Digital Intelligence Technology Drives Sustainable Change in Shipping: Concepts, Applications, and Prospects

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Abstract. Shipping sustainability refers to the long-term adaptive development of the shipping industry, which involves a series of industries related to the shipping industry. Achieving sustainable development is an essential issue in the modern shipping field. At the same time, the world is undergoing digitalization. From the perspective of successful cases in other industries, the sustainability of shipping is inseparable from the support of digital intelligence. There are already many theories about digital intelligence in shipping at home and abroad, but there need to be more practical results. This article uses the review method to define the sustainability of shipping from the perspective of ships and ports. Combing the pieces in the five aspects of shipping lanes, services, and supervision and analyzing how digital and intelligent technologies can ensure the sustainable development of shipping and internal connections. This paper strengthens the relationship between studies and provides theoretical support for the digital transformation of the shipping industry to achieve sustainable development.

Keywords: Intelligent Shipping · Sustainable Shipping · Green Shipping

1 Introduction

The shipping industry is an essential foundation for developing world trade and a vital link for economic exchanges between countries. According to statistics, more than 90% of trade goods are transported by water to achieve global circulation. The development of ocean transportation can improve a country's economic structure and increase foreign exchange; it can also optimize and update the export commodity structure and industrial structure. In the 21st century, all countries attach great importance to the development of the shipping industry. But from the current point of view, shipping is still far from ideal, and there are still problems such as economic crisis, environmental issues, sustainability, talent shortage, and a low degree of digitalization. It cannot achieve long-term stable development. The external demand increases as the world are involved in the digital and intelligent transformation wave. The digital and intellectual transformation of the shipping industry can be regarded as a passive reform. The digital and intelligent transformation of the shipping industry has become current. The focus of this issue is

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that digital intelligence will empower various aspects of shipping and effectively ensure the sustainable development of the shipping industry. Therefore, this article will analyze the problem of how digital intelligence technology can support the sustainable and stable development of the shipping industry. The analysis and summary of the current digital intelligence technology will deeply explore the internal logic between the two. How to comprehensively improve the degree of informatization in the shipping industry provides a theoretical basis for future research.

This study utilizes databases such as cnki.net and Google Scholar, including Chinese and English journals. The search criteria include keywords such as intelligent shipping, sustainable shipping, green ships, and smart waterways, and select the mainstream research results from the past 5–10 years to summarize. Firstly, we define sustainability in the shipping industry and then sort out advanced representative achievements from the five leading players in the industry to deeply understand the internal relationship between digital intelligence research results and sustainability.

2 Definition of Sustainable Shipping

Traditionally, sustainability has been defined as the planning and management of future resources while meeting the needs of the present without jeopardizing the ability of future generations to meet their own needs. But, it involves developing human society within the limits of the environment and available resources. Sustainability encompasses various aspects, including politics, economy, nature, and technology, and as a result, researchers have differing perspectives on it, leading to different definitions. As a service industry and a vital link in the supply chain, the shipping industry comprises ships and shore-based facilities, channel construction, and maritime laws. Consequently, the definition of sustainable shipping can be divided into narrow and broad categories.

From a narrow perspective, sustainable shipping means engaging in activities with low energy consumption and pollution, combining energy conservation and environmental protection with the shipping industry, which we often call green shipping. Feng concluded that green shipping is a shipping management system based on sustainable development, which has the characteristics of environmental symbiosis [1]. It highlights the concept of harmonious coexistence with the natural environment. It reduces the damage to the environment and the waste of resources in shipping, benefiting the sustainable development of the whole society. But from a broad perspective, sustainable shipping includes the sustainability of technology, industry, policy, market, and trade and realizes shipping in an all-around way—sustainable development of business. Fan, the vice president of the China Classification Society), also pointed out that learning sustainable shipping requires multi-industry cooperation [2]. To connect the upstream and downstream of the industrial chain, we must propose maritime regulations and ship regulations that meet the current shipping market. Strengthening ties with related companies, improving energy renewal and ship upgrades service levels, and financing services are also necessary.

Based on the above analysis, this paper believes that the sustainability of shipping refers to the adaptive adjustment, innovation, and optimization of internal factors, such as ships, ports, and waterways. External factors, such as services and supervision, solve

the problems caused by the external environment and Problems caused by changes in internal conditions and has the ability for sustainable development.

3 The Support of Digital and Intelligent Technology for the Sustainable Development of Shipping

3.1 Smart Ships

The intelligent ship combines computer technology with the boat itself. This is achieved through ship networking, extensive data analysis, and satellite navigation technology. Ship sensors gather information on the ship's parameters and environmental data, which are then transmitted to a central processing system. After analysis by system control software, the output provides all kinds of information and instructions that enable the informatization and intelligence of ship navigation. The current hotspots in smart ship research include unmanned driving, virtual simulation, and remote control. Realizing ship intelligence is a fundamental requirement for achieving digital intelligence in the shipping industry, making it a key research field for scholars today. Intelligence is the foundation of ship intelligence.

In terms of perception, traditional ships use radar, AIS, sonar, and electronic charts to obtain information on the surrounding environment. While these methods have gradually become more intelligent, they still require driver intervention. Recently, virtual testing technology has matured, leading to the design of intelligent ship perception test systems, such as the one developed by Zhu [3]. This system uses virtual reality interaction to promote the combination of artificial intelligence and ships effectively. It can also test the perception capabilities of ships in various situations at low cost, providing data and a basic system framework for the construction of the entire ship's autonomous perception platform.

Recent developments in ship control systems have allowed for autonomous navigation and sailing without manual operation, but achieving a truly uncrewed ship is still a work in progress. Algorithm research has led to many algorithm models that can enable ships to drive autonomously in complex environments. For example, Li designed an adaptive algorithm based on event-triggered course logic switching of uncrewed vessels, which ensures the control's reliability and reduces the frequency of signals sent during operation [4].

Machine learning algorithms have been applied to ship energy consumption management to optimize the energy efficiency of ships and reduce energy consumption. Wang integrated the data of the ship's primary sensors and used several machine learning algorithms to analyze them, finding that they could realize intelligent prediction of ship energy consumption [5]. BEŞIKÇI developed a ship operation decision support system using artificial neural networks to output ship fuel consumption and help decision makers plan energy usage rationally [6].

These advancements in smart ship technology help ships reduce operating costs, emissions, and efficiency, effectively enhancing the sustainability of ship navigation.

3.2 Smart Port

Ports are important transportation hubs for shipping, carrying the functions of cargo loading and unloading, ship berthing, material replenishment, and passenger loading and unloading. Therefore, the intelligentization of ports largely determines the intelligent transformation process of the entire shipping industry. However, the current development model of the port still needs to be more robust and rough. The local government has established many shore-based facilities to stimulate the economy. With the establishment of too many oil and gas warehouses, the potential oil spill risk will increase significantly, seriously threatening the port area's ecological safety. Therefore, the sustainable transformation of the port area is of great importance to the entire shipping industry. Significance.

Regarding infrastructure, the energy demand has greatly increased with the proliferation of port construction. The round-the-clock operation of ports has resulted in substantial power loss for conventional power equipment. To address this issue, the State Grid Zhejiang Electric Power Company has initiated the Shanshan Smart Port Shore Power Replacement Demonstration Project, which involves the installation of active power filters (APF) and a new type of transformer for low-voltage reactive power compensation device, transforming the shore power berths in the port [7]. Ships can be supplied power through aviation plugs, enabling efficient and sustainable energy usage.

The stand-alone ship shore power system has the characteristics of replacing oil with electricity and intelligent electricity consumption. Its built-in intelligent monitoring can control other smart devices and realize human-computer interaction, significantly enhancing the device's security. The successful pilot project of this project has demonstrated significance for the construction of port power worldwide. Promoting an intelligent shore power system has significant ecological and economic importance and is an important development in low-carbon transportation.

Regarding information and management, the current hot topic is integrating 5G technology and ports. An intelligent port is the visualization and automation of port information through the network, making reliable network technology a prerequisite for development. The fifth-generation mobile communication technology is characterized by high speed and low latency, which can improve port operation efficiency and provide information support for the development of ports. Dong discussed the application of 5G slicing technology in smart ports and presented the corresponding network capability requirements in three scenarios: AI identification, unmanned truck driving, and indicator detection [8]. The discussion demonstrated that 5G technology could meet the needs of new ports for the network environment, information transmission rate, information dissemination ability, and signal anti-interference ability, playing a vital role in promoting the development of unmanned ports. The application of 5G technology is still in the experimental stage. Once the technology is mature, the information management model can resolve the conflict between low-carbon and large-scale and promote the sustainable operation of ports.

3.3 Smart Channel

With the improvement of shipbuilding technology in recent years, ships tend to be larger, bringing more cargo volume and causing problems such as increased operational difficulty, danger, and crowded waterways. In the context of the ship's navigation, the channel determines whether the vessel can reach the destination safely, and the navigation mark, as the carrier of information transmission in the watercourse, requires the development of high-quality, intelligent, and informatization. Traditional buoys not only have poor accuracy and are prone to failure when water conditions change considerably but also have defects in efficiency, requiring a lot of workforce and material resources to repair and maintain. To improve the safety of ship navigation and the reliability of navigation aids, many scholars have carried out the intelligent transformation of navigation aids, such as Zhu's navigation aid intelligent monitoring system [9]. The sub-communication system and data processing system can accurately collect water depth information and the position of the navigation mark and, at the same time, adjust the position of the navigation mark according to the information output by the server. The system's core is its data acquisition subsystem, which links Beidou satellites with other equipment to form a data acquisition terminal. It establishes a CORS station along the coast, and the navigation mark mobile station receives information and transfers the data through the GPRS/CDMA network. Sent to the data center, its built-in monitoring system can record and output navigation mark information. Such systems can improve the safety factor of waterway navigation, relieve pressure on management and monitor waterway hydrological data to ensure sustainable use of the channel.

3.4 Intelligent Service

The entire shipping industry chain includes shipping, land transportation, warehousing, enterprise, crew training, etc., forming a complete supply chain. Therefore, to achieve sustainable development of the shipping industry, all internal factors must be analyzed by Synergize. Much research has been done in this field in the world. Ioannis G. Koliousis and others analyzed its development and change process based on cluster theory, and Maniati et al. formulated a specific method framework for shipping financing [10, 11]. In China, blockchain technology has been proven to have practical significance for developing the shipping service industry. Blockchain technology stores data in blocks with non-tampering and decentralization characteristics. On this basis, Wang analyzed how to apply blockchain technology to the service model of shipping companies to improve the business collaboration and service capabilities of shipping service companies [12]. From the above studies, it can be seen that the efficiency and data security of the shipping service industry can be effectively guaranteed by putting the service industry into a digitalized environment, and the cooperation between enterprises, countries, and other large entities can be harmonized to make the shipping service industry more personalized.

3.5 Intelligent Supervision

Supervising ships has always been the top priority of relevant government departments. On the one hand, with the increase in the displacement and number of ships, shipping

has always been a significant energy consumer in the transportation field, and illegal sewage discharges often occur; on the other hand, the shipping industry is closely related to different fields and has prominent intermediary characteristics, the entire market is intricate and challenging to manage. As a means for the government to supervise the shipping industry, digital intelligence can comprehensively improve the breadth and depth of supervision. Chen et al. analyzed the status quo of the supervision technology of the shipping system based on inland rivers, pointed out that the dominance of the current supervision system should gradually shift from manual to machine, and proposed an intelligent supervision system based on parallel system theory to enhance the initiative of supervision and comprehensiveness [13]. This system can manage the shipping industry from the ship side, the cargo owner side, the financial segment, and the market size, effectively reducing the pressure on the government. Relevant departments can also obtain a broader regulatory scope and more reasonable solutions.

4 Conclusion

The world is moving towards digital intelligence, and compared to other industries, the digital and intelligent transformation of the shipping industry still needs to catch up. Especially in recent years, the sustainability of shipping has been heavily impacted by the epidemic, revealing issues such as opaque information, significant economic cyclical changes, and low resource utilization. Digital intelligence enables a more detailed division of labor, standardized data, shared knowledge, faster response, and long-term development. Although the digital and intelligent transformation of shipping has been ongoing for several years, there has yet to be any significant breakthrough. This article analyzes the digital and intelligent results of the entire shipping industry from five aspects, most of which are still in the theoretical stage and require further study. However, with the influence of other industries and improvements in theory, the transformation of shipping will be accelerated. Based on the new shipping infrastructure, these five aspects of new empowerment enable the industry to develop towards ecology, economy, and automation, thus achieving truly sustainable development.

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