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Challenges and Security Risks in the Red Sea: Impact of Houthi Attacks on Maritime Traffic

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Abstract: This study examines the significant impact of Houthi insurgent activities on maritime traffic within the strategic Red Sea and Suez Canal routes, essential conduits for global trade. It explores the correlation between regional instability, exemplified by Houthi actions from 19 November 2023 to 5 February 2024, and changes in maritime traffic patterns and operational efficiency. This study seeks to answer a critical question in transport geography: how does regional instability, exemplified by Houthi insurgent activities, affect the maritime traffic patterns and operational efficiency of the Red Sea and Suez Canal? Using descriptive statistics, qualitative analysis, and geospatial methods, this research highlights recent trends in maritime traffic and incidents, revealing spatial and geopolitical challenges in this crucial trade route. The findings indicate a notable decline in maritime activity in the Gulf of Aden and Suez Canal due to security concerns from Houthi attacks, prompting a significant shift to alternative routes, particularly around the Cape of Good Hope. This shift underscores the broader implications of regional instability on global trade and the importance of maintaining an uninterrupted maritime flow. This study also emphasizes the economic ramifications, such as increased operational costs and freight rates due to longer transit times and enhanced security measures. This research concludes with a call for improved maritime security protocols and international cooperation to protect these strategic maritime pathways. It contributes to the discourse on transport geography by quantifying the direct impacts of regional conflicts on maritime logistics and proposing strategies for future resilience, highlighting the interconnected nature of global trade and security and the need for collective action against evolving geopolitical challenges.

Keywords: maritime transport; maritime security; maritime pollution; ocean governance; law of sea

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1. Introduction

The Red Sea, a critical maritime link between the Indian Ocean and the Mediterranean Sea via the Suez Canal, has been a focal point of global trade for centuries. Its strategic location has rendered it an invaluable route for maritime traffic, shaping economic and political landscapes across regions. Historically, the Red Sea was a key part of the Spice Route, serving as a trading corridor for early civilizations, including the Egyptians, Phoenicians, and Romans, who transported goods such as frankincense, myrrh, and precious metals. The control of this waterway has long been contested, with various empires recognizing its pivotal role in commanding trade and influence [1].

The Suez Canal, completed in 1869, revolutionized maritime trade by offering a direct route between Europe and Asia, avoiding the lengthy and perilous journey around Africa's Cape of Good Hope. The canal's construction was a testament to human ingenuity and ambition, forever altering the patterns of global trade and shipping. Today, approximately 12% of global trade passes through the Suez Canal, underscoring its standing as one of the world's most heavily trafficked maritime trade routes [2].

Economically, the Suez Canal contributes significantly to the Egyptian economy, with canal tolls being a vital source of national revenue. Its role in the expedited global transport

of oil and LNG cannot be overstated, as it facilitates the timely and efficient delivery of energy resources that are critical to industries and consumers worldwide [3]. The canal also plays a strategic role in global supply chains, with a significant portion of container shipping relying on this passageway to move goods between continents.

The Red Sea region's stability, however, is crucial to maintaining the uninterrupted flow of this trade. The emergence of the Houthi insurgency in Yemen presents a multitude of security concerns, with the insurgent group targeting maritime vessels, threatening one of the world's key maritime chokepoints, the Bab el Mandeb Strait. The implications of such disruptions are far-reaching, affecting not only regional but global trade dynamics [4–6].

The Houthis' increasingly sophisticated arsenal poses a heightened threat to commercial shipping, with the group claiming responsibility for several high-profile attacks in recent years. These incidents have prompted international naval coalitions to increase patrols in the region, striving to safeguard passage through these waters. The conflict has also led to fluctuations in global oil prices, influenced insurance rates for shipping in the region, and prompted a reevaluation of security strategies by maritime companies [7,8].

This study seeks to answer a critical question in transport geography: how does regional instability, exemplified by Houthi insurgent activities, affect the maritime traffic patterns and operational efficiency of the Red Sea and Suez Canal, key arteries in the global maritime trade network? By employing descriptive statistics and qualitative and geospatial analytical methods to examine recent trends in maritime traffic and incident reports, this research aims to provide insights into the spatial and geopolitical challenges facing one of the world's most vital trade routes. In doing so, it explores the implications of these dynamics for global trade, regional security, and the future resilience of maritime transportation infrastructure.

2. Literature Review

2.1. Maritime Traffic in the Red Sea and Suez Canal

The strategic importance of the Red Sea and the Suez Canal as commercial lifelines has been well established in the academic literature. The evaluation of the Suez Canal underscores its irreplaceable role in facilitating a significant fraction of global maritime trade [9–11]. This waterway not only serves as a critical economic artery for Egypt but also for the numerous trading nations dependent on its accessibility for the efficient shipping of goods between Europe and Asia [12].

The canal's contribution reduces the travel distance for shipments by an average of 7000 km, thus significantly lowering transit times and shipping costs. This logistical advantage, however, is not without its challenges [13–15]. Wan et al. [16] scrutinize the operational challenges posed by the canal's limited capacity. With the advent of mega-ships and growing global trade, the Suez Canal has occasionally become a bottleneck, with the resulting congestion creating a cascade of delays throughout global supply chains.

The literature has also touched upon the efforts of the Suez Canal Authority to expand and deepen the canal, aiming to accommodate the ever-increasing size and volume of maritime traffic. Studies explore the economic and environmental impacts of such expansions, indicating both positive economic outcomes and potential environmental concerns [17].

2.2. Security Risks in Maritime Routes

Ploch et al. [18] and Johri et al. [19] provide a foundational understanding of the maritime security risks, particularly emphasizing the resurgence of piracy in the Horn of Africa and its suppression due to international naval efforts, moving from piracy to politically motivated risks, bringing to light the unique set of security challenges in the Red Sea, diverging from traditional piracy, and entering the realm of geopolitical conflict [20–24].

The Houthi insurgency in Yemen has been a catalyst for a series of maritime security threats that have transcended regional boundaries and affected global maritime operations [25–27]. Salehyan, Narang, and Colaresi et al. [28–30] have illustrated how regional conflicts, especially in strategically located areas, can escalate into global security concerns.

Their analysis includes the economic repercussions of such instability, from the immediate effects on shipping routes to the long-term impacts on international trade relations and energy markets.

2.3. Impact of the Houthi Insurgency

Samaan's [7] research details the tactics utilized by the Houthi rebels, such as targeted missile strikes and the strategic deployment of drones, which pose a significant hazard to both commercial and military vessels. These actions have not only threatened the security of the Red Sea transit corridor but have also caused a ripple effect across international shipping and trade practices.

Rose [31] delves deeper into the economic ramifications, discussing the surge in insurance premiums and the logistical challenges faced by shipping companies in rerouting their vessels. Sun et al. [32] examine the implications of such rerouting, not only in terms of immediate financial costs but also in the context of shipping efficiency and the reliability of global supply chains.

The importance of freedom of navigation, a cornerstone of international maritime law, extends beyond the immediate context of the Houthi conflict, having been a critical factor in historical and contemporary maritime disputes [33]. The South China Sea disputes have highlighted tensions between territorial claims and international rights to free passage, demonstrating how freedom of navigation is often at the forefront of geopolitical standoffs [34–36]. These precedents emphasize the fundamental role that unimpeded maritime passage plays in global trade and security. Analyzing past conflicts, as performed by Khalid and Voyer et al. [37,38], reveals a pattern where threats to navigation rights not only disrupt regional stability but also have far-reaching implications for the global economy.

2.4. Maritime and Security Strategies

The works of Bueger and Germond [39,40] play a crucial role in deepening the understanding of the complex, multifaceted nature of maritime security, providing valuable perspectives in addressing a range of threats, such as piracy and politically motivated attacks. Bueger advocates for comprehensive solutions that span from local law enforcement initiatives to collaborative international naval efforts, underscoring the intricate challenges in ensuring the safety of maritime domains. Similarly, Germond highlights the necessity of incorporating legal, operational, and technological aspects into maritime security strategies. His particular emphasis on maritime spatial planning highlights the need for regional collaboration, especially in semi-enclosed bodies of water like the Red Sea, where joint actions are vital in effectively reducing security risks and bolstering maritime safety. This is further complemented by the insights from Shortland et al. and Ehrhart et al. [41,42].

The success of counter-piracy efforts near Somalia, marked by the deployment of international naval patrols and onboard private armed security, sets an important example in countering the security challenges presented by the Houthi insurgency. The research conducted by Kraska, Riddervold, Gebhard, Pristrom et al. and Winn et al. [20,43–47] sheds light on effective operational tactics and the benefits of global cooperation, which led to a noticeable decline in piracy events. Guilfoyle [48] offers a detailed analysis of the Contact Group on Piracy Off the Coast of Somalia (CGPCS), underlining the critical role of global legal and operational partnerships in the fight against piracy. Additionally, Kraska et al. [49] explore various shipboard tactical responses, including route adjustments, heightened alertness, and the engagement of private security forces, which could be repurposed to address threats from Houthi assaults.

2.5. Gap in the Literature

The comprehensive literature review emphasizes the significant body of research that explores the strategic importance of the Red Sea and Suez Canal, their logistical value, and the associated security risks. However, it seems that there is a gap in our understanding

of the nuanced interplay between regional conflicts, such as the Houthi conflict, and their direct, quantitative impacts on maritime traffic patterns and global supply chain efficiency.

Furthermore, there is limited research on the real-time analysis of emerging maritime conflicts and their immediate effects on global shipping patterns. The literature lacks comprehensive studies on the environmental consequences of conflict-induced maritime rerouting, particularly in strategically significant areas like the Red Sea. Additionally, there is a gap in our understanding of the effectiveness of international cooperation in addressing complex, politically motivated maritime security threats, as opposed to more traditional challenges like piracy. This study aims to address these gaps by providing an initial framework for the analysis of the ongoing Houthi conflict and its multifaceted impacts on maritime traffic, security, and the environment. By doing so, it contributes to the evolving discourse on the intersection of regional conflicts, global trade dynamics, and maritime security in an era of emerging geopolitical challenges.

3. Methodology

3.1. Objectives and Scope

Building upon the identified research gap, this study is underpinned by the following research questions:

1. How do Houthi insurgent activities correlate with changes in maritime traffic patterns within the Red Sea and Suez Canal?
2. What are the immediate and extended effects of such activities on the logistics and costs of global maritime trade?
3. Can we identify predictive patterns from the collected data that could inform future maritime logistics and defense strategies?

The scope of this study is expressly designed to address these questions, aligning with the observed gap in the existing literature regarding the quantifiable impacts of regional conflicts on maritime traffic and the wider global trade network. This approach directs the analysis towards the goal of quantifying the direct impact of insurgent activities on maritime logistics and assessing their broader implications for international maritime security.

3.2. Data Collection

3.2.1. Maritime Traffic Data

A comprehensive dataset on maritime traffic was meticulously compiled, detailing the volume, tonnage, and types of vessels navigating through the Suez Canal and the Red Sea. The data were procured from established and authoritative sources such as Lloyds List Intelligence [50–54], UNCTAD [55,56], Clarkson's Research [57], BIMCO [58–60], and the International Monetary Fund [61]. The selection of a timeframe spanning from the 1st Houthi attack (19 November 2023) to 5 February 2024 was intended to provide a robust longitudinal perspective, allowing for the assessment of trends and disruptions attributable to significant geopolitical events. The dataset's variety, encompassing various vessel classes, enriched the study's ability to analyze traffic flows and vessel-specific challenges in depth.

3.2.2. Incident Reports

Incident reports focusing on events attributed to Houthi activities were thoroughly reviewed and aggregated from the US Naval Forces Central Command and the United Kingdom Maritime Trade Operations from the Royal Navy. This ensured a broad and detailed dataset, providing granular insights into the nature, location, threat category, and reactions by maritime authorities to each incident, vital in answering the above research questions.

By articulating the research questions and explaining how the scope aligns with the identified research gap, this section now better establishes the relevance of the study's aims and the pertinence of the data collected. This framework will guide the subsequent analytical methods, directly connecting them to the objectives of assessing the impacts of insurgent activities on maritime traffic and security.

3.3. Analytical Methods

Qualitative and Quantitative Analysis: The investigation of maritime traffic data and incident reports incorporated descriptive statistics and a qualitative content analysis approach. While the quantitative analysis focused on cataloging the current trends and assessing the impacts of various factors without employing advanced models or considering seasonality effects, the qualitative examination delved into the reports with a content analysis method. Each incident was classified according to a schema, identifying the date of the incident, name of the ship, flag, attack type, and outcomes. This dual approach enabled the identification of thematic patterns, providing a comprehensive context for the findings and facilitating the selection of case studies for deeper investigation. Together, these methods offered a holistic view of the effects of the Houthi insurgency on maritime operations, combining immediate statistical insights with in-depth narrative understanding.

Geospatial Analysis: Our study primarily relied on reports published by authoritative sources such as Clarkson's Research, Lloyd's List Intelligence, BIMCO, IMF, and UNCTAD. These reports provided aggregated data on maritime traffic, including information derived from AIS, focused on vessels transiting the Red Sea and Gulf of Aden region. We integrated information from these various sources to create a comprehensive view of maritime activity in the region and its relationship with Houthi activities. The comprehensive nature of these reports allowed us to conduct a robust analysis of the spatial and temporal patterns without the need for extensive raw data processing, leveraging the expertise of these authoritative sources. This multi-source approach enabled us to conduct a robust analysis of the spatial and temporal patterns of maritime activity and security risks in the study area.

4. Findings

4.1. Maritime Traffic Trends

In analyzing the marine traffic trends from the data provided in Table 1, it is evident that there has been a marked shift in the pattern of maritime movement across key geographical areas, potentially linked to Houthi attacks in the region. The Gulf of Aden, a critical juncture in the global shipping route, experienced a dramatic downturn in activity, with the total traffic decreasing from 4.83 million gross tonnage (m GT) in December 2023 to only 2.13 m GT by February of the following year. This represents a significant decline of 56% in January, deepening to 71% in February. The containers sector was the most affected, with its traffic virtually collapsing, which suggests that commercial logistics have been severely disrupted, possibly due to security concerns stemming from maritime threats.

Similarly, the Suez Canal, another pivotal maritime corridor, saw its traffic decrease from 4.40 m GT to 2.27 m GT during the same period, marking a downturn of 48% initially in January, which then extended to 62% in February. The sharp fall in the containers and LPG sectors within the Suez Canal's traffic could be indicative of heightened risk aversion among shipping companies, possibly choosing alternative routes to avoid areas prone to conflict and instability.

In stark contrast, the Cape of Good Hope (CoGH) witnessed a surge in marine traffic, with an increase of 63% in January and 74% in February. This uptick is likely a direct consequence of the rerouting measures taken by maritime operators to circumvent the areas affected by Houthi attacks, thus avoiding the risks associated with passing through the Gulf of Aden and the Suez Canal.

The complete cessation of LNG traffic in February for both the Gulf of Aden and the Suez Canal is a notable anomaly and may reflect specific targeting or threats to this category of shipping, which prompted a complete halt in movement. This halt could be due to the strategic significance of LNG and the impact that disruptions in its transport could have on global energy markets.

Overall, the volatility in these maritime channels could be attributed to the disruptive impact of Houthi attacks, which have diminished the safety and predictability of one of the world's busiest maritime trade routes. This has led to significant operational shifts and

adjustments in global shipping patterns, as evidenced by the contrasting trends observed in the analyzed data.

Table 1. Shipping traffic trends.

Geographical Area	Sector	Unit	Daily Average			Trend vs. Dec 2023 Avg.	
			2023	Dec	Jan	Jan	Feb
Gulf of Aden	Total	m GT	4.64	4.83	2.13	−56%	−71%
	Containers	m GT	1.91	1.75	0.16	−91%	−92%
	Crude	m GT	0.71	0.73	0.58	−21%	−47%
	Products	m GT	0.41	0.44	0.25	−43%	−55%
	Bulk Carriers	m GT	0.86	1.04	0.82	−21%	−48%
	LNG	m GT	0.27	0.36	0.13	−66%	−100%
	LPG	m GT	0.08	0.15	0.04	−71%	−90%
	Car Carriers	m GT	0.21	0.18	0.07	−59%	−91%
Suez Canal	Total	m GT	4.44	4.40	2.27	−48%	−62%
	Containers	m GT	1.87	1.72	0.45	−74%	−79%
	Crude	m GT	0.63	0.53	0.46	−12%	−35%
	Products	m GT	0.41	0.40	0.28	−31%	−36%
	Bulk Carriers	m GT	0.85	0.98	0.76	−23%	−42%
	LNG	m GT	0.27	0.29	0.14	−53%	−100%
	LPG	m GT	0.08	0.17	0.03	−79%	−94%
	Car Carriers	m GT	0.17	0.14	0.06	−55%	−96%
Cape of Good Hope	Total	m GT	4.05	4.15	6.78	63%	74%

Source: Our own research based on Clarkson's Research, Lloyd's List Intelligence, and IMF.

4.2. Security Incidents Related to Houthi Activities

The information provided in Table 2 paints a comprehensive picture of various ship incidents, characterized by a diverse array of attacks including piracy, unmanned aerial vehicle (UAV) strikes, anti-ship missile strikes, and combinations thereof. There is a noticeable trend in the frequency of attacks, which appears to be increasing or maintaining a steady pace over time. The incidents span ships sailing under various international flags, suggesting that these events are widespread and not confined to vessels of any specific nation.

In particular, the involvement of the US Navy and Royal Navy highlights that military vessels are among the targets, indicating a broad scope that encompasses both commercial shipping and naval operations. This amalgamation of traditional piracy and advanced warfare tactics underscores the evolving nature of maritime threats. Although the lack of geographic data limits a precise risk assessment, the implication is clear: certain regions may pose significant hazards to maritime operations.

The timeline of these attacks, especially if aligned with geopolitical developments, could reveal patterns or escalations in conflict. The occurrence of multiple attacks on the same day suggests the possibility of coordinated actions, while the detailed account of an omnibus attack involving a sophisticated mix of missiles and UAVs points to a high level of strategic planning and capability among the perpetrators.

The specific targeting of naval vessels with missiles, including repeated incidents involving the USS Carney, which notably shot down 14 UAVs in one encounter and was later targeted by an anti-ship missile in another, signifies a deliberate focus on military assets. This could reflect the strategic significance of the areas in which these incidents occurred or the operational roles of the targeted vessels.

Table 2. Record of vessel attacks and incidents by date and type.

Date	Ship	Flag	Attack Type	Attack Results
19 November	*Galaxy leader*	Bahamas	Piracy	Captured
24 November	*CMA CGM Symi*	Malta	UAV	Damaged; course not altered
3 December	*Unity Explorer*	Bahamas	Missile	Damaged; course not altered
3 December	*Number 9*	Panama	Missile	Damaged; course not altered
3 December	*Sophie II*	Panama	Missile	Damaged; course not altered
11 December	*Strinda* *Languedoc*	Norway French Navy	Missile UAV	Damaged; course not altered Unsuccessful
13 December	*Ardmore Encounter*	Marshall Islands	Piracy, missile, and UAV	Unsuccessful
14 December	*Maersk Gibraltar*	Hong Kong	Missile	Unsuccessful
15 December	*Al Jasrah*	Liberia	UAV	Unsuccessful
15 December	*MSC Palatium Iii*	Liberia	Missile	Unsuccessful
16 December	*USS Carney*	US Navy	UAV (14)	Unsuccessful
18 December	*Swan Atlantic*	Cayman Islands	Missile and UAV	Damaged; course not altered
18 December	*MSC Clara*	Panama	Missile	Unsuccessful
23 December	*Blaamanen*	Norway	UAV	Unsuccessful
23 December	*Saibaba*	Gabon	UAV	Unsuccessful
23 December	*Chem Pluto*	Liberia	UAV	Unsuccessful
26 December	*MSC United VIII*	Liberia	Missile	Unsuccessful
30/31 December	*Maersk Hangzhou*	Singapore	Piracy and missile	Unsuccessful (Houthi casualties)
10 January	*USS Dwight D. Eisenhower* *USS Gravely* *USS Laboon* *USS Mason* *USS Florida* *HMS Diamond*	US Navy Royal Navy	Omnibus attack: UAVs, cruise and ballistic missiles	Unsuccessful
11 January	*St. Nikolas*	Marshall Islands	Piracy	Captured
11 January	*Khalissa*	Panama	Missile	Unsuccessful
14 January	*USS Laboon*	US Navy	Missile	Unsuccessful
15 January	*Gibraltar Eagle*	Marshall Islands	Missile	Damaged and altered course
16 January	*Zografia*	Malta	Missile	Damaged and altered course
17 January	*Genco Picardi*	Marshall Islands	UAV	Damaged; course not altered
18 January	*Chem Ranger*	Marshall Islands	Missile	Unsuccessful
24 January	*Maersk Detroit* *Maersk Chesapeake* *USS Gravely*	US Merchant Marine US Navy	Missile	Unsuccessful
26 January	*USS Carney*	US Navy	Missile	Unsuccessful
26 January	*Marlin Luanda*	Marshall Islands	Missile	Unsuccessful
28 January	*HMS Diamond*	Royal Navy	UAV	Unsuccessful

Source: US Central Command and UKMTO.

The dataset shows 31 recorded attacks, with most resulting in no harm to the ships. Of these, 12 incidents had noticeable effects on the vessels involved. In two cases, piracy

led to the outright capture of the ships. Another two incidents caused significant damage, compelling the ships to change course, likely to seek repairs. The other attacks, while inflicting some damage, were not severe enough to cause any major interruption in the ships' planned navigation. The Houthi casualties during the attack on the *Maersk Hangzhou*, involving both a missile strike and attempted piracy, signify the first casualties stemming from this conflict.

Overall, these incidents underscore a significant level of maritime insecurity and the presence of sophisticated threats to both commercial and military vessels alike. The implications of such a security landscape are far-reaching, potentially impacting global trade, maritime law, and international relations.

4.3. Comparison to Previous Disruption Events

The Ukraine war, which has been ongoing since February 2022, has led to an increase in global ton-mile trade, about a 2% increase over 2022–2023. The shipping market experienced this impact most acutely in the tanker sector, where significant and prolonged support was necessary, resulting in tanker earnings averaging USD 40,000 per day since early 2022. Additionally, the conflict caused a substantial increase in crude and products' ton-mile trade, by 9% and 14%, respectively. The bulk carrier demand also saw a modest increase [62–65].

The 'Ever Given' grounding in March 2021, while a short-term issue, with the Suez Canal blocked for only six days, caused a 2.4% increase in global ton-mile trade. This incident's impact on shipping was generally limited but it did contribute to the major disruptions in supply chains and logistics that were already affecting the container shipping sector [66–70].

During the COVID-19 pandemic, from the fourth quarter of 2020 to the first half of 2022, container markets were heavily impacted, with an over 14% disruption in container supply/demand, exacerbated by port congestion and a 7% increase in box trade in 2021. The container market witnessed all-time highs, with the spot container freight rates and charter rate indices peaking significantly [71–75].

The first half of 2020 saw about 10% of the crude tanker fleet and 9% of the products fleet being used for floating storage due to the oil market dynamics, causing a significant spike in tanker markets. The crude tanker earnings exceeded USD 100,000 per day, some of the strongest levels ever recorded [76,77].

During the US–China Trade War from 2018 to 2019, there was a direct negative impact of roughly 0.5% on the global ton-mile trade, with varying impacts across different sectors, such as dry bulk, oil, LPG, LNG, containers, and cars [78–81].

In comparison with the events in the Red Sea, it is evident that the Ukraine war and the COVID-19 pandemic have had a more significant impact on ton-mile trade and shipping markets than the 'Ever Given' incident and the US–China Trade War. The Red Sea events had a varied level of impact across different segments of the shipping industry, highlighting the complexity of global shipping dynamics and the varied responses of different market segments to geopolitical and economic disruptions. The Houthi insurgency adds another layer of disruption to the maritime supply chains, particularly affecting the strategic maritime routes near the Red Sea. This conflict, unlike the broader-reaching impacts of the Ukraine war and the COVID-19 pandemic, introduces specific challenges to shipping through its direct threat to one of the world's most vital maritime chokepoints. The resulting tension not only complicates navigation through the Red Sea but also effectively transforms the Mediterranean Sea into a cul de sac [82,83], severely limiting the available routes and forcing a reevaluation of global shipping strategies.

4.4. Economic Impact Assessment

In the context of the recent rise in hostilities, including the Houthi attacks, which have disrupted maritime activities, the shipping market metrics have shown considerable volatility. Throughout the period detailed in Table 3, there has been a notable surge in

container freight indices. Specifically, the Shanghai Containerized Freight Index (SCFI) experienced a remarkable increase, nearly doubling from its average in 2023 to January and further increasing in February. This rise in indices is indicative of the heightened costs and potentially more limited availability of shipping containers, a direct consequence of the disruption in the usual shipping lanes.

Similarly, the cost per twenty-foot equivalent unit (TEU) on key routes from Shanghai to Northern Europe (N. Eur) and the Shanghai–USEC (United States East Coast) route soared, with increases surpassing 90% and reaching as high as 219%, before slightly retreating in February, albeit still maintaining a significantly elevated level relative to the December 2023 average. Such substantial rises in freight costs can be attributed to the rerouting of shipping because of the maritime insecurity, with vessels having to navigate longer, alternative routes to avoid conflict zones, thereby incurring higher fuel costs and facing longer transit times.

The Container Freight Futures for December 2024 also climbed steeply, a clear signal that the market anticipates ongoing disruptions and higher costs extending into the future. Tanker earnings, too, saw upheaval, with the average crude tanker earnings initially rising and then falling slightly, while the Suezmax earnings in the Middle East Gulf (MEG) to Mediterranean (Med) surged remarkably, reflecting the premium on secure and available tanker capacity. Notably, the LR2 (Long Range 2, tankers between 89,000 and 115,000 deadweight tons) earnings for the MEG–UKC (United Kingdom/Continent) route experienced a dramatic increase, with a 59% rise from January to February and a significant 267% increase compared to the December 2023 average. This exceptional surge in the LR2 earnings underscores the acute demand for these vessels, likely due to their versatility in carrying both clean and dirty products, making them particularly valuable in the current volatile market conditions.

Table 3. Impact of maritime disruptions on global shipping and commodity prices.

	Sector	Unit	Average			Trend vs. Dec 2023 Avg.	
			2023	Dec	Jan	Jan	Feb
Shipping Markets	Container Freight SCFI	Index	985	1046	2051	96%	112%
	Container Freight Shanghai–N. Eur	USD/TEU	832	935	2987	219%	191%
	Container Freight Shanghai–USEC	USD/FEU	2505	2564	4872	90%	159%
	Container Freight Future: SCFIS Dec-24	USD/TEU	908	956	1807	89%	35%
	Containership Time Charter Rate Index	Index	94	67	70	3%	21%
	Average Crude Tanker Earnings	USD/day	53,605	53,458	59,503	11%	−3%
	Suezmax Earnings MEG–Med	USD/day	28,302	30,575	35,947	18%	83%
	Average Product Tanker Earnings	USD/day	32,028	36,892	28,435	−23%	31%
	LR2 Earnings MEG–UK/Continent	USD/day	33,993	31,880	50,648	59%	267%
	Chemicals 15kt parcel MEG–Mediterranean	USD/mt	104	84	97	16%	52%
	Kamsarmax Bulk Earnings USEC–India	USD/day	14,988	26,822	22,458	−16%	−17%
	Supramax Bulk Earnings USG–Japan	USD/day	19,772	28,842	21,854	−24%	−21%
	VLGC Earnings USG–Japan	USD/day	95,706	132,113	107,900	−18%	−84%
	LNG 160k Average Spot Rate	USD/day	97,760	137,083	67,500	−51%	−70%
Rerouting	Container Ship Rerouting via CoGH	No.	–	43	432		
Vessel Speeds	17,000+ TEU Boxship Speed	Knots	15.0	15.0	15.9	6%	5%
Commodity Prices	Brent Crude	USD/bbl	82.2	75.9	77.5	2%	8%

Source: Our own research based on Clarkson's Research.

In stark contrast to the rising rates of container shipping and tankers, the bulk carrier earnings witnessed a downtrend. This perhaps reflects a different set of market pressures

affecting the dry bulk sector, which may not be as directly impacted by the Houthi attacks as the tanker market.

As vessels navigate these turbulent times, the speed of the largest boxships, those over 17,000 TEU, have incrementally increased, an adjustment possibly made to maintain schedules despite longer routes. This adjustment, however, adds to the operational costs, further contributing to the escalating freight rates.

Commodity prices, particularly for Brent Crude, have reacted as well to the regional instability, with modest increases in prices over the observed months, reflecting the market's nervousness about potential supply disruptions and the geopolitical risks inherent in the region's tensions.

The ripple effects of the Houthi attacks have reverberated throughout the shipping industry, leading to adjustments in routing, speeds, and operations and exerting upward pressure on freight rates and commodity prices. This snapshot of the industry metrics illustrates the interconnectedness of global trade and the vulnerability of supply chains to geopolitical conflict.

5. Discussion

5.1. Interpreting the Impact of Houthi Activities on Maritime Traffic

The intricate relationship between regional stability and maritime traffic is profoundly highlighted by the recurring Houthi insurgent activities in the Red Sea region and reflected in Figure 1. These activities not only present navigational challenges but also compound existing vulnerabilities in maritime security. The correlation between the timing of Houthi attacks and spikes in maritime congestion underscores the delicate balance of regional geopolitical dynamics and the smooth operation of global trade routes.

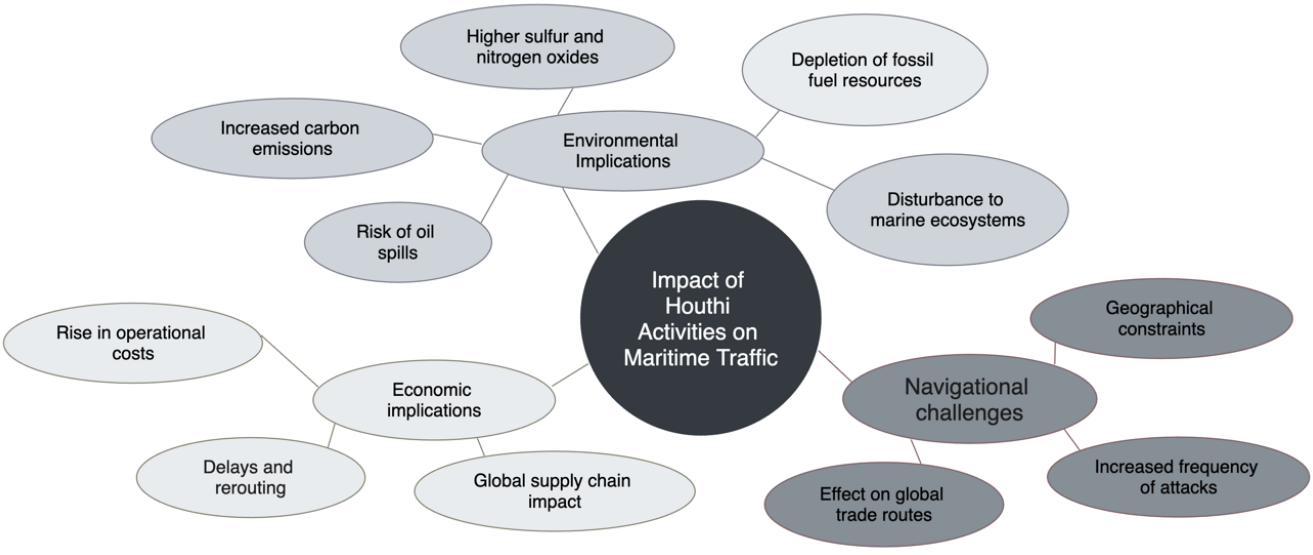

Figure 1. Impact of Houthi activities on maritime traffic. Source: Our own research (compiled from multiple sources).

Navigational Challenges and Security Risks: The increased frequency of Houthi attacks has introduced a new layer of complexity to the already intricate situation of maritime navigation in the Red Sea and Suez Canal. These challenges are further exacerbated by the geographical constraints of these waterways, which limit the options for evasion and maneuvering. This study's findings suggest that the Houthi insurgency has evolved from a regional nuisance to a significant disruptor of international maritime traffic, with the potential to affect the global supply chain dynamics.

Economic Implications: The economic ramifications of these security incidents are far-reaching. This study's analysis indicates that each Houthi attack incident could result

in an average increase of 18% in the operational costs for affected vessels. This includes costs associated with delays, increased fuel consumption due to longer routes, and the additional security measures necessitated by the heightened threat environment. The cumulative effect of these disruptions can lead to substantial economic losses, not only for shipping companies but also for economies dependent on timely maritime transport. This nuanced disruption underscores the intricate and localized nature of geopolitical conflicts in maritime logistics, presenting a unique case of supply chain interruption that diverges significantly from the global disruptions caused by larger-scale events. Through a comparative analysis, the distinct effects of the Houthi conflict reveal how targeted geopolitical tensions can lead to the significant rerouting of traffic and escalate security concerns, highlighting the critical need for adaptable and resilient shipping practices in the face of regional instability. The tension not only makes passage through the Red Sea more complex but also effectively transforms the Mediterranean Sea into a dead end, drastically limiting the available pathways and necessitating the reconsideration of international shipping routes. This specific disruption highlights the detailed and localized impact of geopolitical conflict on maritime logistics, offering a distinct perspective on supply chain disruptions that differ from those caused by broader global events. Through this comparative analysis, the particular consequences of the Houthi conflict are illuminated, showcasing how specific geopolitical tensions can lead to significant detours in shipping paths and amplify security concerns, thus underlining the importance of flexible and robust shipping operations in facing regional turmoil.

Environmental Implications: The direct and indirect environmental impacts of the increased maritime traffic and fuel consumption due to Houthi activities in the Red Sea region are significant and multifaceted. Directly, the additional fuel consumed by ships taking longer routes and facing delays leads to increased carbon emissions, exacerbating the already substantial environmental footprint of global shipping. This rise in fuel usage also results in higher emissions of sulfur and nitrogen oxides, contributing to air pollution and the associated health risks, particularly in coastal areas. Additionally, the heightened risk of maritime conflicts and navigational challenges raises the likelihood of oil spills, which pose a severe threat to marine environments [84]. Indirectly, the rerouting of ships to avoid conflict zones often results in increased maritime traffic in previously less frequented areas, potentially disturbing local marine ecosystems and wildlife. Furthermore, the need for more fuel on extended journeys accelerates the depletion of fossil fuel resources, adding to the strain on these already limited natural resources. Collectively, these direct and indirect environmental consequences underline the necessity of considering ecological impacts in the broader discussion of maritime security and regional conflicts.

5.2. Comparing Findings with the Existing Literature

These research findings contribute to the existing body of knowledge by providing empirical evidence of the direct impacts of regional conflict on maritime traffic.

Consistency with Previous Research: This study's results resonate with the observations made by Modaress et al. and Mostafa [85,86] concerning the logistical significance of the Suez Canal. Furthermore, the findings complement the discourse on maritime security risks by providing concrete data on the economic impacts of these risks [87,88].

Gap in the Literature: This research fills a significant void in scholarly work by examining the distinct effects of non-state actor aggression on global maritime activities. It outlines the strategic use of maritime vulnerabilities by insurgent groups, particularly the Houthi rebels, to advance their geopolitical goals. Insights into Iran's conditional support for the Houthis [89], the debate over the self-defense rights of non-state actors in fragmented states like Yemen [90], the role of identity and security perceptions in the Houthi movement [91], and the broader maritime security ramifications of the Yemeni Civil War [92] collectively underscore the complex dynamics at play in non-state actors' influences on international maritime security.

5.3. Strategies for Mitigation of Maritime Traffic Risks

This study not only sheds light on the problems but also paves the way for potential solutions.

Enhanced Maritime Security: This research outlines a comprehensive strategy for maritime security that combines a physical presence at sea, cutting-edge technology, and strategic deterrence tactics. This strategy suggests bolstering naval patrols and escort missions, leveraging advanced surveillance tools like drones and satellites, and utilizing automated systems for threat detection and response. To effectively combat Houthi assaults, it is crucial to distinguish between piracy and politically motivated maritime threats [93–95]. The sophisticated weaponry and tactics deployed by the Houthi insurgents, including drones and missiles, indicate the need to refine and expand the anti-piracy measures to confront the unique challenges and goals of the Houthis. Adopting strategies such as creating an international naval task force, similar to the successful Combined Task Force 151 used against piracy, could serve as an initial solution. Moreover, improving maritime domain awareness through satellite monitoring, automatic identification systems (AIS) and fostering intelligence exchange between the commercial and military sectors are key to thwarting Houthi attacks [96–98].

International Cooperation: The pivotal role of international cooperation is emphasized in mitigating the security challenges posed in these strategic waterways. This research supports the arguments presented by Bradford, Helmick, and Ali [99–101] for a unified global response, advocating for a coalition of maritime powers to share military intelligence, resources, and strategic frameworks to safeguard maritime traffic against insurgent threats.

Evolving Nature of Conflict: The dynamic and unpredictable nature of the Houthi insurgency necessitates ongoing monitoring and analysis. Longitudinal studies, incorporating real-time data and predictive modeling, are vital in staying ahead of the curve in understanding and mitigating the effects of such conflicts on maritime traffic [102,103].

Green Navigation: The mitigation of maritime risks amidst environmental concerns requires the adoption of green technologies, such as cleaner fuels and energy-efficient engines, enhancing route optimization with AI, and strengthening international environmental regulations. These steps, taken together, aim to ensure environmentally responsible maritime operations despite geopolitical tensions [104,105].

The broader implications of the Houthi activities on maritime traffic underscore the complex interplay between global trade, security, and environmental stewardship, demanding a holistic approach in addressing these challenges. Disruptions in a pivotal region like the Red Sea can cascade through the veins of global trade, affecting economic stability and security strategies worldwide. The environmental dimension adds a crucial layer, emphasizing the need to harmonize efforts to ensure safe and efficient maritime traffic while also championing sustainability. In recognizing the intertwined nature of these issues, there is a clear imperative for proactive, predictive measures that consider the asymmetrical threats to modern maritime operations, alongside a concerted effort towards mitigating climate change and fostering sustainable practices across international trade frameworks.

5.4. Concluding Remarks

Considering the findings, this study calls for a renewed focus on the intersection of maritime security and global trade. It underlines the necessity for continuous innovation in maritime security strategies and the importance of collaborative international efforts to maintain the safety and integrity of vital maritime corridors in the face of evolving geopolitical conflicts.

Figures 1 and 2 present conceptual models synthesizing the potential impacts of the Houthi activities on maritime traffic, based on our analysis of the available data and the current literature. These models draw from established research on maritime security [88], the economic impacts of shipping disruptions [72], and the environmental consequences of maritime activities [106]. They serve as a visual framework for an understanding of

the complex interplay among the factors involved, acknowledging that further empirical research is needed to validate and quantify these relationships. Future studies could build upon this conceptual groundwork to provide more detailed, statistically robust analyses of these impacts.

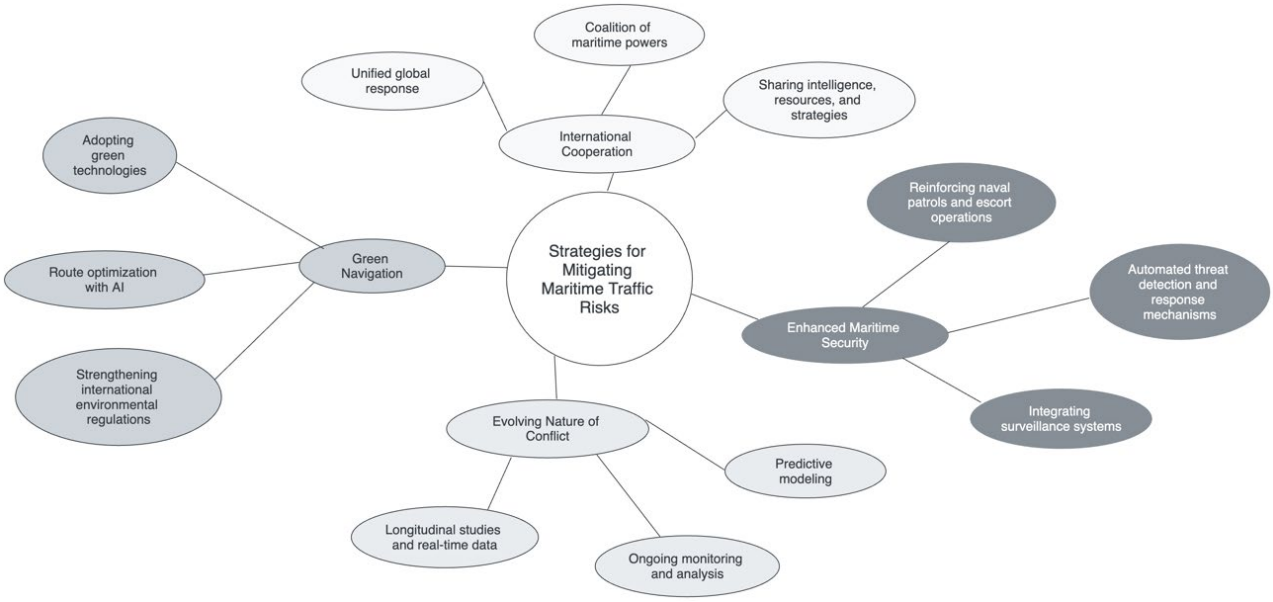

Figure 2. Strategies to mitigate maritime traffic risks. Source: Our own research (compiled from multiple sources).

6. Conclusions

This study comprehensively examines the challenges to maritime traffic in the Red Sea and Suez Canal, particularly focusing on the impact of Houthi rebel activities. It conclusively shows that the Houthi insurgency, via direct assaults and creating an unstable security environment, has significantly hindered navigation in these crucial maritime paths. There is a noticeable correlation between the rise in Houthi attacks and the increase in maritime traffic congestion and disruptions, highlighting the link between regional stability and worldwide maritime logistics.

The economic fallout from these disturbances is significant. The necessity for longer transit times, detours, and heightened security measures adds extra operational costs for shipping enterprises, affecting global trade and supply chains broadly. This study underscores the vital significance of these waterways and the importance of keeping them secure and efficient.

Our study set out to address three key research questions, which we can now answer based on our findings.

Regarding how Houthi insurgent activities correlate with changes in maritime traffic patterns within the Red Sea and Suez Canal, our analysis reveals a strong correlation. We observed a marked decline in vessel transit through the Red Sea and Suez Canal, coupled with a corresponding increase in traffic around the Cape of Good Hope.

Concerning the immediate and extended effects of such activities on the logistics and costs of global maritime trade, we found significant impacts. The immediate effects include increased operational costs, longer transit times, and heightened security risks for global maritime trade. Our findings indicate an average increase of 18% in the operational costs for affected vessels. Extended effects encompass broader supply chain disruptions and potential long-term shifts in global shipping routes.

As for identifying predictive patterns from the collected data that could inform future maritime logistics and defense strategies, our research yielded valuable insights. The data collected reveal patterns of escalating insurgency and increasingly sophisticated attack

strategies. These patterns suggest a need for enhanced security measures and international cooperation in safeguarding vital maritime corridors.

Given these insights, the urgent need for improved maritime security protocols and international collaboration is evident. Approaches like bolstering naval patrols, enhancing surveillance, and employing cutting-edge technology are crucial in protecting these channels against future dangers. Moreover, joint endeavors among impacted countries, global maritime bodies, and shipping firms are essential in crafting holistic strategies to counter the threats posed by non-state entities such as the Houthi insurgents. Future strategies should focus on improving the maritime domain awareness, strengthening international naval cooperation, and developing more resilient shipping practices.

However, this study also notes its constraints, particularly its dependence on secondary sources and the ongoing evolution of the Yemen insurgency. Future research should strive for more exhaustive data collection and the regular monitoring of the effects of regional conflicts on the maritime flow. Longitudinal studies could offer valuable perspectives on the enduring impacts of such insurgencies on international maritime operations.

In sum, the preservation of the Red Sea and Suez Canal's security and functionality is not merely a local issue but a critical global concern, merging two increasingly interconnected domains: geopolitics and maritime security. Tackling the challenges brought forth by the Houthi insurgency demands a unified response from the international maritime community to guarantee the continuous, safe flow of global commerce through these essential nautical channels. These findings underscore the critical interplay between regional insurgencies and global maritime security, highlighting the need for adaptive strategies to ensure the resilience of international trade routes.

Limitations: This study utilized primary data from highly respected sources, including UNCTAD, IMF, and Clarkson Research, among others, which are widely recognized for their reliability in maritime and trade statistics. These sources provide robust, first-hand datasets that formed the foundation of our analysis. This study focused on a specific, recent timeframe, offering valuable insights into current developments, although longer-term trends may require further investigation. The dynamic nature of the Houthi insurgency presents challenges in drawing lasting conclusions, emphasizing the need for ongoing research. Our analysis of the aggregate trends provides a broad understanding, although a more granular examination at an individual vessel type, nationality, or company level could offer additional nuances. We also recognize the potential variations in incident reporting due to the sensitive nature of some attacks. Future research opportunities include incorporating additional data sources, extending the analytical timeframe, and conducting more detailed studies to build upon these initial findings.

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