Institute of
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Position paper
Resilience of maritime transport chains

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Introduction

The outbreak of the COVID-19 pandemic in early 2020, the blockage of the Suez Canal due to the Ever Given container ship in March 2021 and Russia's attack on Ukraine in February 2022 have recently increased the prominence of logistics chain resilience issues.[1]

For decades, global just-in-time logistics chains have been developed by industries to save on warehousing costs. The significant disruptions to supply chains in recent years have made many industrial companies realise how dependent they are on functioning logistics chains.[2] The importance of shipping and the associated risks were underestimated for a long time.

Hypothesis 1:
"The importance of maritime transport chains has long been underestimated"

Research on resilient transport chains has intensified significantly in response to recent developments. However, the focus is often on examining specific events or certain predetermined risks in order to gain insights for comparable events in the future.[3] Comprehensive analyses that include all assets and all risks, by contrast, are rare. As it is impossible to predict all potential risks, we propose not to focus on past and possible future events, but to start with an analysis of potential weaknesses and the critical assets associated with them.[4] Such analyses can show, for example, that a prolonged outage of a lock or a certain section of rail track can pose a greater risk to a country's economy than a global pandemic.

Hypothesis 2:
"There is a lack of systematic analyses of the risks of maritime transport chains"

However, the development of resilient logistics chains cannot be achieved by freight forwarders and transport companies alone. Maritime transport chains in particular are characterised by a high degree of complexity and a large number of stakeholders. These include not only the companies directly involved in transport, such as industry, shipping companies and freight forwarders, but also terminal and port operators as well as customs authorities. Maritime transport chains do not start and end in ports, but often extend far into the hinterland. Resilient maritime

[1] cf. UNCTAD: "Building resilient maritime logistics in challenging times", available online at: https://unctad.org/news/building-resilient-maritime-logistics-challenging-times

[2] cf. Lund, S. et al.: "Risk, resilience, and rebalancing in global value chains", available online at: https://www.mckinsey.com/capabilities/operations/our-insights/risk-resilience-and-rebalancing-in-global-value-chains

[3] see e.g. Notteboom, T. et al.: "Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008-2009 financial crisis", Maritime Economics & Logistics 23 (2021): 179-210, available online at: https://doi.org/10.1057/s41278-020-00180-5

[4] Assets in this sense comprise all elements necessary for the functioning of maritime transport chains. Apart from infrastructure, superstructure and means of transport, this also includes employees and software of the companies that take part in the transport chains.

transport chains, and in particular the development of emergency plans, therefore also require the cooperation of different groups of actors.

Hypothesis 3: "Resilient maritime transport chains require cooperation"

1. Economic significance of maritime transport chains

The outstanding importance of shipping for hinterland industries remains largely underestimated. In some countries, there are also structural reasons for this. In Germany, for example, responsibility for ports lies with the coastal states or port municipalities, while the federal ministry of transport is responsible for the development of state-owned waterway, rail and road infrastructure. Port development is thus carried out by the coastal states, making it necessary that investments in port infrastructure must be justified with regional economic growth. In these studies, only those jobs in the region that could not continue to exist without the port in question are considered as port-dependent.[5] Jobs which depend on maritime transport chains but do not belong to the examined region are therefore not systematically taken into account in the economic assessment of port development projects.

This research gap became particularly clear in a methodological study on the economic importance of German sea and inland ports[6], published in 2019 for the BMDV. In analogy to the aforementioned regional studies on individual port locations, the hypothetical "without port" case was also examined, with the federal study considering the case in which all German ports fail to perform. In this case the alternative possibilities, which often hindered the inclusion of jobs in the hinterland in regional studies, would only exist to a limited extent.

One result of the study was that German seaports secured around 1.2 million jobs in 2017 in exporting companies alone.[7] According to the research, the federal state with the most jobs secured by the German seaports was the landlocked southern state of Bavaria.

The study also showed that in order to secure maritime transport chains, it is not only necessary to have functioning ports, but also an efficient infrastructure in the hinterland. In addition, there is the role of ports for the import of raw materials, primary products and consumer goods, which was not taken into account in the study. In sum, seaports are not only vital for the coastal states, but for the entire German economy. At the global level, even landlocked countries depend on seaports and transit routes are crucial for their economies.

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[5] see e.g. Planco: "Untersuchung zu Arbeitsplätzen und Wertschöpfung sowie Einkommens- und Steuereffekten durch den Hamburger Hafen für das Jahr 2011", September 2013, availabler https://www.hamburg-port-authority.de/fileadmin/user_upload/PLANCO-Schlussbericht2011_final.pdf; ISL: "Beschäftigungseffekte der bremischen Häfen für das Jahr 2015: Kurzfassung", May 2017.

[6] ISL et al.: "Untersuchung der volkswirtschaftlichen Bedeutung der deutschen See- und Binnenhäfen auf Grundlage ihrer Beschäftigungswirkung", Bremen, available online at https://www.isl.org/de/node/638

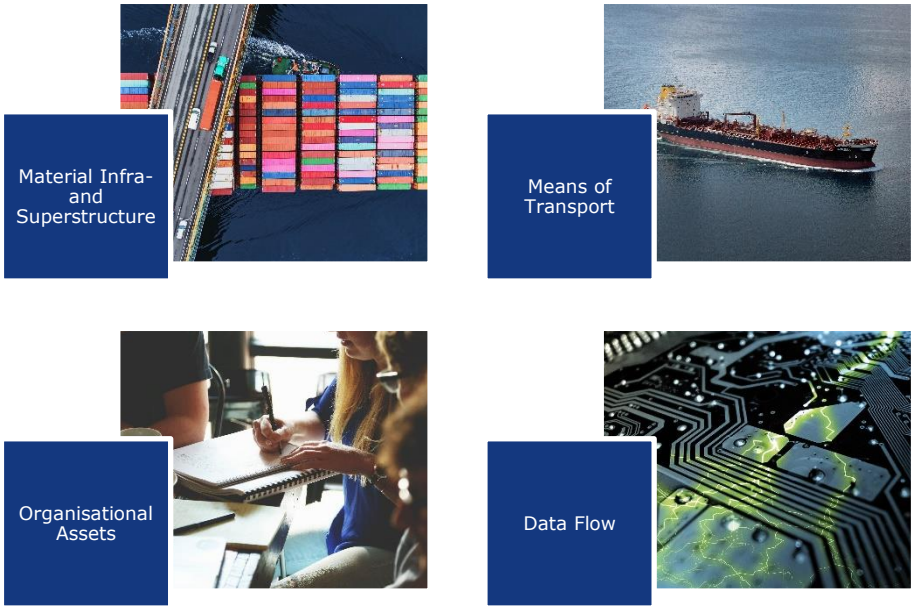
[7] Meaning without employment-securing effects from supplier companies

2. Extensive analysis of the risks regarding maritime transport chains

Studies on the resilience of maritime transport chains mostly focus on single risks (e.g. resilience against climate change or against cyberattacks). Such studies commonly include a detailed examination of risks arising from expected or possible trends as well as potential measures to increase resilience.[8]

In order to provide a comprehensive analysis of maritime transport chain resilience, we propose an approach that abstracts from possible risks and instead identifies the critical assets of the maritime transport chains. From a macroeconomic point of view, critical assets are those that are necessary for a considerable part of the transport volume. Four types of assets can be distinguished (see Figure 1).

Figure 1: Types of assets



Source: ISL

Many studies focus on the material supra- and infrastructure (e.g. in studies on the effects of climate change) and on the protection of data flows (cyber security). For the functioning of maritime transport chains, the means of transport (seagoing and inland vessels, freight trains and trucks) and organisational assets are also necessary. The latter include the employees, but also the financial assets of the companies that are necessary for the execution of transports.

[8] see e.g. Punt, E. et al.: "Beyond the dikes: an institutional perspective on governing flood resilience at the Port of Rotterdam", Maritime Economics & Logistics (2022), available online at: https://doi.org/10.1057/s41278-022-00234-w

Critical infra- and superstructure

In order to identify the most essential infra- and superstructure for maritime transport chains, it is necessary to determine those assets that account for a high share of the transport volume. A characteristic of feature of maritime transport chains is a concentration of traffic in seaports.

Figure 2: Schematic representation of maritime transport chains

Source: ISL

In general, the following assets can be critical infra- and superstructure:[9]

- Sea channels and straits that cannot be bypassed (total maritime traffic of the ports concerned, e.g. Bosporus for the Black Sea)
- Port access channels (total maritime traffic of the concerned port)
- Transport infrastructure within the port and connection to the trans-regional networks (the majority of a port's hinterland traffic)[10]
- Critical segments of the interregional transport networks (e.g. railway lines or water-ways with a high share of total traffic of one or more ports)
- Terminal infra- and superstructure (Terminals with a high share of the total volume)

For the vulnerability of maritime transport chains, the decisive factor is not for what reason parts of the infrastructure become inoperable, but above all how long the situation lasts. The blockage of the river Rhine following a shipping accident can usually be lifted again within a few days and thus only leads to delays in a limited period of time. However, if the navigability of the Rhine is restricted for a longer period of time due to low water levels, shifting the traffic to other modes of transport is unavoidable.

[9] Cf. UNCTAD: "Building Capacity to Manage Risks and Enhance Resilience: A Guidebook for Ports", p.3, available online at https://unctad.org/system/files/official-document/tcsdtlinf2022d3_en.pdf

[10] An example of a critical transregional track is the Bremerhaven-Bremen rail link, which is the only electrified rail connection for the port of Bremerhaven and which has already failed several times due to storms or spray (R. Müller and M. Dreyer: "Klimawandelfolgen für Bremer Unternehmen: Fokus Maritime Wirtschaft & Logistik: Fact Sheet", p.2, available online at: http://bresilient.de/wp-content/uploads/2020/01/BREsilient_FactSheet_MaritimeWirtschaft.pdf)

Means of transport

The vulnerability of maritime transport chains is also determined by the respective means of transports' share in the total volume. For example, the failure of a single truck involved in container transport only affects two standard containers (TEU) directly, whereas a large container ship can carry up to 24,000 TEU. Thus, when considering individual means of transport, seagoing vessels are particularly critical assets due to their bundling effect.

Even if the loss of individual ships can affect several hundred million euros of in terms of goods value, as seen in the case of the Felicity Ace fire in February 2022, this is not a worst-case scenario from a macroeconomic perspective. The maritime transport chains continue to function, as vessels are mobile assets and other ships can be deployed on the same route in the short or medium term.

A more serious threat than the failure of individual means of transport is therefore a shortage of certain means of transport. It can lead to situations where transport demand can no longer be satisfied. This can happen, for instance, through a sudden, unforeseen increase in demand, such as the increased demand for LNG tankers or barges for coal transport due to the lack of Russian gas deliveries in the summer of 2022. In container transport, such a shortage of freight space was observed when a strong growth in demand set in after the COVID-19 pandemic. A sharp increase in freight rates was the result.

Organisational assets

The organisational assets include above all the human and financial resources of the organisations involved in maritime transport chains. Here, too, the companies and institutions that account for a high share of the total transport volume are most critical from an economic point of view. These include not only those active in the seaports, such as port administrations or large terminal operators, but also shipping and hinterland transport companies. For example, some rail transport companies bundle high transport volumes.[11]

The financial stability of transport companies has been challenged time and again in the past by sudden drops in demand. The financial crisis of 2008/2009, for example, caused freight and charter rates to collapse and pushed shipping companies to the brink of bankruptcy. Despite the market turbulences, however, the transport of goods and thus the resilience of transport chains was never threatened for a prolonged period of time, as sufficient capacity was available for the comparatively weak demand for transport. However, a lack of financial resources in a phase of weak demand can lead to limited funds for expanding fleet capacity for future demand growth, which can lead to a shortage of transport assets in the upswing (see section "means of transport" above).

[11] For example, the rail transport company Metrans handles a very high share of the Czech containerised import and export volume (Source: ISL Containerverkehrsmodell Europa, 2022) and owns several hinterland terminals in the Czech Republic.

Human resources are of particular importance for the functioning of companies. For instance, prolonged strikes by container terminal workers in many parts of the world have repeatedly led to interruptions in transport chains and, in some cases, to traffic relocations. During the COVID-19 pandemic, high levels of sick leave as well as lockdowns in ports led to restrictions in terminal operations in many places. In some cases, this resulted in congestion and delays in handling, which then led to delays and instances of production halts.

A more protracted disruption of maritime transport chains could result from the shortage of skilled workers and personnel. In Europe and North America, for example, there is an increasing shortage of truck drivers. Similar developments can be seen in Europe with regard to barge operators and train drivers. From a macroeconomic perspective, there is urgent need for action as otherwise it may be impossible to meet hinterland transport demand in the coming years.[12] Strategies to combat the shortage of truck drivers include improving the profession's image, recruiting skilled workers from abroad and developing technical solutions such as (partially) autonomous driving.[13]

Another aspect that has come into focus through the participation of the state-owned Chinese shipping company COSCO in various container terminals around the world is the decision-making authority over critical assets of the maritime infrastructure. In general, the power of private companies to make decisions about critical assets can lead to macroeconomic aspects not being taken into account when decisions are made. In some cases, it is also feared that this authority can be used by companies or foreign governments as leverage against an economy.

Data Flow

The security of data flows connected to maritime transport chains has been a topic of discussion for many years under the term "cyber security". From an economic point of view, critical incidents are those that affect a particularly high transport volume and hinder the execution of transports over a longer period of time. Due to their bundling function, ports and maritime shipping companies are in the spotlight here.[14] Cyber-attacks have already been reported against shipping companies as well as ports and terminal operators, for example against Maersk[15] and several

[12] In maritime oversea shipping, such a general shortage of personnel is not yet in sight, as this is largely a global labour market and the salaries offered appear to be sufficient to find on-board personnel on the world market.

[13] see BMVI: "Fahrermangel im deutschen Straßengüterverkehr – Strukturelle Treiber und verkehrs-politischer Handlungsbedarf", February 2020, available online at: https://www.bmvi.de/SharedDocs/DE/Anlage/G/fahrermangel-deutscher-strassengueterverkehr.pdf?__blob=publicationFile; American Trucking Association: "Driver Shortage Update 2021", October 2021, availbable online at: https://www.trucking.org/sites/default/files/2021-10/ATA%20Driver%20Shortage%20Report%202021%20Executive%20Summary.FINAL_.pdf

[14] See above for comments on infrastructure and means of transport

[15] see "Maersk Line: Surviving from a cyber attach", Safety4Sea, available online at: https://safety4sea.com/cm-maersk-line-surviving-from-a-cyber-attack/

European oil terminals.[16] In the case of Maersk, the attacks led to weeks of disruption, also affecting Maersk's subsidiary APM Terminals. Prolonged outages or disruptions at major freight forwarders could also potentially affect a large number of companies in the hinterland.

In addition to terminal operators and port administrations, customs authorities are of great importance for maritime transport chains as well, as the majority of goods transported by sea are subject to customs duties and inspections. They cannot be transported onwards without customs clearance. The failure of the electronic customs declaration system affects not only one seaport, but the entire seaborne trade of a country. An exception exists in the European Union, where customs declarations can also be made in seaports located in other member states, so that, for instance, two different customs authorities can be used regularly for the same import flows. The particular importance of the electronic customs declaration – including protection against manipulation of data – has already been incorporated into the development of the systems. In Germany, for example, there is a predefined procedure for the case of disruption, which is laid down in the instructions for the ATLAS customs system.[17]

3. The importance of cooperation for the resilience of maritime transport chains

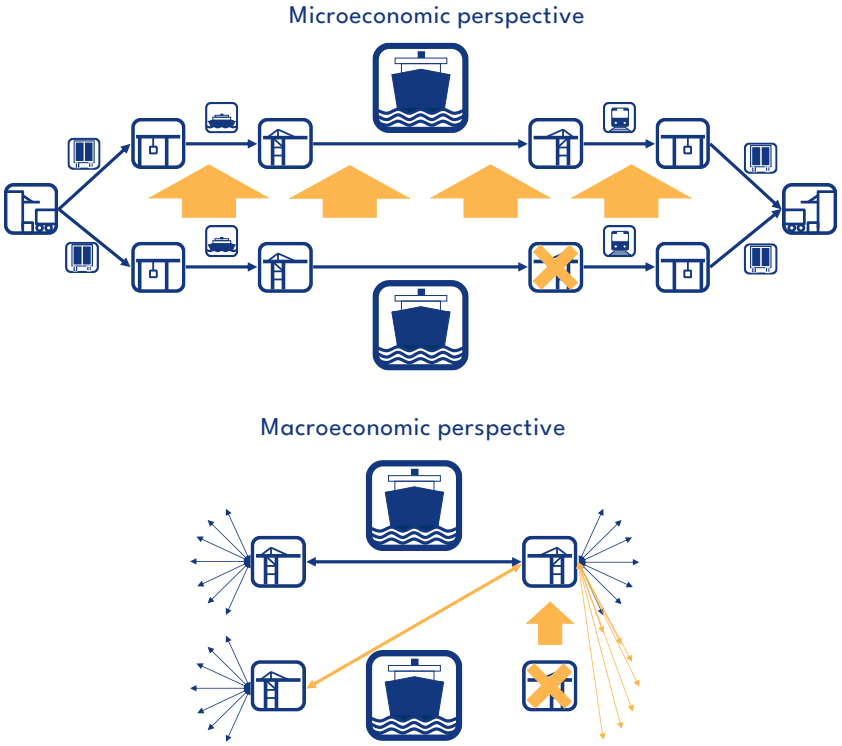
The protection of logistics chains against disruptions is not a new topic for importing and exporting companies and their forwarding agents. Especially for companies where supply interruptions can inflict high damages (e.g. in steel production), the security of supply and the protection against interruptions in production are of great importance.

Therefore, many companies use different supply routes at the same time, so that even in the event of serious disruptions in one of the supply chains, the supply continues to be secured. Ideally, the transport chains differ from the point of dispatch to the point of receipt, so that no disruption along the transport chain would affect both supply routes. At best, in the event of a disruption, the entire transport volume can be shifted to the still existing transport route (see "Microeconomic perspective" in Fig. 3).

[16] see "Rotterdam Port arms itself against a new cyber attack", available online at: https://www.klevenberg.com/rotterdam-port-arms-itself-against-a-new-cyber-attack/

[17] see "Verfahrensanweisung zum IT-Verfahren ATLAS", 8.2, available online at: https://www.zoll.de/SharedDocs/Downloads/DE/Links-fuer-Inhaltseiten/Fachthemen/Zoelle/Atlas/va_atlas.pdf?__blob=publicationFile&v=14

Figure 3: Disruptions of maritime transport chains from a micro- and macroeconomic perspective

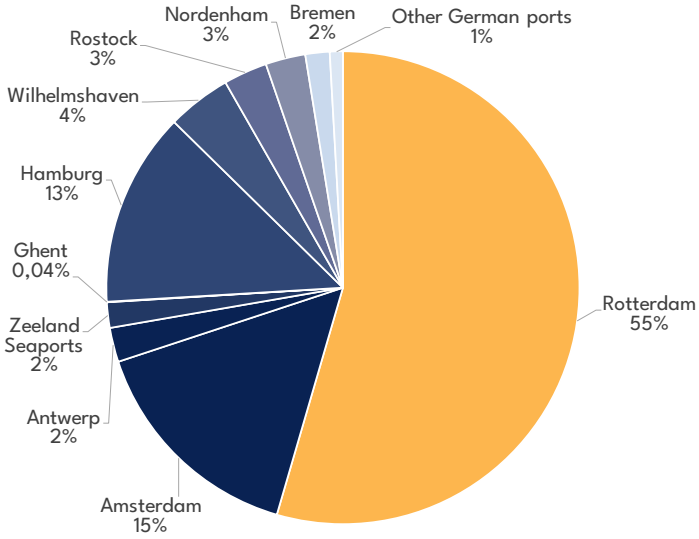


Source: ISL

One example for a particularly strong dependence on critical assets can be found in Germany's coal imports. In 2021, approx. 35 million tonnes of coal were imported into Germany by sea (see Fig. 4). More than half of this (approx. 19 million tonnes) was discharged in Rotterdam and was transported on to Germany by rail or inland waterway. A failure of the port could therefore not be compensated by other import ports.[18] The Rhine plays a particularly important role, too. Along with imports from other western ports, almost 19 million tonnes of hard coal were transported to Germany by inland waterway vessel in 2021 - a volume that in all likelihood could not easily be shifted to rail.

[18] The biggest coal importing port of Germany, Hamburg, imported a mere 5 million tons of coal in 2021.

Figure 4: German seaborne imports of coal by sea ports 2021



Source: ISL based on Eurostat (sea traffic) und German statistical office (inland waterway and railway)

In the case of particularly serious disruptions, it can therefore make sense to intervene in market mechanisms through regulation in order to keep the economic damage of a disruption as low as possible. For instance, priority was given to the transport of energy sources such as coal and mineral oil products in rail traffic after the sharp reduction in gas deliveries from Russia in August 2022.

The resilience strategies of the companies involved do not necessarily result in a consistent strengthening of macroeconomic resilience. The identification of critical assets described in section 2 shows that different groups of actors are responsible for these assets. The findings can be used to define the organisations and institutions to be involved in the development of emergency plans. Possible measures include, for example, the simulation of relocations, the enhancement of certain infrastructures beyond the regularly required capacity or the development of monitoring systems and cooperation agreements that can be used at short notice in the event of an incident. Cooperation between parties that regularly compete with each other could be achieved through reciprocal agreements. For example, different terminal operators in a port could reach agreements on how traffic can be shifted to other terminals in the event of a disruption at one terminal and how costs and revenues shall be distributed for the time of the disruption. Such arrangements could also be made between terminal operators in different ports of the same range in the event that one port is blocked completely. This would also involve freight forwarders and transport companies, which then have to reorganise the hinterland transports, taking into account the available capacities.

In future infrastructure planning, the results of incident simulations should become an integral part of the planning,[19] with greater importance attached to coordination at national and international level. Funding programmes to increase the resilience of maritime transport chains, but also research to identify and secure critical assets could contribute to increasing the resilience of maritime transport chains at national and international level. Research results on critical assets should be classified as confidential with regards to possible acts of sabotage.

Conclusion

Research on the resilience of maritime transport chains gained significant importance, especially after the outbreak of the COVID-19 pandemic. In most cases, the consequences of certain risks, such as future pandemics or climate change, are examined. However, threats to the resilience of maritime transport chains can result from a wide variety of developments and events. For example, the shortage of skilled workers may be a more lasting threat to their stability than individual extreme weather events.

These considerations lead us to call for the systematic investigation of assets that are critical to maritime transport chains, including infrastructures and superstructures, means of transport, organisational assets such as personnel and decision-making authorities, as well as the data flows required to perform the transports.

A look at the resilience strategies of manufacturing companies and their freight forwarders shows that in the event of disruptions, the main focus is on shifting to alternative transport routes. However, in the event of a failure of critical assets, bottlenecks will likely arise so not all transport demand can be accommodated. Uncoordinated competition for the remaining capacities could increase the economic damage. Therefore, contingency plans should be developed in cooperation with the relevant stakeholders to determine how to react in the event of the failure of certain assets. This also requires the cooperation of organisations that are in competition with each other in their daily business operations.

[19] see Weilant, S. et al.: "Incorporating Resilience into Transportation Planning and Assessment", RAND Corporation, 2019, available online at https://www.rand.org/content/dam/rand/pubs/research_reports/RR3000/RR3038/RAND_RR3038.pdf

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