved inquiries. The procedural intricacies of harmonizing port activities with the nuanced functionalities of autonomous vessels constitute an additional dimension of uncertainty. Paramount among these uncertainties is the overarching question of technological readiness and the concomitant challenges associated with integrating autonomous shipping technologies into complementary service industries (Bogusławski et al., 2022). Addressing these pivotal concerns is imperative for comprehensively realizing autonomous shipping on a broader scale.

2. Lack of regulatory guidelines, Social and ethical considerations
Presently, the IMO's Maritime Safety Committee (MSC) is formulating guidelines pertaining to autonomous shipping, delineating distinct levels of autonomy. Nevertheless, implementing these evolving protocols is anticipated to necessitate a substantial timeframe (Xing & Zhu, 2023). Concurrently, the Maritime Labour Convention (MLC), a

foundational component of maritime governance, is actively addressing social and ethical dimensions associated with autonomous ships. This endeavour reflects a conscientious examination of issues pertinent to seafarers' job safety and welfare within the context of emerging autonomous maritime technologies.

C. Opportunities

1. Increased trade accessibility and new business models

The advent of autonomous shipping has instigated transformative shifts within existing business ecosystems, thereby facilitating the emergence of novel market opportunities. This technological paradigm has engendered the establishment of innovative business models, reshaping the landscape of the maritime industry. The application of autonomous technologies has expanded the boundaries of navigable waters and introduced the prospect of accessing hitherto uncharted territories (Tsvetkova & Hellström, 2022).

An illustrative example of this transformative potential is the feasibility of navigating polar regions using autonomous ships. The utilization of autonomous technologies can render previously impassable waters accessible, thereby opening up unprecedented avenues for exploration and commercial activities in polar environments. This paradigm shift underscores the far-reaching implications of autonomous shipping on maritime business dynamics, delineating a trajectory toward unexplored markets and redefined operational frameworks.

2. Diversification of shipping applications

Autonomous shipping has expanded its applications within the maritime domain, notably demonstrated in projects such as the Polar Lander initiative, which involves the development of an autonomous surface vessel dedicated to scientific research in the Arctic. This project is oriented explicitly towards advancing oceanographic studies and seafloor mapping. The MASS in Ice Project, a research initiative, explores the complexities and potential of employing autonomous ships in polar environments (Schubert et al., 2018). These initiatives exemplify the diverse and specialized applications of autonomous shipping technologies in advancing scientific research and operational capabilities within the maritime sector.

D. Threats

1. Cyber-attacks and piracy concerns

In autonomous shipping, the susceptibility to pirate attacks persists, contingent upon the level of autonomy implemented. The potential for pirate takeover remains a concern, notwithstanding the absence or reduction of on-board crew. Additionally, autonomous ships confront a significant peril in cyber-attacks, wherein malicious actors may exploit vulnerabilities to commandeer vessels remotely, either for ransom demands or to inflict substantial damage. The imperative role of robust cyber security measures emerges as a critical component within autonomous shipping, underscoring the necessity for comprehensive safeguards against physical and virtual threats (Wang et al., 2023).

2. Labour disruptions and social impact

As per the International Transport Workers' Federation (ITF), the global maritime sector employs 2.1 million seafarers. This figure encompasses direct employees, with a consequential impact on millions of indirect employees who support this demographic. The transition towards autonomous shipping, characterized by diminished crew requirements, has the potential to induce apprehension within the job market (Issa et al., 2022). This prospect may precipitate social concerns related to job insecurity, thereby warranting careful consideration of the broader societal implications of implementing autonomous shipping technologies (Das & Arya, 2023).

3. Unforeseen technical challenges

The absence of large-scale, fully automated ships in contemporary operational contexts raises a pertinent inquiry regarding the potential consequences of an unforeseen technical issue. Despite the completion of simulation studies and experimental stages, the prospect of encountering an unexpected technical glitch while navigating the open sea remains a plausible concern (Ziajka-Poznańska& Montewka, 2021). This consideration underscores the need to comprehensively understand the potential risks and challenges of deploying fully automated maritime systems in real-world scenarios.

4. Conclusion

The holistic exploration of autonomous shipping viability reveals a landscape brimming with transformative potential and intricate challenges. The overarching vision of autonomous shipping encompasses a paradigm shift toward cost-efficient, operationally streamlined, and environmentally sustainable maritime practices. However, technological

immaturity, integration complexities, and a regulatory landscape in flux currently hinder this aspirational future. The broad opportunities presented include expanded trade horizons and innovative business models. However, these are juxtaposed against looming threats such as cyber-attacks, piracy, labour market disruptions, and unforeseen technical obstacles. Navigating this evolving frontier necessitates a concerted, collaborative effort from stakeholders to not only capitalize on the transformative strengths of autonomous shipping but also address and mitigate the multifaceted challenges, ensuring a future where autonomous technologies seamlessly integrate into the fabric of the maritime industry.

In addition to the ongoing avenues of research delving into the technological aspects of autonomous shipping, a compelling need exists for concurrent exploration of critical dimensions that extend beyond the technical realm. Specifically, research endeavours should emphasize the development of robust regulatory frameworks to govern the integration of autonomous vessels into existing maritime infrastructures. Moreover, attention should be directed towards in-depth investigations into the social and ethical considerations surrounding the implementation of autonomous shipping technologies, acknowledging potential labour market disruptions and societal apprehensions related to job displacement.

Furthermore, an essential but often overlooked aspect involves researching the protocols and procedures in post-mortem situations, particularly vessel hijacking or under-attack scenarios. Understanding and formulating comprehensive strategies for handling these exigencies is imperative, encompassing the delineation of responsibilities, legal frameworks, and ethical considerations in the aftermath of such incidents. This facet of research becomes crucial not only for the safeguarding of valuable cargo but also for addressing potential threats to crew safety and the maritime environment. Thus, while technological innovation remains at the forefront, it is equally vital to broaden research horizons to encompass regulatory, social, and ethical dimensions and contingency planning for unforeseen events in the evolving landscape of autonomous shipping.

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Biographies

Laoucine Kerbache is currently serving as a Full Professor and a founding faculty member of the Engineering Management and Decision Sciences Division at Hamad Bin Khalifa University in Doha, Qatar. Further, he has been Full Professor of Operations and Supply Chain Management at HEC Paris in France for the last twenty-two years. During this tenure period, beside managing many international academic programs, he has also served as Associate Dean of the HEC Paris PhD Program (5 years) and then as Dean and CEO at HEC Paris Qatar (4 years). For over thirty years of academic, research, and consulting activities, he has been very active in his areas of expertise, Operations and Supply Chain Management. He has published over 120 papers in international journals and has been guest speakers at numerous international events. He holds a PhD, an MSc, and a BSc in Industrial Engineering and Operations Research (IEOR) from the Mechanical and Industrial Engineering Department, University of Massachusetts, Amherst, USA. Further, he has an “Habilitation to Direct Research (HDR)” from the University of Nantes (France) and a certification from the “International Teachers Program” from IMD Lausanne (Switzerland).

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