How maritime supply chain sustainability is affected by emerging megatrends

Dr Stavros Karamperidis

Head of Maritime Transport Research Group and Programme manager of MSc International Logistics and Shipping programmes, University of Plymouth

Board Member of Cattewater Harbour Commissioners (Port of Plymouth)

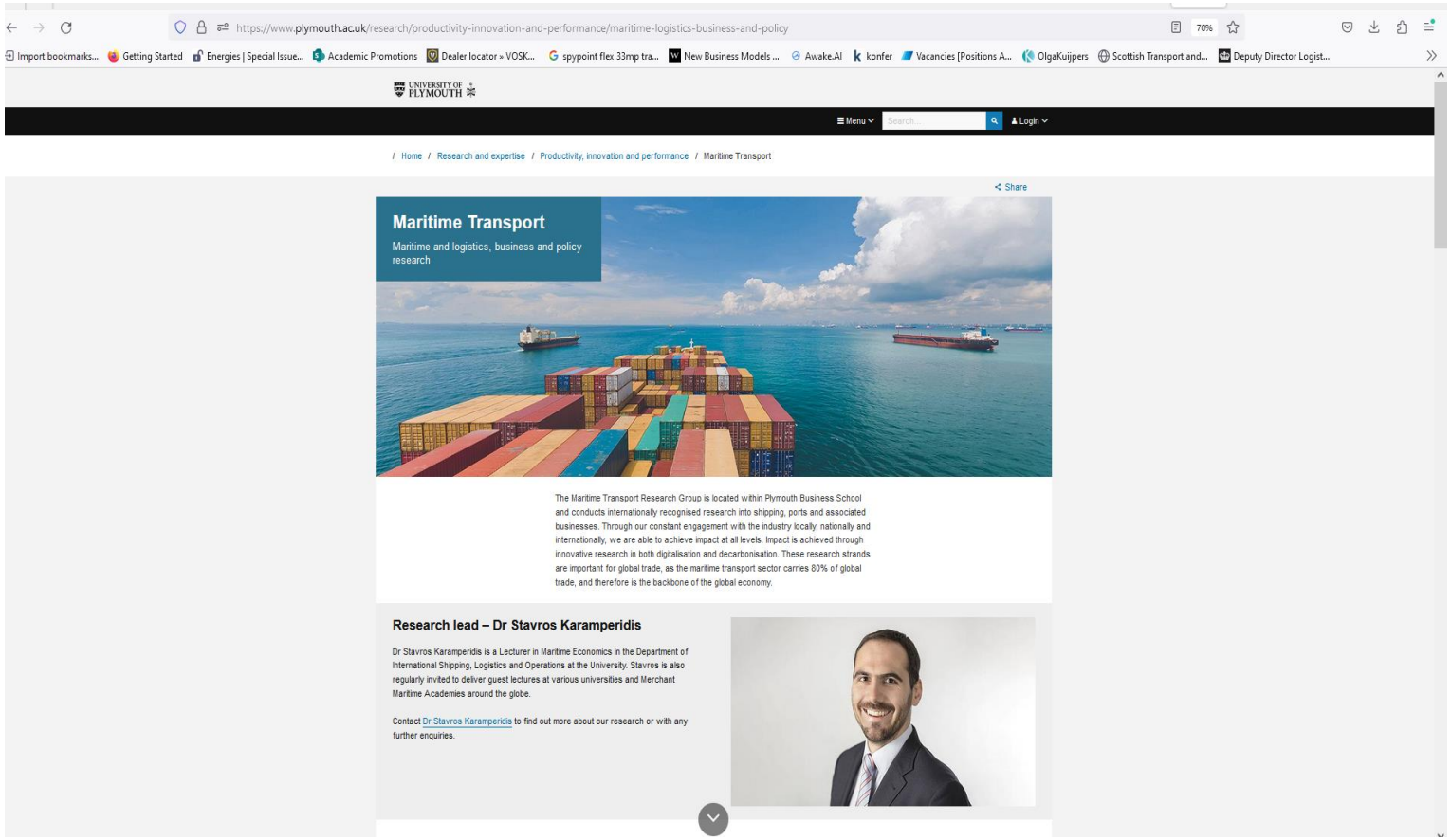
Member of the Ports and Terminals Group of the Society of Maritime Industries UK

UNIVERSITY OF PLYMOUTH

CATTEWATER HARBOUR COMMISSIONERS

SMI Society of Maritime Industries

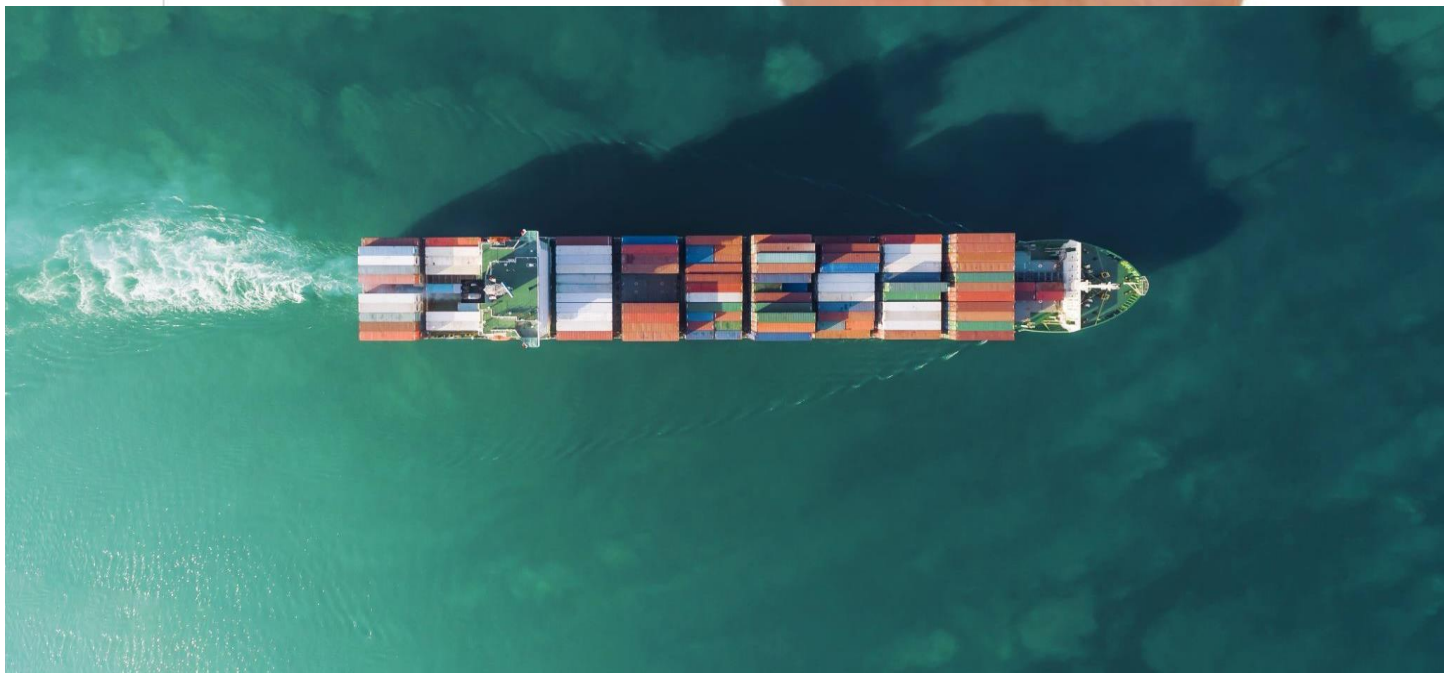
Maritime transport research group



https://www.plymouth.ac.uk/research/productivity-innovation-and- performance/maritime-logistics-business-and-policy

AGENDA

- Description of maritime sector (current status)
- Why decarbonisation in maritime business is important?
- Regulatory element
- How we reach to decarbonisation
- Example: Green Shipping Corridors



Why maritime sector is important for global trade?

Around 80% of the volume of international trade in goods is carried by sea.

Freight rates had increased by 132% according to UNCTAD (2025) -> increase consumer prices up (0.6%) -> inflation -> reduced consumption -> less need for trade/logistics

Source: https://unctad.org/publication/review-maritime-transport-2024

Global risks ranked by severity over the short and long term (2025)

	2 years	10 years
1st	Misinformation and disinformation	Extreme weather events
2nd	Extreme weather events	Biodiversity loss and ecosystem collapse
3rd	State-based armed conflict	Critical change to Earth systems
4th	Societal polarization	Natural resource shortages
5th	Cyber espionage and warfare	Misinformation and disinformation
6th	Pollution	Adverse outcomes of AI technologies
7th	Inequality	Inequality
8th	Involuntary migration or displacement	Societal polarization
9th	Geoeconomic confrontation	Cyber espionage and warfare
10th	Erosion of human rights and/or civic freedoms	Pollution

Source: https://reports.weforum.org/docs/WEF_Global_Risks_Report_2025.pdf

Megatrends affecting maritime supply chain sustainability

A) Geopolitics (The bellow affect negatively trade and make goods more “expensive”)

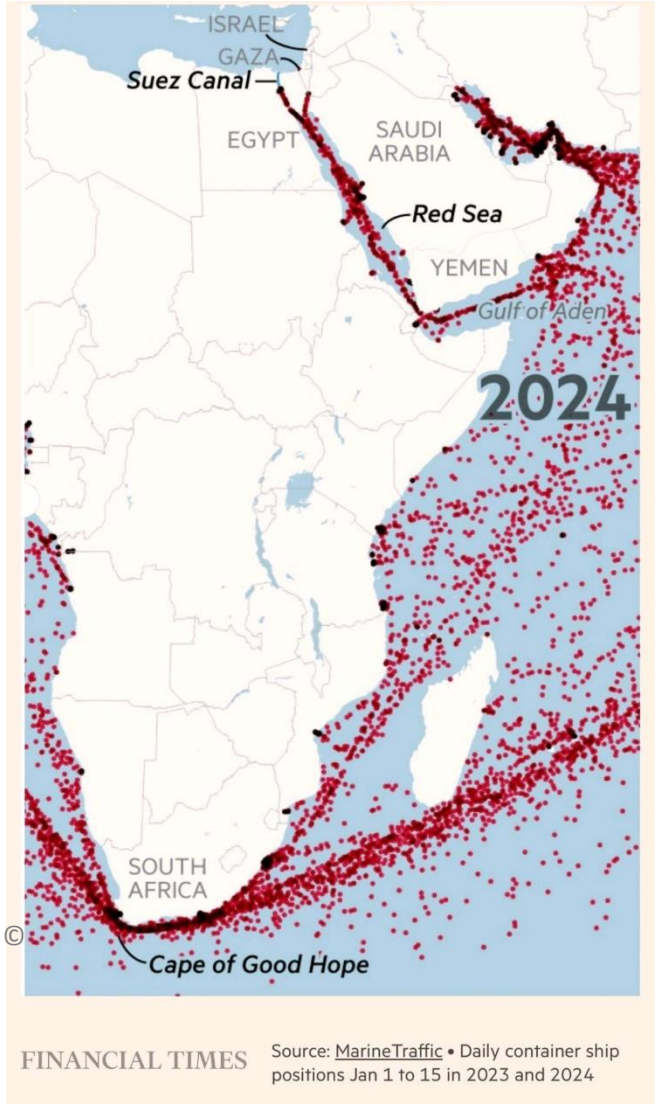
a) Disruptions of trade routes (https://www.rusi.org/explore-our-research/publications/commentary/sounion-attack-brings-red-sea-shipping-crisis-back-fore)

b) Trade protectionism

c) Sanctions and embargoes (shadow fleet)

Sources: https://unctad.org/publication/review-maritime-transport-2024, https://wmo.int/publication-series/state-of-global-climate-2024

Middle east crisis has a huge impact in maritime supply chains

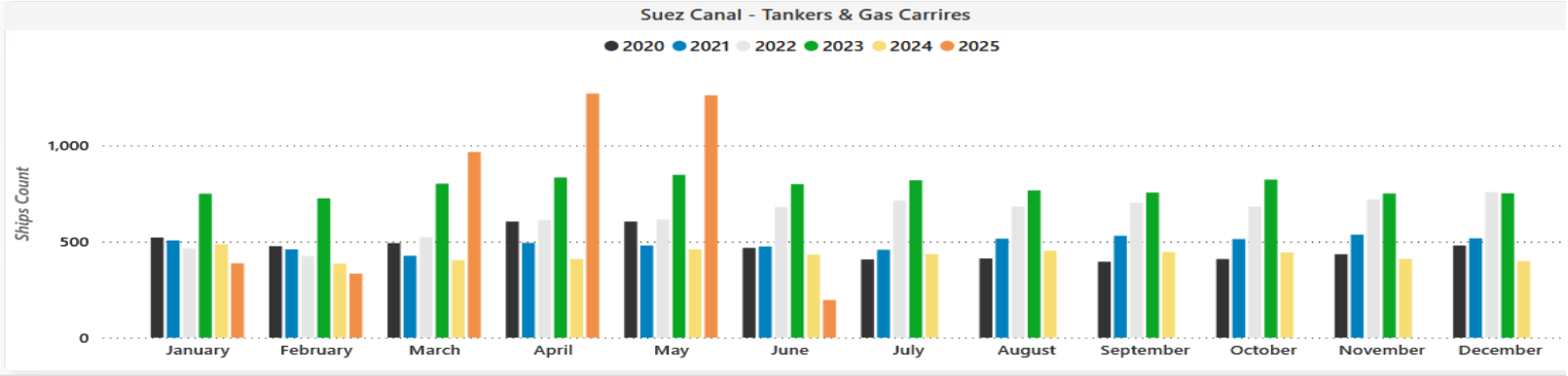


Suez Canal Authority recorded a 50% drop in the number of vessels passing through the canal in 2024 compared to 2023.

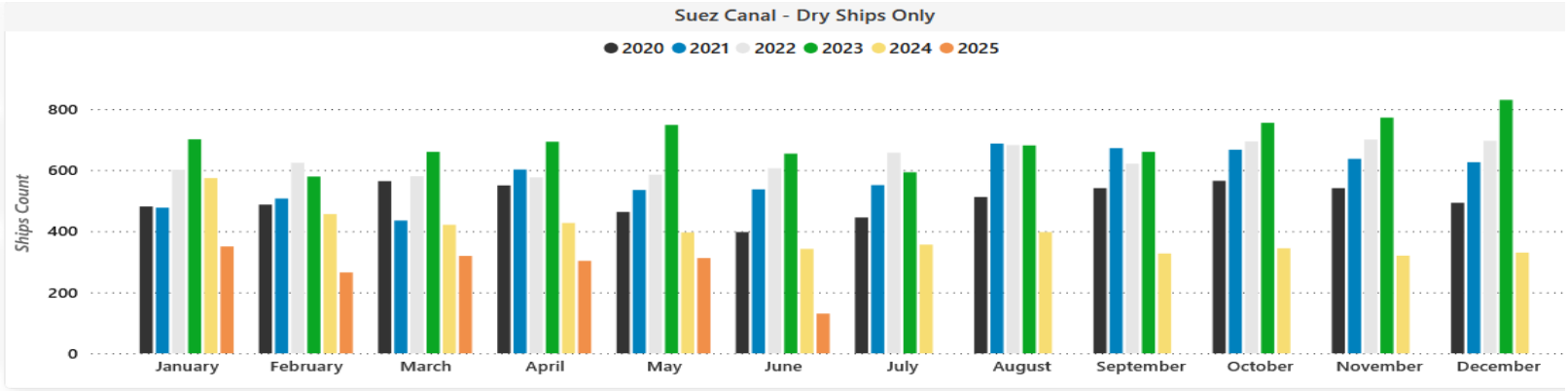
Panama canal drought made the impact global than regional (European).

However not all sectors had the same impact.

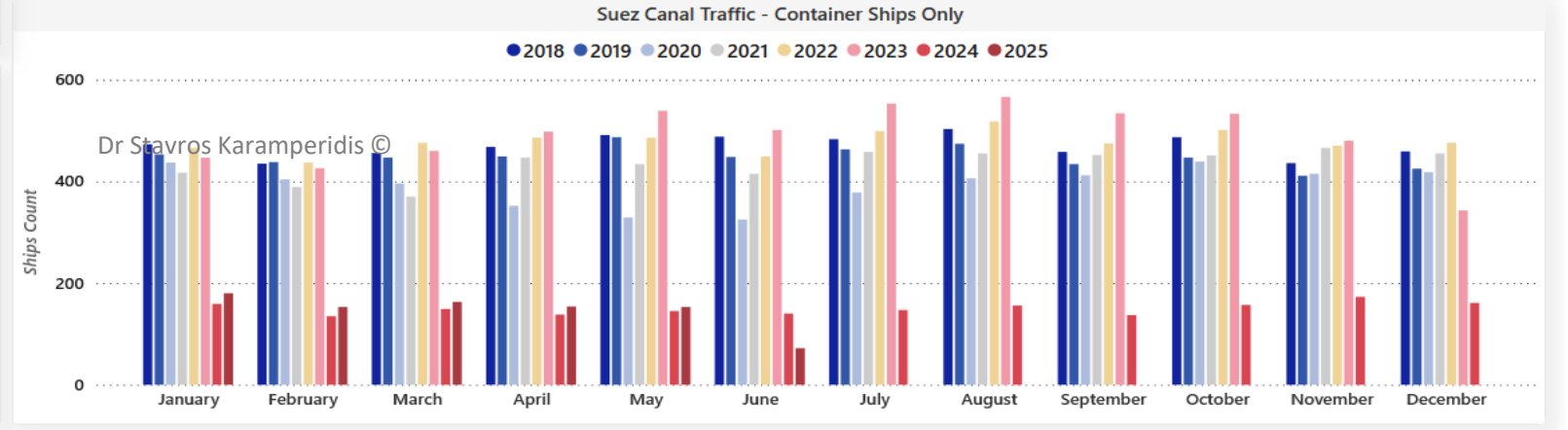
Suez Canal traffic



April 2023 = 833 crossings
April 2025 = 1270 crossings
52% increase



April 2023 = 693 crossings
April 2025 = 303 crossings
56% decrease

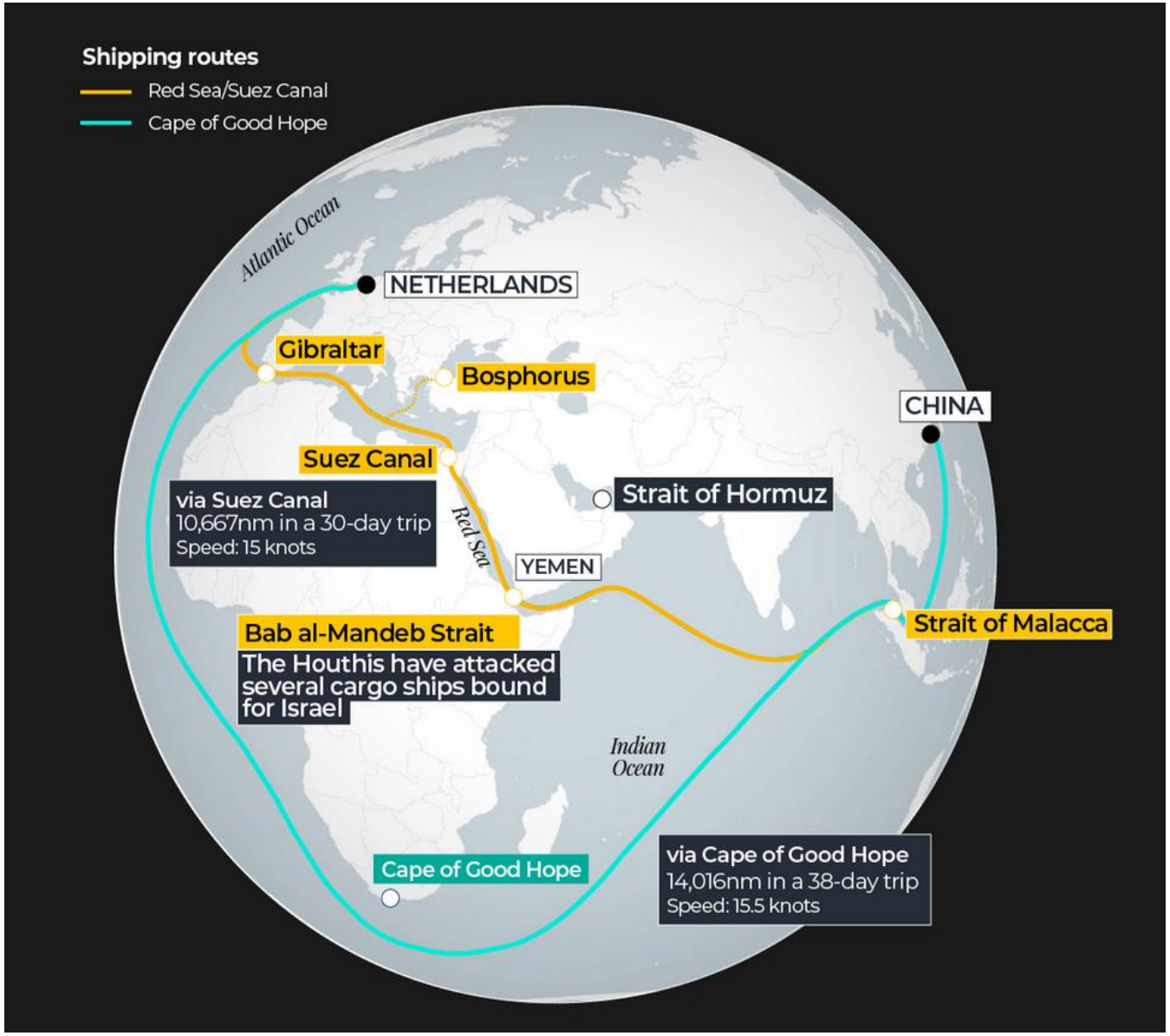


April 2023 = 498 crossings
April 2025 = 154 crossings
69% decrease

Alternative shipping routes, they cost more and have more emissions

Rerouting vessels around the cape of Good Hope adds approximately 4,000 nm and can add up to two weeks to a round trip and 900 tons of CO2 (+30%).

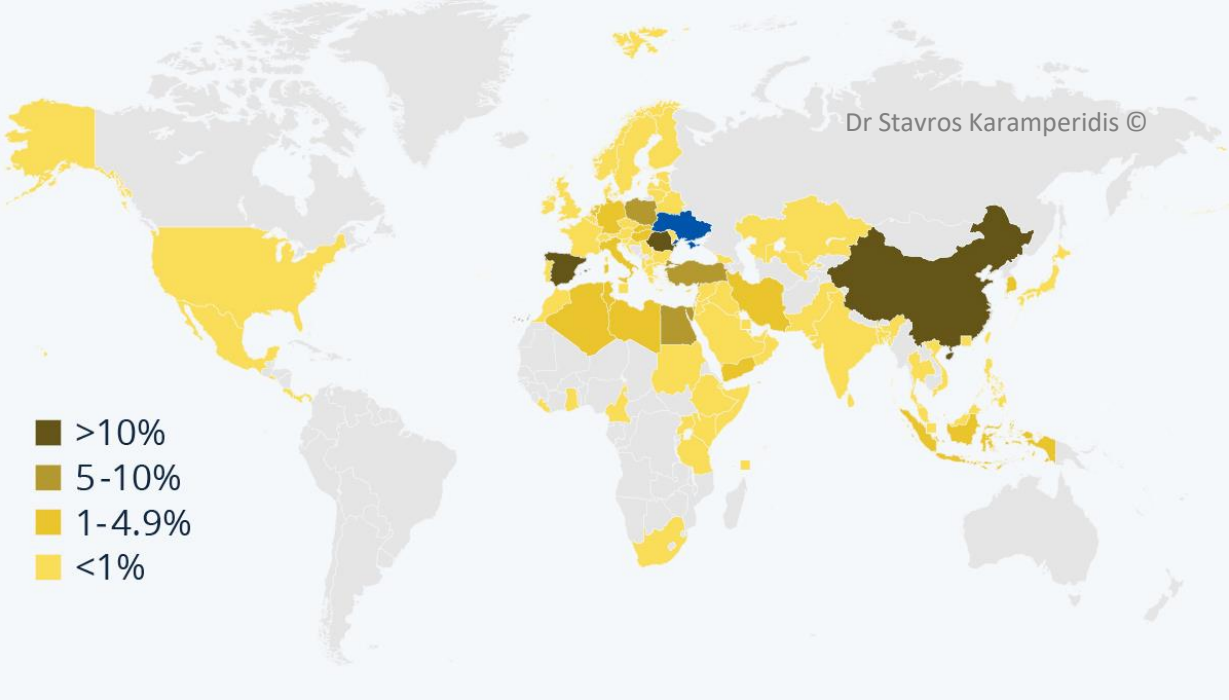
The costs of rerouting are up to 35%, however freight rates had increased by 132% according to UNCTAD.

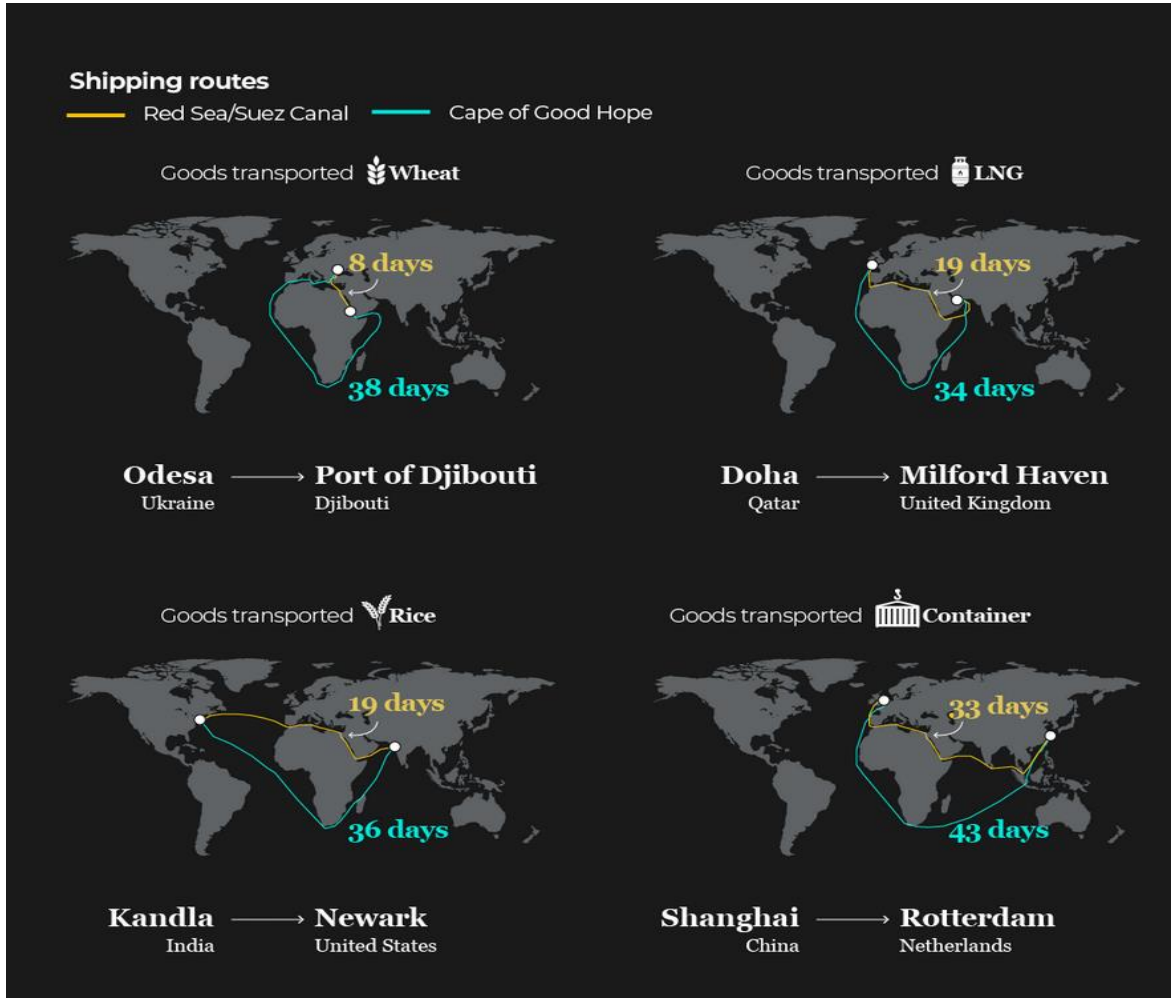


Source: https://interactive.aljazeera.com/aje/2024/mapping-red-sea-shipping-attacks/, https://unctad.org/news/high-freight-rates-strain-global-supply-chains-threaten-vulnerable-economies

But what is the actual diversion for all commodities

Ukrainian Grain (share of Ukraine export by destination country)

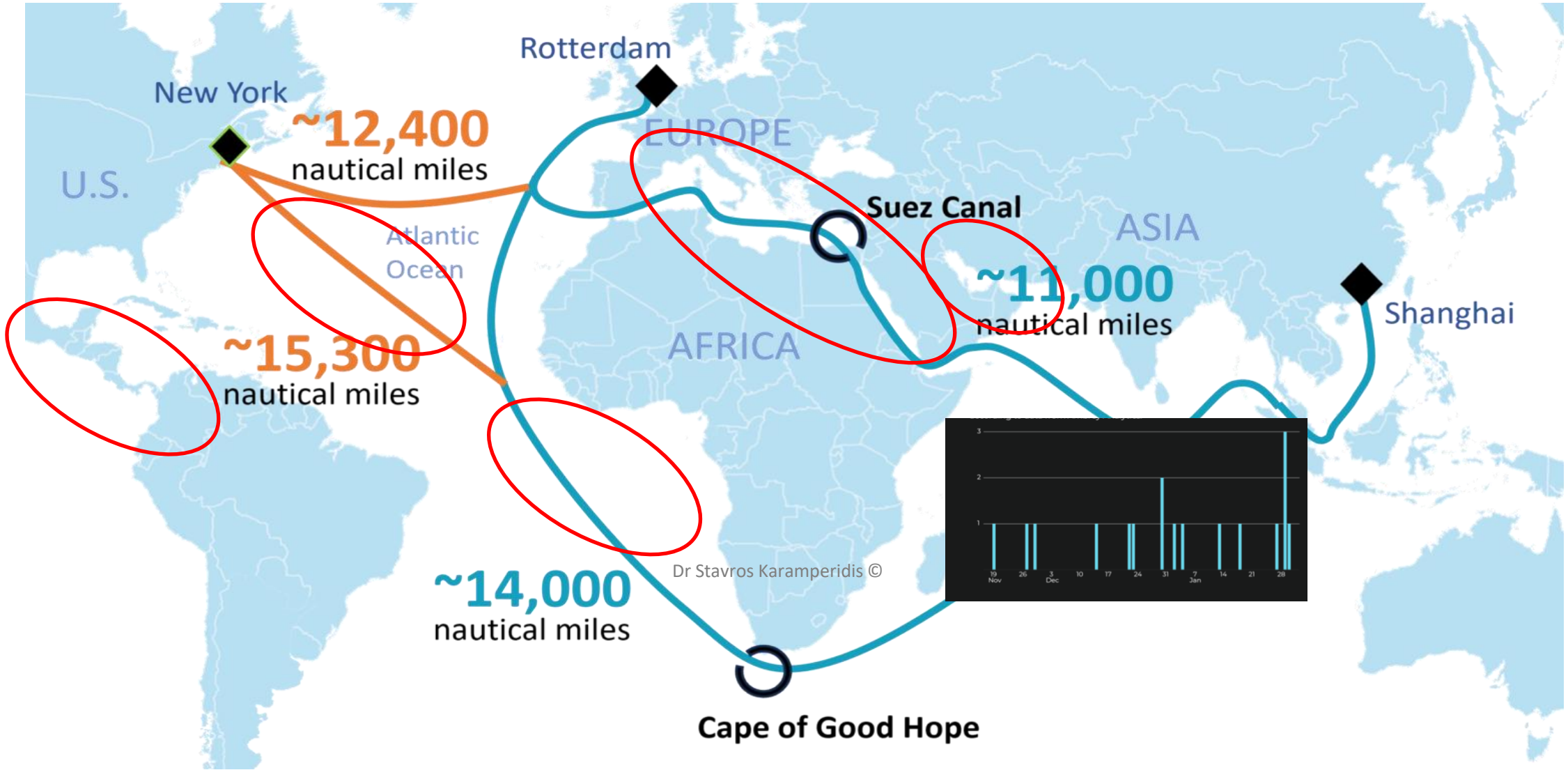




Source: https://interactive.aljazeera.com/aje/2024/mapping-red-sea-shipping-attacks/

https://www.statista.com/chart/30421/ukraine-cereal-grain-exports-by-import-country/

Risks related to Suez Canal diversion



Source: https://oceanair.net/carriers-suspend-operations-in-the-red-sea-to-avoid-attacks/, accessed 15/1/24

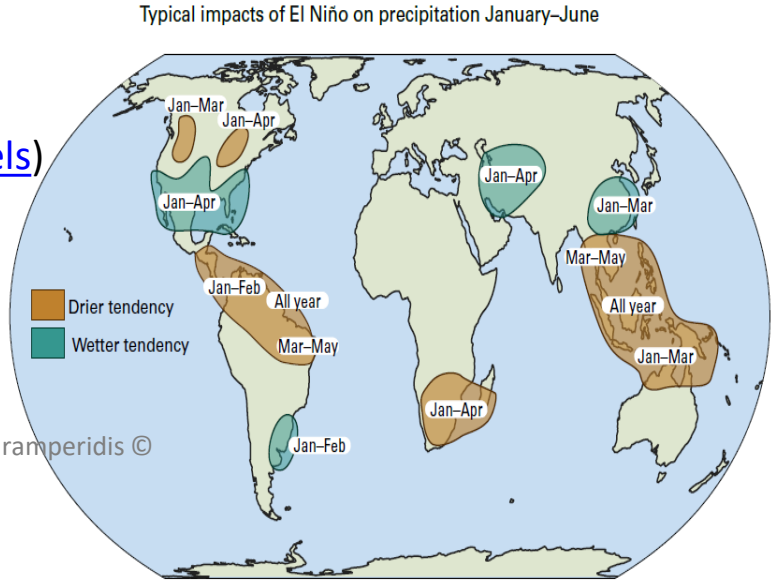
Megatrends affecting maritime supply chain sustainability

A) Geopolitics (The bellow affect negatively trade and make goods more “expensive”)

a) Disruptions of trade routes (https://www.rusi.org/explore-our-research/publications/commentary/sounion-attack-brings-red-sea-shipping-crisis-back-fore)
b) Trade protectionism
c) Sanctions and embargoes (shadow fleet)

B) Climate change

a) Extreme weather events (e.g. El Niño/ Panama Canal)
b) Rising sea levels (please listen: https://www.aig.co.uk/home/insight-page/rising-sea-levels)
c) Changing in shipping routes (e.g. North sea route: https://link.springer.com/article/10.1007/s13437-022-00273-3 and https://www.aig.co.uk/home/insight-page/the-northern-sea-route)
d) Increased pressure for decarbonisation https://link.springer.com/chapter/10.1007/978-3-031-39936-7_24 and https://www.aig.co.uk/home/insight-page/sustainable-maritime-supply



Sources: https://unctad.org/publication/review-maritime-transport-2024, https://wmo.int/publication-series/state-of-global-climate-2024

Effects of climate change: Panama canal and North Sea Route

Source: https://edition.cnn.com/videos/world/2023/09/07/exp-panama-canal-drought-supply-chain-vo-reader-090703aseg2-cnni-world.cnn and https://www.economist.com/the-economist-explains/2018/09/24/what-is-the-northern-sea-route

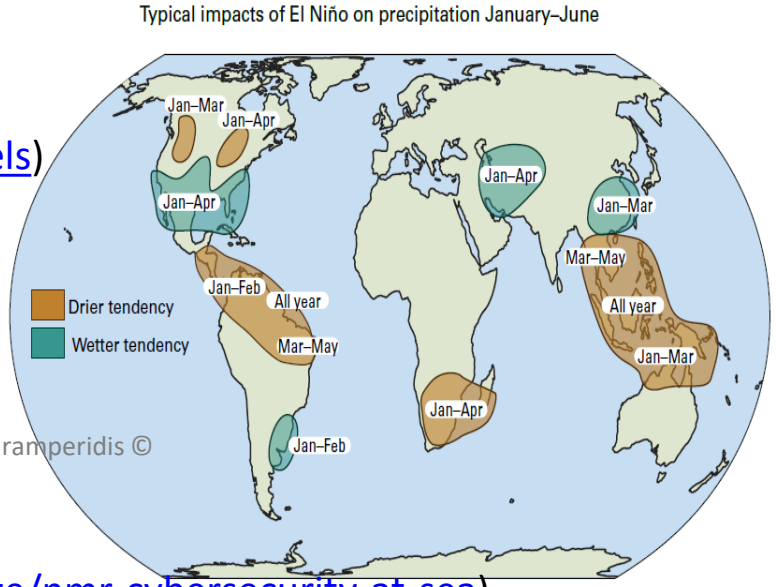
Megatrends affecting maritime supply chain sustainability

A) Geopolitics (The bellow affect negatively trade and make goods more “expensive”)

a) Disruptions of trade routes (https://www.rusi.org/explore-our-research/publications/commentary/sounion-attack-brings-red-sea-shipping-crisis-back-fore)
b) Trade protectionism
c) Sanctions and embargoes (shadow fleet)

B) Climate change

a) Extreme weather events (e.g. El Niño/ Panama Canal)
b) Rising sea levels (please listen: https://www.aig.co.uk/home/insight-page/rising-sea-levels)
c) Changing in shipping routes (e.g. North sea route: https://link.springer.com/article/10.1007/s13437-022-00273-3 and https://www.aig.co.uk/home/insight-page/the-northern-sea-route)
d) Increased pressure for decarbonisation https://link.springer.com/chapter/10.1007/978-3-031-39936-7_24 and https://www.aig.co.uk/home/insight-page/sustainable-maritime-supply



Dr Stavros Karamperidis ©

C) Technology

a) Digitalisation and automation -> cybersecurity (https://www.aig.co.uk/home/insight-page/nmr-cybersecurity-at-sea)
b) Autonomous vessels (https://www.aig.co.uk/home/insight-page/nmr-autonomous-shipping)
c) AI and blockchain technology

Sources: https://unctad.org/publication/review-maritime-transport-2024, https://wmo.int/publication-series/state-of-global-climate-2024

- Average vessel age: 21.9 years -> digitalisation and cybersecurity

- Autonomous shipping

The **Yara Birkeland** fully electric autonomous vessel is designed to replace 40,000 diesel-powered truck journeys annually. This reduction in truck traffic contributes to lower emissions and improved air quality

Mayflower:

1st crossing of the Atlantic

USV Pioneer:

40 days at sea, Hydrogen

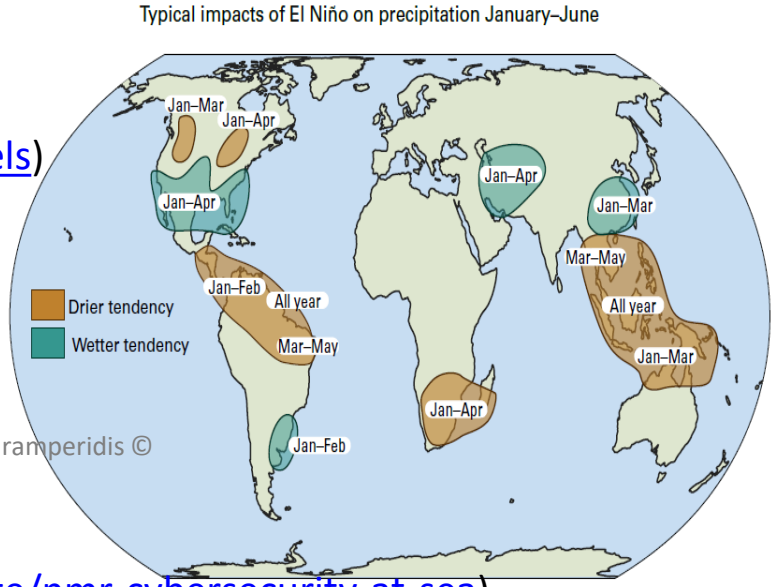
Megatrends affecting maritime supply chain sustainability

A) Geopolitics (The bellow affect negatively trade and make goods more “expensive”)

a) Disruptions of trade routes (https://www.rusi.org/explore-our-research/publications/commentary/sounion-attack-brings-red-sea-shipping-crisis-back-fore)
b) Trade protectionism
c) Sanctions and embargoes (shadow fleet)

B) Climate change

a) Extreme weather events (e.g. El Niño/ Panama Canal)
b) Rising sea levels (please listen: https://www.aig.co.uk/home/insight-page/rising-sea-levels)
c) Changing in shipping routes (e.g. North sea route: https://link.springer.com/article/10.1007/s13437-022-00273-3 and https://www.aig.co.uk/home/insight-page/the-northern-sea-route)
d) Increased pressure for decarbonisation https://link.springer.com/chapter/10.1007/978-3-031-39936-7_24 and https://www.aig.co.uk/home/insight-page/sustainable-maritime-supply



C) Technology

a) Digitalisation and automation -> cybersecurity (https://www.aig.co.uk/home/insight-page/nmr-cybersecurity-at-sea)
b) Autonomous vessels (https://www.aig.co.uk/home/insight-page/nmr-autonomous-shipping)
c) AI and blockchain technology

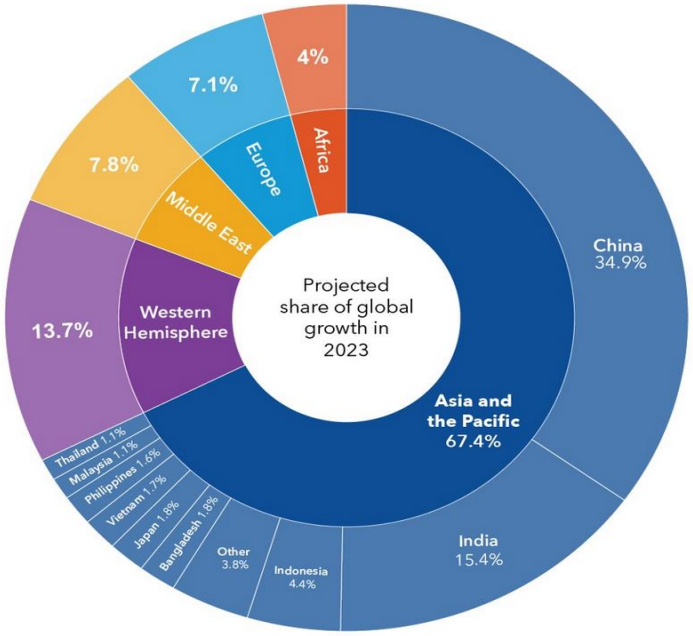
D) Other factors

a) Labour factors (https://www.aig.co.uk/home/insight-page/the-human-element-in-shipping)
b) ESG (https://www.tandfonline.com/doi/abs/10.1080/03088839.2024.2342730 and https://link.springer.com/article/10.1057/s41278-024-00299-9)
c) Global economy (shipping is derived demand)

Sources: https://unctad.org/publication/review-maritime-transport-2024, https://wmo.int/publication-series/state-of-global-climate-2024

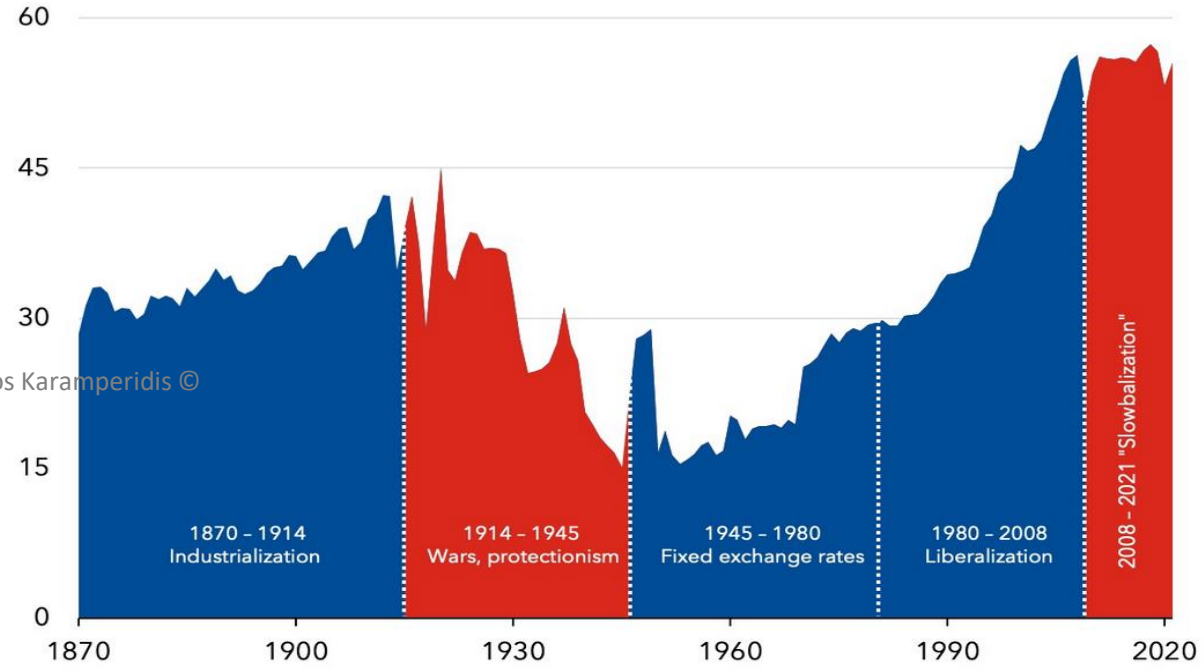
Global economy/trade: IMF

Asia will contribute about 70% of global growth this year.



Source: IMF, World Economic Outlook, April 2023.

Trade openness
(sum of exports and imports in percent of GDP)



Sources: PIIE, Jorda-Schularick-Taylor Macrohistory Database, Penn World Data (10.0), World Bank, and IMF staff calculations.
Note: Sample's composition changes over time.

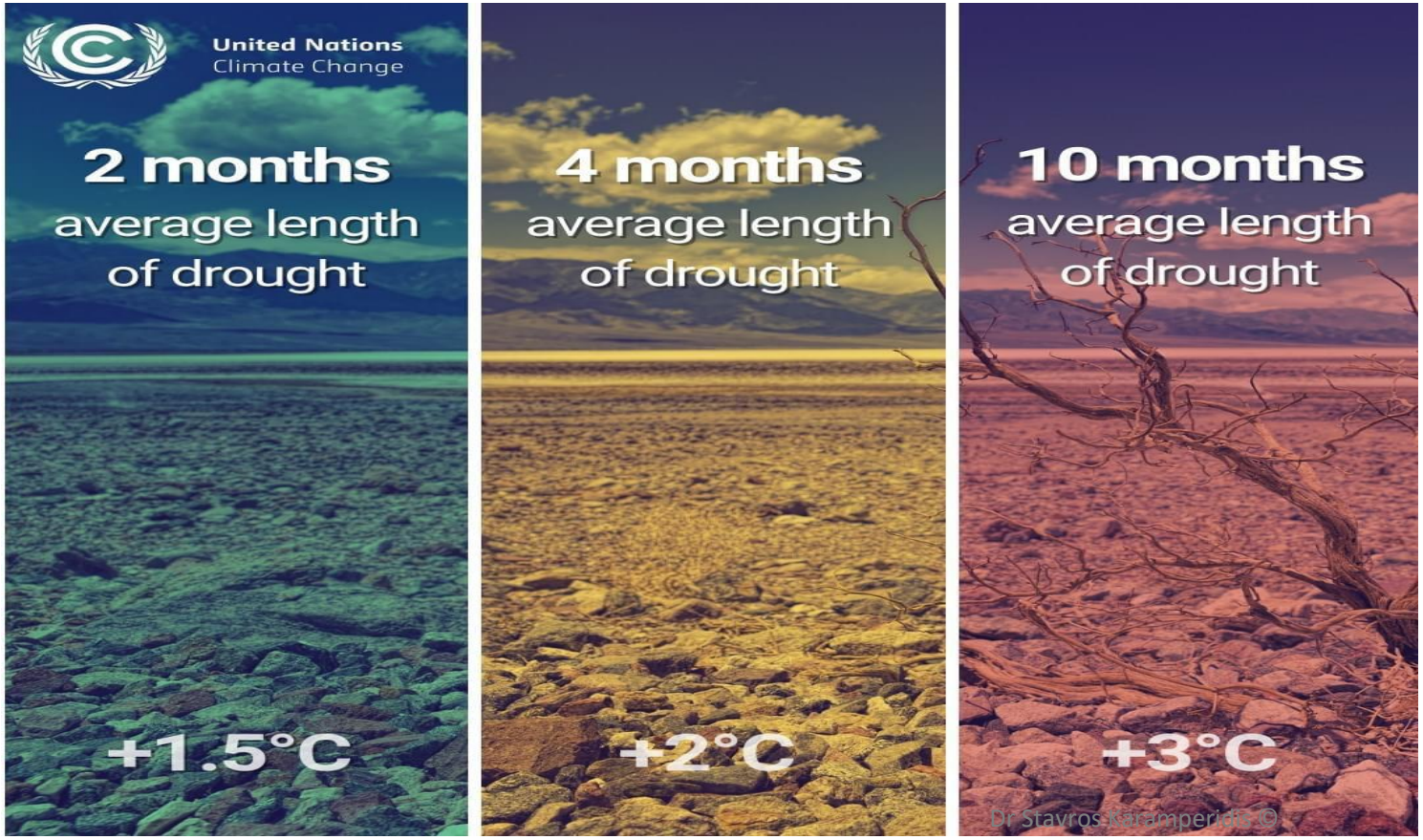
IMF

Source: https://www.imf.org/en/Blogs/Articles/2024/01/12/charts-spotlight-inflation-economic-growth-globalization-and-climate-change

Why decarbonisation in maritime business is important?

Dr Stavros Karamperidis ©

Global warming



CHALLENGE

Global Warming

Burning any kind of fossil fuels releases greenhouse gas emissions - the effects have already started to be seen in the UK and globally!

Decarbonisation

Researches showed that if we fail to limit global temperature increase close to 1.5℃ , the floods and fires will get more frequent and fiercer, crops will be more likely to fail, and sea levels will rise driving mass migrations.

The science could not be clearer: by the middle of this century the world must reduce emissions to as close as to zero as possible.

SOLUTION -> Net Zero maritime transport

URGENT GLOBAL ACTION

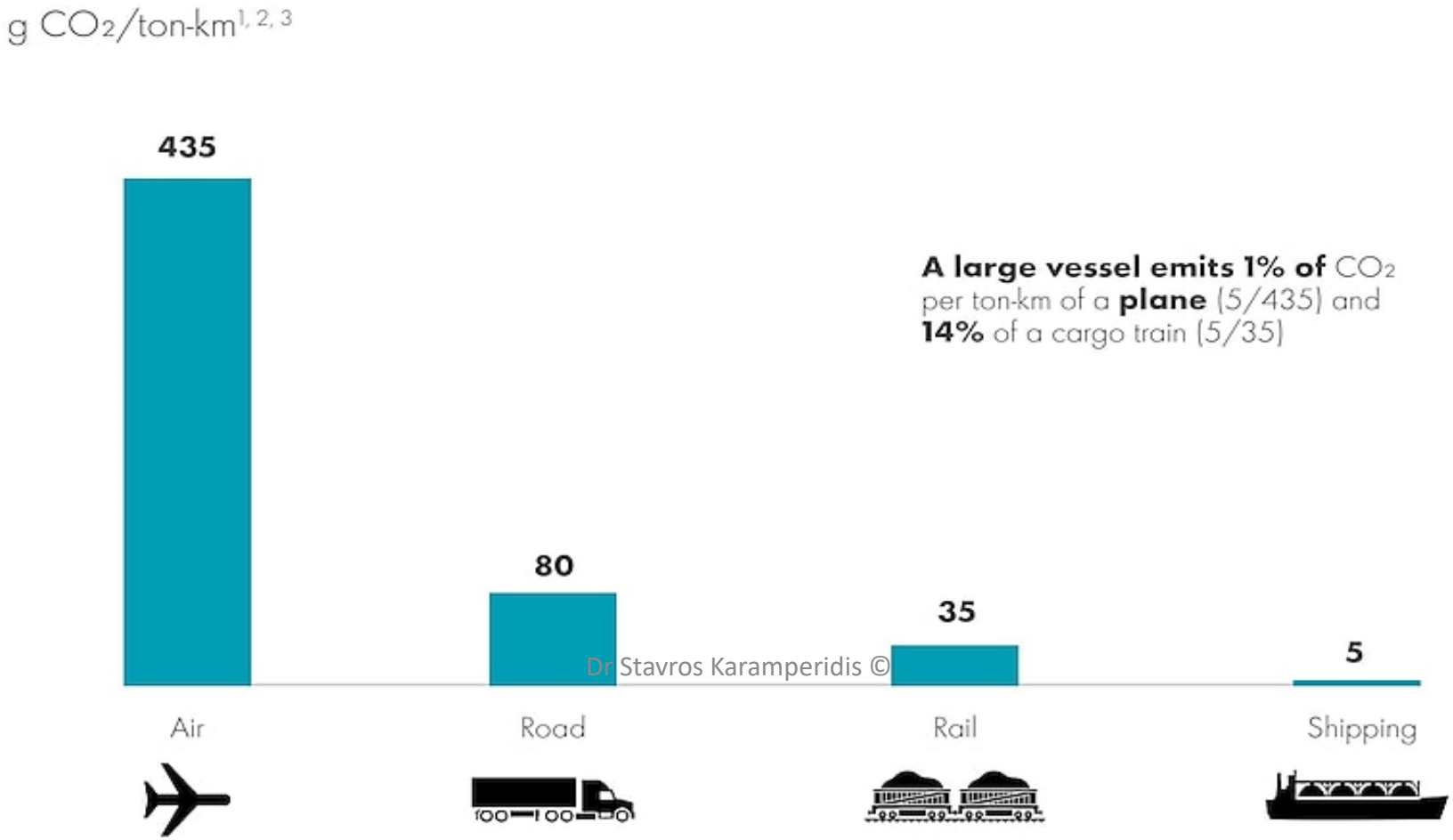
- **Retiring petrol and diesel engines**
- **Ending coal fired power generation**

#EUGREENDEAL

Decarbonisation aims for maritime sector

- The IMO Strategy committed to reach zero GHG emissions by 2050.
- Actions towards maritime decarbonisation was the establishment of the North Sea Emissions Control Area (ECA) which covers SOX emissions and, from 1 January 2021, NOX emissions. ECAs have also been established in coastal waters in North America, US Caribbean Sea, the North Sea, the Baltic Sea and the Mediterranean.
- Agreement at the IMO for a 0.5% Sulphur limit for global shipping outside the ECA .
- On 14 July 2021, the European Commission presented a package of proposals to equip the EU's climate, energy, land use, transport and taxation policies to reduce net greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels – the 'fit for 55' package, in line with priorities set out in the Green Deal.

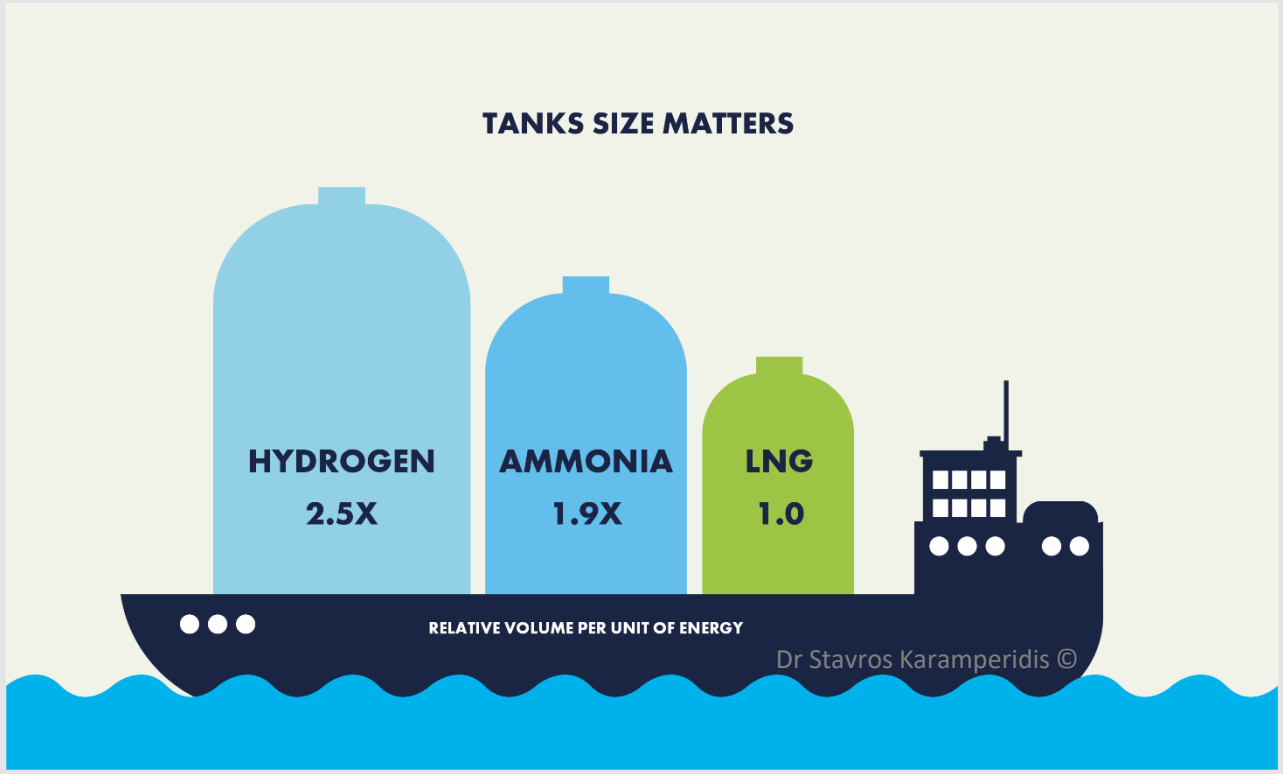
Environmental footprint of Air, Road, Rail and Shipping (g CO2/ton-km)



Why decarbonisation on maritime sector

- If the shipping industry were a country it would be the world's **6th largest** greenhouse gas polluter. Only the United States, China, Russia, India and Japan emit more carbon dioxide than the world's shipping fleet.
- The International Maritime Organization (IMO) calculated that ocean-going vessels released 1.12 billion metric tons of CO2 in 2007. This is equivalent to the annual greenhouse gas emissions from over 205 million cars, or more cars than were registered in the entire United States in 2006 (135 million). In 2023 shipping emissions dropped to 911m tonnes of CO2.
- For companies that want to reduce or offset their corporate carbon footprint, shipping is one of the most significant sources of emissions.
- It is also one of the most difficult to analyse because of complex supply chains, confusing methodologies, and hard-to-access data sources.

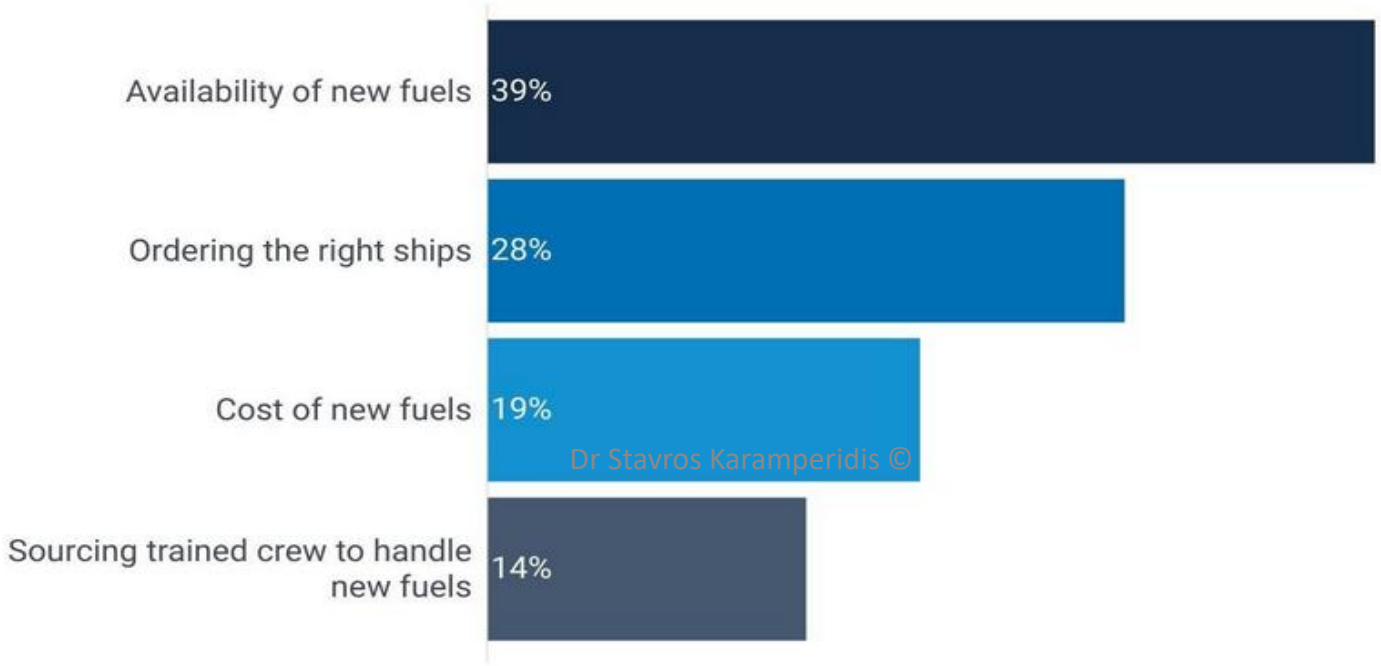
Barriers for maritime decarbonisation



- Cost of infrastructure/new technologies
- Lack of evidence about long term levels of demand from vessels.
- Negative externalities (maritime fuel prices do not reflect the costs of their greenhouse gas and air pollutant emissions).
- High capital costs, especially upfront costs for ports
    1) capital costs for installing infrastructure inside the port
    2) costs for connecting to the network
- Energy intensity of future fuels vs existing (oil, LNG). That leads to either smaller carrying capacity (our main revenue source) or smaller operation range.

Alternative fuels

Biggest challenge the next 5 years for shipping

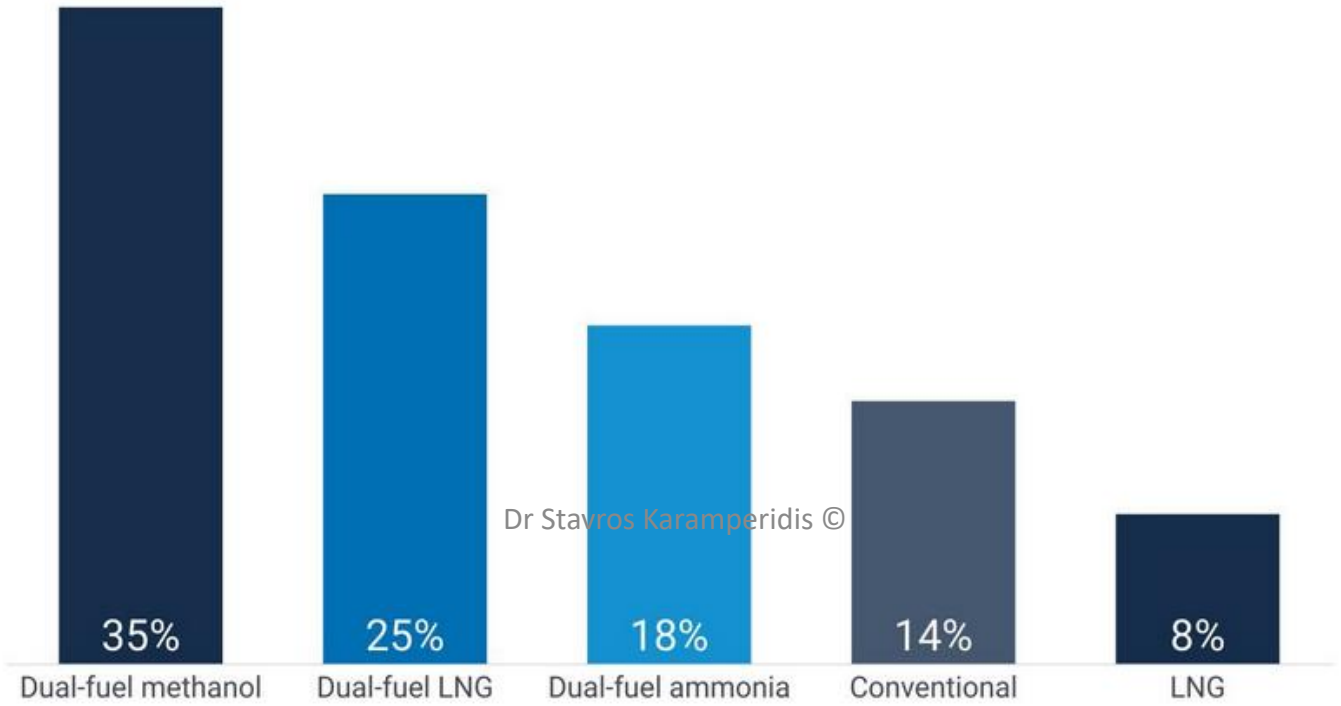


Source: Lloyd's List Shipping Outlook Survey 2023

Hydrogen vs methanol vs ammonia

- If you consider only the fuel:
  - “If you look at green fuels, they all start with green hydrogen. You need to produce green hydrogen, and then you can make these hydrogen carriers. You can make methanol, you can make ammonia,” Prof Lynn Loo.
  - “For every three equivalents of green hydrogen you use, you produce two equivalents of green ammonia. For every three equivalents of green hydrogen you use, you produce one equivalent of methanol”
  - “The 20% difference between the energy densities of methanol and ammonia means ammonia is the more energy-efficient fuel to produce” Prof Lynn Loo.
- If you consider the overall ships operation:
  - Hydrogen seems to be the best solution
- If you consider the fuel production:
  - **There is not a clear answer yet**

If you ordered new buildings next year which fuel type would you choose?



Source: Lloyd's List Shipping Outlook Survey 2023

Is it only shipping facing that dilemma?

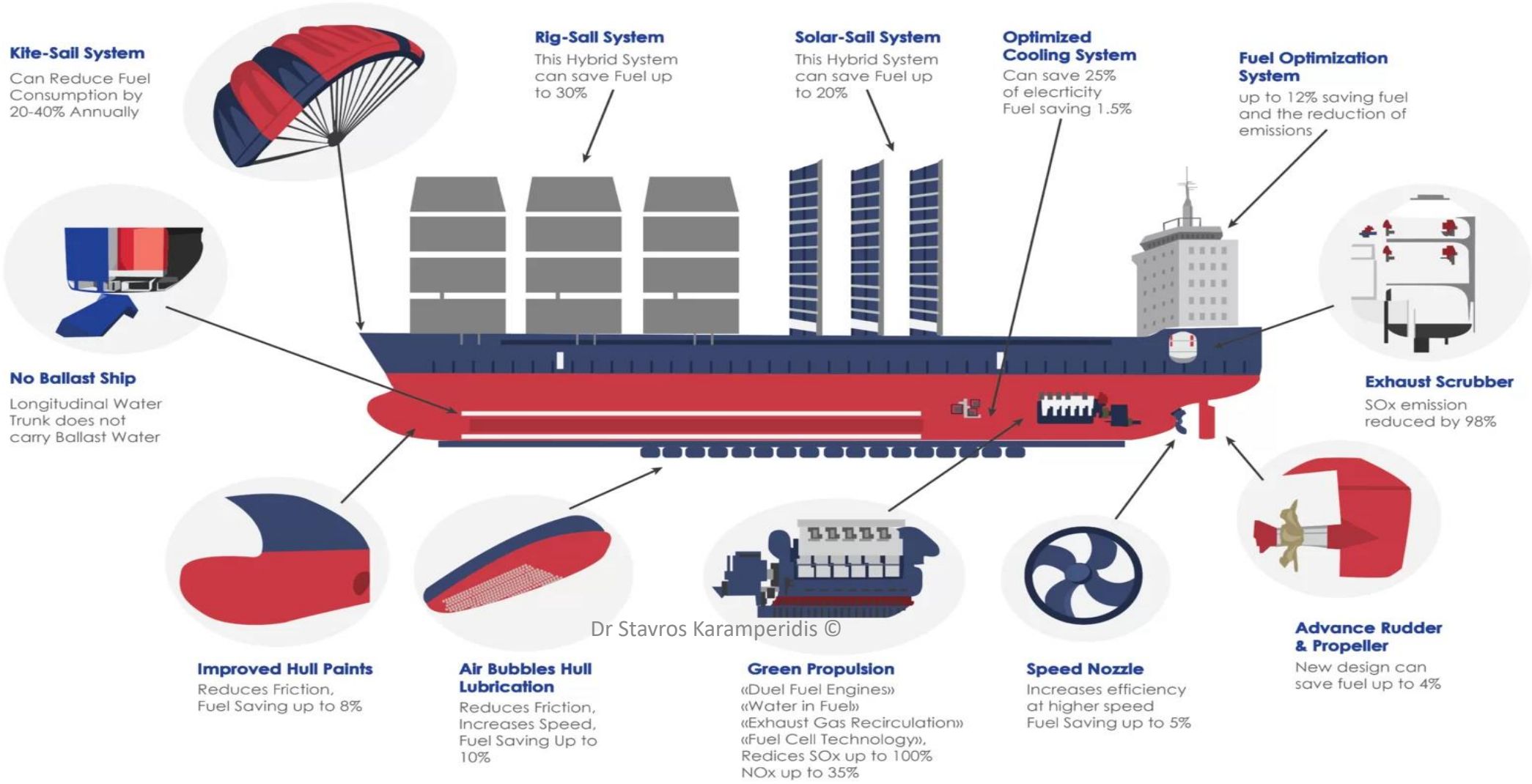
When we consider the future fuel for shipping we have to consider what other transportation sectors are thinking as their future fuel as that will help us to achieve **economies of scale** and bypass some of the aforementioned issues.

Which solution would be the best?

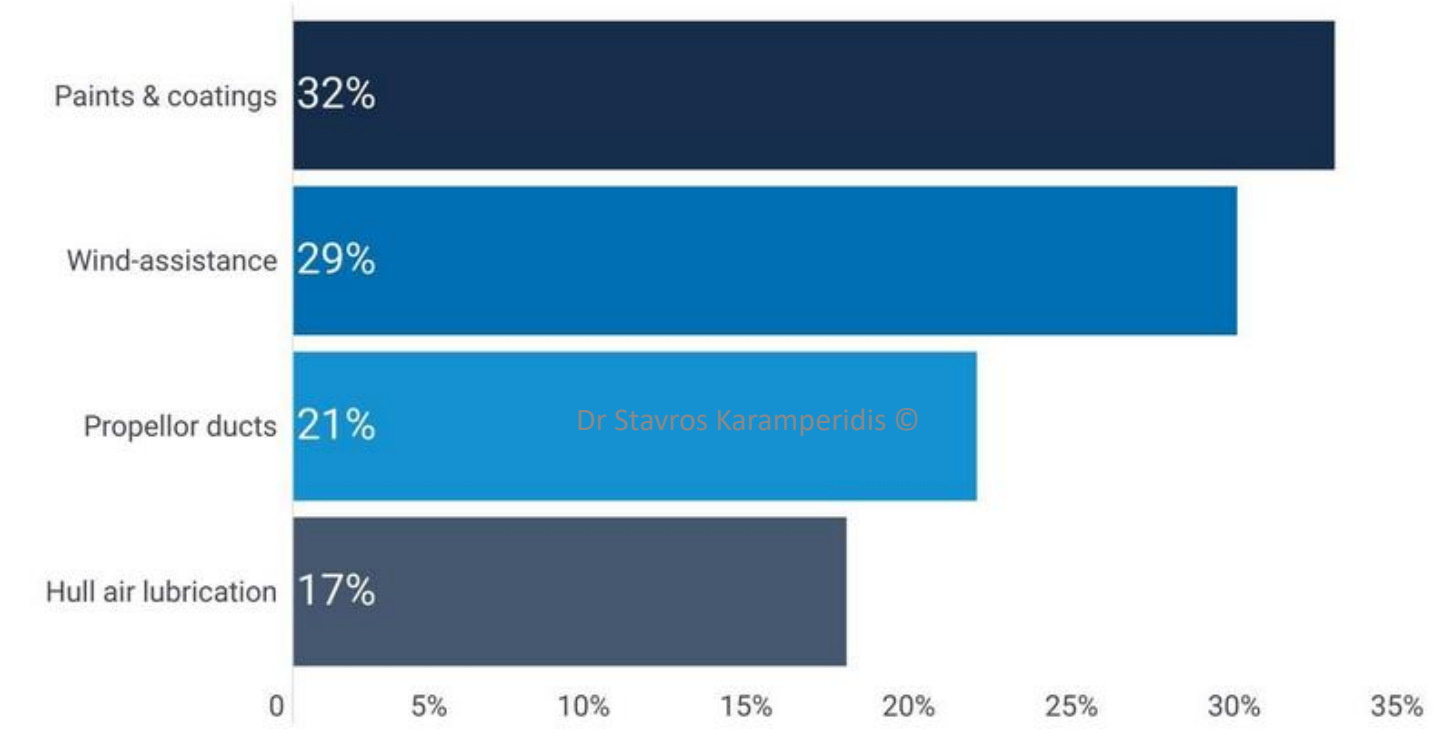
- That is the multibillion dollar question
- At the end of the day everything is about securing the right finance for ships and ports
- Ports seems to be the trickiest part as they have to create bunker facilities for fuels that they will need 3-4 times more space to be stored

- **<u>But let's take a step back and consider the energy usage!!</u>**

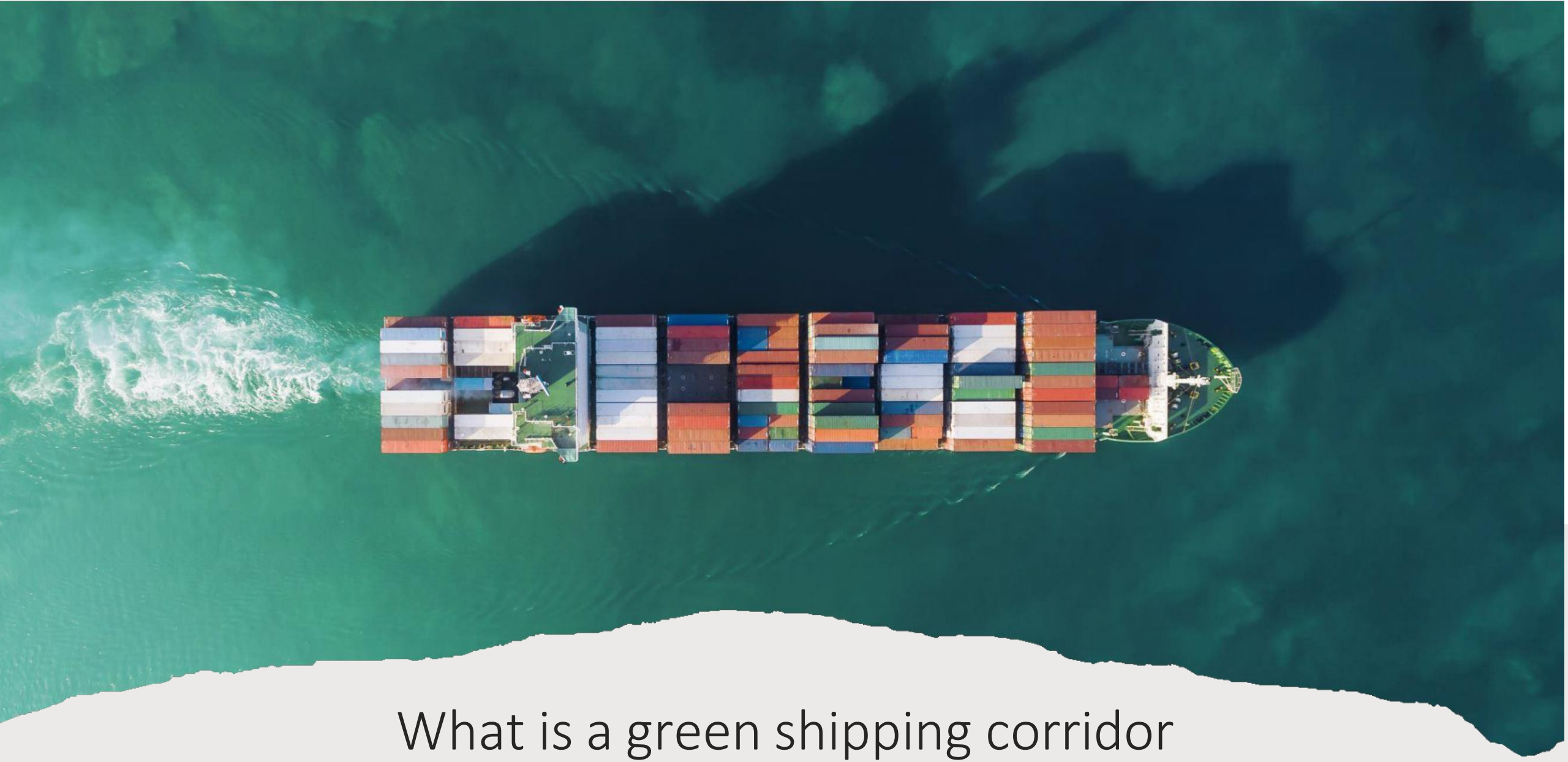
How a “Green” Ship could look like



What emissions/fuel reduction measures do you consider offer the best value?



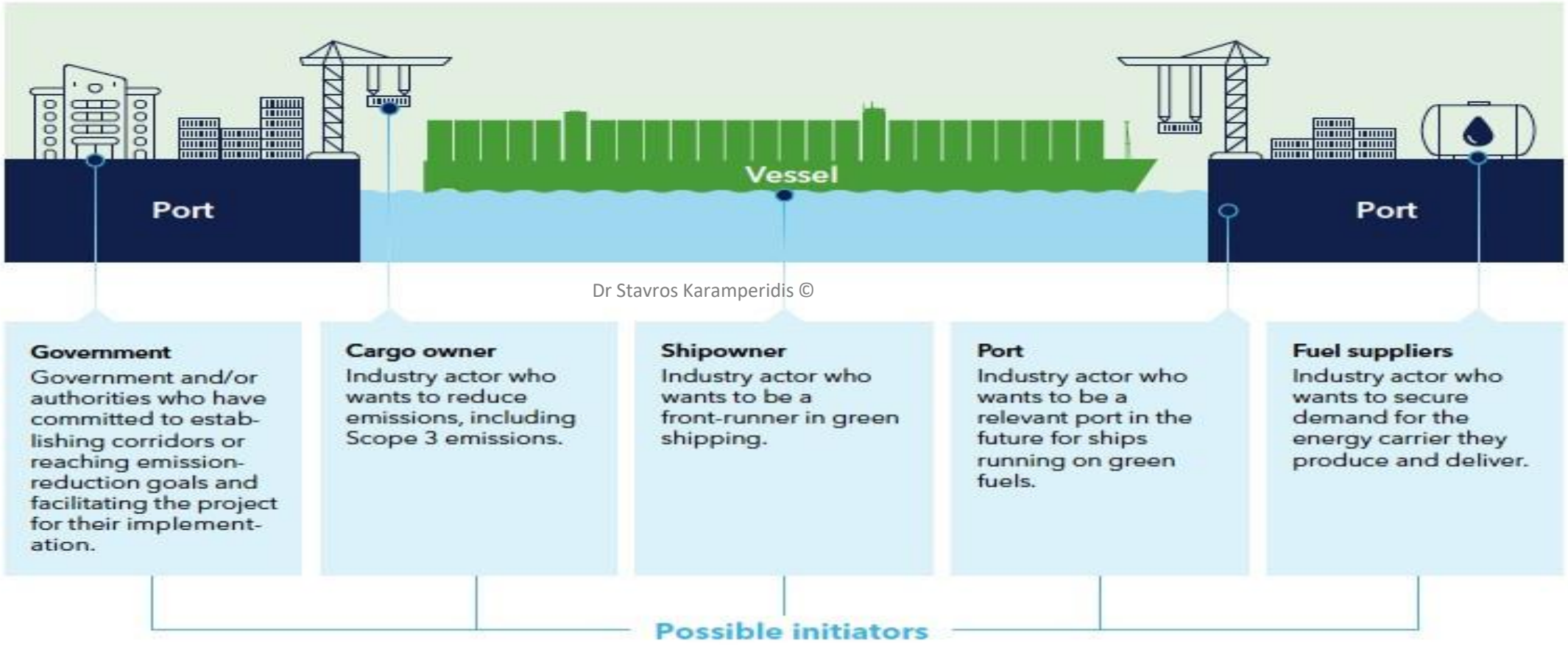
Source: Lloyd's List Shipping Outlook Survey 2023



What is a green shipping corridor (Background)

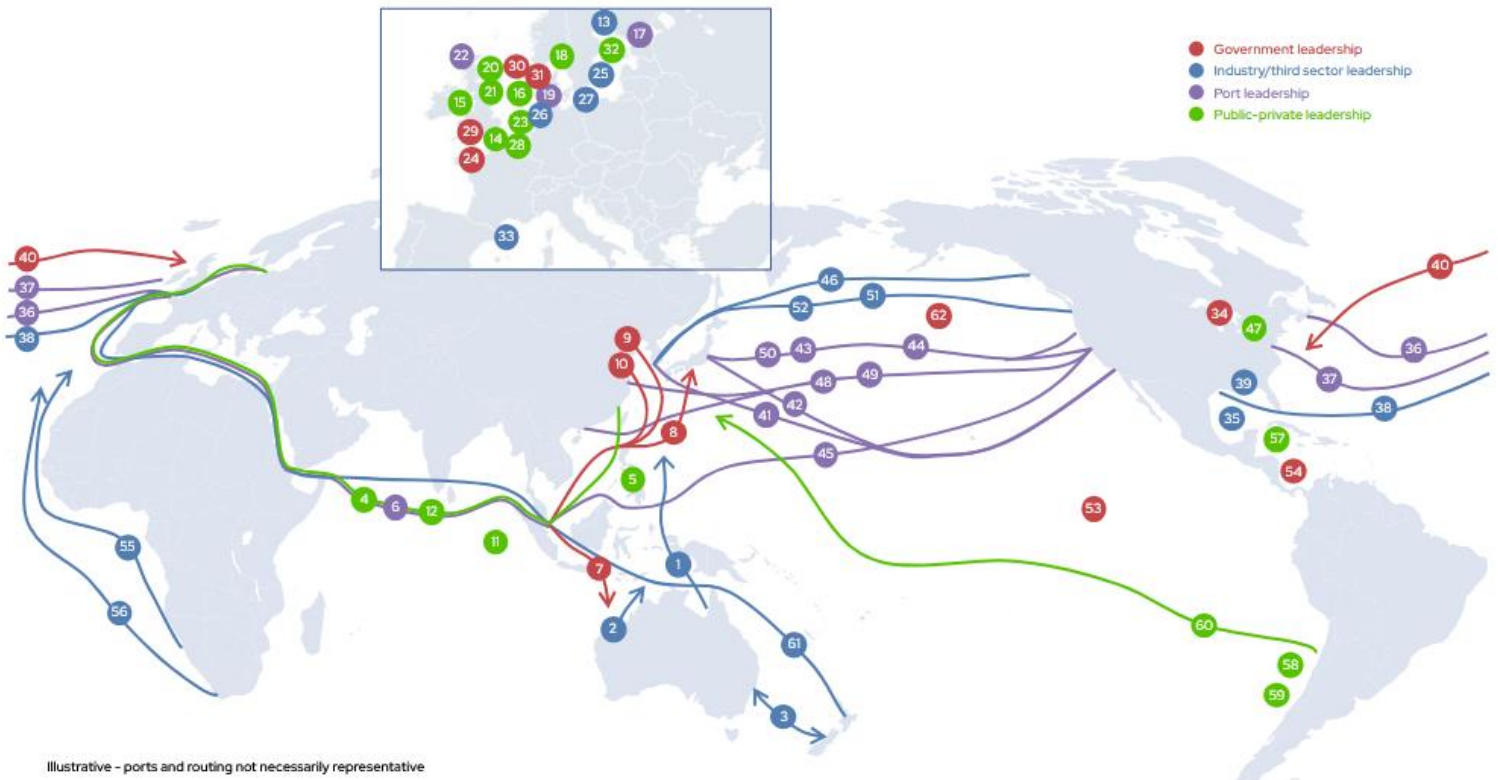
Green Shipping Corridor – **Key Stakeholders**

A green shipping corridor is a route between two or more ports operating with zero environmental footprint, where ships use carbon-neutral fuels (well-to-wake) to move the cargo (Admiralty, 2025; C40Cities, 2025; DNV, 2025).

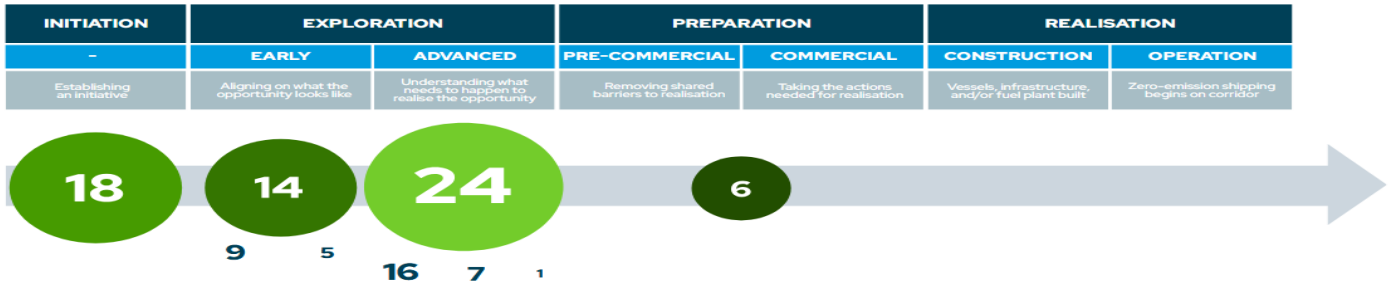


Source: Maritime outlook 2050, DNV, 2023

Green Shipping Corridor Initiatives (62 from 44)



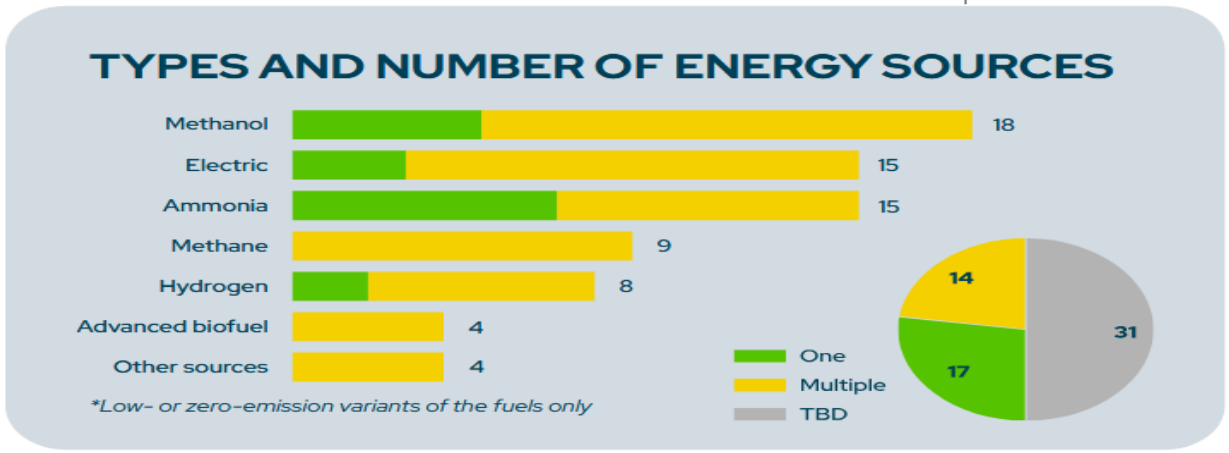
Dr Stavros Karamperidis ©



Current GSC initiatives globally Source: Global Maritime Forum (2024)

Global Status of Green Shipping Corridors

In an attempt to reduce the negative impact on shipping, green shipping corridors were introduced at COP 26 as a strategy which aims to limit the impact of shipping to global temperature and maintain it at less than +1.5^{0}C compared to pre-industrial levels (GOV.UK, 2023). That strategy was adopted from IMO at the MEPC.377(80). During COP 26, 27 countries have supported the establishment of green shipping corridors (GOV.UK, 2023).



Source: Annual Progress Report on Green Shipping Corridors, Global Maritime Forum, 2024

Thank you for your attention

Dr Stavros Karamperidis
stavros.karamperidis@plymouth.ac.uk
https://www.plymouth.ac.uk/staff/stavros-karamperidis
linkedin.com/in/stavros-karamperidis