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The Growth of Maritime Communications and Technology Related to the Trends in the Shipping Industry: A Financial Perspective

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Abstract: This explanatory empirical study aims to investigate the relationship and contribution of the prevailing trends and factors within the shipping industry related to the maritime communications and technology market. It is widely acknowledged that the maritime industry is currently experiencing a rapid transformation, primarily propelled by new safety and environmental regulations but also driven by the growing emphasis on operational efficiency. The ongoing technological advancements in the maritime communications and technology market have significantly transformed the industry, offering opportunities for innovation and efficiency gains. This paper examines key trends and factors in the shipping industry that are crucial for further boosting the maritime communications market's expansion, thus growing both technologically and financially. From the results of our study, we conclude that the increase in the volume of international maritime trade and the volume of the global fleet are indicators that should be considered as incentives by the maritime communication and technology firms in order to provide additional solutions, thus gaining a competitive advantage and subsequently gaining market size against their competitors. On the other hand, the fluctuation of freight rates is not to be considered an indicator of shipping firms' intention to purchase the new products and services of maritime technology; a reduction in freight rates and, subsequently, in available income is not a preventing factor for adopting and exploiting the benefits of new technological solutions.

Keywords: shipping; maritime communications; digital technology; economic growth; financial growth

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1. Introduction

Global research indicates that the COVID-19 pandemic and economic instability impacted various industries and business operations by reducing business activities (Shen et al., 2020) and affecting communication related to financial and non-financial reporting (Charamis & Rodosthenous, 2022). Before the COVID-19 pandemic, digital transformation in the shipping industry was already being explored to streamline processes for enhanced operational efficiency. The disruptions caused by the pandemic accelerated this need. According to a recent survey, two-thirds of shipping companies, logistics providers, and carriers have a digital transformation strategy to digitize their operations (Wartsila, 2023).

In recent years, the term "maritime communications and technology" has been used to refer to the connectivity prospects arising from terrestrial, aerial, and space networks (Alqurashi et al., 2022).

However, the current relationship between the maritime industry and digital systems is not always straightforward. Maritime stakeholders require innovative solutions to tackle the increasing challenges of the energy transition and operating in such a vast, complex industry. Therefore, the industry is transitioning to digital to enhance safety, lower costs, and boost efficiency (Skordoulis et al., 2020).

The maritime communications market primarily focuses on two fundamental types of marine satellite services: MSS (Mobile Satellite Services) and VSAT (Very Small Aperture Terminal). The shipping industry can choose between these two types of connections based on their specific needs. Both MSS and VSAT are designed to provide coverage across a wide area, including remote locations, to support communication with moving endpoints, such as ships, airplanes, vehicles, or individual users carrying portable satellite terminals. Attempting to describe the difference between them broadly, MSS refers to smaller domes and installations. It is more applicable to pay-as-you-go services and, thus, more flexible in terms of cost management (Kang et al., 2015). VSAT requires the use of larger equipment, such as terminals and antennas, which results in a more stable commitment to the service (Wilk-Jakubowski, 2021). Users pay a fixed monthly contract fee for unlimited use and high-quality transmission and reception via satellite. In contrast, MSS allows a vessel to buy access to a service provider's network, similar to buying from a retailer, while through VSAT, a vessel buys capacity directly from the satellite, similar to buying from a wholesaler. In other words, to benefit from the wholesale price, a user needs to commit to purchasing a larger quantity, which, in this case, means unlimited use.

Despite the rapid increase in digital systems technology over the last few decades, new technological and connection capabilities have emerged, such as cloud computing and digital information platforms, and many of them have also been adopted and tested in the academic sector (Kim et al., 2024; Lytras et al., 2025; Gkika et al., 2020). The maritime industry inherently involves managing a wide-ranging, modern fleet of vessels, demanding live data exchange between ship and shore, and interconnected, dynamic processes. Today's decision-makers require unrestricted access to this information and the ability to merge multiple interdependent datasets to reveal insights and guide operational strategy in real time. Furthermore, the maritime electronics market has expanded into new operational segments, including electronic maps and navigation (Lund et al., 2018), with the potential to provide various data to ships. These include Maritime Safety Information (MSI), hydrographic and environmental data, piracy, and security reporting, and updating and monitoring onboard systems (e.g., engine and cargo monitoring systems). Generally speaking, operational efficiency results from advanced maritime technology in terms of optimizing routes through advanced e-Nav systems, better operational management, selecting available ports, and reducing possible demurrage times. Finally, better onboard digital operations may improve speed control and route avoidance through real-time weather forecasts and optimize cargo loadings and discharges.

Our paper is structured as follows: Section 2 includes an overview of current trends in the maritime industry, highlighting the findings of prior studies investigating the importance and continuous growth of wireless communication technologies in the maritime industry. Section 3 refers to the rationale for selecting specific explanatory variables and the dependent variable used (Maritime Communication Revenue) in our explanatory empirical research. Section 4 provides analysis and a statistical examination to investigate the potential correlation using simple individual regression tests. Section 5 includes the findings of our explanatory empirical study and our concluding remarks.

This paper aims to investigate the revenues of maritime communication systems and discuss the most important variables associated with them. This is an innovative approach since, during the literature review, we could not locate relevant research on the direct correlation between maritime communications and the economic growth of shipping.

2. An Overview of the Maritime Industry Digitalization

Among the most significant topics of maritime shipping are the roles of both digital communication technology and the financial and business challenges due to digitalization. In particular, the steady progress of the economy is certainly marked by the digital transformation of various branches and the introduction of new technologies in order to increase the efficiency of various participants in the global market. Such a transition poses new goals and new challenges for companies, and among them, it is noteworthy to explore the multifaceted benefits of shipping companies moving into the digital economy. Digital technologies can improve and optimize various business-centered processes of a company, deducing the companies on a new technological level that will allow them to expand the supply market, subsequently increasing the number of partners who will be assured of the safety of a transported cargo (Al-Hargusi et al., 2024). The following sections analyze the current status of the digitalization of communication technologies in the maritime industry and its financial and business challenges.

2.1. Digitalization of Communication Technologies of the Maritime Industry

The International Maritime Organization issued the EEXI and CII regulations to reduce the shipping industry's greenhouse gas (GHG) emissions. The implementation of these regulations started in 2023, and ships are required to calculate their emissions based on cargo and operational data (Daya & Lazakis, 2023; Liu et al., 2023). It must be noted that environmental regulations such as the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII) on communication technology investment by shipping companies exhibit significant heterogeneity across countries. Differences in the regulatory frameworks, economic conditions, and the applied technological infrastructures mainly explain this fluctuation. Countries with strict legal frameworks, such as those in Europe and North America, are more likely to see shipping companies invest heavily in communication technologies designed to monitor emissions and enhance operational efficiency. On the other hand, countries with less strict legal frameworks may not stimulate such technological investments, and they mostly use older technologies that do not meet modern emission standards (Chang & Danao, 2017).

Furthermore, the International Maritime Organization (IMO) endorses the idea that implementing electronic data exchange from ship to ship and from land to ship enhances efficiency, safety, and data security in navigation and communication (Berg, 2015). This endorsement is a significant indication of support for the concept of connectivity. Over the past few decades, wireless communication technologies have been crucial for ensuring navigational safety during maritime activities. Shipping companies need to have reliable wireless communication. By "reliable", we expect that it should offer consistently high data rates at a low cost (Fjortoft et al., 2009; Ilcev, 2011). Advanced digital communication technologies undoubtedly have significant effects, such as reducing vessel waiting times and expediting processing at terminals and ports. Additionally, these technologies enable crews to adjust their navigation using real-time weather, wind, and ocean data updates, leading to improved safety and reduced energy consumption (Lee et al., 2003).

As the use of maritime satellite communication systems continues to grow, it offers not only Fixed Satellite Service (FSS) connectivity but also Mobile Satellite Service (MSS), providing broad and high-speed voice/data coverage for large geographical areas (land,

sea, air) with nearly complete coverage. However, in cases where significant propagation delay and high implementation costs are identified, these factors can be seen as severe limitations to the rapid development of maritime communications (Disant & Dias, 2020). As the shipping market expands, the increased volume of maritime activities demands a high speed and reliable data transmission system to ensure smooth communication between vessels and the control center (Chen et al., 2021). Key port management challenges regarding facilitating information sharing are currently on the agenda of port policymakers. Maritime technology players need to elaborate on whether digital solutions can overcome the practical challenges of information sharing (Nikghadam et al., 2023).

In addition, implementing 5G mobile communication technology is expected to bring new service and product solutions for the maritime industry. In 2011, Poulis et al. emphasized the growing relationship between the shipping industry and maritime technology, stating that in the global marketplace, organizations are increasingly operating within networked and digitalized landscapes, competing as integrated supply chains. The research also emphasizes the significance of Information and Communication Technology (ICT) in gaining a competitive advantage in the complex shipping environment, highlighting the importance of Maritime Communication Technology in achieving a competitive advantage (Poulis et al., 2011). Moreover, it is of strategic importance to the connectivity of container ports. While the connectivity of ports related to major shipping-affecting events is impacted, changes in connectivity rankings could be adequately explained by the proposed decomposition scheme allowing more detailed analyses and explanations of the impacts of significant economic phenomena, e.g., the expansion of the Panama Canal or the crumbling of Hanjin shipping (Jarumaneeroj et al., 2023).

The recent advancement in the marine communications industry is the concept of eNav (electronic navigation), which involves connecting ships and shore facilities through communication links. The system utilizes electronic charts and maps data, including high speed broadband data links, to ensure safe navigation, especially in coastal and high traffic areas (Weintrit, 2011). It is important to note that electronic charts contain data not only onshore coastal lines but also valid hydrographic data (such as detailed mapping of reefs) and other possible sources of risk for vessels, as well as other actual time data (such as weather prediction) related to each route settled by the vessel's captain. In order to provide high speed data to the mariner on board and the coastal state, the system allows vessels to be constantly connected to maritime electronic highways, particularly during passages through sensitive high traffic coastal areas and vessel traffic schemes (VTS).

Technology providers and retailers in today's maritime industry offer a wide range of connectivity and technology solutions. These solutions come in the form of all-in-one consoles (such as hardware solution boxes or cubes) supported by user platforms (software). These platforms not only meet the fundamental communication needs of vessels (voice/data/e-mail communications) but also provide various types of data to ships, such as Maritime Safety Information (MSI), hydrographic and environmental data, maritime terrorism and piracy, cyber security reporting, interconnection, monitoring of onboard systems (such as engine and cargo monitoring systems), satellite surveillance (Islam, 2024), and multiple others, up to cost management.

2.2. Financial and Business Challenges of Digitalization in the Maritime Industry

By harnessing digital technologies, shipping companies can expand their use of digitized data, leading to improved overall efficiency and performance and access to new revenue streams (KPMG, 2018). Digitalizing the shipping and maritime logistics industry presents numerous opportunities and challenges. While advancements in maritime communication and digitization have greatly improved shipping operations and port handling,

there is still immense potential for further transformation of the maritime industry (Fruth & Teuteberg, 2017). The market's revenue streams can be categorized into two main segments: sales of services (airtime, voice calling, and data flow) and sales of solutions (hardware such as VSAT and MSS devices, as well as software for operating various applications connected to the main functionalities of the vessel, such as safety and e-navigation).

The end-users, or clients, of this will mainly belong to the following categories: commercial vessels (such as cargo ships, tankers, LNG, bulk carriers, and container ships primarily for operational efficiency and compliance), passenger/leisure vessels (including cruise ships and ferries, where passenger connectivity is a significant market driver), government and defense (such as naval vessels and other government-operated ships requiring secure communication), and offshore oil rigs (including platforms and support vessels related to the oil and gas sector). In a geographical segment analysis, we would identify the regions of Europe, North America, Latin America, Asia-Pacific, and Middle East-Africa. North America is the largest established market, driven by high demand in the U.S. for defense, aviation, and emergency services. Asia-Pacific is the fastest-growing region, with increasing investments in satellite infrastructure and rising demand from developing countries such as India and China. China's financial market has emerged as a vital force in the global financial system (Han et al., 2024).

In another geographical based qualitative field research, semi-structured interviews with stakeholders in four international European ports were conducted: Antwerp, Piraeus, Thessaloniki, and Zeebrugge (Notteboom et al., 2016). The port users have determined the supply chain values, referring to choices, value drivers, and satisfaction thinking of ports. The detailed analysis of port-specific interactions attempted to better understand how shipping lines that invest in dedicated terminals can be used as hubs and points of consolidating high volumes of containers; the geographical location of a port, insofar as its capacity to facilitate the offering of global services, stands as the most important value driver. The study disclosed the importance of relational-specific evaluations rather than only the reliability of transactions (Notteboom et al., 2016). Europe is experiencing the second fastest growth rate in the marine industry. This is due to increased sales of luxury vessels, a growing number of high-net-worth individuals, and the rising popularity of marine and coastal tourism, particularly in the Mediterranean region. Greece, a significant market player in Europe, accounts for 17.4% of the global capacity as of 2023 (KPMG, 2024). It has been continuously renewing its fleets, leading to an increased demand for new marine communication systems. The Middle East and Africa are also experiencing growth due to the need for connectivity in remote and harsh environments.

Furthermore, servitization is termed as a business model transition that occurs when global businesses are transforming towards capturing more value from services (González Chávez et al., 2024). Digital servitization is a vital contributor to sustainability since it can help create and maintain a competitive advantage and offer opportunities to tackle major challenges related to environmental pressures and rapidly changing market conditions. The theory-practice gap of digital servitization and its implementation in the maritime shipping sector have been investigated in the literature (González Chávez et al., 2024). These authors introduced three categories based on a PESTEL framework: organizational context, global priorities, and sustainability, offering empirical insights from the existing digital servitization status in the maritime shipping industry. The proposed framework can further identify challenges to support the transition towards digital servitization and developing more sustainable solutions (González Chávez et al., 2024). In the growing digitalization of maritime service ecosystems, the societal transformation of digital servitization (DS) supports autonomous shipping solutions as a vital component of the maritime sector. It was proven that managing DS through autonomous solutions consists of a strategic reorientation

of a firm in the multi-level context of service ecosystem transformation (Makkonen et al., 2022). Similarly, the digital transformation of maritime logistics is predominately driven by the rapidly evolving needs of shippers, rising competition, advancement in digital technologies, and a quest to increase cost and operational efficiencies. However, it is a fact that the often family-controlled and network-centric liner shipping industry has historically been conservative in adopting innovations and embracing digitalization (Raza et al., 2023).

Subsequently, research has focused on determining the current digital maturity capacities through the opportunities provided by digitalization. In this direction, underlying challenges hinder digitalization's implementation in the liner shipping segment within the larger maritime logistics industry, making identification of the essential leading strategies of digitalization (Raza et al., 2023). In a relevant study, the digital maturity categories applied to liner shipping allowed practitioners in the shipping industry to evaluate their business functions' digital maturity levels. The identification of the determinants of digital transformation for the maritime logistics industry, together with major barriers and different pathways to digital transformation, enabled a better understanding of success factors in the industry to approach and resolve digitalization problems, making the overall digital transformation process (Raza et al., 2023).

Recent research in this field incorporated and proposed an integrated framework of five domains: digitalization, maritime business, sustainability, personnel development, and supply chain management (SCM), coupled with 23 sub-knowledge domains among shipping company managers in Singapore (Koh et al., 2024). It was shown that the interface between technology and knowledge management and informed education strategies is mainly determined by digitalization knowledge, followed by maritime business, personnel development, sustainability, and SCM knowledge (Koh et al., 2024). It was demonstrated that strategic agility, innovation ecosystems, and the redesign of organizational structures are the most vital second-order concepts for succeeding in DT in MCS, offering insights into adapting DT roadmaps and investments in MCS while preparing incumbent MCS organizations for the digital future (Wohlleber et al., 2024). This digital future is a contentious goal as maritime markets are particularly affected by recent global tendencies such as increasing delivery costs or political pressure for decarbonization. In this context, digitalization can provide important support for shipbuilding and shipping companies in mastering recent and upcoming challenges (Giering & Dyck, 2021).

Maintaining effective communication within the maritime industry and among all its stakeholders is crucial. This is an essential feature for the market players and the industry's overall growth. Maritime commodities trade is critical to world economic growth because it supports the economic activities that consume energy. The development in the automatic identification system (AIS) and satellite communication capabilities has allowed a variety of benefits in this direction (Kanamoto et al., 2021). Therefore, a significant relationship and correlation between the shipping industry's growth and maritime communications can be identified. Based on the current literature review, there has been limited research on the direct correlation between maritime communications and connectivity and the economic growth of shipping. However, some studies suggest a partial relationship with specific aspects of the market. Saidi et al. (2020) and Banerjee et al. (2020) indicated that transportation connectivity infrastructure can be viewed as a crucial factor in facilitating economic growth and development in a broader context of economic growth and sustainable development (Girdzijauskas et al., 2022).

Focusing on this topic, Wilmsmeier and Hoffmann (2008) and Calatayud et al. (2017) found that enhanced maritime connectivity can impact freight rates. Additionally, Guo and Yang (2019) suggested that improved shipping connectivity could lead to increased demand and trade. However, the direct benefits of connectivity to the maritime market

are not discernible, so further exploration is needed to understand the extent to which improved shipping connectivity contributes to sustained economic growth in the shipping industry (Li et al., 2023).

It is concluded from the above literature review that although a general correlation has been identified between advancing maritime technology solutions and the shipping market's growth, a specific quantification and monetization of these contributions has not yet been exploited in specific aspects of the shipping industry (i.e., an increase in shipping profits). As previously mentioned, the impact on freight rates has been investigated but exhibits only partial correlation. Moreover, most of the literature in maritime communications and technology focuses on technical issues and their solutions (e.g., propagation, transmitters, etc.). Thus, we fill the lack of detailed research on the economic aspects by utilizing the three perspectives explained later, i.e., market activity, market potential, and market demand.

The shipping industry involves the collaboration of various parties, each with its limitations, which complicates inter-organizational communication (Yuen & Thai, 2017). To elaborate further, the shipping industry is distinct from other industries, such as retail, due to the involvement of various stakeholders such as the vessel-owner company, management office, suppliers (e.g., maritime communications providers), and customers (booking the vessel for time charter or voyage charter), among others. Additionally, the industry is governed by stringent legal frameworks related to safety procedures and environmental efficiency, which are continuously monitored by national and port authorities and international organizations such as the International Maritime Organization (IMO, 2024a). The most important regulations on the issue are PPR (Pollution Prevention and Response) sub-committee acts, in addition to extensive information regarding the Global Maritime Distress and Safety System (GMDSS), including radiocommunication systems used in the GMDSS, and consolidated by IMO in a single publication of the GMDSS manual (IMO, 2024b, 2024c). Moreover, the operational scope of shipping spans across the globe, given the mobile nature of chartered vessels.

3. Methodology

3.1. Data Selection

In our literature review, we emphasized the lack of adequate research on establishing a specific correlation between maritime communications growth and the shipping industry's primary trends. However, considering that the maritime communications market inherently relies on the shipping industry, we aim to pinpoint the factors driving its expansion.

In our research, we identified the following three fundamental perceptions as key drivers of growth:

A. The rapid advancement of technology, particularly in the realm of artificial intelligence, is driving market growth by introducing new products and solutions. This includes increased availability of products such as airtime connections, expanded coverage, faster speeds, and innovative software and hardware solutions. As a result, the market itself is becoming more appealing from a marketing perspective, creating an endogenous effect that enhances its attractiveness.

B. Changes in the legal framework governing maritime communications and technology could impact market growth by mandating the adoption of new technologies such as e-navigation. Moreover, additional legal requirements increase demand and subsequent revenue streams on maritime technology products, such as the direction for GMDSS requirements, which has led to the increase in the sale of GMDSS systems. As far as the directive for compulsory possessing two onboard ECDIS systems (i.e., one basic and one spare) gives rise to almost doubling the demand for ECDIS sales.

This external factor could influence the market independently of the growth and financial trends of the shipping industry.

C. The growth of the shipping industry, both in terms of increased revenues and the construction of new vessels, expands the market for maritime communications. At the same time, technological and regulatory factors are important for driving growth, and the financial perspective of the shipping industry plays a crucial role in establishing the conditions for the maritime communications market to thrive. Additionally, the perception that improved maritime connectivity positively impacts the value added and operational efficiency of shipping companies significantly contributes to the appeal of new connectivity products and solutions in the market.

3.2. Model and Variables

Our research methodology was focused on delving deeper into the financial perspective mentioned above. In exploring current trends in the shipping industry, we examined the correlation between key shipping indicators and the growth of the maritime communications market (Table 1). We specified our model with MCREV as the dependent variable (Equation (1)):

$$MCREV_t = f(IMT_t, GMFA_t, GMFB_t, FRTAN_t, FRLNG_t, FRDB_t) \quad (1)$$

t = number of years, i.e., 10 years.

Table 1. Description of variables.

Variable	Coding	Description
Maritime Communication Revenue	MCREV	Maritime Communication Revenue in '000s USD.
International maritime trade	IMT	International maritime trade in billions of tons loaded.
Global maritime fleet—type A	GMFA	Global maritime fleet—type A measurement in '000s of vessels.
Global maritime fleet—type B	GMFB	Global maritime fleet—type B measurement in billions of DWT[1]
Freight rates in tankers	FRTAN	Freight rates in tankers—estimated as annual average of daily VLCC spot rates in '000s USD.
Freight rates in LNG vessels	FRLNG	Freight rates in LNG vessels—estimated as annual average of daily LNG carrier spot rates in '000s USD.
Freight rates in dry bulk carriers of Capesize	FRDB	Freight rates in dry bulk carriers of Capesize—estimated as annual average of daily Spot Rates for dry bulk Capesize carriers in '000s USD.

The rationale for selecting the aforementioned shipping drivers as explanatory variables was based on three main concepts:

- The first concept delves into the volume of market activity in the shipping industry. Given the inherent limitation in collecting financial data, such as revenue and profits, due to reporting and disclosure constraints (e.g., offshore entities), we identify the figures of the international maritime trade to be more representative.
- The second concept explores the volume of market potential. Based on this notion, we assess the size of the global maritime fleet using two different measures of measurement: the absolute number of vessels and total tonnage for all active vessels.
- The third concept examines the volume of market demand. In this case, we consider freight rates, estimated as the annual average of the daily rates of each year. However, considering that freight rates vary based on vessel type, we choose to investigate the rates for the largest version of each major vessel type (e.g., tanker, LNG, dry bulk).

The collection of data figures to be analyzed and examined is retrieved through selected and reliable databases related to the industry, such as UNCTAD and Clarksons for general financial data and Baltic Stock Exchange data requirements, specifically freight rates.

3.3. Data Presentation for the Main Variables

This study was focused on the growth trend of the estimated global revenue for the Maritime Connections market as the dependent variable. The examination period will encompass the last ten years leading up to this research (2014–2023). We did not extend the sample further due to the rapid technological innovation in the industry. Using a larger time frame could lead to comparing non-comparable data, posing a significant risk of bias in the results.

Looking at the dependent variable (Maritime Communication Revenue), we observe a consistent increase in the overall market, with estimated revenue rising from USD 1.8 billion in 2014 to approximately USD 3.9 billion in 2023. This represents a more than doubling of the volume (a 117% increase) over the last 10 years, with continued growth (Figure 1).

However, when we examined the market in terms of the MSS revenue stream and the VSAT revenue stream, we noticed that they demonstrate contrasting trends.

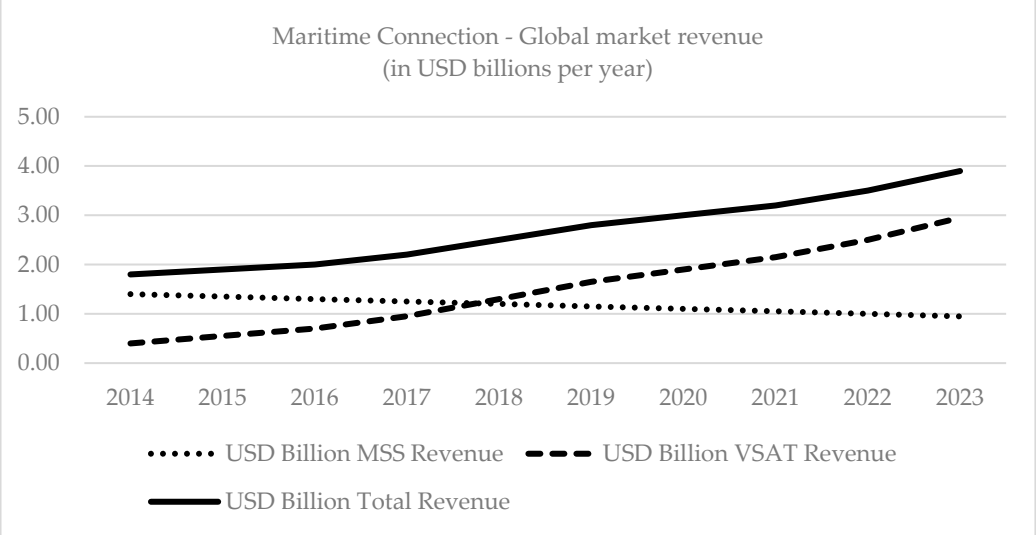

Figure 1. Annual revenue growth in the maritime communications sector for the period 2014–2023. (own work, data from UNTAD Datahub, 2024).

In the past decade, the maritime satellite communications market experienced a noticeable transition from Mobile Satellite Services (MSS) to Very Small Aperture Terminal (VSAT) services. This shift has been primarily fueled by the latter's capacity to offer higher bandwidth at a reduced cost per bit, catering to the increasing data demands. Consequently, it was shown to be more attractive for commercial shipping, cruise lines, and offshore industries. Furthermore, the enhanced performance and cost-effectiveness of VSAT services can be attributed to the introduction of high throughput satellites (HTS), low Earth orbit (LEO) constellations, and advancements in antenna technologies.

In 2014, VSAT services had been primarily utilized in larger vessels, requiring higher data rates. Subsequently, commercial vessels began to adopt these services due to decreasing costs and the need for higher data transfer. By 2018, VSAT services had surpassed MSS for the first time, driven by increased bandwidth needs and improved service coverage.

The recent introduction of LEO satellites has further enhanced traditional VSAT services, providing even higher data rates and lower latency.

One of the main contributors to the observed growth is the continuous technological advancement, particularly in satellite technology, with the emergence of the low Earth orbit (LEO) constellations. This has led to improved coverage, transmission capabilities, and reduced latency, thereby creating new revenue sources.

Another contributing factor to the growth is the rising demand for voice-data services on board. The increasing need for broadband connectivity in maritime operations drives this surge in demand. It is not only a result of the expanding global fleet but also reflects the shipping market's recognition that effective maritime connectivity is essential for efficient operations.

In addition, changes in the regulatory framework and the implementation of advanced safety requirements led to stricter regulations for maritime safety and communication. Consequently, shipping companies are increasing their spending in the communications market. Furthermore, the ongoing digitalization transformation, including the adoption of IoT (Internet of Things) and big data analytics, has spurred the maritime industry to embrace new connectivity and remote monitoring solutions. Subsequently, a higher demand for satellite communication services prompted shipping companies to make further investments in communication infrastructure.

It is important to note that despite disruptions caused by the COVID-19 pandemic and subsequent global economic instability, influencing the utilized technologies in the shipping industry (Tok & Ece, 2022), the market experienced moderate growth as the demand for reliable communications remained high.

Furthermore, we analyzed data related to the volume of the global maritime fleet. The expansion of the shipping sector is typically associated with fleet modernization and expansion. Many companies commonly invest in constructing new, more efficient vessels as older ships become less economically viable, mainly due to fuel costs and evolving emissions regulations. Additionally, the increased scrapping of older, less efficient vessels advances the construction of new ships to improve fleet efficiency and meet the demand, particularly with the emergence of new transported products such as LNG and LPG.

For the data examination mentioned earlier, we assessed two distinct metrics for the size of the global maritime fleet. Firstly, considering the total number of operating vessels in the maritime industry, regardless of their type and size, we estimated at the end of each respective year during the examination period (Figure 2).

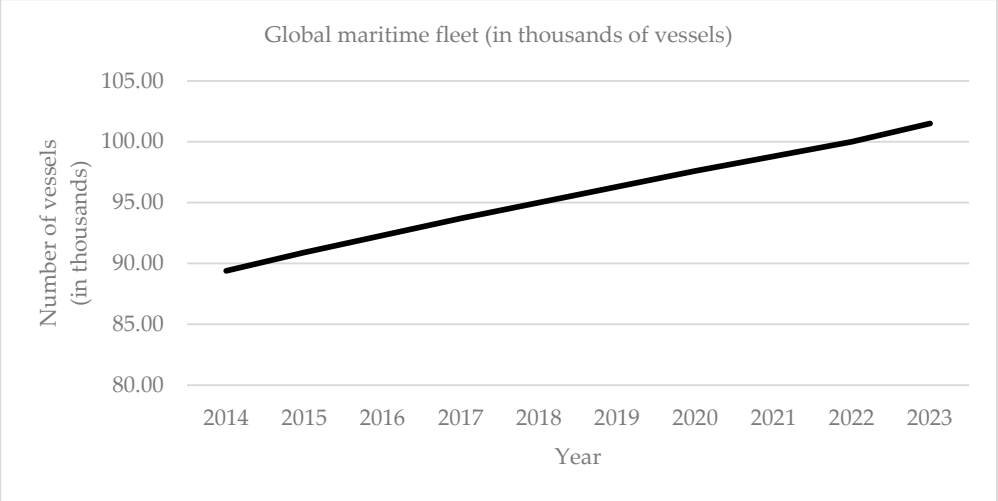

Figure 2. Annual size growth in the global maritime fleet for the period 2014–2023 in thousands of vessels (own work, data from Clarksons, 2024).

Secondly, Figure 3 presents the total Deadweight Tonnage (DWT) of all the operating vessels in the maritime industry at the end of each respective year.

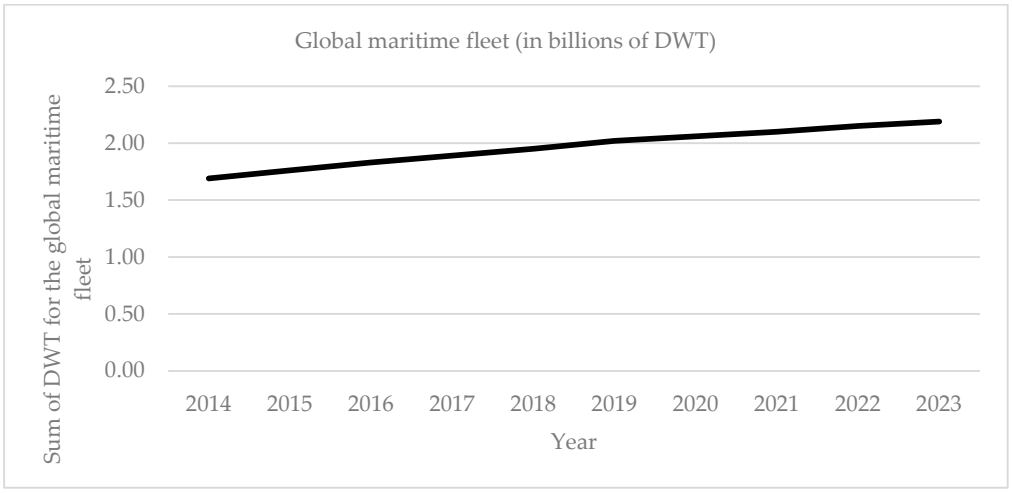

Figure 3. Annual size growth in the global maritime fleet for the period 2014–2023 in billions of DWT (own work, data from Clarksons, 2024).

The data presentation indicated a consistent rise in the maritime fleet, regardless of the measurement method. There is a slightly higher growth rate when considering the increase in the number of vessels. The key point of this growth is the global maritime fleet that has steadily expanded in both the number of ships and carrying capacity. This expansion is driven by global trade growth and the demand for more efficient, larger ships. Furthermore, this upward trend has been influenced by the balance between new ship orders and deliveries as well as the scrapping of older ships. This trend supports fleet modernization, leading to improved fuel efficiency and reduced environmental impact. It is noteworthy that while the COVID-19 pandemic temporarily disrupted the activities of new builders and affected scrapping rates, the shipbuilding industry rebounded in 2021, leading to continued growth.

Finally, we analyzed data from the third perspective of shipping's growth (i.e., Market demand) and especially in terms of freight evolution (Figure 4).

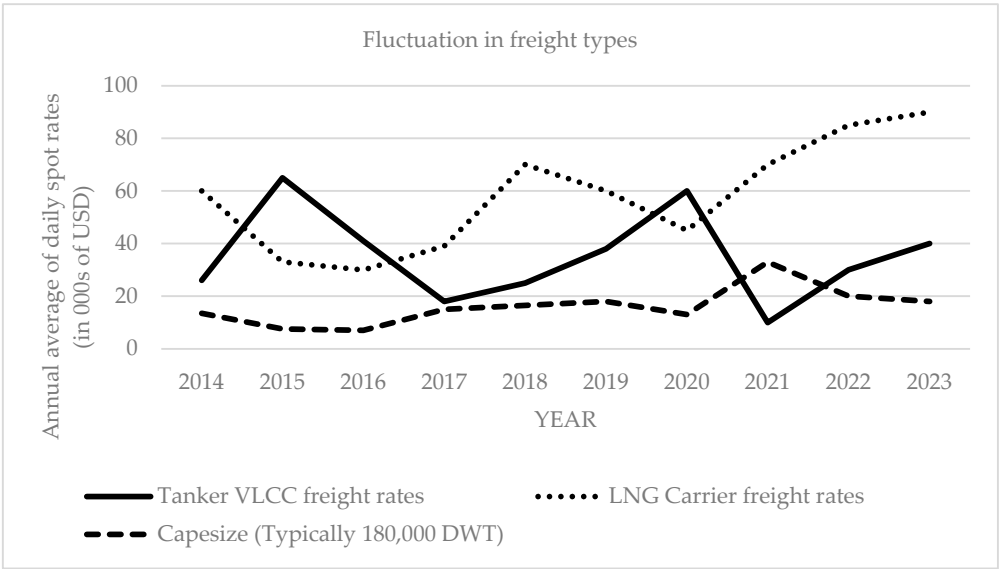

Figure 4. Annual fluctuation in selected freight types for the period 2014–2023 (own work, data from Baltic Exchange, 2024).

In our analysis, we observed that tanker freight rates demonstrated the highest level of volatility within the shipping industry. Short-term demand changes and global events such as fluctuations in oil prices, geopolitical tensions, and pandemics influenced this volatility. Over the examination period, we noted two significant peaks. The first occurred in 2015 due to heightened oil production and demand, leading to increased tanker usage. The second peak, which was observed in 2020, was driven by a surge in demand for floating storage despite the collapse in oil prices caused by the impact of COVID-19. Subsequently, as storage needs decreased and oil demand declined, rates experienced a substantial drop in 2021. However, in 2022, we observed a recovery in freight rates as oil demand increased and supply chain issues were addressed, an observation that is consistent with the relevant literature (Kyriakopoulos, 2023).

The freight rates of the LNG (Liquefied Natural Gas) vessels experience significant volatility due to fluctuations in global LNG demand, fleet availability, geopolitical events, and energy market dynamics. Global LNG has been driven by factors such as increased Asian demand (mainly from China and India), European energy needs, and shifts towards cleaner energy sources, which heavily influence LNG freight rates. Additionally, the seasonal nature of LNG leads to spikes in rates during winter when heating demand rises in northern countries. The COVID-19 pandemic in 2020 caused disruptions, with rates initially spiking as charterers secured vessels for floating storage, followed by declines as LNG demand temporarily weakened. However, in recent years, there has been a strong rate of recovery due to increased demand, particularly in Europe, alongside the energy crisis and the subsequent supply constraints in the energy market chain (Drosos et al., 2020).

The freight levels of dry bulk carriers, typically measured by the Baltic Dry Index (BDI), are relatively less volatile compared to other types of carriers. However, they still experience slight variations due to the transfer of bulk commodities such as iron ore, coal, and grains, which are influenced by factors, such as global trade demand, fleet supply, seasonal fluctuations, and overall economic conditions. During the period of our analysis, we observed an initial decline in rates that was caused by an oversupply of vessels. However, rates began to recover in 2017 as scrapping increased and new ship orders slowed down. Although there was a setback in the early stages of the COVID-19 pandemic, freight levels rebounded in the subsequent years due to strong demand for commodities.

4. Results

In our analysis, we assess the quality attributes of the sample by calculating its fundamental descriptive statistics, which are detailed in Table 2.

Based on the results below, we observe that variables (1), (2), and (4) exhibit the most negligible absolute dispersion, as indicated by their low standard deviation figures. The same trend is also reflected in the standard error, with (1), (2), and (4) showing the lowest figures. In terms of relative dispersion, variables (2), (3), and (4) have the three lowest values. Based on Table 2, it becomes evident that the descriptive statistics for variables (1) to (4) differ significantly from the corresponding statistics for variables (5), (6), and (7) related to freight levels. This finding suggests that the variables that represent the shipping industry's "market activity" and "market potential", as previously mentioned in this research, may be more suitable for our tests compared to the variables related to the "market demand" concept.

In order to investigate the potential correlation between the explanatory variables and the dependent variable, we conducted individual simple regression tests for each of the factors under examination. The results have been summarized in Table 3 below.

Table 2. Descriptive statistics on the main variables.

	Maritime Communications Revenue (in Billions USD)	International Maritime Trade (Billions of Tons Loaded)	Global Maritime Fleet (No. of Vessels)	Global Maritime Fleet (DWT)	Tanker VLCC Freights (Annual Average of Daily Rates in '000s USD)	LNG Carrier Freights (Annual Average of Daily Rates in '000s USD)	Dry Bulk-Capesize Freights (Annual Average of Daily Rates in '000s USD)
Variable I.D.	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Mean	2.680	10.726	95.550	1.964	35.300	58.200	16.150
Standard Error	0.227	0.173	1.266	0.053	5.492	6.656	2.315
Median	2.650	10.840	95.650	1.985	34.000	60.000	15.750
Standard Deviation	0.719	0.547	4.004	0.169	17.366	21.049	7.322
Sample Variance	0.517	0.300	16.029	0.029	301.567	443.067	53.614
Range	2.10	1.66	12.10	0.50	55.00	60.00	26.00
Minimum	1.80	9.84	89.40	1.69	10.00	30.00	7.00
Maximum	3.90	11.50	101.50	2.19	65.00	90.00	33.00
Sum	27	107	956	20	353	582	162
Count	10	10	10	10	10	10	10
Coefficient of Variation	26.84%	5.10%	4.19%	8.60%	49.19%	36.17%	45.34%

Table 3. Individual simple regression estimations on each of the explanatory variables.

	Maritime Communications Revenue (Billions USD)	International Maritime Trade (Billions of Tons Loaded)	Global Maritime Fleet (No. of Vessels)	Global Maritime Fleet (DWT)	Tanker VLCC Freights (Annual Average of Daily Rates in '000s USD)	LNG Carrier Freights (Annual Average of Daily Rates in '000s USD)	Dry Bulk Capesize Freights (Annual Average of Daily Rates in '000s USD)
Variable I.D.	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Intercept coefficient		−9.934	−14.262	−5.470	2.839	1.115	1.703
X variable coefficient		1.176	0.177	4.150	−0.005	0.027	0.060
Rsq-coeff. of determination		80.12%	97.42%	94.99%	1.19%	61.94%	37.90%
r-correlation coefficient		89.51%	98.70%	97.46%	10.89%	78.70%	61.56%
Adjusted R Square		77.64%	97.09%	94.36%	−11.17%	57.19%	30.14%
Standard Error		0.340	0.123	0.171	0.758	0.471	0.601
p-value on Y		0.002 ***	0.000 ***	0.000 ***	0.001 ***	0.041 **	0.008 ***
p-value on X		0.000 ***	0.000 ***	0.000 ***	0.765	0.007 ***	0.058 *
t-stat on Y		−4.47 ***	−14.61 ***	−8.24 ***	5.01 ***	2.43 **	3.54 ***
t-stat on X		5.68 ***	17.36 ***	12.32 ***	−0.31	3.61 ***	2.21 *

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. ***: Null hypothesis of *t*-test rejected at 1%—parameter significant. **: Null hypothesis of *t*-test rejected at 5%—parameter significant. *: Null hypothesis of *t*-test rejected at 10%—parameter significant.

Table 3 illustrates a significant contrast in the effectiveness of results when comparing the explanatory figures for variables (2), (3), and (4) with those for variables (5), (6), and (7). The first group exhibits a very high correlation between the explanatory variables and our dependent variable, with "Rsq" and "r" values consistently exceeding 80%. Notably, the explanatory variables (3) and (4), representing the global fleet volume, demonstrated a perfect fit. These findings are further supported by the evaluation of *p*-values[2] and T-stats, indicating the significance of the examined parameters, even at the 1% level of significance.

The group of variables (5), (6), and (7) representing different freight types demonstrates varying levels of explanatory power for the dependent variable compared to the first group. While variables (6) and (7) exhibit a correlation coefficient above 50% and significant parameter estimations at certain confidence levels, variable (5)—representing freight levels

for VLCC-Tankers—shows notable fluctuation. This fluctuation was expected, and it is attributed to the heightened volatility of this specific category, particularly its close association with the highly volatile oil market, as previously mentioned.

Based on the information above, we have chosen to test a multivariable model that includes parameters related to the concepts of "market activity" and "market potential" from the first group. We will test two different versions of this model, one including variables (2) and (3) and another version including variables (2) and (4). The results of these tests are presented in Table 4.

From the analysis of both model versions presented below, it is evident that they operate effectively, yielding correlation coefficients of above 95%, indicating a perfect fit. Furthermore, the overall significance of the models is supported by the fact that the F-statistic is significant even at the 1% level for both cases.

Based on the processed data, it can be inferred that the maritime communications market may be statistically correlated with a model that includes explanatory variables representing factors of the shipping market, such as the international maritime trade (indicative of shipping industry activity volume) and the global maritime fleet (representative of shipping industry potential).

Table 4. Multiple regression estimations on three variable linear models (two alternate versions).

	Maritime Communications Revenue (Billions USD)	**International Maritime Trade (Billions of Tons Loaded)**	**Global Maritime Fleet (No. of Vessels)**		**Maritime Communications Revenue (Billions USD)**	**International Maritime Trade (Billions of Tons Loaded)**	**Global Maritime Fleet (DWT)**
Variable I.D.	**(1)**	**(2)**	**(3)**	**Variable I.D.**	**(1)**	**(2)**	**(4)**
Intercept coefficient	−14.476			Intercept coefficient	−4.788		
Variable (2) coefficient		−0.158		Variable (2) coefficient		−0.142	
Variable (3) coefficient			0.197	Variable (4) coefficient			4.580
Rsq-coeff. of determination	97.62%			Rsq-coeff. of determination	95.14%		
r-correlation coefficient	98.81%			r-correlation coefficient	97.54%		
Adjusted R Square	96.95%			Adjusted R Square	93.75%		
Standard Error	0.126			Standard Error	0.180		
F-test	143.86 *			F-test	68.55 *		

* $p < 0.01$ Null hypothesis of F-test rejected at 1%—parameter significant.

5. Discussion and Conclusions

Our current research investigated the maritime communications and technology market to examine the primary drivers behind its sustained growth. We acknowledge that technological innovation, new regulatory requirements, and the overall financial health of the shipping industry largely influence the market's growth. While the primary research focus is based on the financial perspective, future analysis is expected to examine the three key components: "market activity", "market potential", and "market demand". For each component, relevant key indicators from the shipping industry were selected, such as "International Maritime trade volume", "size of the global fleet", and "fluctuation of freights", to be tested as explanatory variables for the growth in the maritime communications market. The selection of the last ten years (2014–2023) as the time range for our data sample was made to minimize the impact of technological changes on our financial perspective. By focusing on this period, we aim to reduce the risk of bias from external factors that are not accounted for in our analysis. Additionally, including the period of the

COVID-19 pandemic in our data provides further robustness by capturing the potential financial effects of this crisis.

In our study, the variables of "International Maritime trade" and "size of the global fleet" serve as the most important indicators of the shipping market's "activity" and "potential" compared to the fluctuations in freights when explaining the trends in maritime communications revenues. This conclusion is consistent not only with the descriptive statistical measures used to evaluate the qualitative characteristics of the sample but also with the relative regression models, which demonstrate correlation coefficients approaching levels of almost 90% and higher. The fluctuating freight levels suggest that this cannot be considered a reliable measure for predicting the growth prospects of maritime communications. While higher freight rates may indicate a more significant financial potential for shipping companies, leading to increased spending on maritime communication products and solutions, it is not a guaranteed outcome.

From the conducted statistical analysis, we noticed that the variable of the size of the global fleet is strongly associated with digital communication revenue. This is compatible with the KPMG report (KPMG, 2024) that associates fleet renewal with increased demand for digital communication technologies. Therefore, a more reliable measure for future growth in the maritime communications market could be the number of hulls under construction and new shipbuilding orders, indicating an expanding customer base. However, this only tells part of the story. The other part is the wide range of available digital maritime solutions, from basic mandatory systems to advanced technologies for enhanced coverage, speed, and connectivity for various purposes. The extent of shipping companies' investment in this market may be influenced by other factors, such as international maritime trade and the perception that better maritime communication and digitalization can improve operational efficiency and safety.

As mentioned in the literature review, there is only limited research on this specific issue of exploring the monetary and economic effects of the advancing maritime technology industry, while the majority of relevant research focuses on technical issues (i.e., improving propagation, coverage, speed, and transmission). Although relevant research has been made on establishing a general economic correlation between the shipping market and the industry of maritime communications and technology, the incremental contribution of the current research is to identify and evaluate the contribution on a more specific factor basis. Thus, we conclude that freight rates' fluctuations can only barely relate to the innovation of new maritime technology solutions, but on the other hand, maritime trade in terms of tons loaded and the size of the global fleet are highly related to the financial increase in the maritime communications market. Hence, the focus should be given to providing more technological solutions, as the market is eligible to adopt them (i.e., maritime technology solutions are now considered necessary to sustain competitive advantage and are not considered just optional products/services). Therefore, further research could involve the time range expansion of the data sample jointly with the potential effects of other factors from earlier periods and also with the casualty effects between the variables. It would also be valuable to test other key trend indicators in the shipping industry and value their impact on evaluating the maritime communications market.

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Notes

[1] Deadweight Tonnage.

[2] For the *p*-values expressed as 0.000 in the table, the actual value is not zero but rather very close to it. Thus, we round it to three decimals.

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