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Red Sea Ripples: The Butterfly Effect on Regional Economies and Global Stability

By

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Acknowledgements

Starting this year, I didn't know what to expect. I've heard from past students that the MEL program was really demanding. This turned out to be true and probably even more demanding than I had imagined. This year has probably been the hardest of my life. Not only academically, but also what I had to change in my routine and character in order to be able to go through it. My first goal was to go through the year without any delays and without any missing grades. Fortunately I achieved it, sacrificed a lot in order to be able to pass all my courses successfully. My second goal was to overcome every tiredness accumulated during the year in order to be able to finish my thesis on time.

First I would like to thank the MEL office for accepting me in such an enriching master's degree, and also for there every day support throughout the whole year. Secondly I would like to thank my parents for always supporting me and keep me motivated through every difficult time in my life. Thirdly I would like to thank my supervisor, Prof Koen Berden, who did every thing in his power to help me finish this thesis on time. I have to thank him again for his patience during the last two months and for guiding me. I wouldn't be able to finish my thesis without him.

Abstract

As a vital maritime route connecting Asia and Europe, the Red Sea route is essential to global trade. Recent strikes by the Houthi rebels in the area have severely interrupted this important commercial artery, increasing the operational expenses and security hazards for shipping companies and leading them to search for alternative routes to continue to deliver their services.

Using extensive desk research and quantitative modelling (using the Global Simulation Model, GSIM), this thesis uses a multipronged approach to investigate the effects of these attacks on economies and trade, keeping the geopolitics in mind. In this thesis, we have looked – innovatively – at both the regional effects of the Houthi rebel attacks on vessels passing through the Red Sea, and at global effects.

The results are interesting and important. First, our research demonstrates that there are substantial welfare losses both regionally and globally. For example, Chinese producers lose US$ 7.6 billion in revenues each year while EU producers lose US$ 3.5 billion. EU and US consumers of products shipped through the Suez Canal are hurt most, with EU consumers, losing US$ 4.9 billion each year. Regionally, the Turkish, Israeli and Saudi-Arabian economies suffer. For these economies alternative routes around Africa are particularly expensive alternatives. The second key finding from our research is that alternative routes as substitutes for the Red Sea route are really insufficiently attractive. Only a few percent of trade lost through the Suez Canal is recovered by sailing around the Cape of Good Hope. Third, for Egypt, the one economy that cannot avoid the Red Sea, the effects are particularly negative and significant because for Egypt there are no alternative routes to reach the country. Fourth, as a result of the negative impact on trade, domestic production is also negatively impacted. Egypt and Sudan, for instance, saw total domestic productionn decrease by 0.28% and 0.29% respectively, while, globally, China and India were hit the hardest hit, with domestic production falling by 0.16% and 0.11%. This highlights the fact that clearly both regionally and globally, the economic impact caused of rising transportation costs and supply chain interruptions is significant.

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1. Introduction

“In today’s shipping, anybody who shoots at a ship is shooting at the world” Jan Hoffman, Head of trade logistics at United Nations conference on trade and Development UNCTAD

1.1. Rationale and relevance

The Red Sea since the opening of the Suez Canal in 1869, has been a strategic maritime corridor linking Asia to the Mediterranean Sea. Throughout the years, even though surrounded by politically unstable countries, it has been a relatively stable route for global trade. This essential maritime route has been used to connect the east with the west transporting goods such as oil, natural gas, containerized goods, bulk commodities and chemicals.

However, the region’s stability has been impacted recently due to a series of aggressive attacks from the Houthi rebel group who controls the west of Yemen including most of its Red Sea coast near the Strait of Bab Al-Mandab (Notteboom et al., 2024). The Red Sea is a critical artery for the global trade. It possesses considerable economic importance, for instance, Bab el-Mandeb Strait is 29 kilometers wide and constitutes a maritime chokepoint and strategic link between the Mediterranean and the Indian ocean. (Guzansky & Eran, 2018) In fact one third of the world’s container traffic passes through it, additionally 12% of the world’s oil and 8% of LNG transits through the Suez Canal. (Berman, 2024)The Suez Canal constitutes an important source of income for Egypt, as does the port of Aqaba for Jordan and the port of Jeddah for Saudi Arabia. (Guzansky & Eran, 2018)These attacks have far-reaching implications, threatening global maritime security, disrupting international trade and local economies.

For the ships daring enough to cross the Red Sea, the cost is equivalent of the heightened risk. Another serious environmental problem that has arisen is the increase in carbon dioxide emissions (approximately 71%) due to the greater distance that ships have to travel.
The Red Sea shipping crisis is a stark reminder of the interconnectedness of global trade and the importance of maintaining secure and open maritime routes (Bogetic et al., 2024).

1.2. Research Question, sub-research questions, and objectives

The implications of this crisis can be seen both on the global and regional levels. Our objective is to conduct a comprehensive analysis of these two aspects, while also taking it one step further by quantifying the impacts in order for our conclusion to be more robust and valid. Therefore, our Research Question is:

What are the global geopolitical and regional economic and trade effects of the Houthi rebel attacks on vessels travelling through the Gulf of Aden and Red Sea ?

1) What has been the history, type and scope of Houthi rebel attacks on vessels sailing through the Red Sea?
2) How are the Houthis attacks influenced by global geopolitical dynamics and international relations?
3) What effects do the Houthi rebel attacks have on operational costs of shipping companies?

4) What countries trade most through the Gulf of Aden – Red Sea route and are therefore most impacted, both regionally and globally?
5) How do the Houthi rebel attacks affect trade routes ports and supply chains regionally?
6) What is the best methodological (quantitative) approach to address/answer the research question?
7) What literature and data can we find that already look at the regional and/or global impact of the Red Sea.

Addressing the above sub-questions will enable us to understand the multifaceted nature of the crisis.

1.3. Research Design and Methodology

For this research, we will first conduct a thorough desk research to look at the context of the Red Sea crisis and find cost factors that are needed as inputs for the quantitative analysis. For example, what are the extra costs for shipping companies that continue to sail through the Red Sea.

We then use Global Simulation Model (GSIM) partial equilibrium model in order to quantify the impact of the Red Sea crisis on global and regional economies and trade. In addition, we will convert trade values from the GSIM model into trade volumes to look at transport effects of the crisis in terms of number of containers and tons of bulk trade impacted.

The Global Simulation Model, is an analytical tool used to model global trade policy changes (Francois 7 Hall, 2002). Furthermore, it allows for a detailed examination of the selected countries while still measuring the impact on the rest of the world.

In order to quantify the impacts on the maritime industry, the outputs of the old decreased trade flows and the new increased ones will be converted into TEU's. This conversion will allow us to identify the changes in the trade and subsequently which countries gain or lose trade.

1.4. Thesis structure

After this introductory Chapter, Chapter two will focus on the literature review which will explore the context of the crisis, the cost effects for liner companies, the effect on regional ports. We will also look at whether we can already identify a pattern of how trade flows are impacted (although it is key to separate the Red Sea crisis effect from the overall trends). In Chapter 3 we will discuss the methodology of this thesis and present the GSIM model used to quantify the Red Sea crisis effects as well as the Conversion Method to transfer trade values into trade volumes. Chapter 4 will be presenting the results and analyze the economic trade and transport impact and trade disruptions caused by the Houthi attacks. We will describe both regional and global trade effects of the Red Sea crisis. Finally Chapter 5 will summarize our research findings, give key takeaways and propose areas for further research.

2. Literature review

2.1. Regional and/or global impact of the Red Sea.

In order to understand the impact of the crisis better, we have to go more in depth into the role that this passage plays for the economies and industries of the European countries. As we mentioned earlier the Red Sea crisis has caused delays in the arrival of many cargos shipped from the Asia-Europe trade route. This had a major impact on the European industries. For example, automotive companies like Tesla, Volvo, and Suzuki were forced to suspend vehicle production in Europe for weeks due to the delays in the arrival of parts shipments, and tire manufacturer Michelin had to halt production at its plant in Spain for several days (Kanaya, 2024). Additionally, difficulties were noticed among global sportswear manufacturers like Addidas and apparel company H&M who reported also delays on shipments.

Table 1: East med and Egypt analysis from the impact. Full text can be found at Annex

Country	Description
Turkiye	The Red Sea issue has changed the responsibilities that Turkish ports play in international maritime trade. Turkish ports, particularly the Marmara ports, have developed into important transshipment hubs after a contraction in 2023 brought on by the Russia-Ukraine war. This has resulted in a 23% rise in transit container traffic and decreased overall cargo contraction to less than 2%. Turkish ports handled 43.1 million tonnes of cargo in January 2024, a decrease of 1.81% from the previous year. Turkey's ports are adjusting despite a 4% decrease in overall cargo in 2023; Marmara ports are seeing increases in traffic, while Mediterranean ports are seeing decreases as a result of decreased foreign trade and regional insecurity. Tekirdağ port Asyaport is positioned to become a transshipment hub for freight from the Far East and the Middle East, having seen a 22% rise in transit cargo.
Greece	Greece has been severely impacted by the Houthi attacks in the Red Sea, which have hindered trade through the Suez Canal. Since Asia makes up 31.8% of Greece's imports, the region must contend with increased insurance premiums, delays, and transportation expenses (shipping a container from China or Saudi Arabia, for instance, can be quite costly). Greece's economy is in jeopardy, and the crisis makes geopolitical instability even more pronounced. Container throughput at Piraeus, Greece's primary port and the fifth largest in Europe, has dropped by thirty percent since the crisis. Furthermore, the price of shipping a container to Piraeus has increased thrice to an amount above €6,000.
Italy	Due to its dependency on the Suez Canal for 40% of its international trade, estimated to be worth 154 billion euros in 2022, Italy is severely impacted by the Red Sea problem. Italy suffered foreign trade losses of 8.8 billion euros, or 95 million euros a day, between November 2023 and January 2024. A number of industries have been badly hit by the crisis, including small businesses that export food, metal goods, jewellery, watches, clothing, and furniture. Additionally under jeopardy is Italy's main tomato export sector, estimated to be worth 5 billion euros in 2023. Due to trade route modifications from the Suez Canal to the Strait of Gibraltar, some ports, including Trieste, Venice, and Ravenna, had losses in container traffic in early 2024, while other ports, like

Country	Description
	Genoa, La Spezia, and Salerno, saw increases. Overall we saw a 3.2% decrease for Italian ports overall.
Egypt	The issue is particularly bad for Egypt because the Suez Canal transits, which bring in roughly $10 billion a year, have significantly decreased. Canal dues revenue has decreased by 40–50%, which has led to a serious foreign exchange shortage and increased import prices for goods like food and fuel. Port stockpiles have resulted from this, which has hurt regional industries. More than half of Egypt's exports and more than one-third of its maritime imports pass through the Red Sea, making the country's economic problems worse. Urban inflation is at 38%, up to 60% of the population lives in poverty, unemployment is high, and labour force participation is falling.

Source: Own table adapted from Annex II

Table 2 and 3 show the toll increase between 2023 and 2024 implemented by the Suez Canal port authority:

Table 2: Transit Dues Rates of Suez Canal (1/1/2023) (Crude oil tankers) (USD)

Category	2023 Rate	2024 Rate	Increase (%)
Crude Oil Tankers - First 5000 Tons (Laden)	9,6	11,04	15
Crude Oil Tankers - First 5000 Tons (Ballast)	8,17	9,4	15
Crude Oil Tankers - Next 5000 Tons (Laden)	6,8	7,82	15
Crude Oil Tankers - Next 5000 Tons (Ballast)	5,77	6,64	15
Crude Oil Tankers - Next 10000 Tons (Laden)	5,14	5,91	15
Crude Oil Tankers - Next 10000 Tons (Ballast)	4,38	5,04	15
Crude Oil Tankers - Next 20000 Tons (Laden)	2,55	2,93	15
Crude Oil Tankers - Next 20000 Tons (Ballast)	2,17	2,5	15
Crude Oil Tankers - Next 30000 Tons (Laden)	2,2	2,53	15
Crude Oil Tankers - Next 30000 Tons (Ballast)	1,86	2,14	15
Crude Oil Tankers - Next 50000 Tons (Laden)	1,89	2,17	15
Crude Oil Tankers - Next 50000 Tons (Ballast)	1,61	1,85	15
Crude Oil Tankers - The Rest (Laden)	1,85	2,13	15
Crude Oil Tankers - The Rest (Ballast)	1,58	1,82	15

Source: Own table adapted from Suez Canal dues (2024)

Table 3: Transit Dues Rates of Suez Canal (1/1/2023) (Dry Bulk Vessels)

Category	2023 Rate	2024 Rate	Increase (%)
Dry Bulk Vessels - First 5000 Tons (Laden)	9,65	10,13	5
Dry Bulk Vessels - First 5000 Tons (Ballast)	8,21	8,62	5
Dry Bulk Vessels - Next 5000 Tons (Laden)	7,37	7,74	5
Dry Bulk Vessels - Next 5000 Tons (Ballast)	6,27	6,58	5
Dry Bulk Vessels - Next 10000 Tons (Laden)	5,83	6,12	5
Dry Bulk Vessels - Next 10000 Tons (Ballast)	4,96	5,21	5
Dry Bulk Vessels - Next 20000 Tons (Laden)	2,13	2,24	5
Dry Bulk Vessels - Next 20000 Tons (Ballast)	1,80	1,89	5
Dry Bulk Vessels - Next 30000 Tons (Laden)	1,88	1,97	5

Category	2023 Rate	2024 Rate	Increase (%)
Dry Bulk Vessels - Next 30000 Tons (Ballast)	1,60	1,68	5
Dry Bulk Vessels - Next 50000 Tons (Laden)	1,76	1,85	5
Dry Bulk Vessels - Next 50000 Tons (Ballast)	1,50	1,58	5
Dry Bulk Vessels - The Rest (Laden)	1,69	1,77	5
Dry Bulk Vessels - The Rest (Ballast)	1,43	1,50	5

Source: Own table adapted from Suez Canal dues(2024)

This table compares the Suez Canal transit fees for different types of vessels between 2023 and 2024, additionally it shows the rates for various tonnage categories, with different rates between laden and ballast conditions. We can see that across the Crude oil Tankers there is a consistent increase in fees of 15%. Similarly, for the category of Dry Bulk Vessels, we can see a consistent 5% rise. This lower increase may be a commercial pricing strategy implemented by the port authorities not wanting to deflect them during these times of low flow possibly due to the frequency of Dry Bulk Vessels passing the Canal.

Despite implementing a 15% toll increase in mid-January, Egypt has not yet been able to bridge this financial gap. According to the MSTA the traffic drop between mid-December and April 1 has resulted in $1.2 billion in revenue loss. In March 2024 alone, total transits were 1,115, a decrease of -49.1% on March 2023, of which 402 oil tankers (-44.8%) and 713 other vessels (-51.3%). The SCNT tonnage of ships transited was 43.6 million tonnes (-66.2%) and revenues generated by transits stood at 15.2 million Egyptian pounds (-40.9%). From report the significant increase in the value of revenues generated by transit rights in March 2024 compared to the previous month when amounted to £10.6 million, despite the fact that in February the traffic was only five transits higher by 2.1 million SCNT tons more.

Additionnaly, trade disruptions will likely also affect the Red Sea ports of Safaga and Sokhna, which handle the import of capital goods and grains, and the export of fertilizers and minerals, all of which are crucial to the Egyptian economy. (Deep & Raouf, 2024)

2.2. History of Houthi rebel attacks on vessels sailing through the Red Sea

The Houthi rebels are also known as the "Supporters of God." They represent one side of the civil war that has been raging in Yemen for nearly 10 years. The movement emerged in the 1990s when their leader, Hussein al-Houthi, began a religious movement under the umbrella of Zaidism, a Shia Islamic sect that envisions a return to power after being marginalized by the Sunni regime that rose to prominence during the civil war of the 1960s.

The attacks on vessels begun in the year 2015 where the Houthis started targeting vessels in the Red Sea soon after the Saudi-led coalition intervened in Yemen. During that time the rebel group targeted Saudi and coalition naval vessels where they used similar attack techniques to todays attacks, firing anti-ship missiles.

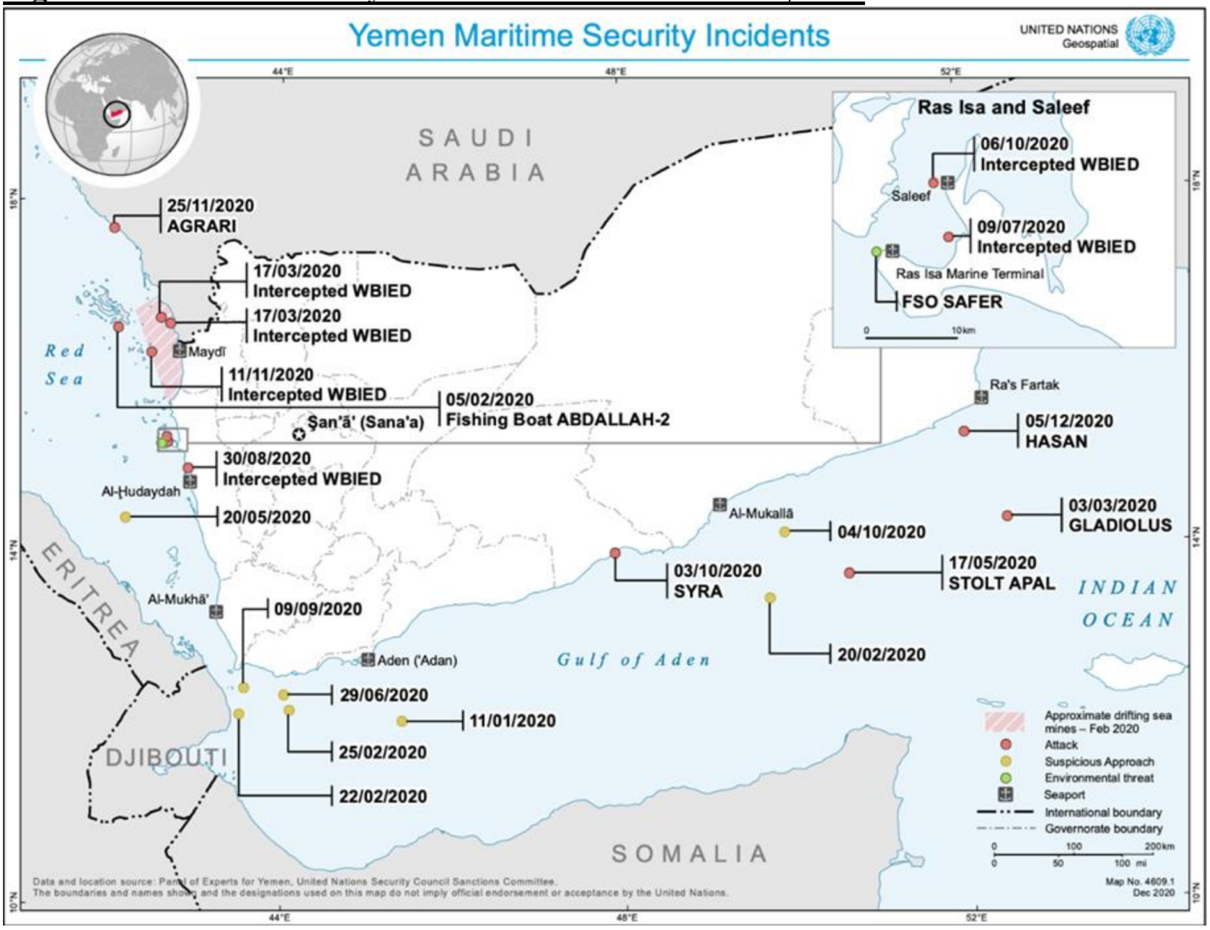
In 2016, 2 attacks were recorded, one of which was on the USS Mason, a naval US ship attacked off the Yemeni coast. On May 10, 2018, the Houthis targeted the Turkish ship Ince Inebolu near the port town of As Saleef. The ship was apparently transporting food aid to Yemen when it was struck by a missile off the shore. This is not the first time the Houthis have targeted an assistance ship. During 2018, Houthi naval attacks declined dramatically. This slowdown, as well as the intermittent nature of naval strike claims, appeared to be directly related to the Saudi coalition's loss of land. However, on July 8 of 2019, a commercial vessel was targeted by a suicide drone boat. The Saudi coalition claimed that its forces were able to intercept and destroy the remote-controlled craft, however merchant or civilian ships have been explicitly targeted at least on nine occasions. Five of these occurrences used suicide drone boats, demonstrating that the Houthis deployed this strategy indiscriminately.

According to the IMO also depicted on the map , on March 3 2020, the Saudi flagged oil tanker *Gladiolus* was approached by three skiffs, two of which appeared to be remotely controlled by the third. One of the unmanned skiffs made contact with the hull of the tanker without an explosion occurring, while the other came within 10–15 metres of it.

The second attack took place on 17 May 2020 when two skiffs approached the chemical oil product tanker *Stolt Apal* sailing under the flag of the United Kingdom of Great Britain and Northern Ireland. On 3 October, the Maltese-flagged tanker *Syra* was loading oil at the Rudum terminal when two explosions occurred, damaging ballast tanks on the port side

"On 25 of November, the Maltese-flagged tanker *Agrari* suffered an explosion on the port side, approximately 1 metre above the waterline, while offloading cargo at the Shuqayq plant in Saudi Arabia" (UN, 2021).

Figure 1: Maritime security incidents of the Gulf of Aden, 2020



Source: UN (2024) [Accessed Aug 28]

Following 2020, Houthi strikes have persisted on an irregular basis, frequently coinciding with escalation in the larger Yemeni conflict. These incidents include drone and missile attacks against Saudi military and commercial ships. For example, in December 2021, the Houthis captured a ship carrying the flag of the United Arab Emirates, saying it was transporting military material, despite the fact that the UAE said it was a civilian vessel.

Since late 2023, the rebel group has systematically aimed to attack commercial vessels crossing the Red sea. “Primarily these attacks begun in relation to the conflict between Israel and Gaza. Iran’s Houthi rebels claimed they were only targeting merchant vessels traveling to or from Israel or of Israeli ownership” (Notteboom et al., 2024). This soon became evident that not only they were attacking vessels related to Israel but also attacking every possible vessel passing the Red Sea with missiles and drones.

Ships from over 65 countries have been targeted since the start of the crises causing significant disruptions. Several key incidents throughout these past months have posed immediate threat to the maritime industry. The first attack done on November 26, 2023, was an attempt to seize an Israel affiliated ship. Few days later three commercial ships took a hit in the south part of the Red Sea. Subsequent months saw continued aggression, with vessels such as the Maersk Hangzhou being attacked on December 31st 2023. Entering into 2024, 3 casualties of sailors have been reported after the attack on the bulk carrier M/V True confidence. Unfortunately attacks continue till this day, with the latest being an attack on the tanker CHIOS Lion reported on 15th of July.

2.2.1. Type of attacks

“The strikes began rather unsophisticated, with some being the result of rocket-propelled grenades (RPG’s), and have advanced in more complex means, utilizing sophisticated remote-controlled vessels as the war has progressed” (Weiss, 2019). The Houthis have been armed with short- and medium-range ballistic missiles from Iran since 2015, according to the defence intelligence report. “These missiles include the longer-range Toofan ballistic missile, which is strikingly similar to Iran's Shahab-3 medium-range ballistic missile, and the Asif anti-ship ballistic missile, which has been fired at targets in the Red Sea” (Gramer & Detsch, 2024). Overall we have identified 5 types of attacks on vessels performed by the Houthi’s. First the Anti-ship Missiles. The rebel group is constantly using anti ship missles to attack passerby ships on the Red sea, specifically one of the missiles used is Noor which is reversed engineered from the Chinese C-802. In parades in 2022 and 2023, the Houthis unveiled additional ASCM’s (Anti-ship cruise missile), including what appeared to be two anti-ship versions of the Iranian Quds/351 LACM. “One version is allegedly equipped with radar-homing seeker, and the other has an electro-optical/infrared seeker” (Hinz, 2024). This shows us that even if the Houthi’s are considered a rebel group, they posess high-tech weaponery that is getting upgraded all the time. Currently the missles described above, have a range of at least 800 km.

Secondly, we have seen instances of explosive boats used as a way to attack ships, more specifically, remote controlled boats which are used to ram and explode close to the vessels often creating extensive damage on the hulls of the ships.

Thirdly one of the tactics used on the recent attacks by the Houthis are drone attacks . “Houthi operations targeting international shipping in the Red Sea and surrounding waterways have significantly relied on drones, with more than 40% of the events ACLED records between

October 2023 and June 2024 involving drones" (d'Hauthuille & Nevola, 2024). However, when compared to missile attacks, drone attacks have been significantly less effective at targeting foreign ships. In fact, 75% of Houthi drone attacks on international shipping have been intercepted by international coalition forces deployed to the Red Sea and the Gulf of Aden region to counter the Houthi threat, compared to approximately 16% of missile attacks (d'Hauthuille & Nevola, 2024). Indeed, the drones' ability to hit the target is secondary to Houthi tactics. The rebel group can produce these gadgets in vast quantities at a low cost, and drones are mostly employed to raise navigational hazards without really inflicting direct damage to vessels. This technique reduces the Houthis' reputational risk and forces the international coalition to deploy expensive air defense systems against relatively inexpensive weaponery.

The fourth tactic they use is naval mines. The group has been using naval mines since 2015, which the Houthis themselves confessed to producing a type of sea mine named "Mersad" in a 2018 documentary. "In 2023, six models of mines were displayed by the Houthis, each with distinct characteristics" (Bakr, 2024). These included, interceptor sea mines or accoustic mines or the floating mines. A more recent addition to their weaponer is the magnetic sea mine which can also be controlled remotely and attach to the ship's hull.

The final technique of the Houthi's attack has been Hijackings, specifically one happened recently. According to the BBC, the Iran-backed group hijacked the Galaxy Leader in the Red Sea in November, a large cargo ship operated by Nippon Yusen. These incidents are comparatively less frequent to the ones mentioned above, but highlight the group's diverse capability to disturb the shipping industry through direct action.

2.2.2. Scope of the attacks

The scope of the Houthi attacks in the Red Sea is wide ranging. As mentioned above, despite the fact that they claim to attack vessels related to Israel, many of the attacks have no connection whatsoever to Israel. Their targets are varied, including container ships, bulk and carriers. "The attacks have indiscriminately impacted a wide array of nations, including the United States, Britain, Turkey, Russia, China, Qatar, and notably Iran." (Helou, 2023). "The increasing tensions and military engagements in the Red Sea have the potential to attract more nations into the dispute, thereby escalating an already limited exchange into a more extensive and protracted conflict."(Romaniuk and Kaunert, 2023). This is partly because governments' compliance with the United governments as a de facto security guarantor in the region cannot be guaranteed, but it is also because of the waterway's essential importance, which impacts all states, albeit to differing degrees. This is already evident in the rejection of some governments to join the joint naval task force and, in certain instances, in their choice to act independently of the joint operation. "Given the increasing militarization and contestation in the region, it is not implausible that the U.S. and coalition powers will mount a more potent military response than the mere deployment of naval task forces. At present, there are increasing demands on the Biden administration to target Houthi strongholds, which increases the likelihood of both horizontal and vertical escalation."(Romaniuk and Kaunert, 2023)

2.3. Influence of global geopolitics

The Houthi attacks on the Red Sea are primarily a geopolitical mean to put pressure. We could say that what is happening currently is an international relations chess game. There are two regional power struggles that play an important role on how and why this crisis has emerged. First of all there is a religion ideology reason. The Houthis are predominantly Shi'ite which is one of the reasons they are backed by Iran. "Tehran bolstered its relations with the group through soft power, particularly religious schools, to integrate the group into its constellation of Shi'ite proxies. Later, it upscaled the group's level in military and security affairs via the Lebanese group, Hezbollah." (Kılıc, 2024). Iran then became more involved in the fight against the Houthis after a coalition led by Saudi Arabia which are predominently Suniite entered the fray in 2015. The Houthis were even more dependent on Tehran for military supplies, intelligence, and training as a result of Iran's increased military assistance. The Houthis in this crisis have been utilized by Iran as proxy forces that allow them to have influence across the Middle East without engaging in direct military confrontations.

Furthermore, the Red sea plays a strategic role for Saudi Arabia. Not only it is a marritime corridor for its oil exports but also a necessary passage for its economy and military development. Saudi Arabia has been involved in conflicts with the Houthis since 2015 but in the two previous years there was a truce between the rebel group and the Saudi's. "Ever since the attacks started again on the Red Sea, the Saudi's have prioritised regional de-escalation and conflict management in order to preserve their economic interests" (Sons & Aguiar, 2024). Saudi Arabia has already plans for investments in the region, a development agenda called "Vision 2030" which will help the Saudi kingdom to position itself as a new regional hub for commerce, investment, and innovation, the country invests in energy diversification, infrastructure, entertainment, and tourism, while it changes and liberalises its society, and invites foreign direct investment. In this regard, the opening of a new Red Sea front puts at risk Saudi Arabia's ambitious economic diversifiaction plans that also focus on the Red Sea.

The Houthis by "blocking" the Red Sea, know exactly what immense global pressure they exerce and they leverage it to their advantage. This has not gone unnoticed by the Western forces, who are closely monitioring the situation. In fact "since 2008, the EU has been active in maritime security through Operation Atalanta, but in light of the escaltion in the Red Sea, the EU is preparing its new Aspides mission, which launched on February 19th by the EU Foreign Affairs Council." (Sons & Aguiar, 2024). The EU's involvement in the region is motivated by the dual goals of defending critical maritime routes and guaranteeing regional stability, both of which are essential to the global economic and security frameworks. "Yet these operations are often constrained by the EU's cautious approach and the need for member-state consensus." (Sons & Aguiar, 2024). On the other side a much more direct Western force, the US, didn't hold back on launching strikes. "On the evening of January 12, the US and UK let coalition known as Task Force 153 bombed Houthi positions for the first time since the group intiated its attacks on maritime shipping via the Bab el-Mandeb." (Langlois, 2024). Unsurprisingly, and based on official Houthi rhetoric, the Task Force mission failed to restore much-needed calm in the Red Sea and the wider region. Instead, the US-led bombings appeared to fuel more and greater attacks on international trade passing through Yemen. The involvment of the US in the Red Sea crisis is not consistent, the US argues that they don't want to escalate the conflict in the region while also attacking and making their presense from time to time. Some argue that the current crisis somewhat benefits the US as the Eu-Asia trade becomes more expensive.

Finally, the main influence that triggered the recent attacks in the Red Sea is the Israel-Gaza war, “the Iran aligned group has demanded that Israel allows humanitarian aid to enter Gaza, which has been reeling from more than ten months of Israeli siege and bombardment.” (Motamedi, 2024). Israel, the Houthis' first direct target, has already suffered the impact of hindered marine traffic. Traffic through the southern port of Eilat, which is also a tourist destination, has come to a halt, and the near future is uncertain as the battle continues. This increases the pressure to Israel and its allies, forcing them to divert their resources used in the war against the Palestians and potentially weakening their position in other areas of the regional conflict.

2.4. Effects of Houthi rebel attacks have on operational costs of shipping

As we can imagine, the effect that the Houthi attacks have on the operational costs of shipping are very significant. Mr. Pavlos Paschopoulos, Director of the International Trading Division at TITAN Group (Cement manufacturer), pointed out that "the crisis in the Gulf of Aden increases the sailing miles for the majority of all types of ships, due to the diversion towards the Cape of Good Hope. “Steering clear of the Red Sea and taking the lengthy detour around the Cape of good Hope, adds around 3,500 nautical miles and 10-12 days sailing time to each trip.” (Baraniuk, 2024). The distance can vary ofcourse based on the exact port and destination, To put this into perspective, circumnavigating Africa as an alternative route to the Suez Canal adds 4575 nautical miles in sailing distance between Shanghai and Rotterdam and 12 days in additional sailing time (Notteboom et al., 2024). This delay increases the total sailing distance by 29%. Undoubtedly, this increases the operational costs of ships. Let’s dig deeper into these costs to identify which specific ones are most affected.

The first operational cost that we can see a direct raise is the **fuel cost**. Making the route longer means also that the vessel is going to need more fuel. “Ships shunning the Red Sea will have to instead sail around the Horn of Africa, which can cost $1 million more round trip in additional fuel costs.” (Berman, 2024) More specifically, according to LSEG research data, diverting the vessels around the cape significantly increases the OPEX cost in terms of bunkers consumed. “For an Aframax tanker, this cost increases by 110% while for a large container vessel it increases by 35% for a voyage between Asia to NW Europe.” (Raja et al., 2024).See more in detail at the table. Another factor that can affect the fuel cost is the average speed that the vessels are using now that they reroute. According to LSEG Shipping Research, the average speed of large container ships has increased in order to expedite the trasportation of goods quicker. “Notably, the average speed peaked at 16.24 nautical miles per hour for larger container ships in early January of this year, comoared to the average of 15.20 nautical miles per hour through the major part of the last year (2023).” (Raja et al., 2024).

Table 4: Aframax Tanker & Large container OPEX cost comparison

	Aframax Tanker		Large Container	
	Via Suez	Via Cape	Via Suez	Via Cape
Load Point	Sikka	Sikka	Shanghai	Shanghai
Disch Point	Mongstad	Mongstad	Rotterdam	Rotterdam

	Aframax Tanker		Large Container	
Total Distance (nautical miles)	6800	11388	10667	14016
SECA (nautical miles)	905	905	416	416
Speed (knots)	13.5	13.5	15	15.5
Voyage Time (Days)	20.99	35.15	29.63	37.68
Average Cons (MT/day)	25	25	150	160
Voyage cons (MT) - non SECA	454.86	808.87	4271.25	5849.46
Voyage cons (MT) – SECA	69.83	69.83	173.33	178.92
Bunker Cost - VLSFO ($/MT)	595	770	625	625
Bunker Cost - LSMGO ($/MT)	910	1130	775	775
Total fuel costs (mln $)	334.2	701.7	2,803.9	3,794.6
% increase in OPEX cost	110%		35%	

Source: Allianz, (2024), [Accessed 30 Aug]

Secondly, another operational cost that increases for ships is the insurance premiums. Shippowners are concerned not just with the possible threat to their ships, cargo, and staff, but also with the costs associated with insuring against such risks. “War cover is typically purchased alongside or seperately to hull insurance, covering war and terrorism perils normally excluded from marine policies.” (Allianz, 2024) . “War risk premiums have risen to around 0.75-1% of the value of a ship from 0.07% in early December. While various discounts would be applied, this still translates into tens of thousands of dollars additional costs for seven-day voyage.” (Saul, 2023). “For a very large container ship this premium corresponds from $1 million to $2.5 million, making the longer route around the Cape of Good Hope more economically viable” (Deep & Raouf, 2024). The situation in the Red Sea is unique as it is not a declared war, which would require insurers to cancel policies and vessels to avoid the afflicted area. Insurers can re-instate coverage on a case-by-case basis, charging an extra premium for vessels transiting the Red Sea.

Thirdly**, crew costs**. It goes without saying that since the journeys have become longer, the time and therefore the days that the crew is working is longer.

Maritime security costs

Ship owners are once again interested in hiring private armed guards as a result of the Red Sea scenario. Even though it is not a direct operational cost, it can be an additional **operational cost** that will be added more frequently as the crisis persists. It has been claimed that ship owners of high-risk vessels have increased the number of guards on board from three teams to six or eight teams, and that the ship owners have also been using these guards for longer than previously. Deploying more armed guards can to assist minimise the extra premiums imposed by insurers on war risk coverage.

When these various cost components are combined together, the additional expenditures for an Asia-Europe roundtrip by a medium-sized container ship are up to USD 1 million if the ship continues to use the Suez Canal route and USD 1.7 million if the ship uses the Cape of Good Hope route.(see figure 4) "This represents an additional cost per 40-ft equivalent unit (FEU) container into Europe of up to USD 160 via the Suez Canal or USD 272 via the Cape of Good Hope ." *(International Transport Forum, 2023)***.**

Table 5: Shipping cost increses due to the Red Sea situation for median size container ships

Cost item	Via Suez Canal (USD)	Via Cape of Good Hope (USD)
Fuel costs		1 million
Charter Costs		1 million
Container Hire		0.3 million
Canal fees		-0.6 million
Insurance costs	Up to 1 million	
Maritime security	0.03 million	
Total additional costs per ship	Up to 1 million	1.7 million
Additional costs per 40-foot container	Up to 160	272

Note: *"The data in this table assumes a load factor of 80%; therefore, a 12 500 TEU ship would carry 5 000 40- foot equivalent units (FEUs). A total of 80% of the costs of the round trip are assigned to the westbound trip." (International Transport Forum, 2023)***.**
Source: ITF (2024) [Accessed 20 Aug]

The rise in the above operational costs, has led to reduced profit margins for shipping companies, which translates into an increase in the freight rates across the market. Global container shipping freight rates climbed by almost 130% between the beginning of November 2023 and the beginning of March 2024, peaking at USD 3,964 per 40-foot container on the Drewry Global Container Index by the end of January 2024.

2.5. Literature on impact of Houthi rebel attacks on trade, ports and supply chains in the region

Trade routes

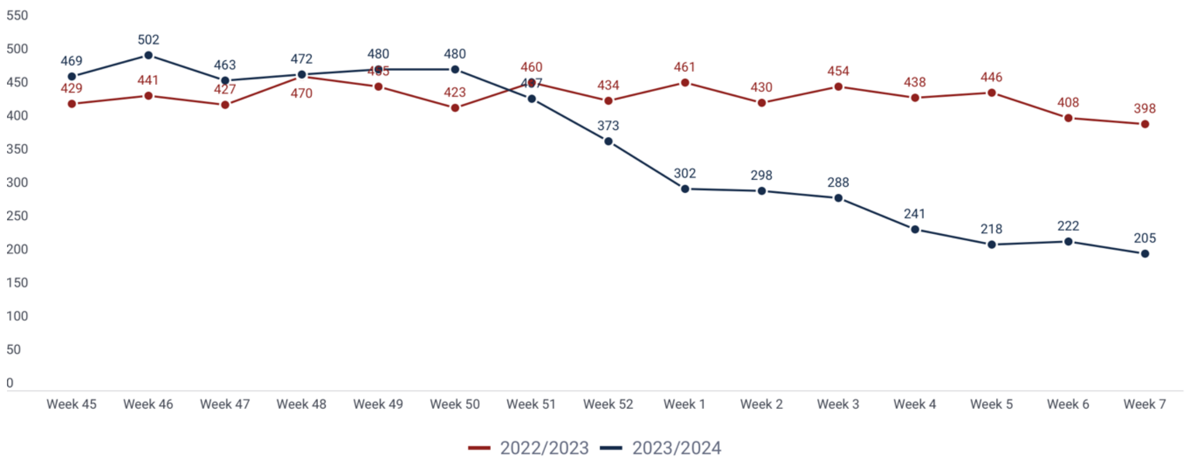
The attacks on ships in the region have significantly reduced traffic through the Suez Canal, the shortest maritime route between Asia and Europe, which normally handles about 15% of the world's maritime trade volume.

Now that the Houthis have demonstrated their ability to significantly impede trade between various trading zones, major companies like Maersk and the Mediterranean Shipping Company (MSC) have chosen to stay out of the southern Red Sea.

"While the full impact of the Red Sea crisis on shipping and global supply chains remains uncertain, business and shipping lines are trying as far as possible, to mitigate the potential logistics consequences of the crisis" (Notteboom et al., 2024). As illustrated in figure 3 and 4, it is interested to see the trade route switch between the Suez canal and the Cape of Good Hope.

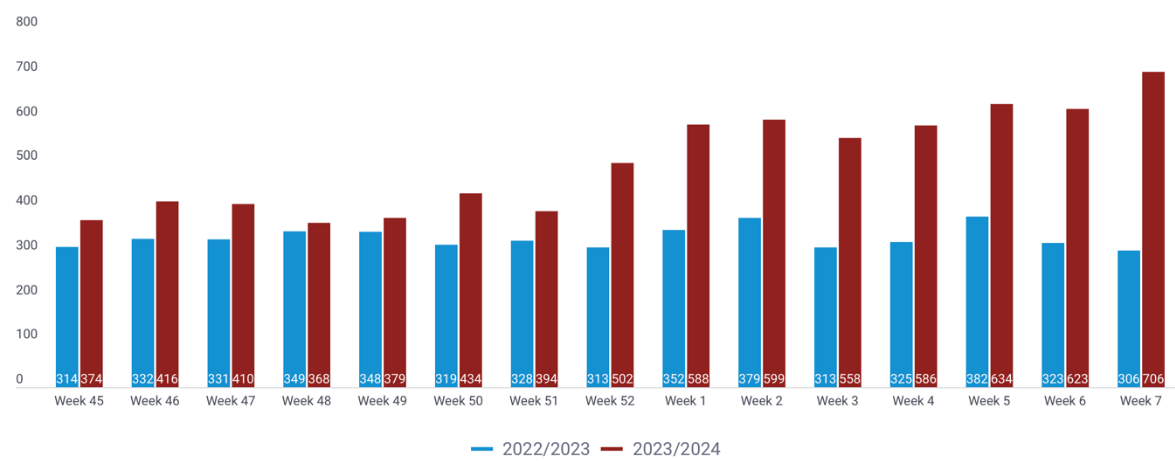
According to Lloyd's List, Transits across the **Suez Canal** decreased by 8% to 205 in week 7, marking the lowest number since the start of the Houthi strikes and a total of 17 fewer than in the week ending February 11. To put things in perspective, this is 57% below the pre-attack average and 48% below week 7 of the previous year. The decrease was mostly caused by fewer bulk carriers using the canal to transfer cargo. The week ending February 20 saw 79 bulk carrier transits, compared to 105 the week before. Ninety-two was the lowest since mid-December.
In the meantime, **Cape of Good** Hope passings increased by 13% to 706 in week 7 from 623 the week before. The increase is 80% when compared to the 4-week average before the assaults, whereas 306 vessels passed during the same week last year, representing a 131% increase year over year.79.7 million dwt passed the Cape of Good Hope last week, up 14% from 69.5 million dwt the week before and 57% over the pre-attack average of 50.7 million dwt.A 45% increase from the pre-attack average of 245 was seen in the number of bulk carriers that passed around the Cape of Good Hope last week, rising to 356 from 294 in the seven days prior.

Figure 2: Number of ships transiting the Suez Canal



Source : Lloyd's List Intellignece (2024) Accesssed [Sep 1]
Note: Vessels only over 10,000dwt considered in the analysis

<u>Figure 3: Number of ships transiting the Cape of Good Hope</u>



Source: : Lloyd's List Intelligence (2024) Accessed [Sep1]
Note: Vessels only over 10,000dwt considered in the analysis

Shipping companies were quick to react by introducing new feeder and shuttle services to access the northern Red Sea market. In order to maintain the connectivity and minimize disruptions, Maersk introduced a Red Sea – West Med liner passing from port Said until King Abdullah and back to the Mediterranean (Barcelona) and Hapag-Lloyd from Antwerp until Jeddah and back.

As of march 2024, the majority of UCLVs diverted their route passing around Africa via the Cape of Good Hope with a steep decline of those entering the Mediterranean. This rerouting has increased transit times. This delay increases the total sailing distance by 29%. Additionally, countries situated in the east med are heavily impacted because their economies rely on the Suez Canal for their trade routes.

Ports
"The Red Sea crisis has cast a long shadow over the ports of the region. From December 1, 2023, to March 31, 2024, ports activity contracted sharply in trade volume, a stark contrast to the bustling activity of the previous year. While a handful of ports have eked out marginal gains, the majority witnessed significant drops in both imports and exports. Jordan's Al Aqabah, Yemen's Al Mukalla and Aden, Saudi Arabia's Jeddah, Rabigh, and King Fahd, as well as Egypt's El Sokhna, have all with- stood the worst of this downturn."

Supply chains
The supply chain may be impacted as a result of traffic on alternate routes caused by the large vessel rerouting via the Cape. Shippers have experienced some short-term effects due to the Cape route's increased transit durations. They face significantly greater fluctuating inventories and postponed deliveries, resulting in increased unreliability that undermines effective global logistics. These effects are especially felt by industries that depend on manufacturing and delivery systems that are just-in-time (JIT) and make-to-order (MTO).For ecxample, "in the automotive industry, Tesla suspended production at its Gigafactory Berlin-Bradenburg between January 29 and February 11 due to a discontinuation in the constant flow of components from Asian suppliers to the German plant caused by vessel reroutings." (Notteboom et al., 2024). Another brand in the automotive industry that got hit in its supply chain section is Volvo. The brand's cars are produced in Belgium, they also ceased production in January due to lack of components. These disruptions demonstrate how supply chains and MTO/JIT-based production facilities are instantly impacted by any significant disturbance to the smooth functioning of the world's production and distribution networks.

2.6. Bilateral trade through the Guld of Aden – Red Sea

The Red Sea route ensures the delivery of energy supplies such as crude oil, gasoline, LNG, and coal, as well as metal goods, both north and south. This stretch of the Indian Ocean runs from the Suez Canal to the Bab-El-Mandeb Strait. On a regional level, six countries border the sea: Egypt, Eritrea, Djibouti, Saudi Arabia, Sudan, and Yemen. Countries in the immediate region will be impacted. As previously stated, Egypt and Djibouti gain revenue from shipping transit. Probably the country most significantly impacted economically by the current crisis is Egypt. Egypt is mainly going to be impacted due to the steep decline in the Suez Canal transits which means the revenue from the canal dues are going to be significantly lower. In fact it is "estimated that the Suez Canal generates approximately $10 billion annually for Egypt" (Khazen, 2024). . According to the PortWatch data, "over one-third of the Egyptian maritime imports and over-half of the exports are through the Red Sea" (Deep & Raouf, 2024). Egypt has also lost revenue due to a decline in tourism since the start of the war, as have Jordan and Lebanon, whose economies were already in bad straits before to the Gaza conflict.

Saudi Arabia is one of the countries that trade most through the Red Sea route regionally. "In 2020, Saudi Arabia exported more than 600 MMb/d of crude oil and more than 800 MMb/d of petroleum products to the EU." (Mestneer & Selemankhel, 2023). The Suez Canal connects the Kingdom with over 100 other countries for bilateral trade. As a result, the Suez Canal's safety, security, and operational efficacy are critical not only to the Kingdom but to the entire world.

Jordan, situated close to the northeastern tip of the Suez Canal, heavily relies on imports passing through this vital waterway. To put it in perspective, "Jordanian imports cover between 85 and 90 percent of the country's food needs, 65 percent of the volume of these imports cross Bab al-Mandab strait towards the port of Aqaba" (Awsat, 2024). On the export side, Jordan biggest export is Fertilizers and accounts for 19% of the countries total exports. Additionally 60.9% of Jordan's export is destined to Asian countries. "The port of Aqaba, which handles nearly one-third of imports and over 50% of exports, plays a pivotal role in the nation's economy" (Anera, 2024). 76% of Jordanian potash used to leave through that port to travel east. Limitations on the movement of goods traded is leading to increased costs which puts pressure on the economic environment of Jordan.

Furthermore Several East African countries rely heavily on the Suez Canal for their international trade. "Approximately 31% and 34% of foreign trade by volume for Djibouti and the Sudan, respectively, is channeled through the waterway connecting the Mediterranean Sea to the Red Sea." (UNCTAD, 2024)

On a global scale, "Countries such as Singapore, Cambodia, New Zealand, Indonesia and Sri Lanka – for which China is the biggest source of imports – will be less impacted by inbound shipping delays than others, such as Japan, India and Australia. Similarly, countries with a high dependency on imports of food products, (e.g. New Zealand, India and Pakistan) will also be affected." (Delivorias, 2024)

While an Europe-Asia trade route crisis would expect China to be very impacted, so far we have seen that "Houthi attacks on maritime shipping have had a limited impact on China's trade." (Urhova, 2023). Chinese ships transiting through the Red Sea have also openly signalled their links with China via communication channels to avoid being wrongfully targeted. "While there has been an increase in shipping costs and insurance premiums for a standard container being sent from China to Europe from $1,500 to $4,000, these values still remain below the COVID-19 levels, where the costs skyrocketed to $14,000. Similarly, the impacts on China's energy imports have been relatively manageable, with prices jumping by about 4 percent and reaching $78 per barrel (lower than the $84 per barrel before Hamas' October 7 attack). Consequently, this is unlikely to cause a severe shock to the Chinese economy." (Urhova, 2023)

Since this crisis is very recent and the countries that are most affected changes by various political factors but also by the fact of how each country adapts to such a crisis, we thought a very interesting way to also back up our findings was to look at a past event where the Suez

Canal was blocked. More specifically, the Canal was completely blocked on march 23, 2021 for six days by the container vessel Ever Given. Looking at the paper “Economic Impatcs of te blockage of the Suez Canal: an Analysis by IDE-GSMby (Gokan et al., 2024) we see that they did a simulation and estimated which countries where most affected worlwide. According to that paper, the most affected countries by the Suez Canal were “ China (-73.0 billion USD), followed by India (-26.2 billion USD), and Israel (-20.4 billion USD). Notably, the EU was substantially affected (-72.9 billion USD).” (Gokan et al., 2024).

3. Methodology

3.1. Methodological (quantitative) approaches to analyse the impact of Houthi Rebel attacks

Choosing a topic that is still ongoing and very recent can be very thrilling but it also comes with its challenges. In order to have a deep understand of the topic, we have done an extensive qualitative research. While our qualitative research on the matter is very extensive, a missing quantitative aspect on the paper is noticeable. Roberta Piermartini, one of the authors and researchers of the book "Demystifying Modelling Methodology for Trade Policy" analyses and stresses out the importance of using a quantitative approach through two types of quantitative tools. The authors identify the quantitative tool in question as (CGE) computable general equilibrium. "In essence, CGE models are computer-based simulations…which compute how today's economy will look in the future as a consequence of a specified set of policy changes." (Piermartini and Teh, 2005). "Gravity models and computable general equilibrium (CGE) models are the most commonly used analytical techniques to perform a quantitative analysis in the area of trade policy." (Ivus and Strong, 2007). For instance, CGE models provide valuable insights into how economies function, which is essential for effective policy-making. Gravity models only explain the patterns of bilateral commerce; they do not provide direct estimates of welfare costs.

"The "general equilibrium" of CGEs reflects the interdependency of economic variables-the notion that every change affects a range of other elements in an economy." (Piermartini and Teh, 2005) This approach stresses out the complexity of all economic systems and underscores that there is no change that is happening in isolation but rather one single change creates a butterfly effect that is depicted throughout the entire economic framework.

Going back to our topic, the Red Sea crisis which has led to an unprecedented decrease in the Europe-Asia trade route, severly disrupts global trade flows and creates significant imbalances in the shipping market aswell as the economies of whole regions. It is intersting to see how CGE models are composed. "CGE modeling takes an ex-ante approach, which involves quantifying the future effects of a new policy CGE models have a bilaterla way of analysing the effect of a trade policy." (Ivus and Strong, 2007) "The ex-ante simulation of a change in trade policy, involves projecting the future effects on a set of economic variables interest." (Piermartini and Teh, 2005) Secondly we have the "ex-post approach which uses historical data to conduct an analysis of the effects of a past trade policy." (Piermartini and Teh, 2005). "Gravity models takes an ex-post approach to perform trade policy analysis." (Ivus and Strong, 2007). They use two types of variables. Endogenous variables refer to variables whose values are decided by the model. While with Exogenous variable, the model does not account for exogenous factors, they are determined externally. The model cannot fully predict the behaviour of an exogenous variable, hence more information from outside sources is required to determine it. Econometric studies have the issue of linking a cause to an effect, such as demonstrating the impact of trade costs on trade flows.

Furthermore, there is another model called PE (Partial equilibrium). Economic analysis can be partial or general equilibrium in nature. "Partial equilibrium analysis focuses on one or multiple specific markets or products, ignoring the linkbetween factor incomes and expenditures, while general equilibrium explicitly accounts for all the links between sectors of an economy – households, firms, governments and the rest of the world." (Bacchetta et al., 2012) Finally it is important to state that "Simulation results are necessarily subject to error and the quality of the results will vary with the appropriateness of the model to the problem at hand." (Piermartini and Teh, 2005)

For our methodological approach we aim to use a model that will provide the best quantitative framework to support our research question. The thesis research focuses on a specific aspect which is to demonstrate the economic impacts of new trade route flows coming from the Houthi crisis on the maritime industry. Our goal for choosing a suitable methodological mean is to effectively quantify and present these effects within the context of trade. Therefore we want to chose a partial equilibrium model that will allow us to quantify the impact of the Red Sea crisis on global and regional economies and trade. The Partial equilibrium model we chose to do our analysis is the GSIM model

3.2. Global Simulation model (GSIM)

The Global Simulation model is a fairly recent model developed by Mr. Joseph François and Mr. H. Keith Hall in 2002. As we mentioned before, Partial equilibrium models do not account for many of the factors highlighted in general equilibrium trade theory, which means that there are some limitations. But as we focus on quantifying the impact of the Red Sea crisis by extracting the costs of shipping companies that continue to sail through the Red Sea, using the Global Simulation model is an advantage for our thesis research. The GSIM model "focuses on a very limited set of factors, the approach followed here allows for relatively rapid and transparent analysis of a wide range of commercial policy issues with a minimum of data and computational requirements." (Francois & Hall, 2002)

Lets look and analyze the equations that the GSIM model uses

Table 6: Equation variables

Variables	Description
M	Imports (quantity)
X	Exports (quantity)
$E_{m,(i,v)}$:	Aggregate import demand elasticity
$E_{x,(i,r)}$	Elasticity of export supply
E_s	Elasticity of substitution
$N_{(i,v),(r,r)}$	Own price elasticity
$N_{(i,v),(r,s)}$	Cross-price elasticity
$T_{(i,v),r}$	Power of the tariff, T=(1+t)
$\theta_{(i,v),r}$	Demand expenditure share (at internal price)
$\varphi_{(i,v),r}$	Export quantity shares

Variables	Description
P	Composite domsetic price
P*(i,r)	World price for exports from region r
P(i,r),v	Internal prices for goods from region r imported into region v
T(i,r),v	Import tariffs fo goods from region r imported into region v

Source: Own table adapted from Francois & Hall (2002)

The first set of equations are the elasticities as described by Francois &Hall

Equation 1: *M (i,v),r = f (P(i,v),r ,P(i,v),s≠r , y(i,v))*

Let's disect the equation to understand what it is representing.

"M i,v),r" is the demand of product *"i"* important from country *"r"* in country *"v"*. (Francois & Hall, 2002)

"Y(i,v)" is the total expenditures on imports of the demand of product "i" in country "v" (Francois & Hall, 2002)

"P(i,v), r" is the internal price of the importing regions "r" to the exporting regions (country "v"). (Francois & Hall, 2002)

"P(i,v),s≠r" is the price of other varieties. (Francois & Hall, 2002)

Equation 2: *N(i,v),(r,s) = θ(u,v),sEs + η(i,v),(r,y) [η(i,v),(y,s) – θ(i,v),s]*

*"θ(i,v),*s" is and expenditure share (Francois & Hall, 2002)

"η(i,v)(r,y)" is the industry expenditure elasticity of demand for product variety r (Francois & Hall, 2002)

"η(i,v)(y,s)" is the price s elasticity of industry expenditure. (Francois & Hall, 2002)

Equation 3: N(I,v)(r,r) = Σθ(i,v),sEs + η(i,v),(r,y)[η(i,v),(y,r) – θ(i,v),r]

Equations (2) and (3) can be further simplified with the additional assumption of homothetic preferences for expenditures which, along with the assumption of weak separability, is sufficient for two stage budgeting. (Francois & Hall, 2002)

Equation 4 (Simplification): η(i,v)(y,s) = θ(i,v),s[1+EM,v]

EM,v "is the composite demand elasticity in importing region v" (Francois & Hall, 2002)

After making substitutions we arrive at the following two equations:

Equation 5: $N_{(i,v),(r,s)} = \theta_{(i,v),s}[E_m+E_s]$

Equation 6: $N_{(i,v),(r,r)} = \theta_{(i,v),r} E_m - \sum \theta_{(i,v),s} E_s = \theta_{(i,v),r} E_m - (1-\theta_{(i,v),r}) E_s$

Now let's look at the equations that represent the individual demand and supply conditions

Equation 7: *P(i,v),r = (1+t(i,v),r)Pi,r* = T(i,v),rPi,r**

Pi,r is "the export price received by exporter r on the world markets".* (Francois & Hall, 2002)

P(i,v),r "is the internal price for the same good." (Francois & Hall, 2002)

T = 1+t is "the power of the tariff." (Francois & Hall, 2002)

Equation 8: $X_{i,r} = f(P_{i,r}*)$

"i" supply exports

"r" exporter

For the three following equations we take the derivatives of equation 1, 7 and 8.

Equation 9:

$$\hat{P}_{(i,v),r} = \hat{P}_{i,r}* + \hat{T}_{(i,v),r}$$

Equation 10:

$$\hat{X}_{i,r} = E_{X(i,r)}\hat{P}_{i,r}*$$

Equation 11:

$$\hat{M}_{(i,v),r} = N_{(i,v),(r,r)}\hat{P}_{(i,v),r} + \sum_{s \neq r} N_{(i,v),(r,s)}\hat{P}_{(i,v),s}$$

On all three equations "^ denotes a proportional change" (Francois & Hall, 2002)

We subtitue "equations 9, 5 and 6 into equation 11 and some over import markets" (Francois & Hall, 2002). We then "set this equation to the modified version of equation 10" (Francois & Hall, 2002) which gives us the following global equilibrium equation:

Equation 12:

$$\hat{M}_{i,r} = \hat{X}_{i,r} \Rightarrow \quad E_{X(i,r)}\hat{P}_{i,r}* = \sum_{v} N_{(i,v),(r,r)}\hat{P}_{(i,v),r} + \sum_{v}\sum_{s\neq r} N_{(i,v),(r,s)}\hat{P}_{(i,v),s}$$
$$= \sum_{v} N_{(i,v),(r,r)}[P_r * + \hat{T}_{(i,v),r}] + \sum_{v}\sum_{s\neq r} N_{(i,v),(r,s)}[\hat{P}_s * + \hat{T}_{(i,v),s}]$$

Next we have the two equations which represent producer and consumer surplus.

Equation 13: Change in producer surplus.

$$\Delta PS_{(i,r)} = R^0{}_{(i,r)} \cdot \hat{P}_{i,r} * + \tfrac{1}{2} \cdot R^0{}_{(i,r)} \cdot \hat{P}_{i,r} * \cdot \hat{X}_{i,r}$$
$$= \left(R^0{}_{(i,r)} \cdot \hat{P}_{i,r} *\right) \cdot \left(1 + \frac{E_{X,(i,r)} \cdot \hat{P}_{i,r} *}{2}\right)$$

R^0 (i,r) “represents benchmark export revenues, either bilateral or in total, valued at world prices.” (Francois & Hall, 2002)

Equation 14: Change in consumer surplus.

$$\Delta CS_{(i,v)} = \left(\sum_{r} R^0{}_{(i,v),r} \cdot T^0{}_{(i,v),r}\right) \cdot \left(\tfrac{1}{2} E_{M,(i,v)} \hat{P}_{(i,v)}{}^{2} \cdot sign(\hat{P}_{(i,v)}) - \hat{P}_{(i,v)}\right)$$
$$where\ \hat{P}_{(i,v)} = \sum_{r} \theta_{(i,v),r} \hat{P}_r * + \hat{T}_{(i,v),r}$$

P(i,v) “represents the price for composite imports.” (Francois & Hall, 2002)

$R^0_{(i,r)} \cdot T^0{}_{(i,v),r}$ “ repesents expenditure at internal prices.” (Francois & Hall, 2002)

In the end we have the two final equations of the Global Simulation Model.

Equation 15: Trade creation

$$TC_{(i,v),r} = M_{(i,v),r} \times [N_{(i,v),(r,r)} \hat{T}_{(i,v),r}]$$

Where “trade generated by own tariff reductions” (Francois & Hall, 2002)

Equation 16: Trade diversion

$$TD_{(i,v),r} = M_{(i,v),r} \times \sum_{s\neq r} N_{(i,v),(r,s)} \hat{T}_{(i,v),s}$$

Where “trade changes generated by changes in tariffs on imports from third countries.” (Francois & Hall, 2002)

3.3. Country selection

Country selection is a crucial part of the GSIM model. In order to have representative results of the situation, we need to select countries that are the most related or "impacted" by the current Red Sea crisis. The rationale for creating a list containing these countries is that we need to evaluate and review data based on the following selection criteria:

a. The percentage share of exports going through the Red Sea
b. The value in USD of exports going through the Red Sea
c. Took into account the geographical vicinity to the Red Sea.
d. Took into account the countries that are geopolitically targeted

As (Francois & Hall, 2002) explains, "our solution strategy involves a partial-equilibrium representation of the multi-country global market. Within this context, we work with a linearized (percent-change) representation of import demand, combined with generic export-supply equations." (Francois & Hall, 2002). The GSIM model allows also to group countries together. By applying these criterias we ended up with a list of 12 countries among them we grouped all the european countries as one, as well as Japan&Korea (see figure 6). This list contains countries which are both regional and international in relation to the Red Sea crisis.

Table 7: Countries selected for the GSIM model

Regional countries	Global countries
Egypt	EU27
Saudi Arabia	China
UAE	India
Israel	Japan & S. Korea
Turkey	US
Sudan	Singapore

Source: Own table

Since we wanted to limit our simulation to 12 countries, we wanted to see how could we split our selection to regional and international countries. For our regional countries we begin by Egypt, a country most impacted by the current situation but the primary reason comes from the lack of revenue from their canal dues. Following this Saudi Arabia and UAE, being the key players in the region for the trade of Oil and LNG coundn't miss from our list. Furthermore Israel, the country which triggered the recent incidents and relies heavily on the passage. Lastly from the Red Sea region, Sudan a very poor country is having huge problems receiving cargos and humanirian aid . Turkey being one of the main countries with a big industry of manufacturing which Europe relies to heavily. Next, the EU, many countries within Europe are heavily impacted therefore we chose to include Europe as a group country instead of picking the most impacted.

*Moving on to the international countries, China one of the biggest exporters in the world relies heavily on the canal. Even though the Houthis are said to not target Chinese vessels, this constantly changes and since the shipping industry is the one who transports products, many companies even Chinese ones avoid passing through the Red Sea creating a problem for China. Moving forward, India a country known for its manufacturing exports Heavily to Europe, from petrochemicals to footwear, textiles, and even Indian agriculture relies heavily on European fertilizers. We wanted to include also countries from the East Asian region and South East, therefore we chose Japan and South Korea as one and Singapore. At the end of the countries list we chose USA, a country that is not as impacted as the rest of the list but we wanted to see it comparatevily how would one of the leading countries in exports and imports react to such an event long term. Finally the list containes ROW(Rest of the World) as a mandatory selection for the GSIM which gives a comparative result compared to the whole world.

3.4. Model data

3.4.1. Trade values

Trade values are one of the necessary information to input for the GSIM model. After we have concluded on the countries that we are going to use, we began searching for the total bilateral trade of each country. For the trade values we mostly used UN Comtrade Database, which provides a great source of info for the annual import or export trade values of each country exports and imports which we put every value with an average of 80% representing the sea trade.

3.4.2. Elasticities

Concerning the elasticities, the GSIM model requires us to input three types of elasticities for each country that we have chosen. The three types of elasticities are, composite demand elasticities which is a mix of import and domestic demand, composite demand elasticity is negative if its positive it means the elasticity is inelastic. Furthermore we have the elasticity of substitution and the elasticity of supply all of them which are price elasticities. The elasticities have a crucial role determining the outcome of the model's result. There are three literatures that we looked in order to determine the right elasticities to use for our paper. The first one is the paper from (Bazjik et al.2019) which talks us through the Armington elasticity. Their findings "indicate that the study characteristics are systematically associated with reported results. Among the 34 variables they construct, the most important are the ones related to the data used in the estimation." (Joseph Bazik et.al). The sample contains 3,524 estimates, "The oldest study in our sample was published in 1977 and the most recent on in 2018 , thereby covering more than 40 years of research." (Bazjik et al.2019). Secondly we looked at the paper of (Ghodsi et al.2016) which is a revisited version of Hiau Looi Kee et.al, titled as the "Import Demand Elasticities revisited". This paper "constitutes an update of their by computing import-specific import demand elasticities for the more recent period 1996-2014 and presents differences across countries, regions and income levels, as well as by products and sectors." (Ghodsi et al.2016). Finally we analyzed the elasticities taken by the thesis of Ana Mercedes Campo since it was also a thesis simulating a vey recent impact of the war between Russia and Ukraine. We concluded that for our substitution elasticity we will be taking 5.0 for all our selected countries. Furthermore for our elasticities of demand, we looked over (Kee et al.2008) paper on Import Demand Elasticities and Trade Distortions. "This paper proposes a methodology that is consistent with GDP maximization in estimating import demand elasticities for more than 4,000 goods in 117 countries." (Kee et al.2008). Out of the table provided on the paper we used the weighted average elasticities for the elasticities of demand for our table. Finally for the export supply elasticity we looked over the paper " A method for calculating Export Supply and Import Demand Elasticities" written by (Tokarick, 2010). According to his research methodology, "an increase in the price of exports alone will increase export volume; thus the "partial equilibrium" export supply elasticity is positive." (Tokarick, 2010). Therefore as Campo mentions, "we will apply the average supply elasticity of 0.99 for all countries." (Campo, 2022).

3.4.3. Initial and final tariffs

Regarding our Initial tariffs, we proceeded to do our research and extract our info from UNCTAD'S World Integrated Trade Solutions (WITS). Since we don't have a specific product and we focus on the general trade, we retrieved data for each individual country to their partner from our list and for the product specification we remained on having the selection of "all products". Furthermore the indicator in which the results of the tariffs were given was (AHS) Weighted Average displayed in percentages, in which we were able to find all the necessary tariffs for our countries.

3.4.4. Non-tariff measures

The NTM's are a core part of our model. Non-tariff Measures are policy measure that act as "trade barriers" that limit imports or exports using methods other than typical tariffs (import charges). Governments adopt these measures to regulate commerce, and they can involve a variety of policies, such as Quotas, sanitary and phytosanitary standards(SPS) or Techincal barriers to trade (TBT) or even embargoes and trade sanctions. In our simulation the NTM's are depicting the extra costs on freight rates associated with the Houthi Rebel attacks. In order to conclude to a correct NTM percentage we had to evaluate which exactly where the extra costs.

The extra cost include:

- Military security onboard average 15-20k USD
- Insurance cost 1 % of vessel's value
- Egypt's Canal dues 15% increase

"the voyage cost for a Suezmax tanker through the Suez Canal is estimated at 2.06 million USD ($13.99/MT). For the same vessel to carry out the voyage through the Cape of Good Hope, the voyage cost is estimated at 2.99 million USD ($20.34/MT). The incremental cost accounts for about 932,905 USD plus the additional time it takes to go round the cape" (Raja et al., 2024). A Suezmax ship under 10 years old is estimated to be worth USD 65 million by LSEG TonnEdge, a ship valuation company. The vessel will incur an additional USD 650,000 in journey costs due to insurance premiums and greater risk. As a result, when these factors are taken into account, the difference in the overall voyage cost is not considerable.

Therefore, we have decided to apply a 5% for all going through the Suez Canal.This approach creates a balance between the necessity for precision in our model and the complexity of computing various percentages for each country, allowing us to focus on the overall impact of NTMs. By imposing a uniform 5% NTM surcharge on ships transiting the Suez Canal, we reflect these multiple interruptions and their impact on freight rates, simplifying our model while capturing the huge financial impact of such geopolitical risks. This approach enables us to systematically account for the additional burden that NTMs impose on global trade without having to calculate different charges for each particular country or shipment.

3.5. Scenario development

As explained above there are two routes which vessels can choose to take, the longer safer route around the Cape of Good Hope and the shorter more dangerous route through the Red Sea passage. We made one scenario that evaluates bilateral trade between countries into Red Sea countries displayed as "country's name" meaning it reflects results of the country using the trade flow of Suez and No Red Sea and "country's name2" meaning it reflects results of the country using the alternative trade route (e.g. trade flow around the Cape of Good Hope) which is the alternative route. In terms of model parameters:

- Tariffs do not change – they remain the same
- To simulate the effect of the Houthi Rebel attacks, we increase the NTMs for trade going through the Red Sea by 5% (based on data calculations – see Chapters 2 and 3), while the trade costs for the alternative (non-Red Sea) routes do not change.

This means that the Red Sea route will get relatively more expensive compared to the other routes. This means that trade will be diverted from the Red Sea route to alternative routes, including the sail around Cape of Good Hope – a route that is much more expensive and takes longer to sail.

4. Results and analysis

4.1. Welfare effects

Our results show us that the Houthi attacks are devastating for the welfare of countries. The graph we have made, displays three different types of data. Producer surplus, consumer surplus and total revenue. As previously mentioned we have included all our countries displayed as "country's name" meaning it reflects results of the country using the trade flow of Suez and "country's name2" meaning it reflects results of the country using the trade flow around the Cape of Good Hope.

Impact for producers

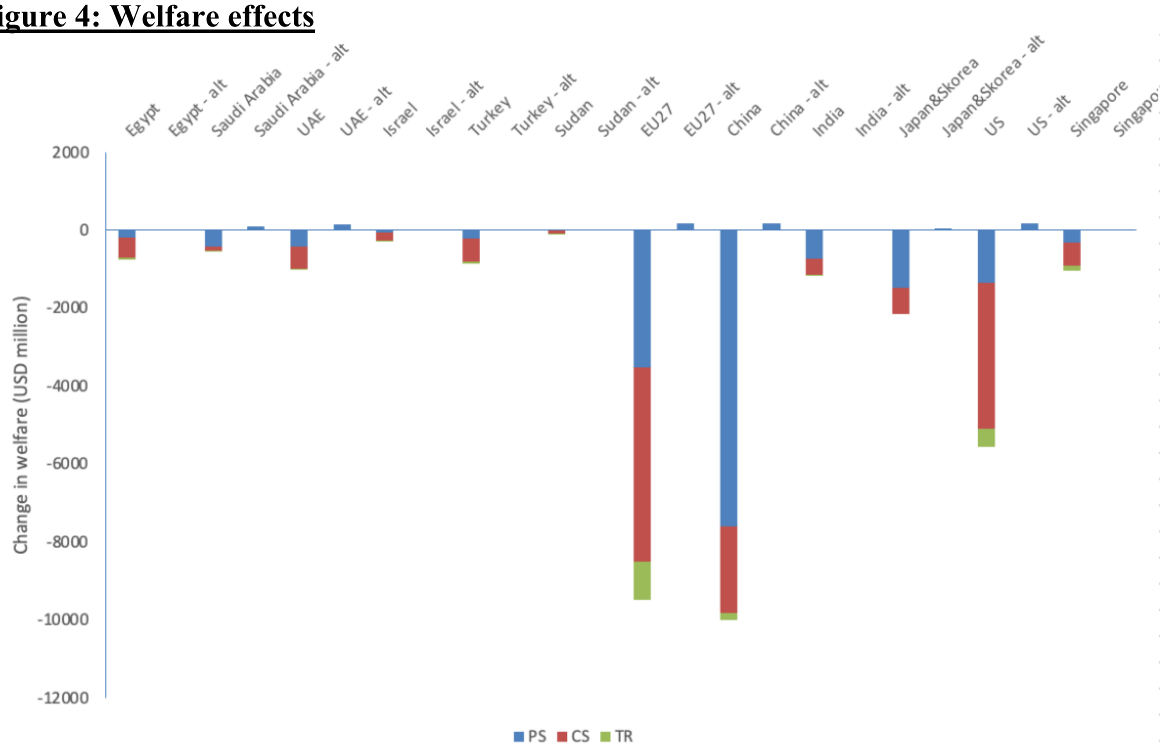
As it is noticeable in Figure 4 we see huge drops in producer surplus. A producer surplus drop indicates that the producers of the country are losing out – in this thesis the producers are the producers of goods being shipped and the providers of shipping services. There are certain countries that stand out in this regard. In order to follow the same approach of our thesis, we are going to analyze the producer and consumer surplus effect of regional countries and global countries. From the **regional countries**, the ones that have the biggest loss in producer surplus from using the Suez are UAE and Saudi Arabia. We see that with the current disruptions UAE has lost 431 million USD in producer surplus while only gaining 147 million USD from the alternative route. To put this into perspective the difference in the loss between the Suez route and the gain of the alternative route for UAE is almost 3 times less. Similarly, Saudi Arabia has lost 423 million USD in producer surplus and gained only 87 million USD from the alternative route. Next on the list is Türkiye and Egypt, with Türkiye reporting a loss of 220 million USD in PS and only a minor 2 million from the alternative route. Egypt having very poor choices due to the fact of its geographical position, records a heavy 181 million USD loss in PS. The two final regional countries are Israel and Sudan. Israel being the target of the Houthis, can not avoid the economic impact. We found a 67 million USD in loss of PS while also a very small 2 million USD from using the alternative route. As we did a comparison before, Israel has to benefit 33 times more from the alternative route in order to reach the level of the Suez in order to cover the impact. Moving on, Sudan reports a loss of 20 million USD in PS and no gain from the alternative route. The relatively "small" loss is because Sudan is a small country. Moving forward to the group of **global countries**. EU and China show the most negative results for PS. China loses a staggering 7,6 billion USD while only manages to gain 185 million from the alternative route. Europe follows next with a decrease of 3,5 billion USD in PS and a weak 169 million USD gain from the alternative route. The reason for seeing losses of this magnitude for EU and China is because both those countries are the key trading partners with each other. For the EU, China is the key trading partner and for China, the EU. In which all of this trade usually goes through the shortest route, the Suez Canal. Next looking over Japan&Skorea and US. Japan&Skorea lose a combined 1,4 billion USD in PS and gain only 52 million from the alternative route. US loses 1,4 billion USD in PS while only gaining 178 million USD. India follows with a loss PS decrease of 728 million USD and no gain and lastly Singapore recording a PS decrease of 317 million USD with a small gain of 7 million USD from the alternative route.

Impact for consumers

Focusing on the consumer surplus indicated in red on the graph, we also notice significant impacts. A negative consumer surplus means that consumers loses. The consumers of transport goods (in our case companies), need inputs that are now way more expensive. Starting again from the **regional countries**, Turkey and UAE have displayed the biggest losses in CS, 598 million of loss for Turkiye and 559 million USD for UAE. Egypt comes next with a decrease of 533 million USD, and Israel with -204 million USD. The last two on the list are Saudi Arabia recording -91 million USD in CS and Sudan recording -78 million. Concerning the **global countries**, Europe takes the first place with a 4,9 billion loss in CS next comes the US with a 3,7 loss following that China with 2,2 Billion and lastly Japan&Skorea with -688 million, Singapore with -603 million and finally India with -424 million in CS.

Overall analysis
Looking at the "bigger picture", in absolute terms we can see that the regional effect is smaller, partly due to the size of the economies of the countries. Summing up the data the Total welfare loss for the regional countries comes to 3.3 billion USD. Contrarily, the global effect is considerably bigger, coming to a loss of 28.8 billion USD. Overall we see that the EU and China lose the most, followed by the US. The reason the US loses much less is simply due to the fact that a smaller share of US trade goes through the Red Sea because the US also trades a lot with Latin America with the EU and China. Furthermore when putting on the same bar on our graph PS and CS we see that the countries that lose the most CS is the EU and the US while for the producers is China that losses the most. This is happening because China as a country exports more than it imports. When a country is majoritively exporting the PS/ producers get affected more. While countries who import more than they export like the EU or the US, the importers are damaged therefore the consumers(companies) who need the input get hurt because it becomes more expensive. Additionally tariff revenues are lost because there is less trade. Our key finding from this welfare effect analysis is that even though the alternative routes lead to some small welfare gains, the loss from the Red Sea is so big that it isn't even close enough to offset that loss and bridge the gap. As mentioned previously the alternative route can even be 30 times less than the Red Sea route.

Figure 4: Welfare effects



Source: Own calculations from GSIM model

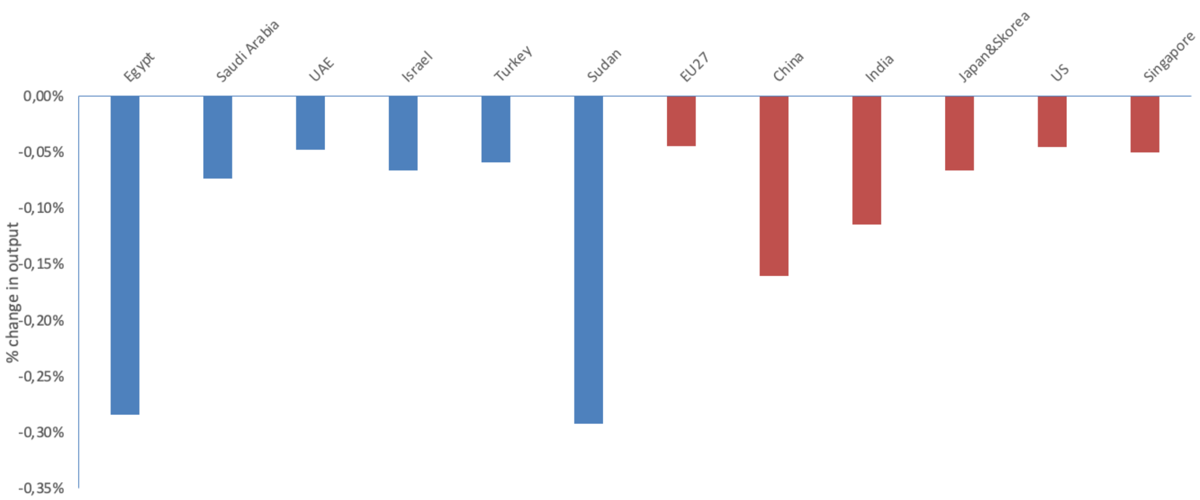
4.2. Change in domestic production

For the change in domestic production, we are looking at the % change in output of our GSIM results. We have made a graph splitting the regional effects output (blue) and the global effects output (red).(Figure 5). Concerning the regional effects output, we can see that Egypt (-0,28%) and Sudan (-0,29%) are the most negative. The reason for that is their geographical position. These two countries cannot avoid the Red Sea route. For example Saudi Arabia or UAE can much more easily avoid it. Additionally as we mentioned before since the Suez Canal income suffers it automatically affects Egypt. Globally we see that China (-0,16%) amd India (-0,11%) suffer the most, contrarily the EU, Japan&Skorea, US and Singapore suffer a lot smaller change. The reason why China and India suffer more is because their share of trade that goes through the Suez is rather high. Houthi rebel attacks have interrupted commercial routes, forcing a shift to lengthier and more expensive alternatives. This leads to greater transportation costs, and for countries that rely on trade in parts and components, it raises production input costs. As a result of the increased input costs, all impacted countries' domestic output falls.

In conclusion, changes in domestic production, as we measured on our GSIM by the percentage change in output, highlight the impact of trade disruptions at both the regional and global levels. Regionally, Egypt (-0.28%) and Sudan (-0.29%) have been hurt the most because they are unable to avoid the Red Sea route. These two countries face considerable obstacles, as opposed to Saudi Arabia and the UAE, who can easily circumvent it. Furthermore, Egypt's reliance on Suez Canal income worsens its economic downfall.

On a global level, China (-0.16%) and India (-0.11%) suffer more than other countries because a greater proportion of their trade goes through the Suez Canal. Meanwhile, the EU, Japan, South Korea, the United States, and Singapore saw far smaller changes. The increase transportation costs caused by the shift to longer, alternative routes (Cape of Good Hope) have a big impact on countries that rely largely on trade in parts and components, rising input costs. As a result, increasing input costs reduce domestic output in all impacted countries.

Figure 5: Change in domestic production (% change)



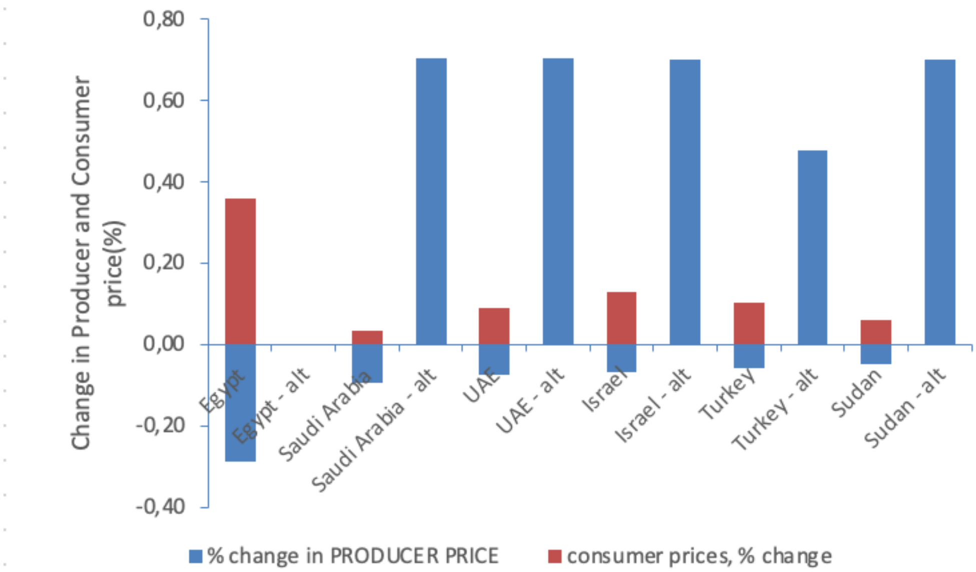
Source: Own calculations from GSIM model

4.3. Price effects

For the price effects, we have evaluated from our GSIM model the % change in Producer price and the % change in consumer price. As we did before, we have made two graphs in order to focus first on the regional effects and then on the global effects.

For the regional effects, as we can see from the Figure 6 below, producer prices (depicted in blue) go down for the Red Sea route when that happens it means that producers get lower prices for services. Contrarily they go up for all the other alternative routes which means that the volumes are relativily small. Concerning consumer prices, they depict prices for companies who ship needed goods (for the countries). For example Egypt case is special, we can see that there both a similar % of producer price change (-0,29) as there is on a %consumer price change (0,36). This is due to the fact of the geographical position of Egypt which leaves the country with no other alternatives. Overall we can understand that regionally producer prices get affected a lot for all our regional countries.

Figure 6 Producer and consumer price changes regionally (%)

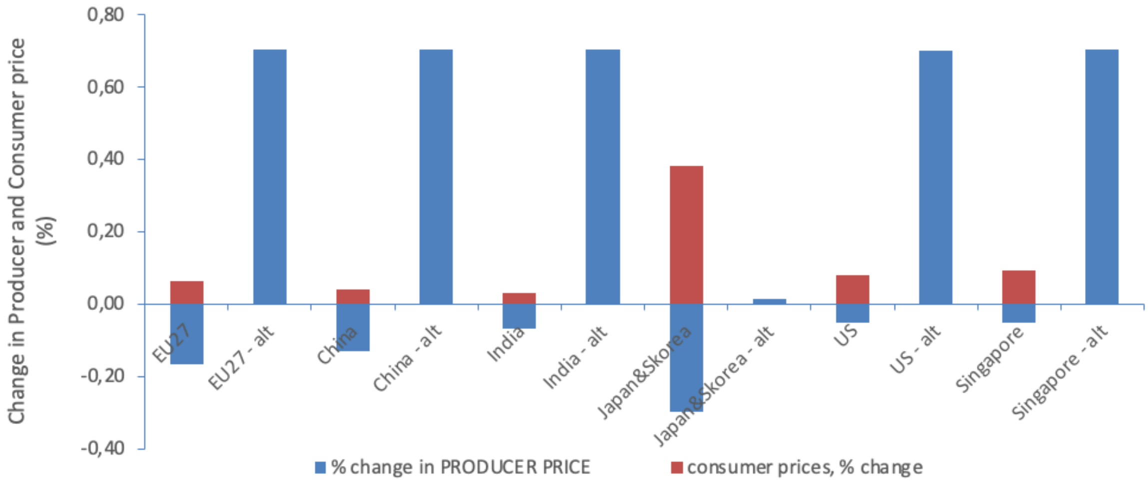


Source: *Own calculations from GSIM model*

Focusing now on the global effects (Figure 7), we see an overall trend of producer prices being negative for the Red Sea route, but they are positive for all the countrie's alternative routes. Like before this means that producers get lower prices for their services but the volumes are low. On the other hand, consumer prices as explained before consumer prices depict prices for companies that ship goods through the Red Sea and need them. For example if we look over at Japan&Skorea, the consumer price change is 0,38% this translates to that the consumer prices have gone really a lot, making life more expensive. Furthermore companies who need shipped goods pay quite a lot more to get them. Concluding that there is not alternative route to ship goods. Overall there is a negative trend for the prices, while the % change are similar with the regional effects we analysed previously. The global effects have a much bigger volume simply due to the fact that there is a lot more traded globally than regionally.
Overall, because of increased trade volumes, the worldwide impact on prices is greater in general. This trend of falling producer pricing and rising consumer prices shows us the larger

economic issues caused by disruptions to the Red Sea route, particularly since alternate routes are insufficient to fully compensate.

Figure 7: Producer and consumer price changes globally (%)



. S*ource: Own calculations from GSIM model*

4.4. Trade effects

Trade effects, are straight forward concerning what they represent. They represent the trade change.We made a color coded table (Figure 8) showing the different trade changes for Red Sea and alternative route, for both regional and global countries We notice that there are significant Trade Changes, for instance the average loss in trade via the Red Sea route is between (-2.0%) and (-2.5%) for most major economies. Countries such as China, India, Turkey, and the United States suffer the most losses. Moving on, we see that original Red Sea route loses the most trade. Major asian economies such as China (-2.2%), to regional economies such as Israel (-2,4%) are the most affected, demonstrating that on both ends from Asia to regional economies around the Suez Canal there are significant impacts. Depicted in light green on our table we can see small gains for the alternative routes, for example Turkey (+1.3% to +1.4%), Saudi Arabia (+1.2%), and Sudan (+0.7%) benefit somewhat from the alternative route,but once again the gains are much smaller than the losses in trade for the original trade route meaning that the alternative route is not “enough” to cover the losses. The general trend is an overall reduction in global trade as the small gains of the alternative route of the Cape, are outweight by the large losses of the Red Sea route.

Focusing on the regional effects, countries such as Turkey experience (-2.5%) declines in trade with large partners such as Saudi Arabia and China, while gaining (+1.3%) to(+1.4%) through alternative routes with partners such as SAR and UAE. The only way for regional countries to compensate is use alternative routes if possible, or increase significantly the trade with countries that trade doesn’t need to go through the suez. For example, Turkiye should start doing less trade with Saudi Arabia, UAE, CHN and India through the suez and more through alternative routes with SA and UAE. Similarly it should hypothetically start doing more trade with Israel, EU and USA.

Concerning worldwide Effects, there is limited worldwide substitution to alternate routes, since even large economies such as China (-2.2%) and the United States (-2.5%) struggle to adapt. The gains from alternate routes (+0.7% to +1.2%) are insufficient to compensate for the significant losses. This particular result was expected to be more positive, since we thought larger economies can adapt more easily to such situation.Which turned out to be as negative as the regional smaller economies as it seems that it is not an easy task for any country to overcome.

In conclusion for the trade effects we see that, regionally, nations such as Turkey are experiencing considerable decreases (-2.5%) in trade with key partners like as Saudi Arabia and China, despite minor increases through alternative pathways. To compensate the loss, these countries may need to divert commerce away from the Suez Canal and focus on routes with unaffected partners such as Israel, the EU, and the United States. Something that takes a lot of time to happen.
On the other hand, globally,we saw that even huge economies like China (-2.2%) and the United States (-2.5%) struggle to adapt, with alternative routes delivering only minor gains (+0.7% to +1.2%). This shows that both large and small economies will struggle to recover from such broad-scale trade disruptions.

Table 8: Trade effects for regional and global countries in %

	EGY	SAR	UAE	ISR	TUR	EU27	CHN	IND	JPN&SKO	SUD	USA	SNG	ROW
Egypt	0,0	-1,8	-1,8	-1,7	-1,7	-1,8	-1,8	-1,8	-1,8	-1,5	-1,8	-1,8	0,7
Egypt - alt													
Saudi Arabia	-2,1		0,4		-2,3	-2,3	0,3	0,3	0,3	-2,1	-2,3	0,4	0,1
Saudi Arabia - alt					0,7	0,7					0,7		
UAE	-2,1	0,3		-2,3	-2,4	-2,4	0,3	0,3	0,2	-2,2	-2,4	0,3	0,0
UAE - alt				0,8	0,7	0,7					0,7		
Israel	-2,2		-2,4		0,3	0,3	-2,4	-2,4	-2,4		0,3	-2,4	0,0
Israel - alt			0,7				0,7	0,7	0,7			0,7	
Turkey	-2,2	-2,5	-2,4	0,3	0,0	0,2	-2,4	-2,5	-2,5	-2,2	0,2	-2,4	0,0
Turkey - alt		1,3	1,4				-1,4	-1,4	-1,4			-1,4	
Sudan	-2,2	-2,5	-2,5	0,3	0,2	0,2	-2,5	-2,5	-2,5	-2,2	0,2	-2,5	0,0
Sudan - alt		0,7	0,7				0,7	0,7	0,7			0,7	
EU27	-1,9	0,5	0,6	-2,1	-2,1	-2,1	0,0	0,5	0,5	-1,9	-2,1	0,6	0,3
EU27 - alt				0,8	0,7	0,7							
China	-2,0	0,4	0,5	-2,2	-2,2	-2,2	0,4	0,0	0,4	-2,0	-2,2	0,5	0,2
China - alt				0,8	0,7	0,7					0,7		
India	-2,2	0,2	0,3	-2,4	-2,4	-2,4	0,3	0,2	0,2	-2,2	0,3	0,3	0,0
India - alt				0,8	0,7	0,7							
Japan&Skorea	1,2	-1,8	-1,7		-1,7	-1,8	-1,8	-1,8	-1,8	0,0	-1,7	-1,7	0,7
Japan&Skorea - alt					0,1	0,0	0,0						
US	-2,2	-2,5	-2,4	0,3	0,3	0,2	0,2	-2,5	0,2	-2,2	0,0	-2,5	0,0
US - alt		0,7	0,7					0,7					
Singapore	-2,2	0,2	0,2	-2,4	-2,4	-2,5	0,2	0,2	0,2	-2,2	0,2	0,0	0,0
Singapore - alt				0,8	0,7	0,7							
ROW	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-0,1	0,2	0,0	0,0	0,0

. *Source: Own calculations from GSIM model*

5. Conclusions

The Red Sea has long been regarded as an important worldwide commercial route, with the Suez Canal connecting Asia, Europe, and Africa. However, Houthi rebel strikes have dramatically damaged the region's stability, disrupting maritime traffic, raising costs, and causing far-reaching economic and geopolitical effects. This thesis investigated these implications by combining literary research with a quantitative analysis using the Global Simulation Model (GSIM), highlighting both global and regional effects on trade, shipping, and security.

5.1. Trade and Economic impacts

In our literature review we saw that the Suez Canal handles around 12%of the world's total trade, more specifically 8% of the world's LNG and 12% of oil use this vital passage. This shows us the critical role that the Suez Canal and the Red Sea have in the global economy, especially for countries that use that are part of the Asia-Eu trade route. As disruptions in the Red Sea worsened, worldwide economic consequences began to emerge, with countries such as Egypt, Saudi Arabia, and key global economies like China and the EU incurring huge losses. As we saw on our results, Our GSIM research clearly shows that the countries that use the Suez Canal have had the biggest welfare losses. For example, the UAE, Saudi Arabia, and Turkey all reported significant declines in producer surplus—$431 million, $423 million, and $220 million, respectively. Even though the Cape of Good Hope route provided a little cushion, the UAE recouped only $147 million and Saudi Arabia $87 million.
The global powers were also heavily impacted, with China and the EU suffering the greatest losses in both welfare and output. China had a startling $7,6 billion reduction in producer surplus and a small $185 million gain via the Cape route. Similarly, the EU had a $3,5 billion loss. These findings are consistent with our literature, highlighting the Suez Canal's crucial role in supporting significant trade volumes between these locations. With 12% of the world's maritime traffic going through the Suez, disruptions have resulted in a global trade drop of up to **-2.5%** for key economies such as China, India, and the US. Given the size of the disruption, this total drop in commerce was expected; yet, our GSIM model clearly shows that the alternative route through the Cape of Good Hope is insufficient to fill for the losses suffered via the Red Sea. Trade movements have failed to provide the volume required to "counter-attack" the negative effects, in particular major economies such as China, the EU, and the United States, are struggling to identify viable alternatives in the face of these disruptions.

Furthermore , our GSIM results also showed a considerable decline in domestic output in nations that rely on Suez commerce. Egypt and Sudan, for instance, saw productionn decreases of 0.28% and 0.29%, respectively, because their geographical locations made it practically impossible to redirect trade to alternative channels. Globally, China and India were the hardest hit, with production falling by 0.16% and 0.11%, respectively. This highlights the greater economic impact caused by rising transportation costs and supply chain interruptions.

5.2. Operations and Logistics disruptions

In our literature we noted a significant increase in shipping operational costs as a result of the Red Sea crisis. Rerouting around the Cape of Good Hope not only extends the journey by 12 days, but also adds enormous costs. We found that maritime companies have been forced to make difficult judgments between risking passage via the Red Sea and beare the additional expenditures connected with the Cape route. Furthermore, in our research we found that insurance prices for ships transiting the Red Sea have gone up, times ten, due to the increased risk of Houthi attacks. Increased insurance premiums, combined with other operational costs, have made it more expensive to carry goods over the Red Sea or around the Cape, resulting in greater costs for businesses and, eventually, higher consumer prices.

When we analyzed the logistical side, rerouting has created significant logistical issues, which includes delays and disruptions to just-in-time (JIT) supply chains. In our literature we listed corporations such as Tesla, Volvo, and Adidas, all of which had production halts due to delays in getting crucial parts and supplies.

5.3. Dynamics of global geopolitics

The geopolitical dynamics explored in the literature indicate that the Red Sea crisis is part of a larger regional battle, with the Houthis leveraging the interruption of world trade to impose pressure. Iran's support for the Houthi rebels is viewed as a deliberate move to destabilize Saudi Arabia and its supporters. This geopolitical lens contextualizes the economic losses identified in the GSIM results, especially for Saudi Arabia and other regional players such as Israel and Egypt.

In our literature we discuss how there is a noticeable minimal international response to the issue. While we have reported that the United States has launched military strikes against Houthi positions, and the European Union has increased its naval presence, the global response has primarily been reactive. This restricted international engagement was mirrored in the GSIM's findings on welfare losses for global powers such as the United States and the European Union, whose economies suffered even without direct military intervention.

5.4. Maritime security

Our literature underlined the importance of securing global trade routes, as well as the risks posed by chokepoints such as the Red Sea. The GSIM analysis really showed us that this that the longer, safer Cape route is not a long-term answer. While it may provide short relief, the increased fuel expenses, longer transit times, and higher insurance premiums make it an expensive option.

Additionally, the literature noted the increasing nature of maritime threats, with the Houthis employing more advanced weapons like drones and naval mines. Which raises immediatly questions about the effectiveness of the current naval security measures, as standard tactics may be insufficient to tackle these new dangers. The findings of this thesis indicate that international collaboration on maritime security should be expanded, with an emphasis on addressing both old and emergent risks to global shipping.

5.5. Areas for further research

While this thesis has provided us with useful insights into the economic, trade, and geopolitical consequences of the Red Sea crisis, future research could expand on these findings by investigating the long-term repercussions on individual industries, particularly energy and agriculture. Furthermore, more research into other trade routes, particularly overland ones for example how the Panama Canal is affected or how that the Panama Canal is dealing with droughts how much it affects the Houthi impact, all of which could provide a better understanding of how global supply chains may adjust to continuous disruptions in maritime routes.

Additionally, it would very interesting to re do a research or a GSIM modelling if the situation continues, as the results will be much more accurate.
Furthemrore we would like to add that, many shipping companies don't publish their data. Upon our research we understood and noticed it on many occasions, when vessels decide to pass through the Suez often they don't like to publish the info since it shows a "risky" behaviour of the shipping company which is negative for their reputation. Therefore it may be that more ships actually pass and risk just for the sake of profitability.

Finally,to summarize, the Red Sea crisis is a significant disruption to global trade, with far-reaching consequences for regional and global economies, operational expenses, and maritime security. The conclusions of this thesis, based on both literature and GSIM research, highlights the fundamental relevance of safeguarding the Suez Canal and other major marine routes. As our world becomes more interconnected then ever, preserving the stability and security of these routes will be critical to sustaine global economic stability and avoiding future crises and what we call a "butterfly effect" of this magnitude…

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Annex II: Country descriptions

The crisis in the Red Sea has reversed the position of **Turkish ports** in global maritime trade. After experiencing a contraction in 2023 due to the Russia-Ukraine war, Turkish ports have emerged as an alternative solution for transit cargo during the Red Sea crisis. With maritime giants choosing Marmara ports as a transshipment hub for East-West trade, the volume of transit containers handled at Turkish ports increased by approximately 23% annually, setting a new record. This development reduced the overall cargo contraction rate from 4% last year to below 2%. According to data from the Directorate General of Maritime Affairs, the total cargo handled at Turkish ports in January 2024 fell by 1.81% compared to the same month in 2023, totaling 43.1 million tons. Aydın Erdemir, President of the Turkish Port Operators Association (TÜRKLİM), evaluated January's data saying, "With the impact of global recession and high inflation, markets in the West are particularly contracting."

In 2023, the total cargo handled at Turkish ports decreased by 4% annually to 521 million tons, marking the first contraction in seven years. Export cargo decreased by 9.8% annually, transit cargo by 17.6%, and cabotage cargo by 7.2%. Last year, only import cargo saw an increase. Erdemir noted that while maritime transport increased globally despite the drop in world trade last year, Turkey could not benefit from this.

TÜRKLİM President Erdemir said, "This situation had positive impacts on ports in regions like Asia, Latin America, and Africa, primarily China. Unfortunately, it did not yield positive results for Turkey. In addition to the impact of conflicts and instability in the Black Sea and Eastern Mediterranean, economic measures that suppressed consumption also played a role. The recession in Europe also affected our ports. Export markets need diversification."

The tension in the Red Sea also altered the balance among Turkish ports. While container cargo volume decreased at Iskenderun Port Authority (Limakport and Assanport) and Mersin Port Authority (MIP Mersin Port) last month, container traffic at Marmara ports accelerated in parallel with the increase in transit cargo. As a result, Tekirdağ Port Authority and Kocaeli Port Authority surpassed Mersin Port in container cargo volume for the first time. The decline in container volume at Turkey's Mediterranean ports is attributed to the losses in Turkey's foreign trade caused by the Israel-Palestine war and developments in the Red Sea. It is noted that these ports are less involved in transshipment, with the primary impact coming from the decrease in Turkey's foreign trade. According to Barış Dilek, General Manager of MSC Turkey, The situation in the Red Sea, adversely affects trade in the region, cargoes from Northern Europe are now being transferred to Arab Gulf countries via Tekirdağ's Asyaport. In January, transit cargo handled at Asyaport increased by 22%. Additionally, Asyaport will become the new transshipment hub for Far East and Middle East cargoes currently consolidated at transshipment ports in countries like Egypt, Italy, and Greece, leading to further volume growth.

Italy is significantly impacted by the Red Sea crisis, primarily because its trade is heavily dependent on the Suez Canal. In fact according to Reuters, some 40% of Italy's international maritime trade relies on that route, amounting to roughly 154 billion euros in 2022. Since the start of the crisis, the damage on the Italian foreign trade from November 2023 to January 2024 amounted to 8.8 billion or a loss of 95 million a day (Casale, 2024). The damage continues till this day hitting hard the industry of the country. Before the crisis, merchandise exported mainly

by italian small enterprises totaled 10.8 billion. This comprises 4.2 billion in food, 1.8 in metal products, 1.8 in jewelry and eyewear, 1.5 in fashion products and 1 in wood and furniture (Casale, 2024). -------
Furthermore Italy's biggest industry is the export of tomatoes. Sales in 2023 reached 5 billion, amount that plays a strategic role in the stimulation of the national economy (Branthome, 2024). Being the third largest producer, Italy exports tomatoes to Asia and Australasia a route that is being threatened by the current crisis.

Additionally it is interesting to look at the performance of Italy's ports. Specifically the container traffic handled by the major Italian ports, shows that Genoa (+1.15%), La Spezia (8.9%), and Salerno (+5.1%) saw an increase in the number of containers loaded and unloaded in the first three months of 2024. In contrast, Trieste (-17.3%), Venice (-12%) and Ravenna (-15.8%) appear to have taken the impact of the Asia-Europe trade route shift from the Suez Canal to the Strait of Gibraltar (Capuzzo, 2024). We can observe that the new route programming is benefitting more the Mediteranean ports closer to the Strait of Gibralatar. For example in Tangier, Eurokai terminal recorded a 26% growth and Spanish ports a 12.1% overall growth. The reorganization of services by shipping companies involves greater use of transshipment and a reduction in ports with direct services. In this regard, It is no coincidence that the Port Authority of Genoa and Savona have also noted a spike in container transshipment in April. Nevertheless the spike in certain ports of Italy don't mean that the crisis has benefited the country. Contrarily Italian ports overall show a 3.2% decline in the first quarter of 2024.

Observing the service offerings' structure reveals various changes by companies, even at the intra-Mediterranean level, which is continually evolving. The shippers' study center reports some examples, among many: X-Press Feeders has activated a new service connecting Tangier and Algeciras with Savona, Civitavecchia, Salerno, and Naples; ONE has reorganized the AIB feeder service by adding Trieste and Piraeus (Piraeus, Alexandria, Damietta, Koper, Trieste, Venice, Ancona); CMA-CGM has removed Genoa and Livorno from the Euronaf (ALGOM) service, replacing them with Barcelona (Barcelona, Marseille, Valencia, Algeciras, Oran, Mostaganem).

Another country on the east med that is affected by the Houthi attacks is **Greece.** Greek exports are mainly delivered in fellow European countries (72.1% of total exports) followed by 14.3% destinated to Asian countries and another 6.9% to Africa. Imports are the weak point of Greece as the country imports more than it exports. One of Greece's best import suppliers is in Asia, as it represents 31.8% of all import purchases by Greece. This indicates that 31.8% of the countries imports were passing through the Suez canal. Now "blocked" Greece is facing the unwanted consequences. For Greek businesses, the burdens include increased transportation costs and time, higher insurance premiums, and costs of raw materials, disruptions in ship schedules (dates – supply locations) and delivery times, as well as wear and tear on products and increased risk of damage. For example, the cost of transporting a 20ft container from China increases by €1,200 – €5,000, and from Saudi Arabia, $400 – $2,500.
This situation threatens to lead to higher interest rates, lower growth, and even greater geopolitical uncertainty. It will serve as a severe "stress test" for the resilience of the global supply chain, causing significant concern about potential damage being passed on to the consumer, just as global inflation is beginning to recede.

The Houthi attacks are also impacting the countries biggest port and 5th biggest in Europe: Peireus. The large container ships that used to reach Piraeus are now arriving in Europe via Africa, docking at ports in Western and Northern Europe, as well as in Tangier, Morocco. From there, they transfer the cargo to smaller feeder ships for delivery to Piraeus, a process that previously took place at the Greek port.Overall, the handling of containers in Piraeus appears to have dropped by approximately 30% since pre crisis (ekathimerini, 2024). Additionally, the conflict in the Red Sea has driven container shipping costs sky-high, with the freight cost to Piraeus exceeding €6,000 per container, up from €2,000 before the crisis, according to port officials.

On **Egypt'**s case, revenue from canal dues has a significant impact on the country's foreign currency reserves, contributing to a substantial shortage. As a result, some of the canal's revenues have decreased by 40-50%. More extreme tensions escalations in the Red Sea could result in a complete halt on traffic, reducing Egypt's foreign currency revenues and increasing the prices of imported goods, such as fuel and some food items.
The severe dollar shortage in Egypt has hindered imports, leading to stockpiles of goods at ports and affecting local industry. Prices of essential food items have risen much faster than the already record-high urban inflation rate of 38% in September. Official data indicated that about 30% of the population was poor before COVID-19, but analysts suggest this number has since increased, with up to 60% of Egypt's 104 million people now living at or near the poverty line. Unemployment is slightly above 7%, but labor force participation has declined (Alhurra, 2023).