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On the Synergy Between Renewable Energy and Npl Reduction in the Maritime Industry

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Abstract: *The recent geopolitical tensions, the rising uncertainties and climate risks pose challenges to all industries. The shipping industry faces challenges such as rising fuel costs and tightening environmental regulations, which decrease the ability of shipping borrowers to meet their loan repayment obligations, exacerbating the likelihood of increased non-performing loans (NPLs). Drawing on existing literature, this study examines the synergy between renewable energy adoption and NPLs in the maritime industry. The findings underscore that the increased renewable energy dependency will bolster the resilience of maritime borrowers. Vessels adopting renewable sources and aligning with tightened environmental regulations may avert the regulatory disruptions that could hinder loan repayments. Renewable sources' adoption will also attract investors and enhance access to additional financing. Consequently, reduced NPLs will stimulate banks' financial stability and foster economic growth. This study also identifies challenges related to renewable energy adoption, offering practical pathways to adoption and outlining the channels of NPL reduction.*

1. INTRODUCTION

The marine industry, being crucial to international trade, currently confronts numerous challenges due to increasing geopolitical tensions, economic uncertainties and the negative spillovers of climate change (Bošnjaković, 2012; Germond & Mazaris, 2019). A key pressing issue arising as an accumulation of these challenges is the bank non-performing loans (NPLs), which present substantial financial risks to both marine borrowers and lending institutions (Campbell, 2007). Within this context, the incorporation of renewable energy sources (RES), arises as a crucial strategy of NPL reduction and simultaneously promotes sustainability goals in the maritime industry.

The scientific literature confirms that the maritime industry is currently grappling with significant economic challenges. These concerns include the rising cost of fuel and the increasing burden of regulatory compliance (Halff et al., 2019). These are exacerbated due to the recent geopolitical tensions and the increasing frequency and severity of the physical and transitional effects of climate change. Borrowers face economic challenges due to the combinational negative effects of geopolitical and climate risks, resulting in the proliferation of NPLs related to maritime borrowers (Shabir et al., 2024).

In response to these challenges, there is a growing interest in the literature, in harnessing the potential of RES to enhance the current maritime operations. The current literature has highlighted the advantageous benefits of adopting RES in the maritime industry. Among them the reduced operational costs (Issa et al., 2022), enhanced regulatory compliance (Yusoff, 2006), as well as

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increased investments (Shahbaz et al., 2020). Vessels that utilize RES are in a more advantageous position to handle the changing regulations and the rising financial uncertainties in the maritime industry, by addressing environmental concerns by lowering their dependence on fossil fuels (Issa et al., 2022; Shahbaz et al., 2020; Yusoff, 2006).

The objective of this study is to explore the synergy between RES and the bank NPLs related to the maritime industry. This exploration is conducted through a systematic literature review (SLR), of the existing literature on empirical, theoretical as well as case studies revolving around the economic, environmental and financial dimensions of the RES-NPL relationship. The ultimate aim is to demonstrate how adopting RES, can enhance the financial stability and resilience of the banking system, by reducing the bank NPLs related to the maritime industry.

Through an in-depth analysis of the current literature on emerging trends, the secondary aim of this paper is also to provide practical insights and recommendations for stakeholders who are inclined to promote sustainable finance practices in the maritime industry. Moreover, financial institutions can navigate the complexities of maritime lending with greater confidence and resilience and therefore contributing to the stability and sustainability of the maritime industry.

We form the following main research questions to be answered: (RQ1) What is the impact of incorporating RES into maritime operations and the decline of NPLs? (RQ2): How can the primary challenges associated with the deployment of RES in the maritime industry be mitigated, to successfully promote sustainable finance?

This study contributes to the current literature, by being the first to in-depth utilize key scientific studies to shed light on the RES-NPL relationship. Second, it examines this relationship by considering a large amount of scientific literature analyzed, comprised of 1467 scientific studies. Third, it accounts for various scientific studies, comprised of theoretical and empirical nature, as well as case studies. Fourth, it also accounts for diverse studies revolving around the economic, environmental and financial dimensions of RES-NPL.

The structure of this paper is organized as follows: Section 2 details the methodology, including the research paper identification, the evaluation strategy and the assessment of the investigated research. Section 3 presents and discusses the main findings based on the analysis from Section 2. Section 4 presents the fulfillment of the research questions. Finally, Section 5 provides concluding remarks and suggestions for future research.

2. METHODOLOGY

The research methodology employed in this study is a Systematic Literature Review (SLR) following the guidelines recommended by Tranfield et al. (2003) and Denyer and Tranfield (2009). This approach ensures a rigorous, transparent and fact-based synthesis of the existing research, facilitating a deep understanding of the current state of research on the integration of renewable energy in the maritime industry and its impact on NPLs.

The SLR was composed of two main phases: (1): Literature identification, comprising of database identification and database search, initial screening, selection of studies meeting specific inclusion criteria, relevant to the research objectives; (2) Mapping of the identified literature into three themes. Specifically, Theme 1: “The Influence of Incorporating Renewable Energy on the

Reduction of Non-Performing Loans (NPLs)"; Theme 2: "Tackling Obstacles and Advantages in the Implementation of Renewable Energy"; Theme 3: "Pragmatic Suggestions for Ensuring Sustainable Funding in the Maritime Industry".

The three themes were then evaluated in accordance with the research questions of this study.

2.1. Phase 1: Identification

Table 1 presents the steps of the paper selection process related to phase (1) and Table 2 presents the paper inclusion/exclusion criteria.

Table 1. Phase 1: Selection Process

Stage	Description
1. Database Identification	Selection of the databases to perform the literature search and initial filtering.
2. Comprehensive Search	A comprehensive search was conducted on the selected academic databases using predefined keywords and combinations.
3.a. Screening	Initial screening of the research papers, based on their titles and their abstracts, to identify potentially relevant papers for full-text assessment.
3.b. Eligibility	Full-text assessment to determine eligibility, based on inclusion and exclusion criteria to ensure both relevance to the research questions and methodological rigor.
4.a. Included	Selection of studies meeting all inclusion criteria and deemed relevant to the research objectives to ensure consistency and reliability.
4.b. Excluded	Studies excluded during full-text assessment due to not meeting inclusion criteria, being duplicates, non-English, or unrelated to the research topic.

Source: Own calculations

Table 2. Inclusion Exclusion Criteria

Criteria	Inclusion Criteria	Exclusion Criteria
Publication Type	Peer-reviewed journals published in the English language.	Non-peer-reviewed sources, non-English publications and research papers from non-academic sources.
Topic Relevance	Research papers addressing the integration of renewable energy in the maritime industry and its impact on non-performing loans (NPLs) among maritime borrowers.	Research papers unrelated to renewable energy adoption, NPL reduction, or maritime finance.
Methodological Rigor	Studies with empirical data or theoretical analysis related to the research questions, employing robust methodologies.	Studies lacking substantive analysis or employing methodologies deemed methodologically weak or unreliable.
Publication Year Range	Research published between 2014 and 2024, to ensure a comprehensive review of relevant literature while capturing recent developments.	Outdated publications or publications published after the year 2024.

Source: Own calculations

The above steps are presented below in detail:

1. Database Identification

a. The literature search was performed utilizing the EBSCO and ABI Inform Global PROQUEST databases based on their comprehensive coverage of up-to-date journals, their capacity to employ Boolean operators, and their strong search functionalities.

2. Comprehensive Search

a. Two search strings were developed to retrieve relevant research studies:
   String 1: ("Renewable energy" OR "Non-performing loans" OR "Maritime industry" OR "Financial stability" OR "Shipping finance");
   String 2: ("Climate change" OR "Regulatory compliance" OR "Operational expenses" OR "Investment attraction" OR "Maritime industry").

The above search strings were designed to encompass peer-reviewed journals scholarly journals in the fields of RES, maritime, sustainable finance and NPLs.

The initial search resulted in 1467 studies (EBSCO: 976, ProQuest: 491). After initial research, 323 duplicate records were removed.

264 research studies were also excluded from further analysis. Surveys, qualitative analysis, proceeding papers and papers not explicitly focusing on the maritime industry were the ones being excluded during this stage.

3. Screening Based on Eligibility

a. Title and Abstract Review: The titles and the abstracts of the identified publications were examined to determine their relevance to the primary topic.
b. Full-Text Assessment: The selected publications were carefully examined to ensure that they were both relevant in terms of topic and methodology.
c. The studies included in the analysis were restricted to publications published between 2014 and 2024 to cover a wide range of relevant literature.
d. Studies focused on diverse ethnic groups and minorities, or studies with only study design descriptions, as well as those only providing a methodology description were also excluded.

Out of the steps outlined above, 59 studies were identified as potentially eligible based on their relevance to the incorporation of renewable energy sources (RES) in the marine industry and their effects on NPLs, aligning with our research goals.

Following a detailed quality appraisal, 39 studies were excluded. Specifically, 33 studies focused on diverse ethnic groups and minorities, 5 studies included only study design and 1 study provided only a description of the methodological outlines.

As a result, only twenty studies (20) met the eligibility criteria and were chosen for further analysis and synthesis, to ensure a comprehensive investigation of the topic. The selected papers encompass a wide range of perspectives and methodologies, thereby enhancing both the breadth and depth of the study's findings, which will be presented in the subsequent sections.

2.2. Phase 2: Mapping

In phase 2, the twenty (20) selected papers were synthesized and mapped into the three aforementioned themes based on the objectives, methodologies, findings and implications of each paper.

Theme 1 (10 papers): Influence of Incorporating Renewable Energy on the Reduction of Non-Performing Loans (NPLs)

Includes studies highlighting financial stability, operational cost reduction, regulatory compliance and environmental reputation.

Theme 2 (5 papers): Tackling Obstacles and Advantages in the Implementation of Renewable Energy

Includes papers related to initial costs, regulatory hurdles and the need for collaborative efforts and financial incentives.

Theme 3 (5 papers): Pragmatic Suggestions for Ensuring Sustainable Funding in the Maritime Industry

Includes research providing actionable recommendations on ESG factors, capacity building, training programs and green investments.

This comprehensive mapping ensured a broad and in-depth understanding of the relationship between renewable energy adoption and financial sustainability in the maritime industry.

3. FINDINGS

This section presents the findings from the twenty (20) selected studies, thematically categorized.

Theme 1

Integrating renewable energy sources into maritime operations significantly affects the performance of borrowers in terms of loan repayments. The selected papers highlight the diverse advantages of this transition, demonstrating that RES can lead to NPL reduction by strengthening financial resilience and promoting regulatory and environmental stewardship.

Key findings include:

a. Reduction of Operational Costs: Hassan et al. (2023) emphasize that the maritime borrowers utilizing RES, can significantly experience increased profitability and enhance financial stability, while simultaneously reducing their operational expenses. Sikiru et al. (2024) agree that vessels utilizing RES witness a significant decrease in fuel costs, which are a major component of their operational expenses.
b. Financial Stability: RES improves profitability and enhances marine borrowers' capacity to fulfill their loan repayment requirements, thus reducing the NPLs (Schwerhoff & Sy, 2017).
c. Economic Resilience: Li et al. (2022) emphasize that the integration of RES in maritime operations can act as a protective shield against external risks since it allows maritime borrowers to adapt and traverse unpredictable market conditions. Consequently, financial institutions view these borrowers as less risky, leading to more advantageous loan conditions, thus reducing the likelihood of non-performing loans (Settembre-Blundo et al., 2021).
d. Regulatory Compliance: Liu et al. (2023a) state that vessels that adopt RES are in a better position and can better comply with the varying environmental regulations. This reduces the risk of incurring penalties while also enhancing their financial stability. Moreover, by

complying with the environmental regulations, maritime borrowers can avoid costly fines, while at the same time, they may an increase in their financial position.

e. Environmental Reputation: Complying with the environmental regulations, improves the environmental reputation related to the maritime borrowers. Borrowers with a strong environmental reputation may attract more investors interested in supporting environmentally responsible firms. This secures additional financing for the maritime borrowers, while at the same time improving the overall financial reputation of maritime companies. These imply decreased volumes of NPLs (Ketterer, 2017).

f. Building Trust: Liu et al. (2023b) state that maritime companies that utilize RES, imply reduced greenhouse gas emissions emitted in the atmosphere. This enhances their brand reputation and builds trust among the company and the investors. As a result, it becomes easier to obtain loans with better conditions. Iqbal and Nosheen (2023) state that the integration of RES in maritime operations is a strategic necessity with significant positive financial consequences. Durrani et al. (2020) add that RES reduces operational costs and improves the resilience of maritime borrowers. They also state that RES assists borrowers in aligning with the regulatory requirements and achieving long-term financial stability. These imply a significant reduction in NPLs.

Theme 2

While RES offers significant advantages, there numerous obstacles regarding their implementation. The selected papers, propose methods to alleviate these obstacles while also exploiting opportunities for sustainable financial practices.

Key findings include:

a. Encouragement of RES Adoption: The literature identified various methods to alleviate the barriers to RES adoption. Feng et al. (2022) propose that financial institutions might encourage investments in RES by providing marine borrowers interested in adopting RES, with advantageous loan conditions.

b. Regulatory Hurdles: Zhu et al. (2022) and Abdmouleh et al. (2015) propose the implementation of global regulatory frameworks that encourage the adoption of RES, while also offering financial incentives to facilitate its implementation.

c. Collaborative Efforts: Sen and Ganguly (2017) and Journeault et al. (2021) emphasize the necessity of collaborative endeavors among stakeholders, such as governments, financial institutions and industry participants, to collectively address the obstacles that hinder the adoption of RES. These partnerships can promote the exchange of knowledge, technology transfer and investment attraction, leading to lower implementation costs and increased viability of RES utilization in the maritime industry.

Theme 3

The selected literature provides practical suggestions to promote long-lasting sustainable finance practices in the maritime industry. The integration of ESG criteria in bank lending decisions as well as the facilitation of capacity building and training programs emerge as the most prominent.

Key findings include:

a. Integration of ESG criteria: According to Ziolo et al. (2019) and Anagnostopoulos et al. (2018), financial institutions should incorporate and consider the ESG criteria when providing new

loans to maritime borrowers. By utilizing ESG criteria, banks can evaluate the sustainability levels of maritime borrowers and extend preferential interest rates to those actively engaging in sustainable practices. Moreover, they could advance RES adoption, by offering preferential loan conditions to maritime borrowers willing to incorporate RES into their operations.

b. Capacity Building and Training Programs: According to Mallouppas and Yfantis (2021) and Majid (2020), the implementation of RES in the maritime industry can be facilitated by undertaking capacity-building. Moreover, Li and Umair (2023) and Majid (2020) suggest that training programs that target the integration, maintenance and optimization of RES can provide maritime personnel with the knowledge and skills needed to adopt sustainable practices and fully capitalize on the advantages of green investments.

4. FULFILMENT OF RESEARCH QUESTIONS

RQ1: What is the impact of incorporating RES into maritime operations on the decline of NPLs?

Research Question 1 (RQ1) is extensively covered in the first theme. This theme illustrates that maritime borrowers utilizing RES, report increased financial stability, due to lower operational costs, enhanced regulatory compliance and increased access to finance. The literature also demonstrates that RES integration reduces financial risks while also strengthening the borrowers' resilience to economic and regulatory pressures.

RQ2: How can the primary challenges associated with the deployment of RES in the maritime industry be mitigated to successfully promote sustainable finance?

Research Question 2 (RQ2) is covered in the second theme. The literature highlights barriers of maritime borrowers to RES adoption such as high initial investment costs, technology constraints and regulatory challenges. The literature also suggests strategies to overcome those barriers, such as the initiation of collaborative initiatives, regulatory frameworks and financial incentives. Additionally, the literature emphasizes the significance of stakeholder involvement and capacity-building to assist the maritime industry in sustainable transition. Strategic interventions and coordinated measures can also assist stakeholders in overcoming barriers while seizing the existing opportunities, to boost RES adoption.

RQ1 and RQ2

The third theme covers Research Question 1 (RQ1) and Research Question 2 (RQ2), by offering fact-based suggestions for ensuring sustainable funding in the maritime industry. The literature provides actionable recommendations including the integration of environmental, social, and governance (ESG) criteria into bank lending decisions. The literature also suggests banks incentivize RES investments with preferential loan terms, while also encouraging stakeholder collaboration to overcome RES adoption barriers. It also emphasizes the significance of capacity building and skill development. By investing in training and knowledge-sharing platforms, stakeholders may assist marine professionals adopt sustainable practices. Regulators and policymakers may also assist in the incorporation of RES in the maritime industry while also offering financial aid and environmental sustainability.

5. CONCLUSION & FUTURE RESEARCH

In the face of geopolitical tensions, economic instability and climate change, this paper investigates the relationship between RES and the reduction of NPLs related to maritime borrowers. Throughout a comprehensive SLR, this paper demonstrates that the NPLs of the maritime borrowers decrease as the rate of adoption related to RES increases. This is based on the examination and analysis of extensive academic and empirical evidence, highlighting the numerous advantages of renewable energy in marine operations. Specifically, the results of this paper show that the RES minimize the operational costs due to lower fuel prices. This ensures compliance with environmental regulations and leads to increased financing options for maritime firms. Environmental stewardship also elevates the reputation of the maritime borrowers, facilitating easier access to funding, while decreasing the risk of default.

Despite the advantages of RES, the paper shows significant impediments to its adoption by the maritime industry/borrowers. Among the major obstacles are the high initial investment costs, the technological limitations, as well as the complex regulatory frameworks. However, these challenges can be effectively addressed by taking proactive measures such as collaborative partnerships, supportive legislative frameworks and through financial incentives that promote sustainability practices within the maritime industry.

This research translates these findings into actionable solutions for stakeholders aiming for sustainability in the marine industry. Key strategies include incorporating Environmental, Social, and Governance (ESG) criteria into lending practices, strengthening regulatory frameworks for reducing vessel emissions and offering favourable loan conditions for renewable energy investments, while also fostering stakeholder engagement and raising public awareness regarding sustainable practices are crucial strategies. Moreover, allocating funds for capacity building, technological innovation and skill development will support maritime borrowers in mitigating the barriers to RES adoption. As a result, they will not only achieve enhanced resilience but also a long-term transition to renewable energy.

Future research could quantify the financial benefits of RES adoption; build robust economic models that quantify the cost savings and revenue potential associated with RES in maritime operations; and develop regional analyses by investigating the specific challenges and opportunities for RES adoption for vessels operating in diverse regions.

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