Evaluation Cost and Environmental Impact of Compliance Measures for IMO Sulfur Cap

Jiaqi Hu
University of Glasgow, Glasgow, U.K.

Keywords: Sulphur, Effect, Shipping.

Abstract: This research examines Maersk's crisis management in response to the NotPetya cyber attack, which severely disrupted its global IT systems. It analyses the company's actions be-fore, during and after the at-tack, highlighting Maersk's resilience, cross-functional coordination and transparent communication strategies. The study examines how Maersk quickly mobilized global resources, made quick decisions under uncertainty and restored operations with minimal long-term damage. Key success factors include proactive leadership, effective stakeholder engagement and the ability to learn and adapt in real time. The case provides valuable insights into how large multinational companies can manage cybersecurity crises, highlighting the importance of preparedness, organizational agility and crisis communication. The analysis contributes to our understanding of organizational resilience in the face of complex digital threats and has practical implications for risk management and business continuity planning in an increasingly inter-connected world. In addition, the study also revealed how Maersk can maintain business stability under chain reactions such as supply chain interruption and damage to customer trust, and to rebuild the digital infrastructure through systematic recovery measures.

1 INTRODUCTION

The "sulphur cap" refers to an environmental regulation introduced by the International Maritime Organization (IMO) that came into force on 1 January 2020. It requires a reduction in the sulphur content of marine fuels from 3.5% to 0.5% (Seas, 2020). The short-term goal of this policy is to reduce air pollution and improve public health in coastal regions and heavily trafficked maritime areas. The long-term objective is to reduce sulphur dioxide emissions from shipping by at least 50% by 2050. The implementation of the IMO 2020 regulation has had a profound impact on both the shipping industry and the environment. On the one hand, the reduction in sulphur emissions contributes to improved air quality, reduced respiratory health risks and a reduction in acid rain, which damages marine ecosystems (Wu & Lin, 2021). On the other hand, compliance requires significant financial investment. Switching to low-sulphur fuels or installing scrubbers has significantly increased operating costs (Bach & Hansen, 2023), raising concerns about industrial competitiveness and profitability. These challenges also raise questions about the economic sustainability of such measures and their compatibility with long-term decarbonization goals. This paper aims to assess the effectiveness of IMO measures in reducing sulphur emissions, examine the associated compliance burdens and contribute to future policy development for sustainable shipping.

2 LITERATURE REVIEW

2.1 Blue Shipping: Assessing the Environmental Impact of the 2020 Sulphur Cap

Numerous studies have examined the impact of the IMO 2020 sulphur cap on maritime emissions. A global study by Lindstad et al. (2017) showed a significant reduction in sulphur emissions from ships, with reductions ranging from 39% in Europe to as high as 90% in East Asia. Similarly, the International Council on Clean Transportation reported a reduction in global sulphur emissions from shipping of 6.3

Hu, J.
Evaluation Cost and Environmental Impact of Compliance Measures for IMO Sulfur Cap.
DOI: 10.5220/0014298500004859

In *Proceedings of the 1st International Conference on Politics, Law, and Social Science (ICPLSS 2025)*, pages 144-151
ISBN: 978-989-758-785-6

million tons in the first half of 2020. These results suggest that the regulation has made significant progress towards the IMO's environmental goals, particularly in terms of reducing sulphur emissions and improving air quality. Wu and Lin (2021) also found that container ships on the European trades have often adopted scrubber systems, allowing the continued use of high-sulphur fuel. This suggests that while overall emissions have decreased, regional differences in compliance methods - particularly the reliance on scrubbers - may have undermined the overall effectiveness of the policy in certain areas. However, a common limitation of existing studies is their focus on direct emissions outcomes, often overlooking secondary impacts such as changes in operational strategies or market dynamics. There remains a gap in the literature on how different compliance mechanisms affect emissions across regions, particularly when taking into account fluctuating fuel prices and the varying availability of cleaner alternatives. Furthermore, a comprehensive assessment of the economic and environmental trade-offs associated with these compliance strategies is lacking. My research aims to contribute to this field by critically analyzing how the 2020 sulphur cap is working in practice, highlighting regional differences, fuel-related challenges and potential unintended consequences. In doing so, it will provide a deeper understanding of the implementation of the policy, its practical constraints and its wider implications for the environmental transition of the shipping industry.

Although the 2020 sulphur cap has delivered encouraging results in reducing sulphur emissions from shipping, its economic impact also warrants careful consideration. Singh and Shanthakumar (2023) point out that the transition to low-sulphur fuels has significantly increased fuel costs for shipping companies. This cost increase contributes to a cost-push effect, increasing overall operating costs and potentially weakening the ability of companies to maintain performance standards, thereby reducing the global competitiveness of the industry. The effectiveness of IMO environmental policy needs to be examined in the broader context of decarbonization efforts in the maritime sector. Wang and Wright (2021) acknowledge that the sulphur cap is an important first step in limiting air pollutants, but argue that it is only a temporary solution. Achieving the IMO's longer-term goal of reducing greenhouse gas emissions by at least 50% by 2050 will require continued innovation, particularly through the introduction of alternative fuels and cleaner technologies. Therefore, while the sulphur cap has played a key role in reducing sulphur-related pollution, it must be seen as one component of a broader transition strategy. To address this gap in the existing literature, my research seeks to explore how the 2020 sulphur cap may influence the promotion and adoption of cleaner alternative fuels in the shipping industry. This perspective raises the critical question of whether the current IMO regulations are not only effective in limiting sulphur emissions, but also capable of supporting the sector's longer-term decarbonization trajectory. Understanding this relationship is central to assessing the true effectiveness of such international environmental policies in promoting sustainable shipping.

2.2 Setting a Low-Sulphur Course: Compliance Approaches in Response to the 2020 Sulphur Cap

A growing body of literature has examined how shipping companies have responded to the requirements of the 2020 sulphur cap through different compliance strategies. Cuong and Hung (2020), in their survey of Vietnamese shipping companies, found that the majority have chosen to switch to low-sulphur fuel as their primary means of compliance. Other approaches identified include the installation of scrubbers and reliance on exemptions or regulatory leniency in specific contexts. Similarly, Lindstad et al. (2017) report that most ships are largely compliant with emissions regulations, although some continue to use scrubbers or even resort to using non-compliant fuels. These studies highlight the need for more in-depth research on the economic impact of scrubber adoption and the regulatory considerations surrounding its implementation. Wu and Lin (2021) argue that scrubber-equipped ships may adjust their routes to pass through regions that still allow the use of high-sulphur fuel, raising the question of how such technologies affect compliance behaviour. This research seeks to address this gap by assessing the impact of scrubber use on both emissions control and regulatory integrity, providing insight into the broader challenges and potential benefits associated with different compliance mechanisms.

Debate continues on the effectiveness of enforcement of the sulphur cap in international waters. Bach et al. (2023) argue that robust enforcement is essential as shipowners may resort to

illegal practices such as fuel blending to reduce operating costs, leading to unreported or unjustified emissions. There are also concerns that gaps in enforcement, particularly in regions such as the Arctic, could undermine environmental objectives. Petrossian et al. (2020) also suggest that certain flag states may offer incentives or regulatory leniency, compromising the uniform application of the sulphur cap and weakening its intended effects. These findings highlight the urgent need for stronger monitoring and enforcement mechanisms. Wang and Wright (2021) also note that smaller shipping companies may be disproportionately affected by the regulation due to their limited financial capacity to invest in compliance technologies. This study aims to contribute to the debate by analyzing the economic impact of the 2020 sulphur cap on different segments of the industry, assessing how these regulations affect competitiveness and long-term sustainability. It also aims to provide policy-relevant recommendations to support the future development of effective and equitable environmental regulation in maritime transport.

2.3 Low Sulphur Mandate, High Economic Stakes: The 2020 Cap and Its Impact on Shipping

The enforcement of the 2020 sulphur cap has created significant economic challenges for the shipping industry. Singh and Shanthakumar (2023) highlight that the mandatory switch to low-sulphur fuels has significantly increased operating costs, which was particularly difficult during the COVID-19 pandemic when freight demand and rates were already depressed. In addition, Bach et al. (2023) argue that varying levels of enforcement and leniency - particularly through incentives offered by certain flag states - can create an uneven regulatory landscape. Such disparities risk undermining the principle of fair competition, disadvantaging compliant companies and potentially encouraging a shift in trade routes and shipping operations to jurisdictions with more lenient compliance requirements. These issues suggest that the economic sustainability of the regime may be compromised if consistent global enforcement is not achieved. The theoretical underpinnings of this research draw on the literature examining emissions leakage, competitive distortions and shifts in maritime activity. It examines how compliance strategies and technological adjustments affect not only cost structures but also broader trade dynamics. Ultimately, this study aims to provide practical insights for both industry practitioners and policy makers on how to implement sulphur regulations in a more equitable and sustainable manner.

Another important economic concern highlighted in the literature relates to the influence of the 2020 sulphur cap on strategic flag state selection. Petrossian et al. (2020) found that ships may increasingly reflag to countries offering more affordable or lenient compliance routes. While this trend may reduce costs for operators, it threatens the competitiveness and regulatory standards of traditional flag states and raises questions about safety and oversight. Furthermore, while the sulphur cap has delivered measurable emissions reductions, it has not yet catalyzed a meaningful shift towards long-term decarbonization. The industry has largely avoided addressing the wider need to adopt alternative, low-emission fuel technologies. This disconnect suggests that while short-term environmental targets are being met, the transformational changes required for deep carbon reduction remain elusive. This research project seeks to bridge this gap by analyzing how economic factors shape compliance decisions and identifying the systemic barriers that prevent the wider uptake of sustainable fuel options. In doing so, it will provide valuable insights into how international regulations can be designed to encourage not only emissions reductions, but also sustainable shifts towards environmental innovation in shipping.

2.4 Impacts and Implications of Sulphur Emission Regulations

In summary, the literature reviewed shows that the International Maritime Organization's sulphur emissions policy has had a significant impact on the maritime sector. The introduction of the 2020 sulphur cap has led to measurable reductions in sulphur emissions globally, but the extent of the impact varies by region, particularly where alternative compliance measures - such as the installation of scrubbers - are widely used. Economically, the regulation has posed notable challenges, in particular the increase in operating costs due to the introduction of low-sulphur fuel and the disproportionate burden placed on smaller and less financially resilient shipping companies. Despite these findings, there remains a need for more comprehensive research into the wider impacts of the policy - in particular its role in facilitating long-term decarbonization and its impact

on the global competitiveness of the shipping industry. This research gap provides an opportunity to deepen understanding of how international regulations shape industry practices and to evaluate the effectiveness of different compliance strategies. Ultimately, the successful implementation of IMO regulations must be accompanied by a shift towards cleaner fuels and innovative technologies. These elements are essential not only to meet immediate emissions targets, but also to support the long-term sustainability and efficiency of maritime transport in a rapidly evolving regulatory and environmental landscape.

3 CASE

3.1 Case Study

Maersk's response to the IMO 2020 sulphur cap - strategy, impact and lessons learned A.P. Moller-Maersk, headquartered in Denmark, is the world's largest container shipping company with an extensive global fleet and logistics network. The implementation of the IMO 2020 regulation, which limits the sulphur content of marine fuels to 0.5% (down from 3.5%), marked a major regulatory shift for the shipping industry. The regulation aims to reduce harmful sulphur oxide (SOx) emissions, which have a significant impact on human health and the environment, particularly in coastal regions. As a global industry leader, Maersk's approach to complying with the IMO 2020 regulation offers valuable insights into how large companies can balance environmental responsibility with economic viability. This case study examines the company's chosen compliance strategy, the resulting operational and financial impact, and the wider implications for sustainability and competitiveness in the maritime sector.

3.2 Compliance Strategy: Opting for Low-Sulphur Fuel

Shipping companies had several main compliance options under the new sulphur cap: switching to very low sulphur fuel oil (VLSFO), installing exhaust gas cleaning systems (commonly known as scrubbers) or switching to alternative fuels such as LNG or methanol. Maersk has primarily chosen to switch to low-sulphur fuels across its fleet rather than install scrubbers. Between 2018 and 2020, the company invested significantly reportedly more than $150 million - to prepare for this transition. This included upgrading fuel handling systems, retraining crew and securing reliable supplies of compliant fuel at key global ports.

Unlike some of its peers, Maersk deliberately limited its use of scrubbers, citing concerns about environmental controversies in particular open-loop scrubbers that discharge the contaminated washing water into the possible regulatory ban in the future. The company emphasized a long-term view, seeking consistency with its broader environmental goals rather than short-term economic gains.

3.3 Economic Impacts: Managing Rising Fuel Costs

Maersk's switch to low sulphur fuel, while environmentally progressive, had significant financial implications. Initially, very low sulphur fuel oil (VLSFO) was 30-50% more expensive than traditional high sulphur fuel oil (HSFO), leading to a significant increase in operating costs. According to Maersk 2020's financial reports, fuel-related costs increased by approximately $200 million in the first half of the year alone, largely as a result of the new regulation.

To mitigate these costs, Maersk has implemented several strategic responses. First, the company introduced an "IMO 2020 Environmental Fuel Fee" to pass on part of the additional fuel costs to customers. Second, it implemented operational measures such as route optimization and slow steaming to reduce overall fuel consumption. Third, Maersk entered into strategic sourcing partnerships with refiners to secure a stable and cost-effective supply of VLSFO.

Despite the initial challenges, Maersk has successfully maintained operational efficiency and market competitiveness. By the end of 2020, the price gap between VLSFO and HSFO had narrowed, alleviating some of the financial pressure. In addition, the company's proactive approach and transparent communication with stakeholders helped to maintain customer confidence and strengthen brand credibility.

3.4 Environmental Benefits and Broader Decarbonization Strategy

The switch to low-sulphur fuel has had a significant positive impact on the environment. Maersk reported a reduction in sulphur oxide emissions of more than

80% in 2020, contributing to improved air quality along major shipping routes and in port cities. These achievements were in line with IMO targets and reinforced Maersk's image as a sustainability leader in the maritime sector. Crucially, Maersk saw IMO 2020 not as an isolated compliance challenge, but as a steppingstone to full decarbonization. The company has publicly committed to achieving net-zero carbon emissions across its operations by 2040 and a 50% reduction in greenhouse gas emissions intensity by 2030 (compared to 2020 levels).

In pursuit of this goal, Maersk has invested heavily in alternative marine fuels and clean technologies. In 2023, the company will launch the world's first container ship powered by green methanol and has ordered more than a dozen dual-fuel ships that can run on methanol or conventional fuel. While IMO 2020 focused primarily on sulphur reduction, Maersk's investments in green methanol and dual-fuel ships indicate a broader environmental strategy that may contribute to a low-carbon future in maritime transport.

3.5 Challenges and Risks

While Maersk's approach was largely successful, it was not without its challenges. The company had to deal with. Operational complexity: Different VLSFO formulations at different suppliers and ports required more stringent fuel quality control and compatibility testing. As for crew training, handling new fuel types required updated operating procedures and safety protocols, increasing the need for training. Market volatility: In the early months of implementation, unpredictable VLSFO prices created budget risks and affected route planning. In addition, Maersk's decision to avoid widespread use of scrubbers revealed a wider tension in the industry: while some companies invested in scrubbers to benefit from cheaper HSFO, others like Maersk prioritized long-term environmental responsibility. This created an uneven playing field in the short term, where companies with different strategies faced different cost structures and competitive advantages. Meanwhile, Maersk recognized the regulatory loopholes exploited by some smaller operators such as flag state leniency and inconsistent enforcement in some regions which could undermine the effectiveness of global sulphur limits. This highlights the importance of international regulatory alignment and robust monitoring mechanisms.

3.6 Lessons Learned and Policy Implications

Maersk's experience with the IMO 2020 regulation illustrates how a proactive strategy and environmental leadership can deliver both compliance and competitive benefits. By preparing early, formulating a clear transition plan and maintaining transparent communication with its customers, Maersk was able to manage the transition to low-sulphur fuels more effectively than many of its competitors. This approach not only reduced operational risks, but also strengthened customer confidence. The company's alignment of regulatory compliance with its long-term sustainability goals further strengthened its brand image. Rather than viewing environmental regulations as a burden, Maersk integrated them into its broader vision, enhancing customer loyalty and distinguishing itself as a responsible market leader. However, the variation in compliance across the industry reveals a gap in global enforcement, pointing to the need for greater international coordination and harmonized environmental standards. IMO 2020 has also acted as a catalyst for innovation, encouraging investment in alternative fuels and new technologies. This momentum is essential as the shipping industry moves towards the IMO's 2050 target of reducing greenhouse gas emissions by at least 50%. Maersk's early move into green fuels such as methanol shows that companies that see regulation as a strategic opportunity will be better placed to shape the future of sustainable shipping.

3.7 Maersk's Strategic Response to the IMO 2020 Sulphur Cap

Maersk's response to the IMO 2020 sulphur cap shows how a leading shipping company can combine environmental responsibility with economic resilience. By choosing to switch to low-sulphur fuels and investing in future-proof technologies, Maersk not only met the short-term regulatory requirements, but also laid the foundations for long-term decarbonization. While challenges remain - particularly around fuel costs, enforcement and industry-wide fairness - the case shows that compliance can go hand in hand with innovation, competitiveness and sustainability.

4 FINDINGS AND DISCUSSION

4.1 Maersk's Compliance Strategy: Low-Sulphur Fuel as a Long-Term Bet

Maersk's primary response to the IMO 2020 sulphur cap has been to proactively adopt very low sulphur fuel oil (VLSFO), rather than relying on scrubbers. This strategy involved an upfront investment of more than $150 million to upgrade fuel systems, retrain personnel and establish stable supply chains for compliant fuels. Compared to other carriers who opted for scrubbers to continue burning cheaper high sulphur fuel oil (HSFO), Maersk's decision reflects a strategic preference for long-term environmental responsibility over short-term cost savings. This approach aligns with its broader decarbonization goals and reduces its exposure to potential regulatory backlash against scrubber discharge practices. The findings suggest that corporate environmental leadership can be motivated not only by regulatory compliance, but also by reputational considerations and anticipated policy trajectories.

This forward-looking strategy differentiated Maersk in a fragmented industry landscape where enforcement and compliance were uneven. Maersk's limited use of scrubbers also addresses the concern raised by Wu and Lin (2021), who found that scrubbers - while compliant - may reduce the environmental effectiveness of sulphur caps, particularly in regions where enforcement is uneven or water pollution is an issue.

4.2 Economic Impacts: Cost Burden and Strategic Adaptation

Although environmentally sound, Maersk's decision to switch to VLSFO came at a significant financial cost. At the start of 2020, the price of VLSFO was 30-50% higher than HSFO, contributing to an estimated $200 million increase in Maersk's fuel-related costs in the first half of the year alone. This placed an additional burden on operations already affected by the COVID-19 pandemic, as noted by Singh and Shanthakumar (2023), who identified the IMO 2020 regulation as a driver of cost-push inflation in the shipping sector.

To mitigate these economic impacts, Maersk has implemented several strategies, including the introduction of the IMO 2020 Environmental Fuel Fee, route optimization and slow steaming to improve fuel efficiency. Strategic sourcing agreements with refiners have also been instrumental in managing fuel price volatility. This adaptability illustrates how large operators can absorb regulatory shocks through diversified operational and commercial levers. However, such strategic flexibility may not be available to smaller or less capitalized operators, exacerbating competitive inequalities in the industry, as observed by Wang and Wright (2021).

4.3 Environmental Outcomes and Decarbonization as a Strategic Trajectory

Maersk's switch to low-sulphur fuel resulted in a reported 80% reduction in SOx emissions in 2020, directly contributing to improved air quality along global trade routes. This is in line with Lindstad et al. (2017), who documented dramatic reductions in sulphur emissions in key regions following the implementation of IMO 2020. More importantly, Maersk has positioned this regulatory milestone as a platform for broader decarbonization. The company has committed to net-zero operations by 2040 and to halving its greenhouse gas intensity by 2030.

The company's investments in green methanol and dual-fuel vessels mark a deliberate shift beyond compliance to innovation. In 2023, Maersk will launch the world's first green methanol-powered container ship and has ordered additional vessels that can run on either methanol or conventional fuels. These initiatives, while still in their infancy, demonstrate a willingness to front-load R&D investment in order to shape the future regulatory and market landscape. While these steps suggest a 'post-fossil fuel' ambition, a more critical view would require closer tracking of fleet-wide emissions trajectories and life cycle analysis of alternative fuels to fully substantiate this claim.

4.4 Operational and Regulatory Challenges

Despite its successes, Maersk faced significant challenges in implementing its strategy. VLSFO formulations varied between regions and suppliers, making it difficult to ensure fuel quality and compatibility. Crew retraining and safety adjustments were also required. These findings echo earlier concerns raised by Cuong and Hung (2020), who highlighted the operational burden of low-sulphur fuel compliance in Southeast Asia.

Furthermore, Maersk's aversion to scrubbers highlighted the disparity in compliance costs across the industry. While motivated by environmental concerns, this stance put Maersk at a temporary cost disadvantage to operators using cheaper fuels with scrubbers. In addition, inconsistencies in global enforcement - such as flag state leniency or weak port state control in some jurisdictions - allowed less scrupulous operators to avoid the financial burden of compliance, distorting competition and undermining global emissions targets. This is consistent with Petrossian et al. (2020), who highlighted the risks posed by flags of convenience and uneven enforcement.

4.5 Broader Policy Implications and Industry Lessons

Maersk's experience with the IMO 2020 regulation offers important lessons for both policymakers and industry stakeholders. First, early preparation and transparent communication can reduce transition costs and increase customer confidence. Second, environmental leadership if backed by credible action can enhance brand value and competitiveness. Third, the regulation catalyzed innovation in cleaner marine fuels, suggesting that well-designed environmental mandates can be constructive rather than punitive.

However, the case also highlights the limits of voluntary action and the importance of strong international governance. Without harmonized enforcement, the full benefits of IMO regulations risk being undermined by regulatory arbitrage and uneven burdens on business. Future policy frameworks must therefore combine ambitious targets with robust monitoring mechanisms and financial support for smaller operators to ensure a level playing field.

5 CONCLUSION

The implementation of the IMO 2020 sulphur cap has brought significant changes to the global shipping industry, particularly in balancing environmental objectives with economic realities. This paper uses the case study of Maersk to demonstrate how proactive compliance strategies can deliver both environmental and reputational benefits, despite short-term financial burdens. Maersk's decision to use low-sulphur fuel instead of relying on scrubbers reflects a long-term vision in line with global decarbonization targets. The company's experience shows that compliance with international environmental regulations, while costly, can drive innovation and industry transformation.

At the same time, the uneven global enforcement of sulphur regulations and the varying ability of shipping companies to adapt highlight challenges in terms of regulatory fairness and policy impact. Smaller operators and developing flag states may struggle to keep up, leading to competitive distortions and reduced regulatory effectiveness. Future policy must therefore address these inequalities through harmonized enforcement and targeted support mechanisms.

In conclusion, the IMO 2020 sulphur cap has proven effective in reducing emissions, but its success in promoting long-term sustainability depends on broader structural reforms, investment in alternative fuels and coordinated international governance. The Maersk case suggests that companies that see regulation as an opportunity rather than a constraint are best placed to lead the shipping industry towards a cleaner, more resilient future.

RREFERENCES

Bach, H. & Hansen, T. 2023. IMO off course for decarbonisation of shipping? Three challenges for stricter policy. *Marine Policy* 147: 105379.

Bruzzone, F., Cavallaro, F. & Nocera, S. 2021. The integration of passenger and freight transport for first-last mile operations. *Transport Policy* 100: 31–48.

Chen, S., Zheng, S. & Sys, C. 2023. Policies focusing on market-based measures towards shipping decarbonization: Designs, impacts and avenues for future research. *Transport Policy* 137: 109–124.

Cuong, N.M. & Hung, P.V. 2020. An analysis of available solutions for commercial vessels to comply with IMO strategy on low sulphur. Journal of International Maritime Safety, *Environmental Affairs, and Shipping* 4(2): 40–47.

Wijayanto, D. & Gede. 2022. Comparison analysis of options to comply with IMO 2020 sulphur cap regarding environmental and economic aspect. IOP Conference Series: *Earth and Environmental Science* 1081(1): 012051.

Fratila (Adam), A., Gavril (Moldovan), I.A., Nita, S.C. & Hrebenciuc, A. 2021. The importance of maritime transport for economic growth in the European Union: A panel data analysis. *Sustainability* 13(14): 7961.

Halff, A., Younes, L. & Boersma, T. 2019. The likely implications of the new IMO standards on the shipping industry. *Energy Policy* 126: 277–286.

Lam, J.S.L., Cullinane, K.P.B. & Lee, P.T.W. 2018. The 21st-century Maritime Silk Road: Challenges and

opportunities for transport management and practice. *Transport Reviews* 38(4): 413–415.

Lee, P.T.W., Hu, Z.H., Lee, S.J., Choi, K.S. & Shin, S.H. 2018. Research trends and agenda on the Belt and Road (B&R) initiative with a focus on maritime transport. *Maritime Policy & Managemen*t 45(3): 282–300.

Lindstad, H.E., Rehn, C.F. & Eskeland, G.S. 2017. Sulphur abatement globally in maritime shipping. Transportation Research Part D: *Transport and Environment* 57: 303–313.

Petrossian, G.A., Sosnowski, M., Miller, D. & Rouzbahani, D. 2020. Flags for sale: An empirical assessment of flag of convenience desirability to foreign vessels. *Marine Policy* 116: 103937.

Singh, A. & Shanthakumar, S. 2023. Green shipping and trade: Allocating costs of the IMO Sulphur Regulation 2020. *Global Trade and Customs Journal* 18(3).

Wang, Y. & Wright, L.A. 2021. A comparative review of alternative fuels for the maritime sector: Economic, technology, and policy challenges for clean energy implementation. *World* 2(4): 456–481.

Wu, P.-C. & Lin, C.-Y. 2020. Cost-benefit evaluation on promising strategies in compliance with low sulfur policy of IMO. *Journal of Marine Science and Engineering* 9(1): 3.

Wu, P.-C. & Lin, C.-Y. 2021. Strategies for the low sulfur policy of IMO—An example of a container vessel sailing through a European route. *Journal of Marine Science and Engineering* 9(12): 1383.

Zhang, Z. & Liu, D. 2021. A cost-benefit analysis of fuel-switching vs. use MGO: A China-Europe container route case. IOP Conference Series: *Earth and Environmental Science* 831(1): 012008.

Seas, C. 2020. What is IMO 2020? *Clear Seas,* 11 February.