# Will global shipping continue to grow?

## Exploring drivers of Change

SEAS AT RISK

# Contents

# Executive Summary

## The "Shipping growth macro-trend" report commissioned by Seas At Risk provides an extensive analysis of the current state of the shipping industry and how it can be transformed to align with the "One Planet Shipping" system-change narrative.

The report explored 2 mega (overarching) trends; globalisation and impact of planetary limits.

The report explores nine key macro-trends affecting the industry:

1. Changes in goods shipped
2. The circular economy
3. Localisation/regionalisation of supply chains and economies
4. The effects of climate change and extreme weather on ports and shipping
5. Decarbonisation of all sectors incl. shipping
6. International demographic change
7. Changing views on large vessels
8. International trade inefficiencies
9. Artificial Intelligence and game theory

The report highlights the importance of addressing these macro-trends to ensure the sustainability of the shipping industry. For example, changes in goods shipped are leading to a shift in the types of vessels required, while the circular economy is driving the need for more efficient use of resources. Localisation/regionalisation of supply chains and economies is leading to a greater focus on regional trade, while decarbonisation of all sectors including shipping is driving the need for cleaner fuels and more efficient vessels.

International trade inefficiencies are leading to increased costs and delays, while international demographic change is affecting the demand for goods and services. The effects of climate change and extreme weather on ports and shipping are leading to increased risks and costs, while changing views on large vessels are driving the need for more flexible and adaptable vessels. Finally, Artificial Intelligence and game theory are leading to new opportunities for innovation and efficiency in the shipping industry. The report also raises important questions about the reliability of models and availability of data, sources of more granular data on goods shipped, narratives that look beyond climate, GHG emissions by commodity sector, and the proportion of shipping accounted for by clothes, food, and timber.

These questions highlight the need for more research and data to support the development of sustainable shipping practices. Overall, the report provides valuable insights into how the shipping industry can transition towards a more sustainable future, and how Seas At Risk can play a role in promoting sustainable shipping practices. The report emphasises the importance of understanding the key macro-trends affecting the industry, and the need for more research and data to support the development of sustainable shipping practices.

**The report highlights the importance of addressing these macro-trends to ensure the sustainability of shipping.**

# Background Context - World macroeconomic outlook

The IMF medium-term world economic outlook of 3% in 2028 is the weakest since the 1990s[1] as "downside risks dominate and **the fog around the world economic outlook has thickened." I**n a severe downside scenario, global GDP growth could fall to 1% this year. Some of the more recent slowdown may reflect "more ominous" forces: the deep impact of the pandemic, the increasingly real threat of geoeconomic fragmentation leading to more trade tensions, less direct investment and a slower pace of innovation and technology adoption. **The** economic slowdown is concentrated in advanced economies, **especially the Eurozone and in the United Kingdom,** where growth is expected to fall to 0.8% and -0.3% this year before rebounding to 1.4% and 1% respectively. In contrast many emerging market and developing economies **are picking up**, with growth accelerating to 4.5% by the end of 2023 from 2.8% at the close of 2022.[2]

According to Swiss Re, climate change poses the biggest long-term risk to the global economy, through physical and transition risks. Physical risks include property damage, disruption to trade due to climate shocks (eg, severe weather events such as storms, floods and droughts), and lost productivity due to rising average temperatures. Transition risks result from the adjustment to a low-carbon economy, including changes to how society deploys resources, uses technology and rolls out regulation. If temperature rise is kept to well below 2°C, GDP in all regions by mid-century will be 4.2% lower than compared with a no-climate change world (Swiss Re Institute, 2021).

Maritime trade is likely to lose steam. Over the medium term, 2023–2027, seaborne trade is projected to grow 2.1% per year, a rate below the historical average of 3.3%. Maritime trade is expected to be slowed by macroeconomic headwinds, inflationary pressures that constrain consumer spending, and by pandemic-induced lockdowns and developments in China's economy. (UNCTAD, 2022). After years of faster-than-GDP growth, seaborne trade will only grow 35% to 2050, while global GDP almost doubles, due to increased consumption in Asia combined with the decline of coal and oil transport (DNV, 2022).

In the medium- and long-term several drivers could cause maritime trade to decline, including further shocks like COVID-19; climate change impacts rendering trade and globalised supply chains more difficult and costly; geopolitics, causing local and regional conflicts and blockages; and policy changes such as regulations and taxes on fuels. A focus on higher quality rather than higher quantity shipping would prioritise smaller companies with smaller ships and less commoditised container shipping transporting fewer low-value goods, which would have a smaller market if the external costs of environmental damage were internalised (Monios J. and Wilmsmeier G., 2022).

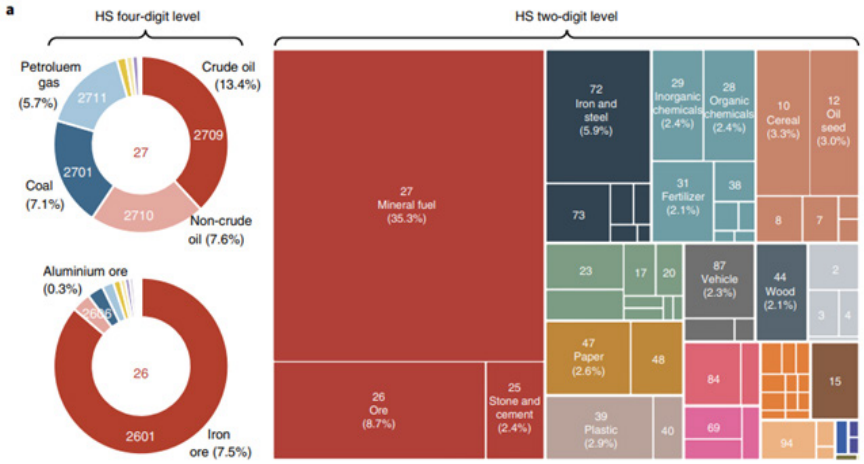
1 Per Financial Times news item, 11th April 2023

2 Per IMF blog, 11th April 2023, based on IMF April 2023 World Economic Outlook

## Trend 1 - Changes in goods shipped

air or sea), including the overall macroeconomic picture and consumer demand, geopolitical considerations and trading relationships, climate change impacts and rising trends such as reshoring and the circular economy. Certain basic commodities such as food, fuel and raw materials will continue to be transported by sea. However one class of commodities currently shipped on a significant scale and for which there is a clear signal for change is fossil fuels.

In 2021 energy products accounted for ~36% of global seaborne trade by tonnage, with crude oil and oil products comprising the majority (~66%) of seaborne energy transported (Jones C., 2022). Seaborne transport of energy products are estimated to contribute ~35% of shipping emissions of CO2 (Wang X.T., 2021). Compared with 2020 levels, total tonnage of energy products shipped is expected to fall by 41% to 52% across a range of 1.5˚C scenarios by 2050 (produced by the International Energy Agency, International Renewable Energy Agency and three distinct 1.5˚C limited overshoot scenarios from the Intergovernmental Panel on Climate Change). This is because growth in the transport of new low-carbon fuels is outweighed by greater falls in shipments of oil and coal, with oil being an energy product traded predominantly by ship (Jones C., 2022). Taken together these findings suggest a decrease of ~14.5-18.5% in both shipping volumes and CO2 emissions from the future net reduction in transport of energy products.




Source: Trade-linked shipping CO2 emissions, Wang X.T. et al, 2021: Trade-linked shipping CO2 emissions, Wang X.T. et al, 2021

As Wang et al illustrate in the figure above, mineral fuels dominate in terms of shipping emissions, with other meaningful contributions from iron, steel and ores. All other sectors contribute less than 3% of shipping's overall emissions.

Narratives:

- Decline in shipping volume due to decreased demand for key goods, ores, and fossil fuels.
- Changes in global energy generation, including greater uniformity.
- Practicalities of storing and transporting future clean fuels.

Research questions:

- What is the detailed breakdown of trade-linked shipping emissions, e.g. by vessel type?
- What is the reliability of the models and the availability of data around which narratives can be developed – is there certainty?
- Are there sources of more granular data on goods shipped (e.g. customs data) and can we strengthen arguments on changes in goods demands?
- Are there narratives that look beyond climate, e.g. at biodiversity?
- Does the GHG emissions by commodity sector above closely match the shipping proportion by commodity sector?
- What proportion of shipping do clothes, food and timber account for?

## Trend 2 - The circular economy

The circular economy (CE) recognises that continuing to use virgin materials at the current rate as part of a linear economy approach to take, make and waste products is unsustainable. It embraces the principles that wherever possible processes should use less materials for longer, before reusing and regenerating them. Uptake of the CE at scale across nations would dampen demand for virgin raw materials and provide new value streams in areas including goods as a service, goods digitisation, modular design and construction processes, reuse markets and waste mining and management. Materials will still need to be traded and transported, so the full implications of increasingly circular approaches on shipping are not clear. The extent of virgin materials such as metals, ores, aggregates and textiles being shipped may fall, provided that CE systems design "leakage" out via comprehensive trade arrangements (see below). By leveraging their domain knowledge, the shipping industry has an opportunity to co-develop future circular ecosystems with customers, digital and supply chain partners, by redefining shipping from a commoditised service to a value-adding facilitator of a more circular flow of products, materials and services. This will require a fundamental mindset change (The Circular Shipping Initiative, 2019).

Deploying 16 transformational circular solutions across four key systems - food, the built environment, manufactured goods and consumables, and mobility and transport – can potentially reverse the current overshoot of 5 of the 9 key planetary boundaries, maintaining thriving ecosystems for water, land and air, and limiting the global temperature rise to within 2-degrees (Circle Economy, 2023). Assessments indicate that CE strategies can cut global greenhouse gas emissions by 39%, mostly in the construction, transport, and food sectors. About one-third of nationally determined contributions to the Paris Agreement submitted in 2021 mention CE measures. Europe is championing the CE agenda globally and has made important progress in achieving material efficiency gains, reducing total material use by 9.4%, from 6.6 bn to 6.0 bn tons over the past two decades (World Bank, 2022).

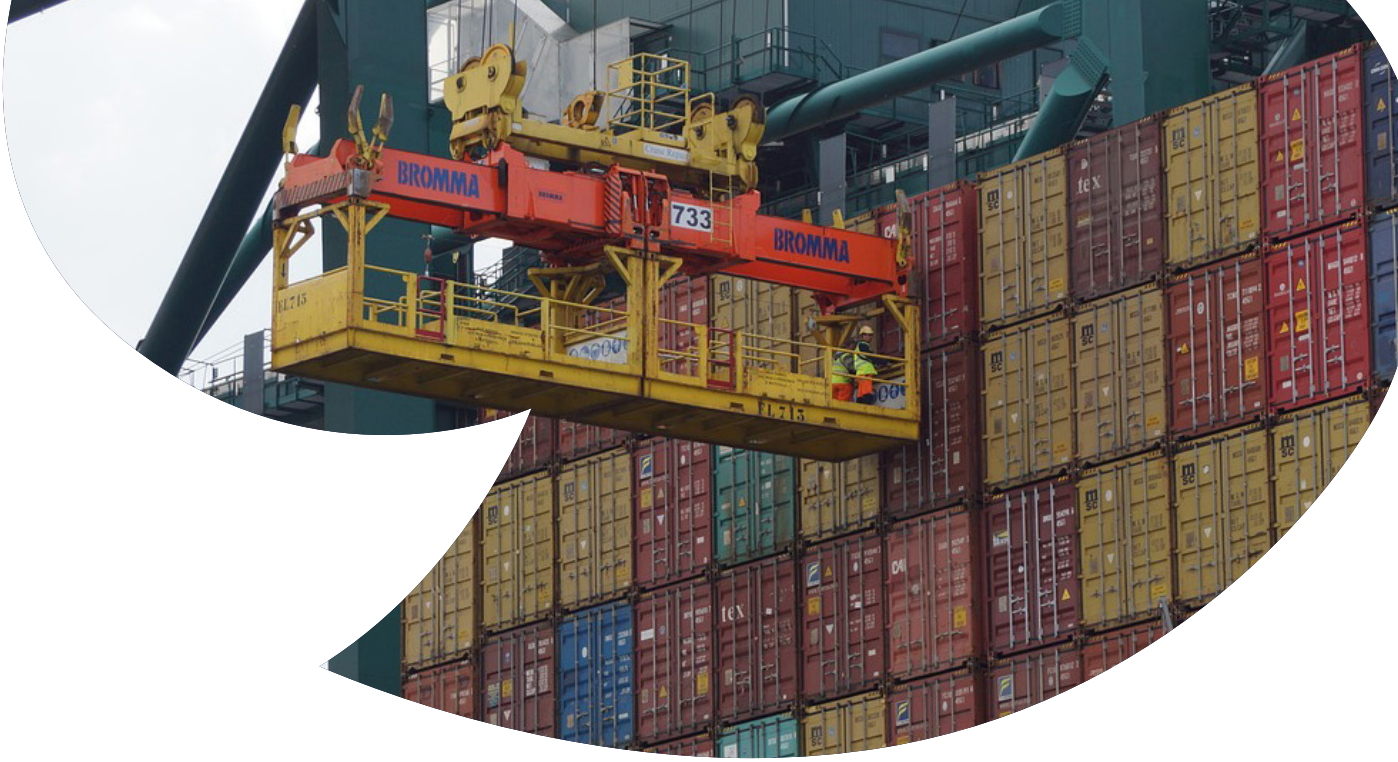
Overall however the CE is still in its infancy, with 7.2% of the global economy considered circular by reference to the level of "secondary materials" which are put back into service in the economy. To scale up action requires a more proactive role from policymakers to incentivise take-up, for example by requiring ushing companies to disclose their scope 3 (supply chain) greenhouse gas emissions, creating market incentives for secondary materials to be more competitive and designing trade policies so that lead firms take responsibility for primary material use and other externalities across the full value chain, to avoid the risk of materials leakage. Policy reform is critical for attracting financing for the CE (World Bank, 2022).

Narratives:

- Circular economic growth is politically relevant and pro-actively supported by industries.
- The circular economy inherently reduces the need for goods to be shipped.
- Ports and shipping are natural hubs for circular economies, and are involved in transformation.
- National resilience depends on circular economic approaches.

Potential research questions:

- Have some major international brands gone circular and what was the impact on shipped goods?
- Are any actors in the shipping/logistics industry exploring the CE?
- Which sectors can go circular, which cannot?
- Are we past 'easy wins' in CE development?
- Does a circular economy necessarily result in fewer goods transported by sea?
- Could there be a positive value-add proposition for shipping, such as new economic models or incentives?
- What macro-infrastructure is needed to realise a CE, and how does this impact ports and shipping?




# Trend 3 - Localisation/regionalisation of supply chains & economies

The shipping of goods is driven by international trade agreements and the degree to which local needs cannot be met domestically . Whilst lean models of efficient, global manufacturing with lengthy supply chains may have delivered business efficiencies in managing inventories and lead times, on average across industries companies can now expect supply chain disruptions lasting a month or longer to occur every 3.7 years, with the most severe events taking a major financial toll (McKinsey, 2020). Globalisation reached a peak in 2012 and since then supply chains are becoming more domestic rather than more regional (Miroudot S. and Nordstrom H., 2020). The covid-19 pandemic created major disruption across international supply chains and challenged industry and governments alike on how to build greater resilience back into sourcing, production, logistics and transport, potentially further accelerating localisation of production. This trend potentially signals less shipping overall, potentially by up to 13% (see below). Shipping across major East-West routes between China, the EU and the US may reduce and shorter distance shipping around continental shelves may increase. Localised production of green shipping fuels (see below) may reinforce this.

Reshoring is the relocation of value creation tasks from offshore locations to geographically closer locations such as to the home country of a company's headquarters - "backshoring"- or to nearby countries - "nearshoring" (Foerstl K., 2016). Analysis by the Asian Development Bank finds that the Covid-19 pandemic accelerated interest in reshoring, enabled by technological advances, the development of robotics and artificial intelligence; and that 69% of companies across North America manufacturing and industrial sectors are likely to bring manufacturing production and sourcing back to their region. 66% of firms globally are considering reshoring to some degree. Reshoring by 5% - 10% may lead to a 5.3% to 13.3% decrease in global trade from its base value, with differing impacts across sectors and regions depending upon the depth of supply chain linkages (Asian Development Bank, 2021). Gradual shifts in sourcing are likely; instead of seeking the lowest cost, companies are pursuing the 'best cost' - weighing manufacturing and transportation costs against factors like supply chain resilience and environmental sustainability (UNCTAD, 2022).

The European Union's Critical Raw Materials Act passed in March 2023 sets out to secure EU access to a more resilient, secure and sustainable supply of critical raw materials, creating new 2030 targets for domestic capacities along the strategic raw material supply chain and for imports. These include a target to recycle at least 15% of the EU's annual consumption through new waste recovery and circularity requirements for member states[1]. Critical supply chains have become important security considerations for governments (Deloitte, 2022). China has adopted a dual circulation strategy to make its economy more balanced and resilient, diversifying trade away from reliance on the United States and Europe to other partners through

1 European Critical Raw Materials Act press release, 16th March 2023

its Belt and Road initiative and in particular the Association of South East Asian Countries. China is also improving domestic supply chains and promoting the role of private consumption and services within the national economy.[2]

As the world moves to electrification and alternative fuels, underlying cost structures could create incentives for more local and regional supply networks and in turn reduce traditional large-volume, long-distance commodity flows for oil, coal, and LNG. In 2050, selected commodities such as hydrogen will be cheaper to produce locally than to import, because transportation and the avoidance of converting and reconverting derivatives can be a significant contributor to overall unit costs (McKinsey, 2023).

2 Atlantic Council article, 24th October 2022

Narratives:

- Global security is demanding localised supply chains to mitigate, risks, major shocks, and evolving geopolitics.
- Major supply chain disruptions are expected to occur every 3.5 years due to 'unknowns' and shocks – localisation is a mitigation. Economies of risk may justify onshoring.
- As risks increase the costs of delaying onshoring grow.
- Onshoring and reshoring may lead to commercial advantage due to costs (e.g. hydrogen generation) or marketability (e.g. local and ethical brands).
- Material recycling and reclamation, e.g. of rare earth metals, is increasingly important as nations attempt to exert control over fragile supply chains. Critical supply chains are key matters of policy.

Potential research questions:

- How much reshoring is happening in practice, can we realistically establish an upper bound?
- What distances will new green ships be capable of?
- How does reshoring and global trade correlate?
- What is the regionality of reshoring, and how does that impact shipping volumes?
- What does reshoring mean for jobs and income security globally?

# Trend 4 - Decarbonisation of all sectors including shipping

The energy transition is triggering major structural changes across the entire global economy, including the shipping sector and how it delivers emissions reductions in line with the Paris Agreement. This transition will influence what goods are shipped where and by what method of shipping. The costs of new clean fuels for transport will influence the competitiveness of shipping goods by sea compared with other feasible alternatives. Due to energy density, power generation and fuel storage requirements, smaller ships running on shorter routes may be the first "green" ships to emerge that are capable of attracting the necessary finance[1]. Port energy generation and infrastructure developments and capabilities will play a determining role in facilitating the green transition for shipping and its competitive advantage relative to other modes of transporting goods.

Currently shipping is still in the research and innovation phase of the energy transition, requiring at least 5% of scalable zero emission fuels by 2030 to enable rapid scaling and mass adoption. This would equate to either 29.8 million tonnes of ammonia or 28.1 million tonnes of methanol as examples. Actions to reach 5% for shipping by 2030 are considered to be partially on track, with progress in industry, national and international developments and significant progress over the past 2 years on R&D and high-level commitments (UMAS and UN Climate Change High Level Champions, 2022). Policy measures such as the US Clean Shipping Act and Europe's FuelEU Maritime initiative will add further impetus to these efforts.

Ships above 5,000 gross tonnage arriving at, within or departing from ports under the jurisdiction of an EU Member State will have to reduce greenhouse gas emissions by cutting the amount of GHG in the energy they use (below 2020 level of 91.16 grams of CO2 per MJ) by 2% as of 2025, 6% as of 2030, 13% as of 2035, 26% as of 2040, 59% as of 2045 and 75% as of 2050.[2] Ships above 400 gross tonnage in the US will have to reduce the carbon intensity of fuel used relative to a baseline intensity (equivalent to the average fuel carbon intensity for 2024) by at least 20% for 2027-2029, at least 45% for 2030-2034, at least 80% for 2035-2039 and 100% for 2040 onwards[3].

Science based emission reduction targets for the maritime industry are achievable, despite "committed" emissions locked in from existing and long-lived fossil fuel infrastructure. Several analyses of shipping emission intensities and sector demand have concluded that it is possible for the sector to meet a 1.5°C temperature goal (SBTi, 2022).

The United States Inflation Reduction Act passed in August 2022 earmarks at least $370bn in subsidies and tax credits for clean energies, and the actual amount made available could be three times this amount, according to analysts.[4] In 2022 all clean electricity sources (renewables and nuclear) contributed 39% of global electricity, a new record high. Record growth in low-carbon power generation is expected to reach an important tipping point in 2023, due to the accelerating

1 London shipping Week Talks: Downsizing the shipping industry is not a negative outcome, Rachel Hoyland, Sep 2021
2 Council of the EU press release, 23rd March 2023
3 Clean Shipping Act of 2022, US Congress, July 2022
4 Financial Post article, 11th April 2023

effect of the US Inflation Reduction Act and the European Union REPowerEU strategy, causing fossil fuel output to decline at an "enduring, structural" level, for the first time (Ember, 2023).

The need for decarbonisation is also reflected in IMO thinking, led by its Marine Environment Protection Committee (MEPC). In 2018 the IMO introduced an initial strategy on the reduction of GHG emissions from ships, with view to a 50% reduction in GHG emissions (and 70% of carbon) by 2050 compared with 2008, and an eventual 'phasing out' of GHG emissions entirely. Despite the conventional inertia of shipping, this is being actively pursued and mandatory measures to cut vessel carbon intensity are being drafted. An overt focus of the IMO's plans is setting stronger energy efficiency requirements on new vessels, however, this does not address the emissions of the existing vessel fleet. With growing cost pressures on shipping and an increasingly uncertain global outlook, willingness to invest in new vessels is decreasing. In the last 10 years the average age of active vessels over 2000GT has increased from 13 years to 14.7 years – and the older the vessel the greater its risk of incident. New vessels, bearing new technologies and fuels, will undoubtedly be more expensive than their traditional counterparts, and come with technical costs and risks, particularly to early adopters. Not unlike the transition to electric vehicles for land transport, practically affecting a paradigm change in vessel technology will be challenging and meet resistance.

Beyond vessel efficiency and new fuels, there is a clear focus on speed optimisation and just-in-time logistics, and underpinning in that in better co-operation between vessels and ports globally. The IMO makes clear that it sees modelling and understanding the global effects of measure that change shipping will be important to building co-operation and setting a pathway towards decarbonisation. Game theory and AI will play a vital role in this, where it can be used to better model global shipping and logistics, find co-operative advantages, and ultimately make predictive statements on how shipping can be optimised towards operational efficiency and decarbonisation. There is a strong sense (e.g. see the Sea Traffic Management programme) that deeply integrated enabling systems will be needed for optimised maritime logistics, and also to manage ocean complexity, providing a far more comprehensive picture of the oceans, optimising logistics, provided guaranteed connectivity, and ultimately managing a very complex environment. Such systems would likely remove significant control from the bridge of a vessel, which, whilst a change in the philosophy of seafaring, could be an enabling for cost-efficiency and risk reduction as much as decarbonisation. The case needs to be made – and accepted by a diverse assembly of stakeholders.

Narratives:

- Shipping's 1.5% carbon budget is running out at 10% per year, there is a need to comply rapidly.
- Decarbonisation of shipping and wider sectors may provide new shipping formats and business models that have future competitive advantage.
- Different shipping needs and risk profiles will disincentivise large vessels and long-distance shipping, promoting small, zero-emissions, ships.
- Opportunity to pursue the best vision of shipping, seeking the best renewable technologies for the sector at scale, e.g. wind, not only clean fuels.

Potential research questions:

- Is there evidence that new green fuels imply smaller vessels? Look to Asia where most shipbuilding occurs and to new commitments under the Green Shipping Challenge.
- How do we make a just transition?
- What is the need for capacity building across the industry?
- .What standardisation enables electrification and decarbonisation?
- What are the ideal renewable/clean technologies for future shipping, and what evidence supports this?
- How necessary is shipping decarbonisation for wider global decarbonisation; is there a strong external demand from other sectors?
- What ports technology and infrastructure will be needed in support of decarbonised shipping?

## Trend 5 - International Trade Inefficiencies

International trade provides various benefits in terms of consumer choice, efficient use of resources and economic growth, but in the absence of safeguards it also has drawbacks, such as environmental degradation, pollution and undermining of people's livelihoods and wellbeing. Over time this has fuelled unsustainable consumption patterns and social injustices in both producer and consumer countries (GCRF Trade Hub, 2021). Full cost accounting, environmental economic accounting and similar approaches can expose the invisible costs of these "externalities" and provide a more balanced evidence base for national decision-makers on the relative benefits and costs of trade, with potential knock-on effects for trade and shipping. 92 countries are now using environmental economic accounting[1].

Around 40% of world trade is highly concentrated, with importing countries regularly relying on three or fewer nations for supply of a given resource or manufactured good. Most of this is by choice, rather than necessity, and applies particularly to agriculture, food and beverages, mining, electronics and natural gas (McKinsey, 2023). Recent disruption caused by world events may motivate countries to diversify trading partners.

At the World Economic Forum Annual Meeting in January 2023 the Coalition of Trade Ministers on Climate was launched, co-led by the trade ministers of Ecuador, the European Union, Kenya and New Zealand, to strengthen global collaboration on trade, climate and environmental sustainability, including identifying technologies and investments required to achieve Paris Agreement climate mitigation and adaptation strategies. The 50 countries represented in the Coalition of Trade Ministers on Climate include not only some of the world's biggest economies, but small, vulnerable economies, including small islands.[2] This has the potential to bring a greater sustainability focus to trade agreements and arrangements.

According to a simulated optimisation scenario, global shipping CO2 emissions of international trade commodities could be reduced by 38% (or 284Tg). Major emissions-reduction efforts are driven by shipping optimisation of crude oils, non-crude oils, iron ores, coals and petroleum gases in particular (Wang X.T., 2021).

1 Assessing the state of the SEEA: 2022 Global Assessment of Environmental-Economic Accounting, UN website, accessed 15th April 2023

2 World Economic Forum press release, 20th Jan 2023

Narratives:

- Shipping's 1.5% carbon budget is running out at 10% per year, there is a need to comply rapidly.
- Decarbonisation of shipping and wider sectors may provide new shipping formats and business models that have future competitive advantage.
- Different shipping needs and risk profiles will disincentivise large vessels and long-distance shipping, promoting small, zero-emissions, ships.
- Opportunity to pursue the best vision of shipping, seeking the best renewable technologies for the sector at scale, e.g. wind, not only clean fuels.

Potential research questions:

- To what extent will distributed ledger technologies and digitalisation drive large-scale supply chain changes?
- Is concentrated trade sustainable in the future, and which sectors are most exposed?
- To what degree is trade concentration truly a choice, and how would this be evidenced?

# Trend 6 - International demographic change

Changes in international demographics and development will influence national level demand for goods and services, in turn influencing international trade patterns and the shipping of goods.

The pandemic accelerated shifts in consumer behaviour and preferences, with more online purchase of consumer goods, which are often transported by container. In 2019 global e-commerce was 15% of total retail sales but in 2021 had increased to 21%. It could increase from a value of $3.3 trillion in 2022 to $5.4 trillion in 2026 (UNCTAD, 2022). Ecommerce is acutely time-sensitive, requiring shipping and port operators to be effective and efficient across their services, connectivity and operations to remain competitive.[1]

A majority of consumers, across backgrounds, demographics and geographies, have reimagined their values and purpose over the past 18 months, changing their buying habits across multiple industries including retail, consumer goods, electronics, property and automotive. Through their purchase choices, they are purposefully seeking to influence their communities and the environment, and to confirm how they see themselves in the world. Consumers will leave brands that don't recognize their new priorities for health and safety, service and personal care, ease and convenience, product origin, trust and reputation, and will pay more for those that do (Accenture, 2021). Globally, 85% of people indicate that they have shifted their purchase behaviour towards being more sustainable in the past five years as consumers see themselves, along with for profit companies, as the primary catalysts for change. 50% of consumers rank sustainability as a top five value driver and companies face significant pressure to prove their sustainability credentials and continue to make it a central part of their value proposition.[2] According to market intelligence agency Mintel, with so much global uncertainty surrounding the economy, sustainability, supply chains and conflict, there will be a greater movement to protect local resources and boost local business. "Localism" will come to mean supporting communities where the product is manufactured rather than where the consumer is located. Over the next five years, brands will increasingly cater to the niche identities of loyal consumer investors, fragmenting large, legacy brands into smaller, more targeted business units. What people wear, eat and drive won't just signal status, but will be a detailed account of their attitudes and beliefs (Mintel, 2023).

The global second-hand apparel market is expected to grow 3 times faster on average than the global apparel market overall, reaching $350bn by 2027, potentially leading to reduced new clothing production. Generation Z and millennials are most willing to buy second-hand clothes, for cost and sustainability reasons.[3] Six in 10 retailers already offer second-hand goods or are seriously considering it, and over 40% of retail executives predict resale will become an important part of their business within the next five years.[4]

1 Safety4Sea article, 28th Dec 2022

2 Global Sustainability Study survey 2021, Simon-Kucher & Partners, per Businesswire news item, 14th Oct 2021

3 Statistica insight, 1st June 2022

4 Newsweek article, 29th April 2022

Narratives:

- Regionalisation due to changing economies and concentration of production.
- Market trends point to circular principles, social values and localism.
- Consumer demand is for reliability and rapid support, which is better serviced by local supply.
- Population is stabilising in China (and stabilising globally faster than expected); demographics and wage changes will affect the costs of production, reducing advantages for off-shoring.
- Shift towards consumers wanting strong traceability tied to products, including origin, environmental/ecological labelling, and the ethical standards of goods. Shipping will have to be accountable, and 'acceptable' goods may change.

Potential research questions:

- What are the demand drivers for shipped goods in developing countries?

# Trend 7 – The effects of climate change and extreme weather on ports and shipping

The threat of climate change is well recognised by the shipping and ports industries (and the associated insurance industries), and wider maritime sector. Projections of the impacts of climate change, particularly sea-level rise, on ports, harbours and coastal communities are stark across scenarios – they indicate likelihoods of disruption in even the best cases, and potentially profound change and need for adaptation in the worst .

An important cause will be sea-level rise, expected to significantly impacts ports  particularly in Europe and the North Sea. Based on predicted global sea level rise and storm surge risk, 64% of ports are expected to face inundation following IPCC 2012 trends, with an 80% increase to seaports exposed to >1m inundation between 2030 and 2080 (PESETA III models). Major in-land ports have enhanced protection, but coastal ports are likely to suffer increased risk and damage, and require investment in storm defences and flooding protection. Even with protection, it's likely that the combination of sea level rise and extreme weather will changeable affect and restrict vessel movement, and the suitability of ports to receive large

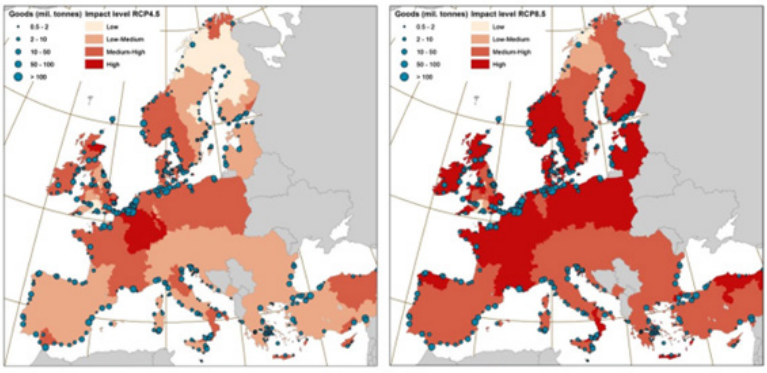


**Fig. 3** Impacts of the ports affected by $ESL_{100}$ increase from 2010 to 2100 on hinterland (NUTS3 regions) according to RCP4.5 (left) and RCP8.5 (right)

**Fig. 4** Worldwide links of European ports affected by ESL increase according to RCP8.5

vessels especially.

Extreme weather events are also significantly increasing, with increased durations and intensities of both heatwaves and storms, with a five-fold increase in water, climate and water disasters over 50 years. There are more, larger, fog and freezing-fog incidents at ocean level , and increasing temperature gradients are adding to threatening sea currents, both having direct safety risks as well as causing less predictable risks such as emergent ice hazards.

Ocean acidification and increasingly varied salinity will also impact shipping and its safety. Ocean salinity is deeply tied to the water cycle, currents, and temperatures, and extreme variations in salinity further contribute to risk of extreme or unexpected currents. Ocean acidification contributes to the degradation of vessels and equipment at sea, increasing the need for and cost of maintenance.

There are additionalities to environmental risk too; arctic ice melting and breaking is leading to the possibility for new transit routes and exploitation of currently untapped oil and gas resource. Arguments have been made that the efficiency of these routes could contribute to maritime decarbonisation

Overall, the effects of climate change and extreme weather on shipping and ports is significant. They point to increased costs for all parties, increasingly changeable conditions, and increased risk. Practically, shipping is becoming more challenging and less predictable; these risks are exacerbated by vessel size and voyage distance.

Narratives:

- Safety of shipping is decreasing, and the risk to life and to goods is increasing.
- Extreme weather events are becoming increasingly common; risk is exacerbated by journey length, vessel size, and crew experience.
- Crew experience is decreasing, further increasing risk – local shipping benefits from mariners more familiar with a specific ocean region, mitigating this somewhat.
- Climate change will have significant negative impact to coastal regions and infrastructure, including ports. Significant investment will be required to maintain and protect them, and the likelihood of ports becoming inundated will grow. Consequently, mega-ports may become less palatable to nations, reducing the usefulness of very large vessels.

Potential research questions:

- How accurate are the environmental models, and what impact would their predictions practically have on ports, shipping routes, and vessel types?

## Trend 8 – Changing views on large vessels

A core component of a narrative against shipping sector growth (certainly in its current form) may be a change in the size of vessels. This may be seen through a decarbonisation lens, or driven by changes in demand for long-distance shipping; however, it is also a question of practical concern to the shipping industry. Allianz's 2022 safety in shipping review extensively highlights problems caused by big ships; it unambiguously draws the conclusion that big ships are risky. When they run aground (e.g. the Ever Given) they cause unparalleled transport disruption and cost, their size makes incidents more likely and harder to resolve. Vessel size is also correlated with vessel draft (their depth beneath the waterline), decreasing navigability of canals and port approaches and increasing needs and costs of dredging.

However, running aground is not the only issue. Fire on large container vessels is becoming an increasing issue, driven largely by highly flammable, energy-dense, cargo (batteries and chemicals). Over 70 fires have occurred on container vessels in the last 5 years, causing considerable cost and danger.

Lastly, the risk corresponding to large vessels is hard to mitigate. When large vessels are in trouble, finding refuge is uniquely challenging due to their size, as the Allianz report states, "Too often, what should be a manageable incident on a large vessel ends in a total loss." This challenge extends to recovery and salvage, for a large container vessel this can reach close to 1 billion USD – these costs are not least driven by the environmental impact of incidents, and as these impacts are becoming clearer and better assessed the costs look to be increasing.

The impact of extreme weather on very large vessels is also greater; their significant volume of exposed containers and large size make their stability at sea less predictable and increase risk of significant container loss or damage in rough weather.

Lastly, the trend towards large vessels also results in a concentration of cargo in a smaller number of mega-ports, capable of handling these vessels. As the risks to ports from extreme weather and sea-level rise grows there is concern that centralisation of cargo shipping logistics may be unduly risky. It is also unclear whether changes to shipping and ports, such as increased short-sea shipping due to regionalisation, will support the large-vessels & mega-ports paradigm.

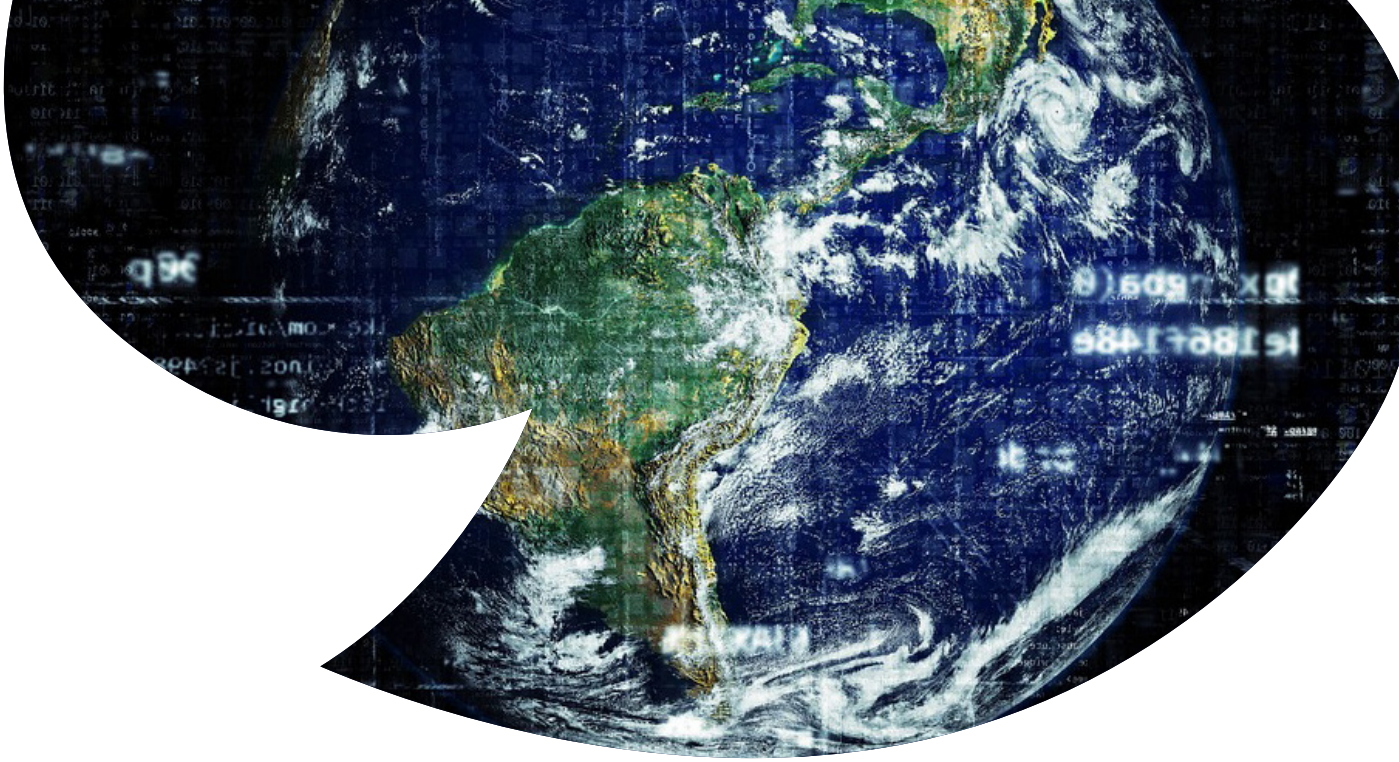
Overall, aside from the justified environmental narratives, the tide may be turning on very large vessels which may be causing unpalatable degrees of risk to insurers and placing challenging requirements on ports.

Narratives:

- Big ships concentrate and centralise trade, which may be broadly undesirable due to risks mentioned across trends, and disadvantage a large number of ports – which may seek competitive alternatives.
- Big ships are resulting in increasingly unpalatable levels of risk to insurers.
- Regionalisation and future zero-emissions vessel architectures may significantly decrease the relevance of very big vessels.
- Container loss in extreme weather is a major problem for large vessels, and is also a significant safety concern in European waters.
- Accountability is improving, better detecting and attributing fault in incidents involving large vessels – increasing their 'real' exposure to risk and costs.

Potential research questions:

- Are big vessels climate friendly; assumptions rely on sailing full, but how true is this?
- What is the balance of safety arguments and potential costs – where do acceptable risk lie?
- How does vessel size positive and negatively affect ease of decarbonisation?
- What is the ship building perspective?
- Are logistics networks unduly influenced by very large vessels, and how does that affect their efficiency?



## Trend 9 – AI and game theory

As with many industries, the role of AI, big data and game theory in the maritime sector whole, and shipping therein, is highly contemporaneous. Our ability to monitor the oceans, spanning human activity and industry, ecosystems, and the environment is improving rapidly, including significant advances in earth observation and a growing philosophy of crowd-sourcing data from opportunistic sources; well-practiced on land, but emerging at sea using data recorders such as ferry boxes. With this comes a wide call for open source data, abiding to FAIR data principles, and algorithms following Open Science – making the data and analysis transparent, democratising capacity, and building consensus through an accepted, shared, picture.

This big-data picture of operations and environment is often uninterpretable to the human analyst due to its vastness and complexity, however advances in machine learning (ML) and artificial intelligence (AI) do enable big-data to be translated into actional information and knowledge. Therein, big data, ML, and AI do not have one specific use – nor a unique way of affecting shipping narratives – but they do underpin a shift in observation and analysis that will affect shipping, and may provide evidence supporting other narratives.

AI for evidence generation is a key part of this. Whether for shipping or other facets of ocean governance and environmental policy, a key barrier is establishing the weight of evidence that forces action for environmental protection. The complexity of the oceans can create a convenient ambiguity by which inaction is justified – AI has the potential to blow this open, retrieving trends and predictive models that are nuanced and complex, but also testable, unbiased, and justified by a rich, comprehensive, dataset. These models may provide greater clarity on the impacts of shipping on ocean (and wider environmental) health, and may also reveal new efficiencies and operational models that challenge growth narratives.

Practically, the use of AI for improved prediction of vessel traffic patterns, ports operations, and local demand may directly make shipping more efficient and predictable. Bringing the industry closer to just-in-time logistics, and reducing the need for rapid transit, potentially decreasing the shipping industry's GHG emissions.

AI may also be used to extrapolate predictive models to new scenarios and operational concepts, this may be combined with game theoretic analysis in order to demonstrate alternatives to the current shipping norm that have upsides for numerous stakeholders (such as ports, insurers, and even parts

of the shipping industry). Game theoretic analysis of shipping is well established, and is likely to be an influential form of argument to business strategists and decision makers – speaking a language they understand and accept.

However, whilst these uses of big-data, ML, AI and game theory may contribute positively to shifting shipping narratives, and will almost certainly become fundamental to the industry, as a stand-alone trend they do not provide a strong narrative against shipping growth. Rather, they are among the tools by which alternative narratives can be developed and justified.

Narratives:

- AI will provide a common picture of shipping, trade, operations, ecosystems, and the environment, which can be widely scrutinised and enable evidence-led decision making.
- Issues of human bias may be addressed.
- Democratising capacity through open science and FAIR data is globally important.
- Data is not intrinsically rivalry unless an organisation possesses a data monopoly; therefore mechanisms of sharing and transparency may benefit the majority of the shipping industry.
- Game theoretic arguments about the future of shipping and port operations.

Potential research questions:

- Numerous practical activities to implement and use big-data, ML, and AI approaches for evidence generation and analysis.
- Trust issues pertaining to AI, particularly research questions around explainable AI.
- What does a game theoretic approach say about shipping growth, and can a reasonable, justified, game theoretic argument be constructed to support a narrative of decreasing shipping growth?
- If there enough data, at a high enough quality, to actually enable AI approaches?

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