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Comparing flexibility-based measures during different disruptions: evidence from maritime supply chains

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Received 10 February 2023
Revised 15 September 2023
15 December 2023
Accepted 8 January 2024

Abstract

Purpose – Severe disruptions to maritime supply chains, including port closures, congestion and shortages in shipping capacity, have occurred during the COVID-19 pandemic. This paper's purpose is to explore flexibility-based countermeasures that enable actors in maritime supply chains to mitigate the effects of disruptions with different characteristics.

Design/methodology/approach – Semi-structured interviews were conducted with shipping lines, shippers, forwarders and ports. Data on the COVID-19 pandemic's effects and countermeasures were collected and compared with data regarding the 2016–2017 Gothenburg port conflict.

Findings – Spatial, capacity, service and temporal flexibility emerged as the primary countermeasures, whilst important characteristics of disruptions were geographical spread, duration, uncertainty, criticality, the element of surprise and intensity. Spatial flexibility was exercised in both disruptions by switching to alternative ports. During the COVID-19 pandemic, ensuring capacity flexibility included first removing and then adding vessels. Shipping lines exercising service flexibility prioritised certain cargo, which made the spot market uncertain and reduced flexibility for forwarders, importers and exporters that changed carriers or traffic modes. Experience with disruptions meant less surprise and better preparation for spatial flexibility.

This research is funded by the Swedish Transport Administration through the project "The role of liner shipping for robust supply chains" and by the maritime collaboration platform Lighthouse through the pre-study projects "Shipping post-covid-19" and "Regionalised supply chains and the effects on shipping". In addition, the University of Gothenburg and Chalmers University of Technology have funded parts of the work through the joint Strategic Research Area Transport. The authors would also like to thank the interview respondents for generously sharing their experiences with supply chain disruptions.

International Journal of Physical Distribution & Logistics Management
Emerald Publishing Limited
0960-0035
DOI 10.1108/IJPDLM-02-2023-0075

Practical implications – Understanding how actors in maritime supply chains exercise flexibility-based countermeasures amid disruptions with different characteristics can support preparedness for coming disruptions.
Originality/value – Comparing flexibility-based measures in a pandemic versus port conflict provides insights into the important characteristics of disruptions and the relevance of mitigation strategies. The resilience of maritime supply chains, although underexamined compared with manufacturing supply chains, is essential for maintaining global supply chain flows.

Keywords Container shipping, COVID-19 pandemic, Disruption management, Flexibility, Port conflict
Paper type Research paper

1. Introduction

Disruptions in supply chains can severely impact companies' performance. Disruptive events affect various operations along a supply chain, including supply, production and transportation (Dolgui *et al.*, 2018). In a memorable case, it took the Port of Kobe two years to recover from the 1995 earthquake (Chang, 2000). Events with massive negative effects have included Hurricane Katrina (2006), the Fukushima earthquake (2011) and the container vessel *Ever Given*'s blockage of the Suez Canal (2021). However, the impacts of those events remained relatively moderate compared with the COVID-19 pandemic's effects, which induced a global labour shortage (Shen and Sun, 2021), changed consumption patterns, imposed constraints on shipping capacity and had various impacts across maritime routes, ports and their hinterlands (Notteboom *et al.*, 2021).

Whilst the literature on disruptions in general and the COVID-19 pandemic in particular describes mitigation strategies, the ways in which the characteristics of disruptions can be used to classify disruptions, understand their effects and develop mitigation strategies for future disruptions have received less focus. Supply chain disruptions, or their underlying events, can be classified according to severity and likelihood (Chang *et al.*, 2015), internal or external cause and duration (Macdonald and Corsi, 2013; Gaudenzi *et al.*, 2023). Low-frequency, high-impact events (Chang *et al.*, 2015; Knemeyer *et al.*, 2009), including the COVID-19 pandemic, are sometimes labelled "black swans", along with, for example, disruptions caused by climate change, financial crises, terrorist attacks and political conflicts (Kovács and Falagara Sigala, 2021). Although it is only somewhat possible to foresee when such an event will occur and what its magnitude will be, it remains important to learn from the events to prepare for the next global mega-disruption (Flynn *et al.*, 2021), including choosing and applying particular mitigation strategies. Along those lines, Chang *et al.* (2015) have highlighted a need to understand how a disruption's contextual variables influence the choice of mitigation strategy. Literature describing in-depth case studies of supply chain disruptions provides valuable knowledge regarding their circumstances and mitigation strategies but often focusses on one type of disruption. Systematically comparing disruptions can therefore expand current understandings of the characteristics of disruptions.

One important mitigation strategy is to mobilise flexibility-based capabilities as a countermeasure to manage a disruption's effects. In a recent review, Kumar and Singh (2020) have underscored the need to study how the dimensions of flexibility can vary according to various types of uncertainties. Flexibility allows organisations to withstand supply chain disruptions by configuring and reconfiguring existing resources (Peck, 2005; Gaudenzi *et al.*, 2023) and adapt to both expected and unexpected changes in the environment (Rao Tummala *et al.*, 2006). However, because those resources are not entirely owned by single organisations, it is important to understand how different actors in supply chains mobilise flexibility-based capabilities to mitigate disruptions. As Ivanov and Dolgui (2020) have argued, it is important to shift focus from how single supply chains handle disruptions to how intertwined supply networks do.

The purpose of this paper is to explore flexibility-based countermeasures that enable actors in maritime supply chains to mitigate the effects of disruptions with different characteristics. Briefly put, freight transport services take place within maritime supply chains, where actors include shipping lines, ports, forwarders, land transport providers, and companies that import and/or export goods. In that context, we analysed flexibility as an enabler of supply chain resilience.

Two disruptions were selected to compare the characteristics of different disruptions – the COVID-19 pandemic and the port conflict at APM Terminals in Gothenburg in 2016–2017 – the effects of which have been analysed by Rogerson *et al.* (2022), Gonzalez-Aregall and Bergqvist (2019), Svanberg *et al.* (2021) and Lindroth *et al.* (2020). Our purpose was operationalised in two research questions (RQs):

RQ1. In what ways have flexibility-based countermeasures used in the COVID-19 pandemic and a port conflict been different and similar?

RQ2. How can the differences be understood according to the characteristics of the disruptions?

The paper is organised as follows. Section 2 builds a frame of reference in which flexibility as a mitigation strategy and the characteristics of disruptions to supply chains are discussed. Section 3 describes the two disruptions compared in the paper and explains the research design. Findings are presented in Section 4 and discussed in relation to the literature in Section 5. The paper concludes with implications for theory and practice.

2. Frame of reference

This section outlines literature on the characteristics of disruptions and flexibility. In supply chains, disruptions are caused by unplanned and unanticipated events that disrupt the normal flow of goods and materials within the chain (Craighead *et al.*, 2007). Sheffi (2005) has divided such disruptions into six stages: preparation, disruptive event, first response, time of full impact, preparation for recovery, recovery and long-term impact. Whilst acknowledging that sequential structure, this paper focusses on disruptive events and their impact before recovery, including some aspects of preparedness. Flexibility-based measures employed by actors in maritime supply chains in response to different disruptions at that stage are explored.

2.1 Characteristics of disruptions

The nature of a disruption is an important dimension that influences how the disruption can be managed and can vary significantly. Delimiting the focus to our empirical setting, this paper pays specific attention to low-frequency, high-impact events, including natural disasters.

Before an event, companies can prepare to some extent, as restaurants in the United States have been observed to do a few months before the annual hurricane season (Ergun *et al.*, 2010). A reason for preparation is that the *probability* of some events can be assessed (Lam and Su, 2015), either quantitatively through simulations based on historical data about natural disasters (Knemeyer *et al.*, 2009) or qualitatively based on the perceptions of the relationships between ports and unions and the degree of union control (Berle *et al.*, 2011). Likewise, such events are *detectable* and not *surprising*, at least on short time horizons (Ergun *et al.*, 2010). By contrast, some events are unpredictable and surprising, including the lightning that ignited a fire at a microchips supplier that netted Ericson a loss of US $400 million due to its lack of a contingency plan (Norrman and Jansson, 2004).

A disruptive event can have different *causes*, often classified as man-made or natural (Macdonald and Corsi, 2013). Man-made events include political conflicts, wars, theft, sabotage and terrorism (Urciuoli *et al.*, 2014). Because they involve decision-making, their *duration* may be short (e.g. terrorist attack) or long (i.e. war). Natural disasters, by contrast, typically do not last long but may cause a disruption that persists for years afterwards

(Macdonald and Corsi, 2013). For some events, including hurricanes, a relationship between the duration and time to recovery has been observed (Verschuur *et al.*, 2020). The severity of events can vary as well (Macdonald and Corsi, 2013; Dirzka and Acciaro, 2022). As a case in point, all earthquakes are not of the same magnitude, nor do they always occur in locations that affect supply chains.

The *intensity* of man-made events may also fluctuate due to decision-making, as witnessed in a port conflict (Rogerson *et al.*, 2022) and the recent disruption of grain supplies from Ukraine. In the aftermath of such events, links and nodes in a supply chain might operate on an on-and-off basis. Furthermore, an event's intensity can mean that a certain node works only in part, such as when a hurricane affects ports (Verschuur *et al.*, 2020). The *location* of a disruption is of particular importance as well. The vessel *Ever Given*'s six-day blockage of the Suez Canal, in disturbing various supply chains (Wieland *et al.*, 2023), made headlines in 2021, whereas *Ever Forward*'s 35-day grounding in the Chesapeake Bay on the US East Coast in 2022 was far less covered because it affected only companies with cargo on board. Location also includes geographical spread (Craighead *et al.*, 2020), for it can affect a single node or a larger geographical area encompassing multiple ports (Verschuur *et al.*, 2020).

In some cases, the relationship between an event and the time until its effects take hold is remarkably clear. For instance, an earthquake might damage the physical infrastructure of a port within minutes, if not seconds (Chang, 2000). However, in the case of the COVID-19 pandemic, it was unforeseeable how the disease would spread. In parallel, various types of *uncertainty* emerged regarding when and how companies would be affected by the disruption (Gunessee and Subramanian, 2020).

An event that disrupts a critical node or link can *propagate* other disruptions and have devastating effects across an entire system (Scheibe and Blackhurst, 2018). A disruption in a port, for instance, may have amplified effects for the regional or the global transport network (Verschuur *et al.*, 2022). Along those lines, Verschuur *et al.* (2021) have found large disparities in the geographical and sectoral impacts of the COVID-19 pandemic. The severity of a disruption can be assessed in different ways, including in terms of breadth, depth and duration, all in relation to the focal firm (Hughes *et al.*, 2022). Table 1 lists various characteristics of disruptions mentioned in the literature.

Table 1.
Characteristics of disruptions and their categorisation

Characteristic	Supporting literature
1. Preparation	
Element of surprise or detectability	Ergun *et al.* (2010) and Norrman and Jansson (2004)
Probability	Berle *et al.* (2011) and Lam and Su (2015)
2. Disruptive event	
Cause	Macdonald and Corsi (2013) and Urciuoli *et al.* (2014)
Duration	Macdonald and Corsi (2013) and Urciuoli *et al.* (2014)
Intensity	Rogerson *et al.* (2022) and Verschuur *et al.* (2020)
Magnitude	Dirzka and Acciaro (2022) and Macdonald and Corsi (2013)
Location of disruption, including geographical spread	Craighead *et al.* (2007), Rogerson *et al.* (2022) and Verschuur *et al.* (2020)
Criticality (i.e. node, network and link)	Craighead *et al.* (2007) and Wieland *et al.* (2023)
3. Impact	
Time to effects	Chang (2000)
Uncertainty	Hughes *et al.* (2022) and Gunessee and Subramanian (2020)
Severity	Hughes *et al.* (2022) and Macdonald and Corsi (2013)
Propagation	Scheibe and Blackhurst (2018) and Verschuur *et al.* (2021, 2022)

Source(s): Table by authors

2.2 Flexibility as a mitigation strategy

The literature on supply chains describes various strategies for managing disruptions, including proactive risk management before and disruption management during and after events (Sheffi, 2005; Blackhurst *et al.*, 2005; Macdonald and Corsi, 2013). Strategies can be classified as passive, internal, collaborative or integral (Revilla and Saenz, 2017) and can involve adding capacity or inventory, using redundant suppliers and/or increasing responsiveness, flexibility and/or capability (Chopra and Sodhi, 2004).

The *Oxford Advanced Learner's Dictionary* defines *flexibility* as "the ability to bend easily without breaking". In manufacturing and supply chains, it often means "the ability of a system to change or react with little penalty in time, effort, cost or performance" (Martínez Sánchez and Pérez Pérez, 2005). Most of the literature on flexibility focusses on the manufacturing industry (e.g. Slack, 1987, 2005; Oke, 2005) and supply chains from a broad perspective (Martínez Sánchez and Pérez Pérez, 2005). Even so, the need to study the concept from the standpoint of freight transportation is also emphasised in the literature (Naim *et al.*, 2006; Mason and Nair, 2013a, b).

By extension, Dubey *et al.* (2021) have defined *organisational flexibility* as "the ability of organisations to deploy resources quickly, efficiently and effectively in response to sudden changes in the market conditions", which establishes flexibility's clear link with resilience. Flexibility is an inherent part of resilience (Peck, 2005) that allows organisations and supply chains to adapt to both foreseen and unforeseen changes in the environment (Rao Tummala *et al.*, 2006; Gaudenzi *et al.*, 2023) and navigate high degrees of uncertainty (Manuj *et al.*, 2010).

The classification of flexibility-based measures differs depending on the context. In manufacturing systems, flexibility-based measures are classified as pertaining to new product flexibility, mix flexibility, volume flexibility and delivery flexibility (Slack, 2005). In supply chains, by comparison, flexibility-based measures can span production and product development and include the flexibility of logistics, the supply base and suppliers (Jin *et al.*, 2014). However, in both contexts, the interface between inbound and outbound logistics activities – in a word, transportation – is obvious. That interface relates to Oke's (2005) categorisation of internal and external flexibility, with the former meaning actions related to the manufacturer's internal systems and the latter meaning actions visible to external parties and that define the firm's perceived performance.

Departing from the literature on transport services, Naim *et al.* (2006) have introduced nine internal and five external dimensions of flexibility in freight transport that they subsequently applied to the ocean carrier industry during a global economic crisis and collapse in demand (Mason and Nair, 2013a, b). More recently, Rogerson *et al.* (2022) applied those transport flexibility-based measures in a similar context but refined the list by referring to logistics flexibility-based measures listed by Jafari (2015). Although the duality is similar, the descriptions of flexibility-based measures for transportation operations differ significantly because they are performed with a service mindset and within service supply chains. A selective, non-exhaustive list of transport flexibility-based measures is provided in Table 2 together with their brief definitions.

Most of the definitions in Table 2 were developed by Naim *et al.* (2006) and take a general perspective on transportation. However, the ones used by Mason and Nair (2013a, 2013b) and Rogerson *et al.* (2022) were adapted to the shipping context examined in their respective studies. For example, *temporal flexibility* was adapted to reflect the ability of rearranging the timing of delivery (Rogerson *et al.*, 2022). Hence, different case settings call for the adaptation of flexibility-based measures that are observed.

Although the literature addresses flexibility in manufacturing, logistics and supply chains in general, how flexibility resonates in service supply chains, including transport chains, has yet to be explored. Recently, Rogerson *et al.* (2022) studied the impacts of a disruption in terms of flexibility and capacity during a port conflict in a maritime supply chain. By extension, this

Transport flexibility-based measure	Brief definition	Supporting literature
1. Internal flexibility		
Mode flexibility	Ability to provide different modes of transport	Naim *et al.* (2006), andMason and Nair (2013a, 2013b)
Fleet flexibility	Ability to provide different vehicle types and/or vehicles	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Vehicle flexibility	Ability to configure vehicles to address diverse demand	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Node flexibility	Ability to introduce new nodes or terminate old nodes in a network	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Link flexibility	Ability to establish new links in a network	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Temporal flexibility	Ability to balance the provision of transport infrastructure with its use	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Routing flexibility	Ability to accommodate variations in traffic demand	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Capacity flexibility	Ability to accommodate different routes	Naim *et al.* (2006), Rogerson *et al.* (2022) and Mason and Nair (2013a, 2013b)
Communication flexibility	Ability to manage different types of information	Naim *et al.* (2006) and Mason and Nair (2013a, 2013b)
Organisational flexibility	Ability to align the labour force, including changes to tasks and the number of workers	Rogerson *et al.* (2022)
Horizontal inter-organisational flexibility	Degree to which the use of infrastructure can be coordinated between users (e.g. alliances)	Mason and Nair (2013a, 2013b)
Speed flexibility	Ability to accelerate or decelerate transport	Mason and Nair (2013a, 2013b)
Service flexibility	Ability to buffer service levels by adjusting delivery windows	Mason and Nair (2013a, 2013b)
Mobility flexibility	Ability to switch vessels to other geographic areas	Mason and Nair (2013a, 2013b)
Ownership flexibility	Ability to utilise outsourced agents to minimise risk of asset exposure due to under-utilisation (e.g. in charter agreements)	Mason and Nair (2013a, 2013b)
2. External flexibility		Naim *et al.* (2006)
Product flexibility	Range of and ability to provide new transport services	Naim *et al.* (2006)
Mix flexibility	Range of and ability to change the transport services being provided	Naim *et al.* (2006)
Volume flexibility	Ability to accommodate variations in transport demand	Naim *et al.* (2006)
Delivery flexibility	Ability to change delivery dates	Naim *et al.* (2006)
Access flexibility	Ability to provide extensive distribution coverage	Naim *et al.* (2006)
Supply flexibility	Ability to shift or use multiple production sites and/or supply sources	Rogerson *et al.* (2022)

Source(s): Table by authors

Table 2.
Definitions and categorisations of transport flexibility

paper builds on their flexibility-based countermeasures in maritime supply chains by adapting them to similar strategies deployed by shipping lines during the COVID-19 pandemic.

3. Method and cases

To realise this paper's purpose, a multiple-case study approach was followed that involved comparing the responses of organisations in Sweden to two disruptions: the port conflict in Gothenburg in 2016–2017 and the COVID-19 pandemic. Case studies can be powerful examples (Siggelkow, 2007), investigate contemporary phenomena (Eisenhardt, 1989), provide in-depth understandings of complex situations (Dubois and Gadde, 2002), reveal rich information (Flyvbjerg, 2006) and furnish background information regarding the cases examined (Dyer and Wilkins, 1991).

Steps for the comparative case study were designed in a sequential manner that allowed longitudinal data collection and analysis given that the two disruptions occurred at different points in time. When the first disruption occurred, the COVID-19 pandemic was neither known to nor expected by the authors. However, the occurrence of the second disruption enabled a comparative research design that allowed the same inquiry within a subset of the initial sample whilst accommodating the differences resulting from the different nature of the second disruption. Both pandemics and port conflicts are examples of events with high impacts but differ in geographical scope. Whereas the COVID-19 pandemic had enormous effects on global supply chains and unprecedented global impact, the effects of the Gothenburg port conflict remained mostly local.

3.1 The Gothenburg container port conflict, 2016–2017

The Swedish labour market is characterised by strong labour unions engaging in well-organised collective bargaining with employer organisations and strikes are relatively uncommon. For ports, however, there had been a long-term dispute with two competing labour unions that culminated in 2016–2017 with a lockout and strike at APM Terminals in Gothenburg, the only Swedish container port allowing direct calls by deep-sea vessels. The events prompted not only the closure of container port operations for a few days but also long, distressing periods of significantly reduced capacity. Analysing the effects of the conflict, Gonzalez-Aregall and Bergqvist (2019) have described mitigation strategies that involved moving cargo by truck or rail, thereby pinpointing the importance of hinterland transport surrounding the port. In similar work, Lindroth *et al.* (2020) have examined the mitigation strategies for the disruption used in the fashion retail industry, whilst Svanberg *et al.* (2021) have reported rerouting vessels to other ports and its effects on port efficiency. For example, amid reduced capacity in Gothenburg, containers were transshipped in other main ports using feeder services to smaller ports or truck, rail and ferry combinations to reach Sweden. More recently, Rogerson *et al.* (2022) have analysed problems with capacity related to the port conflict and the flexibility-based countermeasures applied. Ultimately, an agreement between both labour unions and the employer organisation was signed in 2019, and the current situation at the port is reasonably calm.

Gothenburg is far from an exception because port workers are prone to labour strikes. Lam and Su (2015) have identified strikes and natural disasters as the two principal reasons for disruptions in Asian ports, whilst Farris (2008) has described conflicts at US West Coast ports. The critical role of ports in maritime supply chains also emerges when they close for reasons other than conflicts in the labour market. On that count, Childerhouse *et al.* (2020), for instance, have described strain on the logistics network for ports and facilities whilst modelling a yearlong closure of a port in New Zealand.

3.2 COVID-19 pandemic

The COVID-19 pandemic's effects on container shipping are well-known and represent a rare example of freight transport being widely covered in mass media. In short, lockdowns prolonged the Lunar New Year holiday in China in early 2020, followed by a mid-March decline in global shipping demand due to the lack of raw materials, parts and workers, along with trade restrictions and closed manufacturing facilities. Shipping lines, meanwhile, responded with blank sailings and increased scrapping (Notteboom *et al.*, 2021). Volumes recovered unexpectedly fast, however, primarily due to government stimuluses and shifts from spending on travelling and dining to buying consumer products online that spurred the need for increased shipping capacity (Altuntas Vural *et al.*, 2021). As waves of COVID-19 followed, dealing with infections entailed isolation, port changes and cancellations (Altuntas Vural *et al.*, 2021). Container shipping capacity, particularly in ports, became scarce, and as freight rates soared, near-shoring strategies were considered to increase resilience (Notteboom *et al.*, 2021; Van Hassel *et al.*, 2022). As restrictions were lifted and capacity came to match demand, freight rates sunk gradually during 2022 and reached pre-pandemic levels in 2023.

3.3 Data collection

Semi-structured interviews were conducted to collect data from multiple actors in maritime supply chains in order to ensure a supply network perspective. The same interview guide was used in all interviews, albeit with minor adaptations for each case. The interview guide focussed on three areas: effects of the disruption, countermeasures taken and lessons learnt. The guide was developed with reference to Macdonald and Corsi (2013) for themes, Blackhurst *et al.* (2005) for effects and Tang (2006), Van der Vorst and Beulens (2002) and Lam and Su (2015) for countermeasures. Initial interviews were conducted, and the phrasing of questions was discussed with other researchers before the guide was finalised. Not focussing on specific types of flexibility in the guide meant that the interviews were not limited to capturing preconceived aspects of the disruptions in question.

The supply chain actors to be interviewed were identified based on indications that they were influenced by the disruptions. The focus of the inquiry, however, was their ability to facilitate waterborne freight transport services. Thus, in both cases, the actor most affected by the disruption and its ability to facilitate that objective was selected as the point of departure. In Case 1 (i.e. the port conflict), ports were the point of departure, whilst the focus in Case 2 (i.e. the COVID-19 pandemic) was shipping lines that were heavily affected by the disruption. Early interviews during COVID-19 as part of a different study that focussed on another shipping segment indicated limited effects on Swedish ports also for container cargo flows. Following the interview with a Swedish port in this study, it was deemed sufficient with only one port interviewed in Case 2. In both cases, different actors representing maritime supply chains were sampled, but only the data explaining the flexibility-based countermeasures taken to continue facilitating waterborne freight transport services were considered, in line with this paper's purpose. Thus, in Case 2, data saturation with certain actor types (e.g. shippers) was achieved relatively early, whereas further data elaboration was needed with other types of actors (e.g. shipping lines). The interviewees were selected for their knowledgeability regarding the disruption's effects and countermeasures in each company, although their titles varied depending on the organisation.

Altogether, 29 companies were interviewed in Case 1 and 13 in Case 2, including companies importing and exporting goods, shipping lines, freight forwarders and port-terminal operators (Table 3). Lasting approximately 1–1.5 h, the interviews in each case were conducted from March to September 2018 and from November 2021 to January 2022, respectively, by one to three researchers, with one designated interview leader.

Actor type	Company interviewed		Role of interviewee(s)	Years in the industry*	Years in the company*	Time
Case 1 (Port conflict, $n = 29$)						
Company importing goods	1-ImpA	Fashion retailer	Import and export manager	10	4	May 2018
	1-ImpB	Retailer (sports)	Logistics director	17	17	Sep 2018
	1-ImpC	Manufacturer (textiles)	Purchasing manager	10	10	Jun 2018
	1-ImpD	Small textile trading company	Finance	29	29	Apr 2018
	1-ImpE	Small fashion retailer	1. Owner and 2. Purchasing manager	1: 23 2: 11	1: 23 2: 11	May 2018
	1-ImpF	Manufacturer (automotive)	Inbound logistics	13	3	Mar 2018
	1-ImpG	Small supplier (automotive)	Managing director	20	20	Apr 2018
	1-ImpH	Retailer	Head of transport	32	16	Apr 2018
	1-ImpI	Retailer (electronics)	Logistics manager	14	3	Sep 2018
	1-ImpJ	Large company (home furnishings)	Purchasing and transport manager	30	30	May 2018
	1-ImpK	Retailer (grilling equipment)	Logistics manager	24	14	Jun 2018
Company exporting goods	1-ExpA	Manufacturer (forestry)	Director logistics of supply chain management	28	28	May 2018
	1-ExpB	Manufacturer (automotive)	Manager of outbound transport	28	25	Apr 2018
	1-ExpC	Manufacturer (chemical)	Global logistic development and sourcing manager	25	10	Apr 2018
	1-ExpD	Small manufacturer (machinery)	Managing director	>5 years	>5 years	Apr 2018
	1-ExpE	Manufacturer (bearings)	Manager of outbound transport	38	38	Mar 2018
	1-ExpF	Manufacturer (forestry)	Senior vice president of logistics	32	10	May 2018
Port-terminal operator	1-PortA	Large Swedish port	Chief operations officer	28	23	May 2018
	1-PortB	Swedish port, container capability	Business support manager	8	5	May 2018
	1-PortC	Swedish port, container capability	Marketing manager	16	16	May 2018
	1-PortD	Swedish port, container capability	Operations manager	10	3	Sep 2018
Shipping company	1-LineA	Shipping company	Managing director	20	5	Jun 2018

(*continued*)

Table 3. Companies interviewed

Actor type	Company interviewed		Role of interviewee(s)	Years in the industry*	Years in the company*	Time
	1-LineB	Shipping company	1. Managing director Scandinavia 2. Trade manager	1: 23 2: 28	1: 23 2: 11	Jun 2018
	1-LineC	Shipping company	Regional manager, feeder and network in Scandinavia	30	30	May 2018
	1-AgenA	Shipping agent	1. Managing director 2. Import and equipment manager	1: 25 2: 30	1: 21 2: 10	May 2018
	1-AgenB	Shipping agent	General manager	32	14	Jun 2018
Freight forwarder	1-FwdA	Freight forwarder	Country head of ocean freight, overland and logistics	28	2	Apr 2018
	1-FwdB	Freight forwarder	Head of import	17	17	May 2018
	1-FwdC	Freight forwarder	Head of ocean freight	18	14	Jun 2018
Case 2 (i.e. COVID-19 pandemic), $n = 13$						
Company importing goods	2-ImpA	Fashion retailer	Import and export manager	11.5	5.5	Jan 2022
	2-ImpB	Retailer (sports)	Logistics director	18.5	18.5	Dec 2021
Company exporting goods	2-ExpA	Manufacturer (forestry)	Logistics director of supply chain management	30	30	Jan 2022
Port-terminal operator	2-PortE	Swedish port, container capability	Operations manager	17.5	7	Nov 2021
Shipping company	2-AgenA	Shipping line agency	Managing director	26.5	22.5	Jan 2022
	2-LineB	Shipping line	1. Key client director 2. Country sales manager 3. Area head of key clients, Scandinavia	1: 14.5 2: 23.5 3: 13.5	1: 3 2: 11.5 3: 7.5	Jan 2022
	2-LineC	Shipping line	Regional manager, Scandinavia	31.5	31.5	Jan 2022
	2-LineD	Shipping line	Operations director	13.5	2.5	Jan 2022
	2-LineE	Shipping line	Country manager	28.5	4.5	Jan 2022
	2-LineF	Shipping line	Director, Scandinavia	22	4	Jan 2022
Freight forwarder	2-FwdB	Freight forwarder	Head of ocean freight	16.5	15	Jan 2022
	2-FwdC	Freight forwarder	Head of ocean operations, Sweden	19.5	15.5	Jan 2022
	2-FwdD	Freight forwarder	Head of ocean freight	11.5	3.5	Jan 2022

Note(s): *At the time of the interviews (i.e. mid-2018 and beginning of 2022)
Source(s): Table by authors

Table 3.

3.4 Data analysis

All interviews were audio-recorded and transcribed before being analysed using NVivo R1.6. Using that software enabled a systematic analytical process that allowed practical screening for data saturation. Two authors analysed the data and discussed it with the author team several times; in the case of disagreement, a third author was invited to read the interview in question, which was followed by a discussion to reach a consensus. As the analysis proceeded, the findings were discussed by all authors, as well as with industry representatives, to confirm the interpretations of the data (Marshall and Rossman, 2006). The measures of research quality that guided the study, adapted from Ellram (1996), Halldórsson and Aastrup (2003) and Strauss and Corbin (1998), are presented in Table 4.

The data were coded in three steps: open coding, code matching and selective coding (Strauss and Corbin, 1998). In the first step, an iterative open coding process with constant comparison was followed. In a simultaneous process, previously coded data were continuously revisited as new codes emerged or certain patterns were observed. Any clear pattern between the dataset of effects and the dataset of countermeasures was recorded.

In the second step, the open codes from countermeasures were matched with previously reviewed flexibility-based measures in transport from the literature. That code-matching process revealed relationships between countermeasures and their similarities and differences with previously reviewed flexibility-based measures. The process also provided axial codes that were later used to construct higher-order categories.

In the third step, several flexibility-based measures were observed to be used either simultaneously or interdependently. Those relationships guided the selective coding process that allowed the grouping of flexibility-based measures into four higher-order categories (i.e. spatial, capacity, temporal and service flexibility). That categorisation is unique for maritime supply chains focussed on service provision and was necessary, given that literature on flexibility dimensions focusses heavily on manufacturing but neglects the service setting.

Last, the empirical examples of flexibility in the COVID-19 pandemic were listed next to those of the port conflict and compiled in tables listing similarities and differences. Those flexibility-based measures were subsequently analysed in relation to characteristics of disruptions reviewed in the literature (Table 1) and observed in the two cases. We coded the data for all characteristics listed in Table 1, but a few had only limited data, possibly owing to the type of disruptions studied, in which it may be easier to identify the time until effects occur and propagate other disruptive events. The difference may also indicate that other

Measure	Application in the study
Construct validity	- Discussion of the findings with industry representatives and other researchers - Multiple sources of data and multiple actors in maritime supply chains
Reliability/dependability	- Use of a standardised interview guide to allow comparison between the cases - Use of data analysis software for a structured case database - Audio-recording and transcription of interviews
Internal validity/credibility	- A multi-stage data coding and analysis process - Comparison and refinement of data with reference to the literature - Discussion of findings with uninvolved practitioners and researchers
External validity/ transferability	- Detailed description of the two cases - Former study on a similar sample - Multiple sources of data and multiple actors in maritime supply chains

Source(s): Table by authors

Table 4. Measures of research quality

methods, including mathematical modelling, are better suited to studying certain characteristics – for instance, propagation, as studied by Ivanov and Dolgui (2021). In particular, our study elucidated how six characteristics related to flexibility-based measures: geographical spread, duration, the element of surprise, uncertainty, intensity and criticality. The findings regarding flexibility and characteristics of the disruptions were cross-checked to identify connections.

4. Comparing flexibility-based countermeasures during the pandemic with the port conflict

This section compares flexibility-based countermeasures used and thus available during the Gothenburg port conflict and the COVID-19 pandemic, with particular focus on shipping lines but also other actors that affected the shipping lines (e.g. port capacity) and, in turn, how other actors were affected by flexibility-based countermeasures exercised by shipping lines (e.g. changing traffic mode). Thereafter, the implications of the characteristics of disruptions on flexibility are described for the two cases.

4.1 Flexibility as a countermeasure

The coding process resulted in four major groups of flexibility-based countermeasures – spatial, service, temporal and capacity – defined based on the different measures that they represent. First, *spatial flexibility* is mobilised when a disruption to the supply chain blocks the physical transport infrastructure and thus creates bottlenecks therein. For that reason, changes are needed with respect to loading and unloading locations, preferred nodes and links. Second, *capacity flexibility* involves the ability to expand or shrink the available space used to provide the transport service. Capacity is not always flexible, particularly when managed by strict contracts; however, there are ways to inject flexibility into maritime supply chains by utilising short-term contracts, adding other vehicles or vessels and/or lifting restrictions on authorised transport unit types. Third, *temporal flexibility* relates to the temporal dimension of the transport service, which is an important measure of transport performance. A blockage or disruption puts pressure on the temporal dimension, but that impact can be mitigated by expediting or slowing the service provision and by adapting the timing of required information on shipments. Furthermore, some effects from supply chain disruptions can be mitigated by changing the components of the service provided. In the cases that we examined, changes to different components of the transport service were observed. Fourth and finally, *service flexibility* can relate to the service provider, the type of vehicle enabling service provision, the prioritisation of services provided amongst different customer segments and the means of service provision.

Regarding flexibility-based measures applied in the Gothenburg port conflict versus the COVID-19 pandemic, spatial flexibility was exercised in both disruptions by changing ports. Given simultaneous problems in many ports during the pandemic, lower spatial flexibility was indicated, but shipping lines were also able to move vessels between routes. Compared with the port conflict, capacity flexibility-based measures during the pandemic were often described, including removing and adding vessels; however, overall capacity flexibility was lower and quickly reached the capacity ceiling. Although temporal flexibility existed for shipping lines in both disruptions (e.g. delaying deliveries), it was challenging for more actors during the pandemic than during the port conflict. For example, shipping lines expressed being negatively influenced by decisions made by ports. Concerning service flexibility, shipping lines adapted their service offerings more during the pandemic, meaning higher service flexibility, than during the port conflict. Even so, flexibility was lower for other actors such as forwarders, importers and exporters who changed carriers or traffic modes due to longer contract duration requirements. Details of the comparison of flexibility-based measures are presented in Table 5.

4.2 Flexibility and characteristics of disruptions

The two cases provided insights into the implications of characteristics of disruptions for flexibility-based countermeasures, which are described below and summarised in Table 6.

4.2.1 Geographical spread. The disruptions differed in that the COVID-19 pandemic had global effects, whereas the port conflict was primarily a local problem. First, the geographical spread had implications for flexibility insofar as shipping lines' *spatial flexibility* and *capacity flexibility* during local disruptions can draw upon resources (e.g. ports, empty containers and routes) from other geographical areas. 2-LineF explained how "Normally, you have one port coming into problem then you can go to [another port] [. . .] or [a third port] or [a fourth port]. But this time [during the COVID-19 pandemic], all three ports had, like, labour shortages". Regarding empty container movements, 2-LineF explained: "China again resurfaced back with really strong volumes out and then the need for containers to go back empty again rather than going up to Scandinavia for export [. . .] a container from Rotterdam, it takes you 4 weeks to turn it around going up to Sweden to get paper products. Those 4 weeks, you can almost get to [. . .] Asia and then earn much more money". With global spread, shipping lines needed to add capacity such as vessels and containers. Second, the geographical spread meant that shipping lines' *service flexibility* was focussed regionally and intercontinentally, respectively, for example, in the prioritisation of certain trade lanes.

4.2.2 Duration. Both disruptions had long-lasting effects: the port conflict's for approximately 2 years and the COVID-19 pandemic's for even longer. Regarding the port conflict, interviewees indicated that changes that required time before mitigating effects were of little interest during a short-term disruption. In disruptions with long-term effects, however, decisions that required more time warranted attention. During the COVID-19 pandemic, for example, shipping lines added new capacity (i.e. containers and vessels) and thus dared to exercise *capacity flexibility*, even though it would take time before the new capacity could be deployed. Shipping lines' decisions about investments during the pandemic were also facilitated by their accumulation of capital. As the pandemic's effects lingered, some shipping lines also began demanding long-term commitments from forwarders, importers and exporters, which effectively lowered their *spatial* and *service flexibility*. For short-term commitments, by contrast, changes could be made more easily, as 2-LineB reported: "Many trade lanes [. . .] to Africa, for instance, they are very exposed to short-term cargo [. . .] the ones where we started to try to optimise, where we started to take out. We didn't remove all capacity [. . .] but maybe on a bi-weekly basis".

4.2.3 Uncertainty. In both disruptions, uncertainty regarding the effects was common. In the port conflict, it was even uncertain whether individual companies would be affected. Such uncertainty can help to explain difficulties in applying flexibility-based measures. For example, if the effects of disruptions on ports remain uncertain, then planning and implementing *spatial flexibility* (e.g. using other ports) is more difficult. Uncertainty regarding effects also influenced initial expectations during the COVID-19 pandemic that flows of goods would remain low. Shipping lines with previous experience of the financial crisis a decade earlier thus exercised *capacity flexibility* by reducing capacity. Subsequently increasing capacity took time and some decisions, including about scrapping, were irreversible. In addition, 2-LineF claimed to be "quite conservative in ordering new vessels because of uncertainty about the future fuel".

During the port conflict, the *spatial flexibility* exercised by shipping lines to offload cargo in many ports induced uncertainty for forwarders and haulers regarding which port the import containers would arrive in. 1-FwdC described how the information about ports to be used

Flexibility-based measure[1]	Disruption	Flexibility applied	Empirical examples
Spatial - Making or coping with changes to other nodes and using multiple nodes and rerouting	COVID-19	Moving vessels between routes	Shipping lines moved vessels between routes. 2-LineB: "We are keeping our capacity as it is, but we're flexing it instead. We're moving capacity from not-so-crucial trade lanes over to the more crucial trade lanes". This could involve, e.g. reducing the frequency to certain ports. 2-LineB: "We didn't remove all capacity; we're still moving cargo to Africa, for instance, but maybe on a bi-weekly basis". For flexibility in fleet deployment and routing, shipping lines wanted to keep some short-term contracts with importers and exporters
	Both	Changing to other ports	2-LineF described a normal procedure to be able to change ports, including if there is a problem in one port. Adding extra port calls increased costs. A prerequisite of changing ports was flexibility for other actors to reroute inland transport
Capacity - Making or coping with changes to quantities (e.g. to meet transport demand)	COVID-19	Adding and/or removing vessels, including chartering Postponing scrapping and maintenance	Shipping lines first removed capacity. 2-LineB: "We and many other shipping lines started to basically scrap some of our older vessels. We started to take out some of the loops to make sure that we were balancing our capacity to what was needed. This is what you normally do in a situation like that of crisis. Because if you just keep the capacity out there, you also create a downward spiral of your own economy [. . .]. Many of them [our decisions] were impossible to reverse, because when you first signed up a vessel for scrapper or sold the vessel for scrapping, you can't get it back. I don't know exactly how many, but quite a big number [of vessels] in the entire industry were scrapped during that period or sold for scrap during that period. So that's also one of the reasons why the overall capacity went down." Later vessels were added—for example, for chartering or procuring. However, there were simply not enough vessels. 2-LineC described how the shipowners had the upper hand during the COVID-19 pandemic. Chartering vessels was done for a longer period, which led to risk. 2-LineC: "Three years? Hmm. Not very good but I might have to accept that. [. . .] If I don't take it, then maybe my competitor takes it". Container capacity could also be sourced from a third party To maximise each vessel's utilisation, shipping lines shifted vessels of different sizes between routes
	Port conflict	Using feeders instead of deep-sea vessels	Shipping lines were able to adapt to the container volumes—for instance, by using feeders instead of deep-sea vessels. 1-LineB: "During the conflict, we often did not run a mainliner but three or four feeder vessels"

(*continued*)

Table 5.
Comparison of flexibility-based measures in the COVID-19 pandemic versus the Gothenburg port conflict

Flexibility-based measure[1]	Disruption	Flexibility applied	Empirical examples
	Both	Changing order sizes; using trucks other than container chasses	Ports operated on very high container yard density. The following example, experienced by 2-LineC, highlights the lack of capacity flexibility in ports: "We had a feeder just before Christmas. [. . .] They know we come every Sunday. They [the port] said, 'Sorry, there weren't as many German import containers picked up on Friday and Saturday as expected'. They didn't have any spots on the terminal where they could place the containers that we had on board" Even if order sizes were changed in both disruptions, during the COVID-19 pandemic shipping lines decreased flexibility for forwarders, importers and exporters to make changes to volumes (e.g. ask for guarantees of volume). 2-FwdB described that the allocation in some cases was reduced: "We couldn't overperform". 2-FwdC described that cancelling bookings became more difficult, or at least costly, due to the need to pay depending on how late a booking was withdrawn. The spot market was available but costly To cope with container shortage, trucks other than container chasses were used for inland transport
Temporal - Making or coping with changes to timing of deliveries	COVID-19	Changing the timing of port calls	The shipping lines emphasised a lack of temporal flexibility in relation to ports. One example concerns how the lack of lift capacity in Yangshan 2 months earlier resulted in a 2-day delay into the Port of Hamburg, which affected subsequent transport to Sweden. 2-LineC: "The cargo I was supposed to keep with my vessel on Monday only came in on Wednesday. [. . .] Shall I wait and then destroy my schedule [. . . or] leave, but then my vessel is only half full?" Furthermore, whilst Swedish ports can receive calls during the day, overtime costs extra The shipping lines also reported changing speeds and not slow steaming as usual. 2-LineB: "During that period, we actually sped up to sail at maximum speed"
	Port conflict	Leaving containers in European ports	Shipping lines delayed the delivery of containers and left them longer in European ports. In the COVID-19 pandemic, European hub ports were congested
	Both	Shifting cargo flows in time	Shipping lines delayed cargo. 2-LineB explained how they, during the COVID-19 pandemic, "were preparing for looking over blanking potential, how we can delay cargo, how we can spread it out" Importers and exporters placed orders earlier. During the COVID-19 pandemic, forwarders indicated that volumes moved 1–3 months earlier

(*continued*)

Table 5.

Flexibility-based measure[1]	Disruption	Flexibility applied	Empirical examples
Service - Making or coping with changes to other or multiple carriers; to the range, variety and mix of products; and to other modes	COVID-19	Prioritising certain vessels, trade lanes and less-than-container loads (LCL)	The shipping lines reported that European ports prioritised deep-sea over feeder vessels. The flexibility exercised by ports influenced how shipping lines could deliver to and from Swedish ports, especially feeder operators Shipping lines had the flexibility to prioritise certain trade lanes. Certain routes were more lucrative for shipping lines; for example, containers were positioned to Asia following increased revenue in the Asia–Pacific region. At the time of the interviews (i.e. January 2022), the intra-Asia market was booming. 2-Line A: “Export-wise, if you’re talking today from Europe to the Far East and we’re talking rates down to US $1,500 to $2,000 [. . .] for intra-Asia shipment, they pay up to $3,000 back from Shanghai or to the Philippines. So you can imagine when we come in with a container from Sweden, [. . .] a rate of $2,000 that even don’t cover the feeder leg in Asia." The use of Less-than-container load (LCL) became a more interesting product. 2-FwdB says: “We have shipped a lot more LCL cargo” and 2-FwdC explains: “To secure the departures, because LCL is pre-booked”. Shifting to LCL exemplifies flexibility for the forwarders and for the shipping lines that were able to adapt their offerings to more profitable LCL business
	Port conflict	Backup solutions; prioritising import/export; opening/closing ports	During the port conflict, backup solutions were sought by importers and exporters. For instance, 1-ImpI described not wanting to “to put all your eggs in one basket, one shipping line”, whilst 1-ExpA “wanted an alternative port”. During the COVID-19 pandemic, asking for backup plans did not appear to be popular. 2-FwdB: “An alternative carrier, [. . .] they don’t go to this port. They go to that port” During the port conflict, shipping companies opened or closed ports for booking and prioritised certain containers

Table 5. (*continued*)

Flexibility-based measure[1]	Disruption	Flexibility applied	Empirical examples
	Both	Shifting to road, rail and air; using alternative carriers	In both disruptions, there was flexibility for forwarders, importers and exporters to change traffic mode—for instance, during the COVID-19 pandemic, by switching to rail or air from Asia to Sweden. 2-FwdD described a dramatic increase in rail transport and moving exceptionally large volumes from China to Sweden by rail: "When the market went bananas, I think rail was something that you were considering paying for". During the port conflict, there were more alternatives for land transport between Europe and Sweden; during the pandemic, however, such flexibility was reduced by limited intercontinental capacity. For instance, 2-FwdB said about rail across China that "There's been capacity, but it's been booked". It should be noted that flexibility regarding mode affects costs and environmental performance; for instance, 2-ImpB did not opt for air for reasons of sustainability In both disruptions, there were examples of changing to other types of transport. For instance, 2-ExpA changed to break-bulk and 1-ExpF to RoRo; however, in the COVID-19 pandemic, other segments, including RoRo and RoPax, faced problems that only containers faced during the port conflict In both disruptions, forwarders, importers and exporters sought out alternative carriers. 2-FwdD: "You talked to anyone". However, in the COVID-19 pandemic, flexibility was reduced for those actors as shipping lines introduced longer contracts. Shopping around was often futile because shipping lines prioritised long-term customers. 2-LineB: "We were more or less going out to them and saying take it or leave it". For shipping lines, longer contracts meant that they were protected from forwarders', importers' and exporters' changing carriers

Note(s): [1]Definitions developed from Rogerson *et al.* (2022)
Source(s): Table by authors

Table 5.

often changed: "It will be shipped tomorrow, but to Malmö instead of Gothenburg [. . .], but it did not come to Malmö [. . . but went] back to the continent again or [was] unloaded in Norway or unloaded in Denmark. Nobody really knew".

Furthermore, importers, exporters and forwarders were uncertain whether the spot market would provide the needed capacity, because shipping lines used *service flexibility* to prioritise certain cargo. To reduce that uncertainty in combination with the uncertainty regarding freight rates, importers, exporters and forwarders made longer-term commitments both regarding contract length and volumes than before. 2-FwdD explained feeling as though some shipping lines were exploiting the opportunity to generate profits on the spot market: "Why should we honour a deal with a low rate [. . .] when we can get maybe 10 times more on a spot basis? The customers who had a contract at a low rate were left on the gate with no container, no shipment, and they [ocean carriers] focused much more on spot [market]".

4.2.4 Criticality. Both disruptions highlight how shipping is sensitive in critical ports: in the port conflict because APM Terminals Gothenburg handles a large share of Swedish container volumes and during the COVID-19 pandemic due to reliance on European hub ports and Asian ports for imports to Europe. Difficulties with replacing the affected ports indicated low *spatial flexibility* and affected the available *capacity flexibility.* To some degree, shipping lines were able to use *spatial flexibility* to mitigate the effects of the lack of *capacity flexibility* in ports, whereas replacement capacity was insufficient. Thus, as critical ports were disrupted and delays occurred during transport, other ports needed to be relatively elastic, which facilitated *spatial flexibility*. As 1-PortC reported, "Problems that occur at that end, in the big ports, regarding keeping their times, [. . .] often the Swedish ports have to help to solve those problems. The shipping line says, 'We can't come on Thursday. We have to come on Saturday instead'". At the same time, shipping lines' use of *spatial flexibility* boosted *capacity flexibility* in key trade lanes during the COVID-19 pandemic, which 2-LineB described as "moving capacity from not-so-crucial trade lanes over to the more crucial trade lanes".

4.2.5 The element of surprise. The port conflict was not a surprise. There were signs indicating the escalation of the dispute, and APM Terminals Gothenburg even announced that it would be closed. In the COVID-19 pandemic, by contrast, the geographical spread was a surprise. As 2-LineB stated, "We expected this [COVID-19] to be somewhat retained in that area". However, in time, port closures and congestion came to be expected. According to the interviewees, it is generally easier for shipping lines to implement *spatial flexibility* when disruptions are expected. 2-LineD explained: "The worst situation is [. . .] late surprises. [. . .]. If a vessel is loaded in Antwerp, it's sailing to Sweden, and the three days will increase to four days due to bad weather coming unexpectedly. Then we will have a problem [. . .] have to order the gangs in the ports the day before". In both disruptions, having experienced disruptions over time made the interviewees less surprised and better prepared to implement *spatial flexibility*. 2-LineD said, "I think that we are not necessarily more pre-warned [. . .] I just think that we have now internally developed a mechanism as to how do we then react, how do we divert vessels, how do we very quickly identify Shanghai, here in this case, to be an alternative, and how do we divert off fleet. And, actually, the more you start to operate on that basis, the quicker you get to be able to operate on that when something happens".

4.2.6 Intensity. During both the port conflict and the COVID-19 pandemic, the level of intensity varied. Compared with disruptions with a significant, potentially fixed impact followed by slow recovery, the port conflict entailed punctual fluctuations, whereas the pandemic entailed waves of them. In the pandemic, new waves of infections broke out that prompted new port closures, amongst other things. Whilst capacity in Asian ports fluctuated depending on local outbursts of COVID-19, capacity utilisation in European hub ports, along with capacity utilisation on vessels, remained high over time; thus, for actors other than shipping lines, the effects appeared to have stabilised at a high intensity. Such high intensity affects the degree to which shipping lines require *capacity flexibility*. In the port conflict, one shipping line described replacing a trans-ocean vessel with feeder vessels during a short but extremely intense period, which assumed the availability of enough feeder vessels. However, sufficient resources to recover lost ground were unavailable during such a long period of high intensity. Moreover, with stably high intensity, *service flexibility* for shipping lines rose but weakened for customers with less flexibility to change carriers. As 2-LineB reported, "We were more or less going out to them and saying take it or leave it". An overview of implications of characteristics of disruptions on flexibility-based countermeasures is provided in Table 6.

Characteristics of disruption	Flexibility-based countermeasure type	Implications of characteristics of disruptions on flexibility-based countermeasures	
Geographical spread		*Local*	*Global*
	Spatial flexibility	Potential to bypass the problem	Many ports and routes affected
	Capacity flexibility	Capacity available elsewhere	Increased importance of adding capacity
	Service flexibility	Regional focus	Intercontinental focus
Duration		*Short*	*Long*
	Spatial flexibility	Reactive change of nodes Relative ease of making changes with short-term commitments	Less flexibility with long-term commitments
	Capacity flexibility	Reallocation of capacity	Daring to invest in adding new capacity
	Service flexibility		Less flexibility with long-term commitments
Uncertainty		*Low*	*High*
	Spatial flexibility	Reactive change of nodes Relative ease of planning rerouting	More difficult to plan amid uncertainty regarding how ports would be affected
	Capacity flexibility	Relative ease of planning the use of resources	Misjudgement of the situation Reliance on past experience (e.g. irreversibility of scrapping) Reluctance to add capacity amid uncertainty about such capacity should be designed
	Service flexibility		Shipping lines' prioritisation of certain cargo, which made the spot market uncertain even though carriers could reap greater benefits
Criticality		*Low*	*High*
	Spatial flexibility	Alternatives available	Less spatial flexibility Increased difficulty with replacing critical ports
	Capacity flexibility	Alternatives available	Capacity flexibility boosted by spatial flexibility by shifting resources to where they were most crucial
Surprise		*Expected*	*Unexpected*
	Spatial flexibility	More spatial flexibility by planning, having mechanisms in place, diverting vessels and identifying alternatives	Reactive use of spatial flexibility
	Temporal flexibility		Lack of flexibility in ports to receive vessels on short notice
Intensity		*Stable (high)*	*Fluctuating*
	Capacity flexibility	Extra capacity needed over time Relative ease of assessing the needed capacity	Max capacity needed during a short period Reduced relevance of adding capacity
	Service flexibility	Forced acceptance amongst customers	Reduced ability to change carriers Interest in using other modes

Source(s): Table by authors

Table 6. Implications of characteristics of disruptions on flexibility-based countermeasures

5. Discussion

With reference to the literature, this section discusses our findings regarding flexibility-based countermeasures taken during the COVID-19 pandemic and the Gothenburg port conflict and further considering various characteristics of disruptions. This paper contributes to the maritime literature on disruptions such as the COVID-19 pandemic, particularly actors' insights into decisions made by shipping lines and how those decisions influenced and were influenced by other actors. On that topic, whereas Notteboom *et al.* (2021) and Sun and Zhang (2022) have described how shipping lines managed the COVID-19 pandemic relatively well, this paper reveals the pandemic's extended impacts on other actors in maritime supply chains, including increased costs and delays. The perspective of shipping lines extends the literature's attention to port congestion (Kent and Haralambides, 2022) and ports' attempts to mitigate it during the pandemic (Mańkowska *et al.*, 2021).

5.1 Flexibility-based countermeasures

Whilst Rogerson *et al.* (2022) have focussed on a relatively large set of actors when describing flexibility-based countermeasures, this paper shows how such countermeasures can be applied by shipping lines and how their effects spread across various actors in maritime supply chains. It also offers a new categorisation of flexibility-based countermeasures – spatial, capacity, service and temporal – that departs from the literature by focussing on service supply chains. That focus is important because the resilience-based countermeasures of service supply chains in general and of maritime supply chains in particular have either been underexamined or studied from the perspective of manufacturers. Therein, flexibility has mostly been analysed from the perspective of production capacity, supply capacity or flexibility in the supply base, all of which are less relevant in maritime supply chains. That being said, maritime supply chains are prone to significant disruptions. A bottleneck occurring in those chains has rippling effects on global manufacturing supply chains, which depend on the uninterrupted, on-time flow of goods around the world. For that reason, an in-depth understanding and special categorisation of flexibility from the perspective of maritime supply chains can help with grasping nuances that are specific to those chains and their actors.

Our results corroborate Dirzka and Acciaro (2022) findings showing the forms of flexibility available to shipping lines when the maritime industry has needed to withstand network disruptions. Similar to Dirzka and Acciaro (2022), we observed how shipping lines have used service rescheduling and cancellation, although we have described those approaches in terms of flexibility. Flexibility clearly exists but also comes at a cost, whether in terms of money, time, or both. As described by Rožić *et al.* (2022), freight rates increased dramatically during the COVID-19 pandemic. A striking similarity between the pandemic and the port conflict was that some actors presented positive financial results. Those positive results, notably for shipping lines and haulers, relate to the mismatch between available capacity and demand. Although that dynamic may be viewed as good disruption management – for instance, that shipping lines managed the pandemic much better than the financial crisis a decade earlier (Notteboom *et al.*, 2021 – that view is problematic when considering the entire network (Ivanov and Dolgui, 2020; Rogerson *et al.*, 2022), because capacity is in fact not sufficient for the demand. Per our findings, other actors had to pay the price for shipping lines' limited capacity flexibility (e.g. not finding the desired space for their cargo), whilst the shipping lines were able to increase freight rates and profit from the lack of capacity. Thus, limited flexibility was not necessarily adverse for the shipping lines. That finding agrees with what Chua *et al.* (2022) found: that reducing capacity was an effective strategy for the carriers that they studied but sacrificed the level of service provided to shippers and end customers.

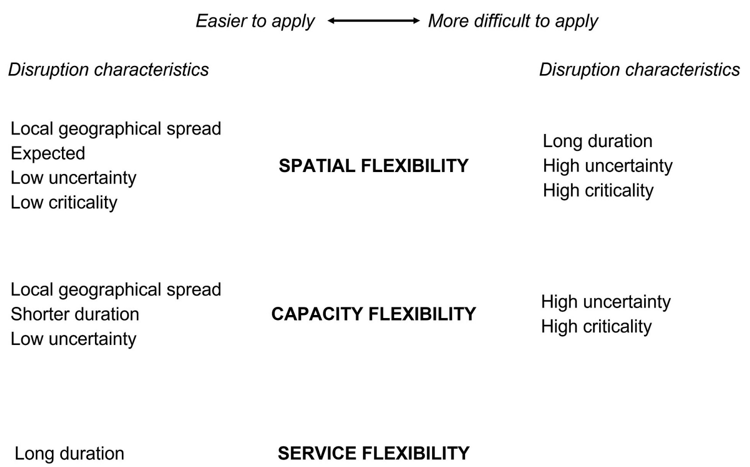
This paper, by adopting the lens of flexibility, can expand current understandings of decisions underlying changes in traffic flows that have been described in the literature, including variations in maritime traffic for container vessels in major trade lanes during the initial months of the COVID-19 pandemic (March *et al.*, 2021). Another example concerns spatial flexibility, which relates to the connectivity of the container port network and choice of hub, as mapped by Yap and Yang (2022). The paper also nuances understanding of problems with positioning empty containers put forward by Toygar *et al.* (2022).

In the vast amount of literature on supply chain disruptions, the dominant perspective is that of transport buyers and their mitigation of supply chain disruptions – for example, by redesigning supply chains, including by incorporating the concept of the plastic response (Hughes *et al.*, 2022) or resilience in managing products, partnerships and processes (Cohen *et al.*, 2022). However, whereas that literature takes a long-term perspective, this paper contributes by offering in-depth descriptions of mitigation strategies during disruptive events and in the acute phase of their impacts with a particular transport provider focus.

5.2 Flexibility considering various characteristics of disruptions

This paper illustrates how characteristics of disruptions in supply chains may influence flexibility in maritime supply chains, particularly by drawing on examples from and comparing the port of Gothenburg conflict and the COVID-19 pandemic. On that count, six characteristics were particularly revealing: geographical spread, duration, uncertainty, criticality, the element of surprise and intensity. The ease of applying various flexibility-based countermeasures given various characteristics of disruptions is illustrated in Figure 1.

Spatial flexibility is easier to apply when the disruption has a local geographical spread, is expected, has low uncertainty and has low criticality. If a disruption is less surprising (i.e. more expected), then companies can have mechanisms in place to divert vessels and identify alternatives. Meanwhile, if uncertainty is low, then it is easier to plan rerouting, and if criticality is low, then alternatives are available. Beyond that, a local geographical spread typically means that problems can be bypassed. That understanding can be compared with what Gunessee and Subramanian (2020) found in the local disruption of flooding in Thailand in 2011: that sourcing flexibility existed such that companies could shift to facilities in



Source(s): Figure by authors

Figure 1. Ease of applying various flexibility-based countermeasures given various characteristics of disruptions

alternative locations. Conversely, *spatial flexibility* is relatively difficult to apply when a disruption has a long duration, high uncertainty and high criticality. In our study, both disruptions had long durations and thus needed long-term flexibility. That result aligns with Cariou and Notteboom (2022) finding that whilst supply chain disruptions in the United States of America due to natural disasters (e.g. hurricanes) resulted in limited possibilities to substitute ports, the longer disruption of the COVID-19 pandemic involved lockdowns and slowdowns at major ports.

If a disruption has high uncertainty, then it remains unclear how ports will be affected, which makes it more difficult to plan. Meanwhile, the high criticality of the node and network (Craighead *et al.*, 2007; Knemeyer *et al.*, 2009) means increased difficulty with finding alternatives. That understanding can be compared with the conclusion of Guerrero *et al.* (2022) that large ports and small but densely interconnected ones better resisted the disruption of the COVID-19 pandemic. In particular, densely interconnected ports may imply particularly high *spatial flexibility*. Verschuur *et al.* (2020) have described barriers to substituting ports, including contracts and specialised equipment, which consequently reduce spatial flexibility. Dirzka and Acciaro (2022) have described the flexibility available to shipping lines in terms of service rescheduling and cancellation despite the global pandemic but have also highlighted that a disruption occurring in various locations instead of emanating from a specific geographical cluster, such as during the pandemic, would have been more challenging. Meanwhile, Pais-Montes *et al.* (2023) found that hub ports were more easily substitutable and that large ports were more often cancelled during the pandemic. Reducing the element of surprise (Azadegan *et al.*, 2021) of the effects of disruptions can also allow shipping lines to develop strategies for best utilising spatial flexibility (e.g. diverting vessels and identifying alternatives).

Capacity flexibility is easier to apply when a disruption has a local geographical spread, a shorter duration and low uncertainty. A local spread means that capacity is available elsewhere, whilst a short duration implies that capacity can be re-allocated. Even so, it should be noted, as stated by Verschuur *et al.* (2020), that spare capacity in potential substitute ports may be less if the disruption is not local. When uncertainty is low, it is easier to plan the use of resources. Conversely, *capacity flexibility* is more difficult to apply when there is high uncertainty and high criticality. We found a reluctance to add capacity if it remained uncertain how that capacity should be designed. The case studies illustrate that high uncertainty makes decision-making more difficult regarding use of flexibility (e.g. misjudging the situation), such that shipping lines initially reduced capacity, as described by Notteboom *et al.* (2021). In that vein, this paper contributes by describing how increasing the capacity again was less straightforward. Also, given high criticality, there were fewer alternatives available. Furthermore, both cases involved insufficient replacement capacity. Even so, a global geographical spread, a long duration and high intensity produced favourable conditions for adding capacity. As pinpointed by Dirzka and Acciaro (2022), the COVID-19 pandemic was a unique, unprecedented disruption, whereas mitigation in recurring disruptions can be easier. In rare disruptions, it is difficult to motivate overcapacity in scarce resources (e.g. ports, vessels and containers) and may also be difficult to anticipate warning signs that aid the detection of disruption (Bradley, 2014). Both disruptions also entailed varying degrees of fluctuating intensity, which for flexibility means that peak capacity is needed that will not be needed later.

Service flexibility is easier to apply when a disruption has a long duration. When durations were long, we found that long-term commitments and contracts became more prevalent, meaning that it became more difficult for shipping lines to make changes between trade lanes. With high uncertainty, shipping lines could prioritise certain lanes and take advantage of the situation. Although service flexibility existed for shipping lines, it was less available to other actors. Conversely, Özcan and Yumurtacı Hüseyinoğlu (2023) have reported that 3PLs used a flexibility strategy during the COVID-19 pandemic that involved switching to RoRo and intermodal transportation to overcome uncertainties, including port congestion. In our study, such flexibility was lowered due to the scope of the disruption, which influenced many transport segments.

The implications of characteristics of disruptions on temporal flexibility were relatively few. Although the global spread of COVID-19 resulted in less temporal flexibility, fewer possibilities to store containers and lower vessel utilisation, it was possible to change speed due to the scale of the disruption, and the extreme revenues footed the hefty bills for fuel. Furthermore, there were interdependencies between the various types of flexibility. Therefore, the effects of characteristics of disruptions on temporal flexibility can be somewhat expected. For example, Verschuur *et al.* (2020) have highlighted that production recapture (i.e. increasing work in ports to move delayed cargo) depends on the duration of the disruption.

6. Conclusions

The disruptive effects of the COVID-19 pandemic on supply chain management have been thoroughly studied. This paper contributes to literature on the topic by comparing the disruption of the pandemic with the disruption of a port conflict and how they similarly and differently affected maritime supply chains. Our framework, focussing on flexibility-based measures available to shipping lines and effects on surrounding actors, outlines spatial, capacity, temporal and service flexibility. Furthermore, the paper discusses important characteristics of disruptions in relation to flexibility. The COVID-19 pandemic was characterised by global spread, a long duration, uncertainty regarding effects (e.g. spread and duration), varying intensity and, initially at least, the element of surprise. From a Swedish perspective, it has also illustrated the critical role of Asian and European hub ports. Meanwhile, the Gothenburg port conflict was a local disruption with effects lasting two years that was characterised by a high level of uncertainty (e.g. regarding who was affected and duration), varying intensity, not unexpected and displayed the criticality of a specific Scandinavian port.

Similarities between the disruptions include spatial flexibility in terms of switching to alternative ports. Differences, by contrast, included the global scale, for instance, in shipping lines prioritising certain trade lanes. Needing to add capacity during the COVID-19 pandemic may be explained by the disruption's global scale and long duration. This paper has also highlighted that high uncertainty can lead to decisions that are irreversible, including scrapping and ordering new vessels, as done during the pandemic.

It has been debated whether the COVID-19 pandemic was a black swan event (Parameswar *et al.*, 2021), even though there have been pandemics before. Regardless of label, the pandemic has highlighted the difficulty for many actors of foreseeing some types of disruptions. On that topic, a managerial implication of this paper is that understanding the characteristics of major disruptions and their relationship to flexibility-based measures can help in planning for future disruptions. This paper highlights flexibility for shipping lines in particular, and our results offer guidance to them regarding applying flexibility-based countermeasures in different types of disruptions with different characteristics and how they can focus their resources. Such flexibility could promote the effective use of existing capacity whilst providing a high level of service to customers. In particular, shipping lines can use the identified characteristics (e.g. criticality of the node) and our illustration of how they affect possibilities to apply various flexibility-based measures in order to create scenarios with different configurations to stress test their operations as well as prepare for and improve their sense-making of potential disruptions in the future. For example, shipping lines could assess difficulties in applying adequate flexibility-based measures in a scenario with high uncertainty and large geographical spread.

This paper also contributes to literature on disruptions in transportation networks where many supply chains may be affected. Drawing on the experiences of several actors, it clarifies how decisions by one actor influence the other actors – for example, how shipping lines are influenced by decisions at ports and how importers are influenced by the decisions of shipping lines. Therefore, other actor groups in maritime supply chains, including forwarders, importers, exporters and ports, can apply the offered understanding of how shipping lines act to their scenarios. Understanding system-wide implications can also benefit authorities, including civil contingency agencies, in understanding resilience; indeed, they can incorporate our findings regarding countermeasures used during the COVID-19 pandemic and a port conflict in their planning for future disruptions. Because national authorities act mostly domestically, our findings can improve their understanding of how their domain is affected by events in other parts of the world and which actor groups they can coordinate with in implementing countermeasures.

In both disruptions, human resources were central and uncertainty related to recovery followed from their centrality. Along those lines, Rogerson *et al.* (2022) have noted uncertainty regarding when to return cargo through the Port of Gothenburg. By comparison, recovery from an earthquake or hurricane may involve a relatively linear return to capacity, which makes decisions regarding when to return more straightforward. We therefore propose that describing disruptions as human-centric is useful and should be further explored in future research. Doing so would complement categorisations of causes, at least in Macdonald and Corsi (2013), as being human-made or natural. From another angle, whereas this paper presents two cases of disruptions with different characteristics to understand the nuances in flexibility-based countermeasures, additional research might extend the focus on the characteristics of disruptions and identify patterns in flexibility in not only maritime supply chains but also in larger logistics networks. Last, given the importance of acknowledging the different responses needed to navigate different crises, further scholarly attention to the variety of responses to disruptions is needed as well.

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