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EMISSION STANDARDS' IMPACT ON SHIPPING LINES' COST IN CONTAINERIZED FREIGHT TRANSPORT: A CRITICAL REVIEW

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ABSTRACT - The maritime sector has been under increasing pressure due to strict environmental regulations. Shipping companies face difficulties in meeting emission standards while keeping operational efficiency and cost-effectiveness at desired levels. This study looks into the approaches taken by shipping companies to meet emission standards and evaluates how they affect operational expenses.
This study utilized a critical review method to examine previous research on adherence to emission standards in the maritime sector. The database Scopus was used for the literature search. The initial Scopus search yielded 174 documents in the search results. After systematically filtering out 174 papers, 49 peer-reviewed journals were reviewed. The method of inductive reasoning was used to group papers according to themes. Through qualitative data analysis tools, insights were extracted to understand the strategies employed by shipping lines and their cost implications.
The study revealed a range of strategies adopted by shipping lines, including fuel switching, engine optimization, and route optimization, with varying impacts on operational costs which can be categorized into three main themes; (1) Operational measures (2) Environmental technologies and (3) Fleet management techniques. Emerging trends and innovative approaches in emissions reduction and cost management were identified, contributing to a broader understanding of sustainable practices in the maritime industry.

Keywords: Emission standards; Shipping lines; Container shipping; Operational costs; Sustainability

1. INTRODUCTION

Emission standards in maritime transport have become a significant topic of concern due to the rapid growth of transport emissions, particularly in the maritime sector. Shipping accounted for 15% of annual nitrogen oxides emissions from anthropogenic sources, 13% of sulfur oxides, and 3% of CO2 emissions [1].The container shipping industry is increasingly recognizing the need for environmental accountability and taking steps to address its ecological footprint [2]. The International Maritime Organization is now taking steps to reduce polluting emissions and greenhouse gases generated by vessels. The IMO's initial strategy for the reduction of GHG from ships sets ambitious targets, including cutting total yearly GHG emissions from global shipping by at least half by 2050 compared to 2008 [3]. In 2018, the IMO implemented a global sulfur cap, reducing the marine fuels Sulphur content to 0.5% [4]. The IMO has also adopted energy efficiency measures and established goals to decrease CO2 emissions. These measures consist of the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). Starting in 2023, all ships are mandated to calculate their Energy Efficiency Existing Ship Index (EEXI) and launch their annual operational Carbon Intensity Indicator (CII) by legal requirements [5]. Compliance with these regulations necessitates container shipping lines to adopt various strategies, incurring costs in the process. While individual studies have examined these strategies and their respective impacts on shipping lines' costs, a comprehensive review amalgamating these findings is notably absent from the literature. To address this research gap, this study aims to critically review existing literature on emission regulations' impact on container shipping lines' costs, exploring various compliance strategies adopted by companies.

2. MATERIALS AND METHODS

The review methodology for this study includes four steps: material collection, descriptive analysis, material categorization, and content analysis. The process of material collection is focused on choosing the appropriate literature for future examination. Then, a detailed examination is carried out to uncover underlying research patterns. Afterward, the resources are sorted according to their themes and content. Finally, the classified materials are subjected to a thorough analysis to produce insights on how Emission Standards affect the cost of container Shipping Lines.

2.1. Material Selection

A Boolean search strategy was developed to capture literature specifically addressing emission standards in the context of shipping lines' costs within containerized freight transport. The final Boolean search query is described in the following way: (("emission* standard*" OR "emission* regulat*" OR "environment* regulat*" OR "emission* control*") AND (shipping OR maritime) AND (container*) AND (cost* OR rate* OR econom*)). Scopus was used as the database for the study, known for its various modules to explore scientific literature. A total of 174 articles were initially retrieved, with 126 remaining after on-site filtration to exclude irrelevant subject areas. Those subject areas are “Pharmacology, Toxicology and Pharmaceutics”, “Physics and Astronomy”, “Agricultural and Biological Sciences”, “Computer Science”, “Chemistry”, “Chemical Engineering”, and “Earth and Planetary Sciences”. Only peer-reviewed journal articles published in English from 2003 to 2023 were included in the final selection, resulting in a literature pool of 93 papers. Further scrutiny resulted in 49 eligible papers for in-depth review. The methodology employed a systematic approach to filter out irrelevant literature and select papers that contribute directly to the objectives of the review.

2.2. Analytical Techniques

An inductive reasoning approach and the qualitative analysis software ‘NVivo’ was employed to identify themes and content within the literature. Subsequently, the materials were categorized under these themes to facilitate further in-depth analysis. The strategies identified using the inductive reasoning approach were divided into three main themes utilizing thematic analysis techniques as shown in Figure 1. These themes are; (1) Operational measures (2) Environmental technologies and (3) Fleet management techniques.

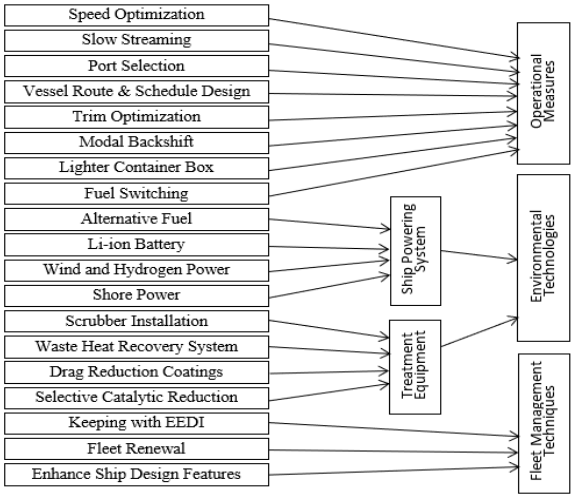

Figure 1: Themes Classification

3. RESULTS AND DISCUSSION

It was observed that shipping lines employ a variety of strategies to adhere to emission standards, including fuel switching, engine optimization, and route optimization. These strategies vary in their effectiveness and cost implications. For instance, fuel switching from traditional heavy fuel oil (HFO) to marine gas oil (MGO) or the installation of scrubbers were found to be common approaches [6]. However, the cost-effectiveness of these strategies varied depending on factors such as fuel prices, regulatory requirements, and vessel characteristics [6]. Slow streaming is the most commonly used operational measure for decreasing emissions and improving operational efficiency in the maritime sector. Studies show that slow streaming has a great potential to save fuel and reduce emissions, especially when dealing with expensive bunker prices and low market rates. Effective vessel routing and scheduling are vital for improving operational efficiency and lowering emissions. Furthermore, the analysis highlighted the varying impacts of these compliance strategies on operational costs. While some strategies were found to result in cost savings, others incurred additional expenses. Investing in scrubber technology may involve initial capital outlay, they can lead to long-term cost savings through fuel efficiency and regulatory compliance [7]. The

analysis identified emerging trends and innovative approaches in emissions reduction and cost management such as exploration of alternative fuels, the development of energy-efficient vessel designs, and the implementation of digital technologies for route optimization and performance monitoring. The findings underscore the complex interplay between emission standards compliance strategies, operational costs, and environmental impact. By understanding these dynamics, shipping companies and policymakers can make informed decisions to promote sustainability while ensuring the economic viability of maritime operations.

4. CONCLUSION

The study revealed a range of strategies adopted by shipping lines, including fuel switching, engine optimization, and route optimization, with varying impacts on operational costs which can be categorized into three main themes; (1) Operational measures (2) Environmental technologies and (3) Fleet management techniques. Emerging trends and innovative approaches in emissions reduction and cost management were identified, contributing to a broader understanding of sustainable practices in the maritime industry.

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