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Research article

Towards sustainability in the port sector: The role of intermediation in transition work

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ABSTRACT

Intermediation has received substantial attention from transition scholars. Intermediaries play important roles in configuring, brokering, and facilitating transition efforts and operate in different parts of socio-technical systems. Their node position between transport and energy systems makes port authorities a potentially crucial intermediary in transitioning the many different sectors that intersect in ports. Ports are increasingly orienting their environmental endeavours towards energy issues and are pressured to reduce their global emissions. This paper explores intermediation in ports and investigates how intermediation connects to transition work. Based on a quantitative survey among 96 Norwegian ports, we find that ports engage in intermediation to varying extent, and that intermediation is associated with progressive transition work. The study complements previous research on intermediaries by conceptualising and quantitatively measuring transition work, allowing us to explore in what ways ports rely on intermediation in their sustainability endeavours.

1. Introduction

Scholars seeking to understand sustainability transitions have increasingly turned to the role of actors in pursuing or obstructing systemic change. Among the actor roles most vigorously investigated is the intermediary role (e.g., Stewart and Hyysalo, 2008; Mignon and Kanda, 2018; Kanda et al., 2020). Intermediaries are typically placed centre-stage in orchestrating, facilitating and brokering among actors involved in transition work. Given their positioning in-between various actor-networks, intermediaries are as such instrumental in transition work, i.e. pursuing joint goals and actions promoting sustainability transitions, by contributing to different types of intermediary activities. Thus, the intermediary role could significantly shape the scope and content of transition work, and thereby produce more and less effective courses towards transformation.

Existing literature has yet to elaborately conceptualise transition work. As discussed further in Section 2, we consider transition work to hold both a processual dimension and an outcome dimension; the former among other referring to vision and network building, strategising, and planning, and the latter referring to specific results and impacts on sustainability. To increase our understanding of transition work and its connection to intermediation we turn to a sector hitherto largely overlooked by transition studies, namely the port sector.

Ports have received increasing attention for their negative impacts on GHG emissions, noise and emissions to water (e.g. Lozano et al., 2019; Acciaro, 2015; Lawer et al., 2019; World Ports Sustainability Program, 2018). However, ports are in a unique position to

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manage the negative externalities produced both within and beyond port area boundaries (Langenus and Dooms, 2018). This position rests on ports being important nexuses for transport and energy production, harbouring literally and figuratively a heterogenous set of users and suppliers in transport, energy production, and the many industries and business sectors whose supply and value chains depend on functional port operations. This node position above all allows ports to operate at the intersection between the port, sea transport, and hinterland transport domains (Bjerkan et al., 2021).

Hence, physically and operationally, ports already hold an intermediate position in socio-technical systems, making them a useful transition site when studying intermediation. Historically, ports have served as engines in regional economies through connecting increasingly global value chains (Becker et al., 2013; Cheon, 2017), and have only recently started to address social and environment aspects of their commercially-oriented operations. This dual nature of many ports, compelling them to strive for economic, social, and environmental sustainability alike (Sislian et al., 2016), might call for port-specific approaches to intermediation and transition work. Given the complexity and heterogeneity of the port sector, in terms diversity in actors, activities and relevant niche-innovations, intermediation could be assumed particularly important for port-related transition processes. However, the complex nature of ports could also place substantial strain on the intermediary role and the need to navigate the various users, stakeholders, technologies, and economies that constitute the individual port. This complexity could lead not only to different types and degrees of intermediation, but also to transition work that goes beyond the port to encompass the activities of the many sectors each port comprises. The port sector therefore represents a useful case for enhancing our understanding of the role intermediation can play in transition work, encouraging us to *explore what role intermediation plays in the transition work of ports.*

To do so we examine transition work and intermediation through an online survey among a heterogeneous sample of 96 Norwegian ports, i.e., public and private port management organisations or enterprises. Data collection was based on previous qualitative research on ports, understandings of transition work and intermediaries in transition studies, as well as literature on port sustainability. This literature provides an overview of ports' sustainability efforts and how they associate with different port authority functions. The research presented in this article thus also provides interesting discussions on how the roles and functions of port authorities have evolved, bearing strong connotations to the intermediary role described by transition scholars.

By applying quantitative methods to study intermediation and transition work, this paper adds to the methodological diversity of the sustainability transitions research field, which is dominated by qualitative case-based studies (Zolfagharian et al., 2019). Empirically the paper contributes with novel insights into the port sector, which has largely been neglected in transition research (for exceptions see e.g., Frantzeskaki et al., 2014; Bosman et al., 2018), and also pays attention to an under-studied type of intermediary actor, i.e., port management organisations/enterprises. Conceptually the paper clarifies conceptions of transition work and intermediation, and explores how intermediation at particular transition sites can connect to transition processes and outcomes.

The paper proceeds as follows. Section 2 presents our conceptual understanding of transition work and gives an overview of main tendencies in ports' transition work. This section also presents understandings and conceptualisations of the intermediary role as described by transition scholars, as well as the resembling 'community manager' function in the port sustainability literature. Section 3 presents the data and methods used to investigate how intermediation connects to transition work. Section 4 presents the results of our quantitative analysis, before we in Section 5 discuss the implications of our findings. Finally, Section 6 presents our concluding comments.

2. Transition work and intermediation

2.1. Understanding transition work

The literature on sustainability transitions is ripe with studies on transition work, but it has yet to explicitly conceptualise what this entails. Although transition scholars widely refer to the actions and endeavours of different types of actors, e.g. incumbents actors (e.g. Steen and Weaver, 2017; Berggren et al., 2015; Mühlemeier, 2019), niche actors (e.g. Raven et al., 2016; Fudge et al., 2016), social movements (e.g. Blanchet, 2015; Hess, 2018), the term 'transition work' is rarely used. Sørensen et al. (2018) refer to 'transition work' when investigating the agency of consulting engineers in shaping contemporary transitions, suggesting four types of transition work: technological problem solving, persuasion, mediation, and institutional work. Although they do not provide an explicit, general definition of transition work, their narration seems to hint at transition work as the set of activities an actor group (e.g. engineers) knowingly engages in that impacts transition. Skjølsvold et al. (2018) also refer to transition work without providing a specific definition, but refer to four processes of orchestration which could be considered elements of transition work conducted by households: production of visions, expectations and imagination, network construction and reconfiguration, scripting, and domestication. Komatsu Cipriani et al. (2020:1013) further state that visions are the "'cornerstone of all transition work", while Poland et al. (2019:182) emphasise the 'lived' experience of transition work in addition to impacts and outcomes following transition work.

Hence, we believe that the deliberate efforts and activities of actors to promote or enable transition should be more clearly conceptualised. We define transition work as *the targeted goals, strategies and actions that promote sustainability transitions.* Transition work is therefore a wide concept that incorporates all the core processes that transition literature considers essential in shaping transitions, such as the formulation of visions and expectations, the building and aligning of networks, and the development, use, and diffusion of new technology.

We continue to suggest that *transition work should be understood as a process as well as an outcome*. For one, transition work should be considered processual because sustainability transitions themselves are processual, i.e. "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (Markard et al., 2012:956). Although under other labels, several strands of the transition literature indeed address the

processual dimension of transition work. For instance, the four stages of transition management processes could very well be understood as different types of transition work, be it strategic, tactical, operational or reflexive (e.g. Loorbach, 2010; Markard et al., 2012:956). Research on strategic niche management refers to key agentic processes - formulating visions and expectations, building social networks and engaging in social learning (e.g. Schot et al., 2016; Kemp et al., 1998) – which are also expressions of processual transition work. Research focusing on processes relating to power and politics (e.g. Hendriks and Grin, 2007; Hess, 2014; Avelino and Rotmans, 2009) also deal with instrumental components of transition work.

Second, Silva and Stocker (2018) argue that transitions should also be understood as an *outcome*, referring to the practical or specific sustainability results of transition. They explored the transition research community's understanding of transitions, which were perceived as outcomes of systemic change leading to "a new but unspecified state" (ibid.:69). Similarly, Luederitz et al. (2017) define outcome as "the extent to which generated changes support progress towards sustainability". The *outcome dimension* of transition work is also emphasised by literature concerned with transition pathways (e.g. Geels et al., 2016) or studies emphasising transition governance or management in achieving particular outcomes (e.g. Markard et al., 2012; Smith et al., 2005).

3. Intermediation

An encompassing understanding of transition work also suggests that intermediation could be found among the many different activities that foster transitions[1]. For two decades the transition field has delved into the role of intermediaries in progressing and shaping transition work (e.g. Kivimaa et al., 2019a; Barnes, 2019; Stewart and Hyysalo, 2008; Gliedt et al., 2018; van Lente et al., 2003; Kanda et al., 2020). For example, Kivimaa et al. (2019a) discuss the positive impact intermediaries have on transition processes, while Kanda et al. (2019) and Lukkarinen et al. (2018) more specifically argue for the contribution intermediaries can have on the performance of regions and companies. Intermediaries "perform relational work between multiple actors and technologies" (Barnes, 2019:773) and the agency of intermediaries lies with three key processes, facilitating, configuring and brokering, which are all contextually, spatially and temporally dependent (Kivimaa et al., 2019b,a, Bush et al., 2017; Stewart and Hyysalo, 2008; Barnes, 2019). Based on the work of Kivimaa (2014) and Hargreaves et al. (2013), Bush et al. (2017) suggest four dimensions of intermediary roles: i) articulation of values and visions, ii) social network building, iii) knowledge exchange and learning processes, and iv) brokering/coordination of partnerships beyond the niche. Others apply a broader scope in investigating actors who facilitate transition work (e.g. Matschoss and Heiskanen, 2018), for instance as "middle actors" that hold substantial capacity and purpose beyond their role as a transition facilitator (Parag and Janda, 2014).

Considering how transitions are complex processes occurring through different system elements and dynamics at different levels, and involve various types of actors (private, public, civil), intermediaries are moreover considered to contribute differently during different transition phases (van Lente et al., 2003; Kivimaa et al., 2019b). In emerging phases, intermediaries are for instance important for nurturing activities related to learning and development of new technologies, while in acceleration phases key intermediation activities to a greater extent include supporting technology diffusion and market creation. Overall, the transitions literature offers several approaches to categorise and analyse intermediation. Among the earlier contributors on intermediation, van Lente et al. (2003) discuss the roles of so-called systemic intermediaries, which in a port context would engage strategically between the variety of port actors to facilitate joint perceptions and narratives, thereby laying the grounds for learning. More recently, van Lente et al. (2020) interpret the role of systemic intermediaries in light of positioning theory to explore how intermediary roles are found and developed. Further, Kanda et al. (2020) address conceptual challenges related to systemic intermediation, suggesting that intermediation occurs at different levels with different scopes of actor and network involvement. Other studies have targeted niche intermediaries (Smith et al., 2016) and innovation intermediaries (Gliedt et al., 2018). Kivimaa et al. (2019b,a) present a typology of five different intermediaries and discuss how these can advance transitions. In addition to the already mentioned systemic intermediaries, their typology comprises niche/grassroot intermediaries, regime-based intermediaries, process intermediaries and user intermediaries. Furthermore, Kanda et al. (2020) usefully discuss how intermediation activities also depend on the positioning of intermediary actors in-between different networks, actors, and institutions.

In the following we expand on transition work and intermediation conducted by ports, demonstrating how the geographical and relational positions of ports enable them to act as regime-based intermediaries. In so doing we also draw on the growing literature on port sustainability.

3.1. Transition work and intermediation in the port sector

Ports (here denoting public and private port management organisations/enterprises) can be understood as regime-based transition intermediaries. They are established actors that fulfil a particular function, which they in many cases are politically mandated to do, which is to provide harbour and logistics services in-between sea and land-based transport systems. As regime-based intermediaries, ports therefore operate at the inter-section of different socio-technical systems and aim to translate policy and regulation into incremental, practical action (Kivimaa et al., 2019a). Qualitative studies have shown how ports respond to local emission reduction targets and political ambitions by explicitly engaging port users and stakeholders to develop joint visions and strategies for transition work (Bjerkan and Ryghaug, 2021; Bjerkan and Seter, 2021).

[1] Intermediation and the role of intermediaries has also received substantial attention in research on innovation, innovation systems and clusters. Here we limit our discussion of the concept to its use in sustainability transitions research.

Table 1
Summarised dimensions of intermediaries and community managers in ports.

Dimensions of intermediaries	Dimensions of community managers
Promote systemic change	Manage stakeholders and the port community
Facilitate, manage and coordinate	Manage relation with city
Brokering	Stimulate adoption of green techs and practices
Configuring	Lobby on behalf of port community
Create stories	Green profiling and environmental awareness
Capacity building	Resource management
Promote niches	
Pursue self-interest	

Table 2
Top five priorities in ports surveyed by ESPO (2020).

Rank	1996	2004	2009	2016	2020
1	Port development (water)	Garbage/port waste	Noise	Air quality	Air quality
2	Water quality	Dredging operations	Air quality	Energy consumption	Climate change
3	Dredging disposal	Dredging disposal	Garbage/port waste	Noise	Energy efficiency
4	Dredging operations	Dust	Dredging operations	Relationship with local community	Noise
5	Dust	Noise	Dredging disposal	Garbage/port waste	Relationship with local community

According to Kivimaa et al. (2019a) intermediation on behalf of already established actors (e.g. an organisation) is rather typical, and there are also studies pointing to the importance of intermediation on behalf of more incumbent actors to advance transitions (e.g. Parag and Janda, 2014). Ports can perform different types of transition work, for instance implement new technology or practices that enhance the sustainability of their operations. Given both their role and positioning, ports can however also perform intermediation, but it is important to point out that this is not a core function associated with port's raison d'être. For this reason, and because of the immense variety of ports, it is highly interesting to better understand how and to what extent different ports perform intermediation that potentially impacts sustainability transitions in the socio-technical systems that they are both part of and that they serve to connect.

The focus on intermediation in transition studies sees its parallel in the port literature's attention to the roles port authorities can take in their sustainability efforts, and how this is related to port authority functions (Verhoeven, 2010). The landlord function refers to the port as an owner or trustee of areas, estate, infrastructure, and facilities. As landlords, ports are responsible for managing, maintaining, and developing these physical resources, as well as establishing strategies and policies associated with their responsibilities. When it comes to shaping transition work, the landlord function can among other urge ports to protect their ecosystems, ensure environmental concerns when dealing with users and economic activities in the port, and ensure sustainability in construction work, waste reception and infrastructure development (Acciaro et al., 2014).

The regulator function refers to the port authority's responsibilities in controlling, surveillance and policing (Verhoeven, 2010). This includes upholding regulations on safe handling of goods and vessels, environmental protection, and labour. Sometimes ports also, alone or in cooperation with government agencies, issue and enforce own regulations. In terms of transition work, ports can rely on their regulator function to monitor emissions, implement necessary measures and promote sustainable port activities through prohibitions, sanctions and rewards (Acciaro et al., 2014).

The operator function refers to the port's carrying out of port services, such as the shifting of goods and passengers, technical-nautical services (pilotage, towage, mooring) and other services (waste handling, energy provision, warehousing, logistic services etc.) (Verhoeven, 2010). As operators, ports can shape transition work by reducing emissions from and increasing energy efficiency in own operations, and include sustainability criteria when selecting subcontractors (Acciaro et al., 2014).

In addition to the above functions, a new port authority function has emerged, initially conceptualised by De Langen (2007) as the "community manager function". This function has evolved as a result of increasing globalization in the port sector, in which economic actors are no longer bound to or vested in the localities of the port, compelling ports to reassess their strategies for maintaining actor relations (Verhoeven, 2010). Further, this function has emerged as a response to pressure from markets and governments to address societal issues in ports (De Langen, 2007), thereby increasing the ports' stake in environmentalism, urban development, labour conditions, and the interests of neighbouring communities (Verhoeven, 2010). Ports uphold their "license to operate" by engaging in collective action, aligning conflicting interests and lobbying on behalf of the port community. As community managers, port authorities can also shape transition work through coordinating environmental activities among users and stakeholders in the port, encouraging these to adopt sustainable practices and technologies, and through enhancing their green profile by raising awareness, showcasing, and marketing sustainable activities (Acciaro et al., 2014). As summarised in Table 1, the community manager function of ports and the intermediary role share several traits, especially activities such as managing and coordinating, and work *in between* actors for creating change, through promoting niches (intermediaries) and stimulating adoption of green tech (community managers). Several of the dimensions of intermediaries listed in Table 1 can also be considered as intermediation mechanisms, such as facilitation, brokering and configuring. Although not explicitly mentioned as dimensions of community managers, they are likely mechanisms here as well. This suggests that the community manager function could be considered a port-specific application of intermediation.

Table 3
Research topics included in survey.

Topic		Contents	References
#1	The port	Information about the port organization and traffic at the port	Statistics Norway (2019)
#2	Strategies	Port priorities, ambitions and objectives, barriers and drivers, port roles	Damman et al 2019 ESPO Environmental Report 2019 Transition literature* Literature on port governance **
#3	Implementation	The port's implementation of practices and technologies	Bjerkan and Seter (2019) GHG Protocol, WPCI (2010)
#4	Expectations	Port's expectations regarding provision of alternative fuels and energy carriers	GREENFLEET project (Steen et al., 2019)

*e.g. Schot et al. (2016), Kivimaa et al. (2019a), ** e.g. Acciaro et al. (2014), Verhoeven (2010).

Despite a few studies on the port of Rotterdam (Bosman et al., 2018; Baas, 2008; Frantzeskaki et al., 2014) and Norwegian ports (e.g., Bjerkan and Seter, 2021), the sustainability transitions field has thus far paid limited attention to ports. To study transition work in ports, it is therefore useful to draw on the substantial port sustainability literature. The majority of these studies relate to the 'outcome dimension' of transition work, emphasising the potential use of different innovations and technologies that could enhance port sustainability.

The European Sea Ports Organisation gives an overview of the environmental efforts of European ports. Its latest report (ESPO, 2020, see Table 2) clearly indicates that priorities have shifted from topics such as water quality, dredging, dust, waste and noise, towards issues related to local pollution, energy and climate change. ESPO's environmental reports also show managerial approaches to be prominent in sustainability efforts among ports. Although this is also reflected in the port sustainability literature, among other synthesised by Lim et al. (2019), the actual sustainability efforts of ports have been poorly accounted for by research, implying limited knowledge about processual dimensions of transition work. Bjerkan and Seter (2019) review the existing literature on practices and technologies that ports can implement to enhance port sustainability, including managerial approaches (e.g. port fees, concession agreements), provision of fuels/energy carriers and production of energy (e.g. hydrogen, LNG, solar and wind power), innovations in sea transport (e.g. virtual arrival), and innovations in land transport (e.g. automation). They conclude that there is limited knowledge of actual experiences with the implementation of novel practices and technologies that can improve port sustainability. In response to this criticism, qualitative studies have targeted the transition endeavours of Norwegian ports (e.g. Damman and Steen, 2021; Bjerkan and Ryghaug, 2021). Among these, Bjerkan et al. (2021) investigated the roles taken by port actors to progress transitions at the intersection between port and transport systems, arguing that the prevalence of strong and prominent intermediaries is crucial for the ability of port actors to engage in transition work. In the remainder of this paper, we will pay specific attention to the intermediary role of ports to quantitatively investigate how it connects to their transition work.

4. Data and methods

The long and jagged Norwegian coastline is specked with ports and has fostered a strong maritime sector that includes offshore petroleum, fishing, aquaculture, and shipping. The main port network consists of 32 ports located in cities and large towns along the entire coast, governed by publicly owned enterprises. Regional authorities further regulate more than 600 fishing ports. Additionally, there are a range of privately owned ports serving specific industries, and other ports catering to local communities, leisure activities and tourism (e.g., cruise ports).

The density and diversity of ports along the Norwegian coastline makes it an interesting case for studying transitions in the port sector. Norway is already a frontrunner in the transition towards low- and zero-emission transport on land (Figenbaum, 2017) and sea (Steen et al., 2019), driven by ambitious national policy agendas (Ministry of Climate and Environment, 2019), public procurement (Bjerkan et al., 2019), and the emergence of low-emission technologies (Bach et al., 2020). As nodes in transport systems, the transition work of ports could be crucial to consolidate emerging transitions. In the remainder of this section, we elaborate on how we have studied transition work and intermediation in Norwegian ports.

4.1. Survey

To study ports' intermediation and transition work we chose a quantitative approach, relying on a survey among 96 Norwegian ports conducted between March and June 2020. To survey the four topics summarised in Table 3, we relied heavily on previous research and existing questionnaire batteries. Questions about port characteristics (Topic #1), especially related to types of traffic and port ownership, conformed with port data categorisations from Statistics Norway (2019). The survey was also based on substantial, qualitative interview data with 39 Norwegian port actors, which provided rich insights into intermediary work and transition efforts in three publicly owned ports (see Damman and Steen, 2021 for an overview). This research particularly inspired questions under Topic #2, which addressed each port's priorities in their work with climate and environment, ambitions and objectives regarding emission reduction, and barriers and drivers associated with reducing emissions in the entire port area. ESPO's environmental report from 2019 was also instrumental in developing this section of the survey. Questions relating to different roles that ports can take in their transition work were inspired by understandings of intermediaries and community managers presented by scholars of transition studies and port governance. Survey questions related to implementation of practices and technologies that enhance port sustainability (Topic #3)

Table 4
Ports targeted in the study (N).

	Public ports	Private ports	Unspecified	Total
Population	60	339		399
Survey distribution	60	304		364
Survey sample	52	41	3	96

Table 5
Operationalisation and distribution of port characteristics. The percentage shows the proportion of the total sample for each category.

Item	Measure	Categories	n	%
Port size	Number of employees in port organization	1-5	40	41.67
		6-19	25	26.04
		20 or more	31	32.29
			96	100
Dedicated staff	Port personnel responsible for climate, environment, and emission reduction	Yes	51	53.13
		No	45	46.88
			96	100
Port ownership*	Port owned by private company or public enterprise (municipal, inter-municipal, federal)	Private	52	55.91
		Public	41	44.09
			93	100
Port calls	Number of port calls per year	0-100	23	24.47
		101-350	24	25.53
		351-2000	24	25.53
		2001-10,000	17	18.09
		More than 10,000	6	6.38
			94	100
Traffic complexity**	Number of different types of traffic calling per year	1	19	19.79
		2	10	10.42
		3	15	15.63
		4	9	9.38
		5	2	2.08
		6	7	7.29
		7	5	5.21
		8	11	11.46
		9	6	6.25
		10	6	6.25
		11	4	4.17
		12	2	2.08
			96	100

* 3 ports reported other ownership, and were not included in analyses which included ownership

** Additive index based on types of traffic. The number categories show ports with between 1 and 12 types of traffic. Types of traffic is based on the following categories from Statistics Norway (2019): bulk/container carrier (dry), liquid bulk, container ship, general cargo ship, RoRo, barges, offshore/supply, fishing and aquaculture vessels, Ro/Pax, cruise ship/coastal routes, other passenger boats, other. Increasing values thus means increasing variation in types of traffic.

relied on the overview of such solutions presented by Bjerkan and Seter (2019).

All questions were loaded into a survey software, Survey Design, and the survey was distributed to Norwegian ports as an open link in an e-mail invitation. A pilot survey was conducted with representatives from the interest organisation of Norwegian public ports, Ports of Norway (PoN), prior to broader distribution. Relevant respondents in public ports were identified by the PoN, who provided a list of contacts (with email addresses) for each port. Private ports were identified from a list of all Norwegian ISPS[2] ports provided by the Norwegian Coastal Administration. The researchers used this list to search for and identify relevant contact persons and information. Despite hard efforts, we were not able to obtain contact information for 35 of the private ISPS ports.

As seen in Table 4, we distributed the survey to 364 public and private port organisations/enterprises, whereof 96 (26%) responded. The respondents are administrative personnel at public and private ports with insights into each port's sustainability efforts. Respondents also include organisations and enterprises with facilities at quays or bays used for loading and unloading vessels. When presenting and discussing the results from our study we will refer to the respondents as 'ports', implying port authorities or port management organisations.

To avoid the e-mail being falsely detected as spam, the survey was distributed directly to respondents with an open link. Responses were therefore also anonymous. The response rate was significantly higher among public ports (87 %) than among private ports (14 %). One of the reasons could be that we only had generic email addresses for contacting several of the private ports. This may have

[2] All port facilities that serve vessels engaged in international traffic must comply with the ISPS code (International Ship and Port Facility Security) and be approved by the Norwegian Coastal Administration.

Table 6
Operationalisation and distribution of port authority functions, hereunder intermediation. "Would you say that the port...". The percentage shows proportion of total sample answering 'yes' to the different statements.

Roles	Item	Would you say that the port..	n	%	Total
Landlord	1	…works with administration, maintenance, and development of property	77	81.91	94
Regulator	2	.. works to ensure safety and security for vessels and cargo	93	96.88	96
	3	…places requirements, rules, and fees for users in the port	90	93.75	96
	4	… controls/monitors activity in the port	95	98.96	96
Operator	5	… owns own vessels and vehicles	58	61.05	95
	6	… conducts physical reloading of goods and passengers	40	42.11	95
	7	… provides port services (pilot, towage, anchor services)	24	25.26	95
Community manager/ intermediary	8	…works politically to promote port interests in general	60	65.93	91
	9	… actively facilitates dialogue and collaboration between port users	82	86.32	95
	10	… enables users of the port to reduce their emissions	71	77.17	92
	11	… speaks up for concrete solutions that can reduce emissions in and around the port	72	79.12	91

resulted in a potential non-response bias, where those that responded tend to be more progressive (in terms of transition work) and perhaps not representative of the entire study population (Gail, 2005) However, given our explorative research question into the role of intermediation in transition work, ports that do not perform transition work are of limited interest. In any case, this implies that our results should be read with some caution with regard to differences between private and public ports.

4.2. Sample and operationalisation

This study explores how intermediation connects to transition work by investigating transition work in ports with different degrees of intermediation. In the following we account for measures used to describe port characteristics, intermediation, and transition work.

4.2.1. Measuring port characteristics

We relied on two sets of measures for port characteristics: i) organisational and traffic characteristics, and ii) perceived preconditions for transition work. The first set of measures are displayed in Table 5. The second set of measures included statements about factors that drive or obstruct sustainability efforts (Table A1), and statements about ports' documented overview of actual emissions and energy use (Table A2). Ports responded to these by indicating to what degree they agreed with these statements, on a five-point Likert scale.

4.2.2. Measuring intermediation

In operationalising intermediation, we relied on conceptualisations from the transition and port sustainability literatures, asking respondents to mark statements about the port's work relevant to them. Intermediation was measured by four statements about the ports' intermediate activities (8–11) with answer categories of 'yes/no', as well as an intermediation index that summarised each port's aggregated value on these statements. The index is based on questions 8–11 in Table 6, producing an adequate coefficient level of 0.4477 (van Griethuijsen et al., 2015, Taber, 2018).

4.2.3. Measuring transition work

We included three measures for the processual dimension of transition work, all relying on Likert scales reported in full in Appendices 2–4. The first measure was the port's *environmental priorities*, where we, inspired by ESPO (2019), distinguished between priorities to reduce i) global air emissions, ii) local air emissions, iii) emissions to water, iv) energy use, and v) noise (see Table A3). The second measure was *strategising*, which included whether the port i) explicitly aimed to become a zero-emission port, and ii) worked strategically to transition the port towards low or zero emission. The third measure related to the port's ability to *pinpoint its transition efforts* based on overview of actual emissions and energy use.

We refer to the outcome dimension of transition work as the ports' implementation (or not) of 17 port-specific practices and technologies (see Table A5) that enhance sustainability, based on self-reporting (see overview in Table 12). These 17 measures were identified by Bjerkan and Seter (2019) in a review of the port sustainability literature. Second, the outcome dimension was measured by an additive index showing how many practices and technologies each port had implemented, ranging from 0 (minimum) to 12 (maximum) which we refer to as 'Aggregated implementation'. This list of implementations clearly demonstrates the potential importance of intermediation in the transition work of ports, as most practices and technologies directly interlock with the transition work of port users and stakeholders.

To operationalise an aggregated measure for transition work that included both the processual dimension and the outcome dimension, we used Principal Component Analysis to define a dependent variable "transition work" to be included in statistical analyses. This is elaborated below.

4.3. Statistical analyses

To explore intermediation we conducted descriptive analyses of the intermediary/community manager functions and the additive

Table 7
Prevalence of intermediary activities in Norwegian ports: additive intermediary index, based on Table 6.

		Frequency	Percent
Intermediary index: number of intermediary activities	0	1	1.15
	1	12	13.79
	2	11	12.64
	3	15	17.24
	4	48	55.17
Total		87	100

Mean value: 3.11. Standard deviation: 1.16.

Table 8
Comparison of average scores on intermediary index. Port ownership and dedicated personnel.

	Mean	Rank sum	Expected rank sum	Wilcoxon-Mann-Whitney, Z	P-value	Obs.
Port ownership				-5.223	0.0000	84
Private	2.44	1294	1827.5			
Public	3.76	2276	1742.5			
Port personnel responsible for climate, environment, and emission reduction				1.082	0.2786	87
No	3.26	1831	1716			
Yes	3	1997	2112			

intermediary index. We also performed bivariate analyses with significance tests between the additive intermediary index and port characteristics to identify key features of ports with more intermediation activities.

To investigate the connection between intermediation and transition work we also relied on bivariate analyses. First, we investigated bivariate correlations between the additive intermediary index and the processual dimension of transition work, which included variables described in Section 3.2.3.[3] Second, we investigated the outcome dimension of transition work by comparing intermediation in ports that had and had not implemented specific practices and technologies. Finally, we conducted regression analyses to investigate i) how intermediation (i.e., the additive intermediary index) related to the outcome dimension of transition work, and ii) how intermediation related to the aggregated transition work variable. These methods are elaborated together with the presentation of findings in Section 4.

5. Results

5.1. Intermediation in Norwegian ports

This section presents the prominence of intermediation in Norwegian ports, above all referring to the number of intermediary activities that ports conduct (i.e. intermediary index). We interpret high values on the intermediary index (i.e. conduct many intermediary activities) to signify a strong intermediary role. Conversely low values on the intermediary index (i.e. conduct few intermediary activities) signifies a weak intermediary role.

Table 6, which presented our sample, showed that more than half of all Norwegian ports ticked off every dimension of intermediation measured in this study. However, the table showed significant variance in the share of ports complying with the different items. For example, 66 percent of ports worked politically to promote port interests in general, while 86 percent actively facilitated dialogue and collaboration between port users. Further, Table 7 shows how many ports have implemented 0-4 of the intermediation activities based on an additive index. In total, 55 percent of ports incorporated all intermediation activities, while one port conducted none.

To investigate what characterises ports with a strong intermediary role we performed bivariate analyses with significance tests between the additive intermediary index and port characteristics. For categoric variables, such as port ownership and port personnel responsible for climate, environment, and emission reduction, we applied Wilcoxon-Mann-Whitney-test to investigate inter-group variation. Wilcoxon-Mann-Whitney is an equivalent to the t-test, but more appropriate as the intermediary index had a non-normal distribution. For ordinal variables (port size, traffic volumes, traffic complexity, documented overview of emissions) Spearman's rank correlation measure was used to examine the strength and significance of intermediation, based on established strength criteria (Akoglu, 2018). We also measured the correlation between intermediation and barriers and drivers that affect ports' sustainability work (Table 10).

Table 8 shows intermediation to be higher in public ports than private ($p < .001$), but no statistically significant difference in the number of intermediary activities between ports with and without staff responsible for climate, environment, and emission reduction. Table 9 shows correlations between the intermediary index and port characteristics, where statistically significant findings ($p < .001$) show a higher number of intermediary activities to strongly and positively correlate with more port calls and increasing traffic

[3] We also investigated the processual dimension of transition work through regression analysis, but these produced no relevant findings regarding intermediation. These are therefore not included in section 4.

Table 9
Correlation scores on intermediary index. Port characteristics.

	Correlation measure, Spearman	P-value	Obs
Size of ports (ordinal measure)	-0.063	0.561	87
Port calls	0.529	0.000	87
Traffic complexity	0.547	0.000	85

Table 10
Correlation scores on intermediary index. Perceived barriers and drivers.

Barriers and drivers	Correlation measure, Spearman	P-value	Obs
Pressure from owner	0.310	0.004***	87
Pressure from users	0.144	0.183	87
Pressure from surroundings	0.271	0.012**	86
Support from owner	0.190	0.078*	87
Support from surroundings	0.319	0.003***	87
Economy	-0.048	0.658	87
Own competence	-0.070	0.521	87
Time and personnel resources	-0.023	0.830	87
Regulation	-0.214	0.046**	87
Technological maturity	-0.076	0.485	87
Political governance and guidelines	0.144	0.183	87
Steering/governance from owner	0.195	0.071*	87
Attitudes and ambitions among port users	0.260	0.017**	87
Collaboration and coordination	0.298	0.005***	87
Other	-0.084	0.438	87

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.

Table 11
Correlations between intermediary index and processual and outcome dimensions of transition work. Significance: $P \leq 0.1$.

Transition work: processual and outcome	Correlation measure, Spearman	*P*-value	Obs.
Prioritises to reduce global emissions	0.067	0.539	87
Prioritises to reduce local pollution	-0.037	0.735	87
Prioritises to reduce emissions to water	-0.212	0.049*	87
Prioritises to reduce energy use	0.211	0.050*	87
Prioritises to reduce noise	-0.020	0.855	87
Ambition to become zero emission port	0.065	0.547	87
Works strategically to become low/zero emission port	0.283	0.008**	86
Documented overview of emissions	-0.153	0.163	85
Documented overview of energy use	-0.010	0.926	85
Aggregated implementation	0.285	0.007**	87

*, ** indicates significance at the 95%, and 99% level, respectively.

complexity.

Table 10 presents correlations between the intermediary index and the barriers and drivers that ports experience in their sustainability efforts, i.e. perceived preconditions for transition work. It shows that the number of intermediary activities was higher in ports that experienced pressure from owner and/or surroundings, as well as support from owner and/or surroundings. Further, there were more intermediary activities in ports that experienced steering/governance from owner and supportive attitudes and ambitions among port users. Finally, ports that experienced collaboration and coordination with others also conducted more intermediary activities than ports which did not. The strength of these correlations varied. We found only moderate correlations for pressure from owner, support from surroundings and collaboration. Other correlations were weak.

5.2. Transition work in ports with more and less intermediation

This section attends to how transition work in ports with strong intermediary roles differs from transition work in other ports. The first set of analyses relate to the *processual dimension of transition work*: setting priorities, strategising, and pinpointing transition efforts. Table 11 shows that ports with more intermediation activities, i.e., a strong intermediary role, more than others prioritised to reduce energy use, while ports with less intermediation activities, i.e., a weaker intermediary role, prioritised to reduce emissions to water. The table also shows a close-to-moderate positive correlation between the intermediary role and whether ports worked strategically to become low/zero emission. When it comes to the *outcome dimension of transition work*, i.e., ports' actual implementation of practices and technologies that promote sustainability in and around the port, a correlation test between the intermediary index and the outcome dimension (aggregated implementation) suggests that the number of implemented practices and technologies increased with

Table 12
Average intermediary levels in ports who have and have not implemented specific practices and technologies.

	Intermediary mean: not implemented (0)	Intermediary mean: implemented (1)	*P*-value [a]	Effect size [b]
Support scheme for users' emission reduction	2.99	3.65	0.033**	0.651
Environmental requirements in contracts	3.06	3.26	0.519	0.543
Environmental port fees	2.89	3.71	0.002***	0.688
Increased energy efficiency in infrastructure	3.10	3.16	0.898	0.510
Increase port's knowledge	3.00	3.39	0.329	0.561
Facilities for alternative power	3.06	3.83	0.150	0.676
Low voltage shore power	2.64	3.56	0.000***	0.711
High voltage shore power	3.01	3.47	0.145	0.601
Shore side charging	2.95	3.62	0.017**	0.655
Alternative fuels to users	3.03	3.62	0.086*	0.638
Reduce the speed of ships to/from the port	3.07	3.36	0.444	0.564
Virtual arrival systems for ships	3.10	3.4	0.756	0.552
Zero/low emission terminal equipment	3.06	3.35	0.376	0.566
Automated operations	3.10	3.33	0.660	0.561
Increase efficiency in loading/unloading	3.14	2.89	0.477	0.435
Reduce emissions from industrial activity	3.25	2.63	0.024**	0.344
Emission reduction in land transport	3.12	3.11	0.989	0.499

*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.
[a] . Wilcoxon-Mann-Whitney testing Ho: no difference in distribution on the index between implemented and not implemented.
[b] . Probability that the variable for group 1 is higher than variable for group 0)

Table 13
Quantile regression model with transition work-outcome dimension as dependent variable.

	Transition Work-Outcome
Intermediary role/intermediation	.788*
	(.426)
Pressure from owner	1.236**
	(.562339)
Traffic complexity	-1.042*
	(.530)
Traffic complexity^2	.0760*
	(.0397)
Pseudo R-squared	0.3661
No. observations	81

Only significant coefficients, full model in Table A6. Standard errors are reported in parentheses. *, ** indicates significance at the 90% and 95%, respectively.

an increasing number of intermediary activities ($p < .01$). The correlation is close to moderate (rho=0.285).

We also compared the average number of intermediary activities in ports that had and had not implemented particular practices and technologies (Table 12). Here, we relied on the Wilcoxon-Mann–Whitney-test to compare effect sizes, which measures the probability that the intermediation index is higher in one group than in another. The table shows significantly more intermediary activities in ports that had implemented the following practices/technologies: support schemes, adjusted port fees, low voltage shore power, shore side charging and alternative fuels. Further, we found the number of intermediary activities to be higher in ports that had *not* implemented solutions for 'reducing emissions from industrial and production activity'. Conversely, ports that had implemented such practices conducted fewer intermediary activities.

We also studied the outcome dimension of transition work through regression analysis (Table 13) with the additive index of implemented practices and technologies as dependent variable and the intermediary index (i.e., number of intermediary activities) as the main independent variable. As we found issues with heteroskedasticity, which violates assumptions of ordinary-least-squares (OLS) regression, we relied on quantile regression. Quantile regression estimates the conditional median (or other quantiles) of the dependent variable and is especially useful when one does not assume any specific conditional distribution and when the assumption of homoscedasticity is violated. Furthermore, it is robust against outliers (Waldmann, 2018).

The regression included control variables measuring port characteristics, and barriers and drivers that ports experienced in their sustainability efforts. Significant findings are shown in Table 13 (full model in Table A6). The number of intermediary activities had a positive and significant ($p < .10$) correlation with the outcome dimension of transition work when controlling for port characteristics, drivers and barriers. Thus, ports that conducted more intermediary activities also implemented more practices and technologies than ports that conducted fewer intermediary activities

Table 13 also shows a positive and significant ($p < .05$) relation between the outcome dimension of transition work and the degree to which ports experience pressure from owners in their sustainability efforts. The slight curvilinear contribution of traffic complexity and traffic complexity^2 ($p < .10$) indicates that the number of implemented technologies and practices declined with increasing traffic

Table 14
OLS regression model 1 with aggregate transition work as dependent variable (based on PCA-results) ($N = 78$).

	Aggregate Transition Work
Public ownership[a]	1.56268*
	(.8579908)
Port calls	-.3935094**
	(.1924933)
Dedicated climate staff	.5709286**
	(.2710425)
Pressure from owner	.6481425***
	(.1983355)
Support from surroundings	.5905839***
	(.1714306)
Economy[b]	.480333***
	(.1369738)
Regulation	-.3039761*
	(.1576498)
R-squared	0.6770
Adj R-squared	0.5394
No. observations	78

Only significant coefficients, full model in Table A8. Standard errors are reported in parentheses.
*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.
[a] Public ports experiencing economy as a barrier.
[b] Those experiencing economy as a driver and has private ownership.

complexity until a certain point of complexity, when implementation extent increased slightly.

Finally, to investigate how intermediation connects to transition work, we conducted an OLS regression on the aggregated measure for transition work that included both the processual dimension and the outcome dimension. This variable derived from a Principal Component Analysis followed by Promax rotation, which was used to examine if the variables loaded onto one or several components, i.e., if there was an underlying theme among these variables (see Table A7). Based on the best component/factor we created a principal component score. This analysis produced a model (Table 14, full model in Table A8) with more explanatory power than the analysis of the outcome dimension of transition work alone[4]. The significant results show that the number of intermediary activities no longer significantly correlated with transition work ($p > .10$) when controlling for other variables than port characteristics.

However, several control variables were themselves statistically significant. We found pressure from owner ($p < .01$), support from surroundings ($p < .01$) and having dedicated climate staff at the port ($p < .05$) all to increase the level of transition work. We also found transition work to decline when the number of port calls increased ($p < .05$) and when ports experienced regulation as a driver ($p < .10$).

It is also worth noting the rather mixed findings related to port ownership (public versus private). Ownership alone did not correlate statistically significant with aggregated transition work but became significant when we introduced an interaction term between ownership and economy. Thus, table 14 suggests that transition work was higher in public ports that experienced economy as a barrier in their sustainability efforts ($p < .10$). Conversely, the economy variable - which due to the ownership-economy interaction term applied to private ports – suggests that transition work was high in private ports where sustainability efforts were driven by economy ($p < .01$).

When developing the regression models, we started out with models only measuring covariation with port characteristics and intermediation. In both models (Tables 13 and 14, Tables A6 and A8), adding the full set of barriers and drivers caused the importance of intermediation to decline, although it remained positive and statistically significant for transition work-outcome. This suggests that some effects of intermediation were instead effects of these drivers and barriers. For instance, the effect of intermediation appeared to blend with effects of pressure from owner, support from surroundings, and sustainability efforts driven by regulation, which all significantly affected transition work.

6. Discussion

6.1. Intermediation in Norwegian ports

We find that almost all ports (99 %) in the sample conduct one or more intermediation activities, and that more than half conduct all the intermediation activities included in our survey. Intermediation is particularly prominent in ports with many port calls and high traffic complexity. This suggests that the larger the complexity and diversity of port activities, the greater the need and opportunity for the port to actively coordinate and orchestrate actors and activities.

[4] Note: R2 and Pseudo R2 are not directly comparable.

Our findings also indicate that public ports engage in more intermediation than private ports, and that intermediation is more prominent in ports that experience pressure from their owners regarding sustainability efforts. This corresponds with previous research on public intermediaries, suggesting that public actors' neutrality, legitimacy and sustained engagement make them well equipped to facilitate activities aiming for systemic renewal (Mignon and Kanda, 2018; Glaa and Mignon, 2020; Kivimaa, 2014). Further, it adds to existing knowledge about port governance. Although the port literature is vested in conceptualisations of port governance, there is limited research on how sustainability efforts vary between governance models. One exception is van der Lugt et al. (2015), who studied how public ownership and political port board members impacted sustainability efforts. Further, Sornn-Friese et al. (2021) studied how government ownership impacted implementation of measures for reducing air emissions. Both studies found a positive but non-significant impact of public port ownership. In Norway, recent changes in port regulation (Ministry of Transport, 2019) have provided public ports more influence over port business, and our data also indicates a reorientation in the (public) port sector towards more active involvement in transition work. This corresponds with research on the port of Rotterdam, emphasising the port's repositioning as a driving force behind transition efforts (Bosman et al., 2018) and behind its move towards encompassing, embedded involvement of actors and relationships (Baas, 2008).

Changing role perceptions (Bjerkan and Ryghaug, 2021) could also explain why public and private ports experience the influence of economic factors differently. Our findings display an interesting divide indicating that private ports do transition work when they can afford it and/or profit from it, while public ports do transition work despite the economic strain this places them under. The latter could result from the progressiveness of public ports, who also engage more in intermediation and whose owners could be expected to exert more pressure than owners in private ports. More encompassing intermediation and transition work could thus increase their awareness of costs, as well as the costs themselves.

Finally, our study finds the number of intermediary activities to be higher in ports that experience support (and pressure) from surroundings, and where sustainability efforts are driven by the ambition and attitudes of their users, as well as collaboration and coordination. Surroundings are known to be particularly sensitive to increased visibility of sustainability problems in ports (Poulsen et al., 2018). Indeed, our findings indicate that ports take the intermediary role not only because they are ushered by their owners, but also as a result of users, neighbours and the public expecting them to take such a role. This corresponds with our qualitative research on Norwegian ports, showing that port actors refer to the port as "an epicentre for dialogue" that allows them to collaborate across sectors (Bjerkan et al., 2021:6). It also underscores how transitions in ports are highly multi-sectoral. On the one hand, this represents an opportunity for ports to take an intermediary role in whole-system transitions (McMeekin et al., 2019). On the other hand, this myriad of actors with potentially diverging interests and leeways could also represent a substantial barrier for ports, whose organisations and owners do *not* motivate or facilitate progressive transition work. In fact, our data shows that intermediation is lower in ports whose sustainability efforts are driven by regulation (Table 10). This could imply that some ports apply a minimum-effort strategy, in which the minimum expectations expressed through regulation are exceeded by the actor involvement and ambition inherent in intermediation. As such, the many different motivations that guide intermediation in ports, suggest it is likely that ports will follow very different transition pathways.

6.2. *Intermediation to advance transition*

This paper set out to explore the role of intermediation in the transition work of ports. In the following we make clear how intermediation associates with ambition and progressiveness in transition work. Section 2 showed the instrumentality of intermediation in transitions and that intermediation can advance transition through different activities in different phases of transition (see Kivimaa et al., 2020 for an overview). Although our quantitative data only captures a few dimensions of intermediation, this study contributes to demonstrate intermediation as a feature of more progressive transition work.

This is evident in how intermediation relates to processual dimensions of transition work, particularly regarding scope, boundaries and the identification of core focuses and efforts. This could underscore the importance of intermediation in advancing transitions, as this presumes the ability to identify relevant problem agendas and orienting own efforts accordingly. In our study, this was evident in how ports that conducted many intermediation activities emphasised contemporary and future-oriented problems (i.e., energy issues), while ports that conducted few intermediation activities were oriented towards more historic problem agendas (i.e., water quality). The role of intermediation in advancing transition also relates to the ability of intermediaries to formulate explicit visions and goals (Kivimaa et al., 2019b). This is echoed in our study, where explicit goals and ambitions were a particular feature of strong intermediary roles: ports with more intermediation activities more often worked strategically towards low- or zero emission operations.

There is extensive research on the many types of work intermediaries engage in to advance transitions (Kivimaa et al., 2020, 2019b; Gliedt et al., 2018; van Lente et al., 2020; Kanda et al., 2020), and these activities clearly represent aspects of processual transition work. Hence, the strong relation between intermediation and transition work displayed by our analyses could very well result from theoretical and empirical challenges with distinguishing between these two concepts. In our empirical data, the overlap is apparent in how certain variables (e.g., public ownership, port size, traffic complexity) correlate with intermediation and transition work in similar ways, and in difficulties with delineating their quantitative measures. For instance, "enabling port users to reduce emissions" (Table 5) is a core character of intermediation, but simultaneously an inherent aspect of transition work. One could thus argue that any transition work would contain some element of intermediation.

As such, it is not necessarily a question of *whether* intermediation relates to transition work, but rather to what degree intermediation is a precondition for successful transition work. The port sector is a highly relevant case for enhancing our understanding of this. As an actor, the port can engage in transition work related to its own activities, operations, and sustainability issues. In our study, such unilateral transition work is represented by the ports' implementation of measures to increase energy efficiency. Such endeavours

Table A1
Operationalisation of port characteristics: perceived drivers and barriers ($N = 96$).

Measure	Categories	Mean	Std. dev.
In the port's sustainability work, to what degree do you experience the following?	1 No degree 2 Small degree		
Pressure from owner	3 Neither/nor	3.52	1.16
Pressure from users	4 Some degree	3.10	1.14
Pressure from surroundings	5 Large degree	3.71	1.09
Support from owner		4.27	.87
Support from surroundings		4.00	1.05
To what degree do you experience the following as barriers or drivers in your sustainability work?			
Economy	1 Significant barrier	2.41	1.48
Own competence	2 Small barrier	2.76	1.11
Time and personnel resources	3 Of no consequence	2.44	1.08
Regulation	4 Small driver	2.95	1.04
Technological maturity	5 Significant driver	2.76	1.15
Political governance and guidelines		3.45	1.05
Steering/governance from owner		3.54	.96
Attitudes and ambitions among port users		3.17	.91
Cooperation and coordination		3.14	.79
Other factors		3.0	.54

Table A2
Operationalisation of port characteristics: ability to target transition work ($N = 93$).

Measure	Categories	Mean	Std. dev.
Documented overview of energy use	1 No degree	3.73	1.33
Documented overview of emissions	2 Little degree	3.42	1.43
	3 Insignificantly		
	4 Some degree		
	5 Large degree		

Table A3
Operationalisation of transition work: ports' environmental priorities ($N = 96$).

Measure	Categories	Mean	Std. dev.
Reduce global air emissions	1 No priority	3.438	1.064
Reduce local air emissions	2 Low priority	3.875	0.965
Reduce emissions to water	3 Medium priority	4.073	0.885
Reduce energy use	4 High priority	3.708	0.870
Reduce noise	5Very high priority	3.948	0.887

Table A4
Operationalisation of transition work: strategising ($N = 96$).

Measure	Categories	Mean	Std. dev.
Aims to become zero emission port	1 No degree	4.042	0.983
Works strategically to transition the port towards low-zero emission	2 Little degree	3.947	1.124
	3 Insignificantly		
	4 Some degree		
	5 Large degree		

leave little need and opportunity for intermediation activities. Most of the transition work in ports, however, is directly linked to the operations, activities and sustainability issues of other actors that use and occupy the port area. Implementations of for instance shore power, environmental port fees, and automated operations are all examples of this. Thus, this transition work has a strong bi- or multi-lateral character, which by necessity requires a certain degree of intermediation. The port's reliance on intermediation to succeed with transition work is further supported by the different functions that ports master as landlords, regulators, and operators. It also hinges crucially on their position in-between actors and networks (Kanda et al., 2020), and their regime-based characteristics. (Kivimaa et al., 2019a) furthermore suggests that they may be well set to engage in dialogue and interaction with multiple other stakeholders. Our findings also show that most of the implemented technologies and practices somehow demand collaboration or dialogue with port users and stakeholders. In short, this suggests that intermediation is integral to much of the transition work performed by port organisations.

Table A5
Operationalisation of transition work: implementation of sustainable practices and technologies. The percentage shows proportion of total sample of ports that have implemented 0-12 of the sustainable practices and technologies.

Measure	Categorization	n	%
Number of sustainable practices and technologies implemented in port	0	17	17,71
	1	11	11.46
	2	15	15.63
	3	14	14.58
	4	13	13.54
	5	8	8.33
	6	4	4.17
	7	7	7.29
	8	1	1.04
	9	2	2.08
	10	3	3.13
	12	1	1.04
Total		96	100
Types of practices and technologies implemented	List of 17 practices and technologies		

Table A6
Full regression analysis with outcome dimension of transition work as dependent variable ($n = 81$).

TransitionWork-outcome	Coef.	Std. Err.	t	P>t
Intermediary role/intermediation	.788	.426	1.85	0.070
Public ownership	1.242	2.405	0.52	0.607
Port calls	.268	.554	0.48	0.630
Medium port	-.852	.953	-0.89	0.375
Large port	1.908	1.227	1.56	0.125
TrafficComplexity	-1.042	.530	-1.97	0.054
Dedicated climate staff	.580	.754	0.77	0.445
TrafficComplexity2	.076	.040	1.91	0.061
Pressure from owner	1.236	.562	2.20	0.032
Pressure from users/customers	-.208	.434	-0.48	0.633
Pressure from surroundings	-.016	.464	-0.04	0.972
Support from surroundings	-.356	.481	-0.74	0.462
Economy	.378	.386	0.98	0.331
Competence	.192	.406	0.47	0.638
Time and personnel resources	.043	.448	0.10	0.923
Regulation	.511	.445	1.15	0.255
Technological maturity	.219	.381	0.58	0.568
Political steering and governance	.191	.503	0.38	0.706
Steering from owner	-.389	.587	-0.66	0.510
Attitudes and ambitions among users	-.263	.516	-0.51	0.612
Collaboration/coordination from others	-.281	.561	-0.50	0.618
Other factors	-.180	.731	-0.25	0.806
Public ownership-Economy	.276	.613	0.45	0.654
_cons	-1.864	2.940	-0.63	0.529
Number of obs	81			
Pseudo R2	0.3661			

Intermediation has been shown to impact diffusion of innovations (Kivimaa et al., 2020) and resource formation processes associated with new technologies (Kanda et al., 2019; Lukkarinen et al., 2018). Our analysis also demonstrated correlation between intermediation and progressiveness in the outcome dimension of transition work: intermediation was particularly prominent in ports that implemented many practices and technologies for enhancing sustainability, as well as particularly progressive practices and technologies. Intermediation activities were for instance prominent in ports that provided alternative fuels for shipping, where demand is currently low. In these cases, intermediation activities could be considered to reflect ambitions on behalf of frontrunner ports to create or stimulate demand (Bjerkan et al., 2021) . Further, ports' wish to stimulate transition work among their users by establishing support schemes, could also motivate intermediation activities, as developing such schemes by necessity requires relational work, facilitating and learning.

Conversely, ports that conducted few intermediation activities were less progressive in their transition work, pursuing also less progressive practices, such as 'reducing emissions from industrial and production activity'. Such practices are likely established through bilateral transition work, as they could be more prominent in ports specialised in serving a particular industry and a small set of users. As such, implementation complexity (Poulsen et al., 2018) could be considered lower, which in turn limits the need and opportunity for intermediation.

Thus, there is a clear distinction between ports that conduct few and many intermediation activities with regard to how progressive their transition efforts appear to be. While ports that conduct many intermediation activities orient towards energy issues and

Table A7
Principal component analysis with calculation steps.

Principal components/correlation		Number of obs	92		92
				Number of comp.	10
				Trace	10
Rotation: (unrotated = principal)				Rho	1.0000
Component	Eigenvalue	Difference	Proportion	Cumulative	
Comp1	3.94602	2.44857	0.3946	0.3946	
Comp2	1.49745	.498338	0.1497	0.5443	
Comp3	.999111	.0702587	0.0999	0.6443	
Comp4	.928852	.162813	0.0929	0.7371	
Comp5	.766039	.304912	0.0766	0.8137	
Comp6	.461127	.011405	0.0461	0.8599	
Comp7	.449722	.014513	0.0450	0.9048	
Comp8	.435209	.108758	0.0435	0.9484	
Comp9	.326451	.13643	0.0326	0.9810	
Comp10	.190021	.	0.0190	1.0000	
Promax rotation					
Principal components/correlation				Number of obs	92
				Number of comp.	4
				Trace	10
Rotation: oblique promax (Kaiser off)				Rho	0.7371
Component	Variance	Proportion	Rotated comp. are correlated		
Comp1	2.03514	0.2035			
Comp2	2.03265	0.2033			
Comp3	1.6774	0.1677			
Comp4	1.64254	0.1643			
Rotatio: (blanks are abs(loading)<.3)					
Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
Prioritises to reduce global emissions			0.6545		.1985
Prioritises to reduce local pollution			0.6750		.1928
Prioritises to reduce emissions to water		0.6028			.2544
Prioritises to reduce energy use	0.3580	0.4885			.2465
Prioritises to reduce noise		0.5658			.2947
Additive index for implementation	0.3305				.51
Ambition to become zero emission port	0.5199				.3287
Work strategically with transition to zero- low emission port	0.6719				.1896
Documented overview of emissions				0.6155	.2427
Documented overview of energy use				0.7445	.1708
Component rotation matrix					
	Comp1	Comp2	Comp3	Comp4	
Comp1	0.5530	0.5336	0.4536	0.4512	
Comp2	-0.5518	0.6390	-0.4230	0.3507	
Comp3	-0.3107	0.4077	0.5940	-0.6091	
Comp4	-0.5451	-0.3765	0.5134	0.5533	

dedicatedly implement more sustainable technologies and practices to become zero-emission, ports that conduct few intermediation activities orient towards more traditional environmental issues and tend to implement fewer and simpler practices in their transition work.

Although we saw a positive connection between intermediation activities and progressive transition work, it is difficult to determine if this progressiveness is the result of intermediation, or whether intermediation is a strategy performed precisely because these ports wish to be progressive. As mentioned above, it is also difficult to make a clear distinction between intermediation and processual transition work. This leads to one possible pitfall in this study, namely the empirical operationalisation of theoretical constructs. Considering how transitions are presented through a range of cross-disciplinary and interlinked understandings of actors, processes, structures and artefacts, empirically identifying and delineating the many different conceptualisations that transition scholars build on remains a challenge in preserving the validity and applicability of the research field (Sorrell, 2018; Berkhout et al., 2004; Genus and Coles, 2008; Smith et al., 2005). One ambition of this study has thus been to quantitatively operationalise the concepts of intermediation and transition work, thereby providing a more applied approach to understanding contemporary, emerging transitions. The above reflections on the relation between intermediation and transition work display one difficulty with this. Another is the possibility to extract substantial knowledge about highly complex and qualitative phenomena (i.e., intermediation, transition work) from quantitative data, which has not been a prominent endeavour in transition studies. Although our analyses provide novel insights into ports' intermediation and transition work, our sense-making around these findings was supported by extensive prior qualitative work (reported in Bjerkan and Ryghaug, 2021; Bjerkan et al., 2021; Damman and Steen, 2021; Bjerkan and Seter, 2021). A methodological take-away from this study, therefore, is that mixed-methods and data triangulation to greater extent should be employed in transition studies.

Table A8
Full regression analysis with aggregate transition work as dependent variable ($N = 78$).

Aggregate TransitionWork – PCA based	Coef.	Std. Err.	t	P>t
Intermediary role/intermediation	-.097	.148	-0.65	0.518
Public ownership	1.563	.858	1.82	0.074
Port calls	-.3944	.192	-2.04	0.046
Medium port	-.090	.333	-0.27	0.789
Large port	.720	.449	1.60	0.114
TrafficComplexity	-.159	.187	-0.85	0.399
Dedicated climate staff	.571	.271	2.11	0.040
TrafficComplexity2	.018	.014	1.32	0.194
Pressure from owner	.648	.198	3.27	0.002
Pressure from users/customers	.067	.151	0.44	0.659
Pressure from surroundings	-.167	.164	-1.01	0.315
Support from surroundings	.591	.171	3.45	0.001
Economy	.480	.137	3.51	0.001
Competence	-.047	.142	-0.33	0.739
Time and personnel resources	-.210	.157	-1.34	0.185
Regulation	-.304	.158	-1.93	0.059
Technological maturity	.216	.132	1.63	0.109
Political steering and governance	.060	.176	0.34	0.736
Steering from owner	-.272	.206	-1.32	0.193
Attitudes and ambitions among users	.011	.181	0.06	0.950
Collaboration/coordination from others	-.147	.195	-0.75	0.454
Other factors	.196	.258	0.76	0.452
Public ownership-Economy	-.246	.228	-1.08	0.286
_cons	-3.378	1.044	-3.23	0.002
Number of obs	78			
R-squared	0.677			
Adj R-squared	0.539			

On a final note, we recognize that although the sample is balanced in terms of public and private ownership, private ports are underrepresented compared with the total population. It is likely that the ports that did respond are generally more progressive when it comes to sustainability, considering the topic of the survey. This may suggest that actual transition work in the population of private ports is lower than indicated by our results. We suggest further research is needed on the transition work and intermediation activities of private ports to confirm this.

7. Conclusion

The purpose of this study has been to explore what role intermediation plays in the transition work of ports. As part of this, we conceptualised transition work as having both a processual and an outcome dimension, and discussed the relationship with intermediation. Our study of Norwegian ports finds that all ports engage in intermediation, that the extent of intermediation varies considerably, and that there is a positive correlation between intermediation and the outcome dimension of transition work. Further, we find a clear relation between the extent of intermediation and the progressiveness of transition work.

Overall, this study enables us to anticipate certain success factors for sustainability transitions in ports. One is ownership strategies and active port governance, which appear crucial to advance transition work. It could be considered particularly effective when ports' mandates explicitly include environmental sustainability and when they actively stimulate extensive transition partnerships based on aligned ambitions and support among port users and stakeholders. As such, port governance should deliberatively make use of ports' position in-between actors and networks, as well as their relational resources, to purposefully engage as intermediaries in the port sector's transition work.

This points to another success factor for sustainability transitions in ports, namely the important role of intermediation in progressing transition work. Although progressive transition work in ports is also a matter of orienting towards (new) energy issues and priorities, we have discussed whether progressiveness also follows the need or opportunity to engage in intermediation activities that balance the many different (in)ambitions and (in)efforts of complex actor-networks, and whose sustainability efforts are driven by different and potentially opposing factors.

In contrast to most studies on sustainability transitions (Zolfagharian et al., 2019), we have relied on a quantitative study design. This study has demonstrated challenges with operationalising and empirically distinguishing between theoretical concepts of intermediation and transition work. However, as empirical applications in quantitative studies require even more stringent interpretations and specifications of theoretical sentiments and nuances, quantitative approaches can serve as a useful test of the empirical applicability of the many concepts and understandings in transition studies. A future research effort could be to study intermediation with Structural Equation Modelling, measuring intermediation as a mediating variable between port characteristics and the transition work more directly, thus allowing for exploring various causal pathways (see for instance Meelen et al., 2019). A quantitative design was also useful to move beyond case studies of intermediation, allowing us to capture the intermediary behaviour within an entire sector,

where types and degrees of intermediation vary. As argued by a representative of the Norwegian association of public ports: "If you've seen a port, you've seen *one* port!". The complexity and diversity of the port sector suggests a variety of intermediation and transition work, with different scopes and directions. This heterogeneity is to some extent more easily captured with quantitative data. This variation also extends beyond Norwegian shores, and the frontrunner position of Norway in transitioning its transport systems towards low- and zero-carbon energy solutions renders more research necessary to assess if intermediation plays similar roles in port sectors elsewhere. A better understanding of this variety, including the different drivers and barriers for ports to engage in intermediation, can support the development of better intervention strategies (Zolfagharian et al., 2019).

Future research on transition work in ports should also more explicitly account for the (lacking) correspondence between intermediation and the interests of the port itself, as intermediaries could be placed between competing interests (e.g. Mignon and Broughel, 2020). How and whether ports engage in transition work could very well be shaped by the different societal functions they hold, for instance as nodes for transport and logistics or as wheels in regional economies. Intermediation activities and the transition outcomes they produce could as such result from problem agendas and niche innovations related to these functions, more than the desire to broker and facilitate sustainability transitions. Thus, the port sector represents a useful case for furthering our understanding of clashes between intermediation and interests in transition work.

Declaration of Competing Interest

No conflicting interest.

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Appendix

Tables A1–A8

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