Knowledge Strategies Facilitating Future Port Development and Management

Trine Marie Stene and Lone Sletbak Ramstad
SINTEF Digital, SINTEF, Trondheim, Norway

Trine.M.Stene@sintef.no
LoneSletbakk.Ramstad@sintef.no

Abstract: The European transport network is extensive and integrated, encompassing major ports, roads, airports, and rail systems. However, global demand proactive perspectives and measures. Europe is facing emerging developmental challenges, including increased geopolitical instability, climate changes, shortage of energy and natural resources, and intensified trade competition with China and US (Draghi, 2024). Transport plays a vital role in the European economy, prompting efforts to enhance integration between transport modes - for example through the Trans-European Transport Network (TEN-T). This paper focuses on ports as critical nodes in a multimodal transport system, and Its main objective is to explore how two theoretical perspectives – strategic knowledge management and resilience – can support planning and decision-making. Central in both approaches is the concept of "known and unknowns", referring to how organisations can prepare for and respond to future changes, events, and disruptions. The study is based on semi-structured interviews and addresses themes such as current collaboration and coordination of plans and practices, anticipated challenges and threats, and potential regional impacts of climate changes and geopolitical instability. The informants are key port stakeholders in Norway. The discussion reflects on how the two theoretical perspectives can inform the transformation of current management practices to better address future changes, disruptions and crises.

Keywords: Strategic knowledge management, Resilience, Integrated planning, Inter-organizational coordination, Emerging rends and challenges

1. Introduction

Europe is currently facing a range of emerging developmental challenges, including increased geopolitical instability, climate changes, shortage of energy and natural resources, and growing trade competition with China and United States (Draghi, 2024). Transport is a vital component of the European economy. The European transport network is extensive and integrated, encompassing major ports, roads, airports, and rail systems. In response, efforts are being made to enhance the integration between different transport modalities - for example through the Trans-European Transport Network (TEN-T). The TEN-T policy serves as a key instrument for planning and developing a coherent, efficient, multimodal, and high-quality transport infrastructure across the EU (European Commission, 2025). The network includes railways, inland waterways, short sea shipping routes, and roads that connect urban nodes, maritime and inland ports, airports and terminals.

This paper is a contribution in the MARMAN (Maritime Resilience Management of an Integrated Transport System) project financed by the Norwegian Research Foundation for the period 2021 – 2026. The overall objective is to develop a resilience-based knowledge foundation for governance, management and work practice that ensure a safe and secure integrated Maritime Transport Systems (MTS), particularly in the context of implementing connected and automated vessels (CAV).

Ports and terminals are critical nodes in a multimodal transport network. However, global trends point to significant future challenges, necessitating proactive perspectives and measures. The main objective of this paper is to explore and reflect on how knowledge management theory may support planning and decision-making in addressing these emerging trends and challenges.

2. Theory

This chapter presents two theoretical perspectives – strategic knowledge management and resilience – emphasising a proactive approach to address future scenarios, along with associated challenges and opportunities. Central to both perspectives is the concept of "knowns and unknowns", referring to how organisations can prepare for and respond to future changes, events, and disruptions. As such, both frameworks can support managerial preparedness and responsiveness in face of both anticipated and unforeseen scenarios.

2.1 Strategic Knowledge Management

This presentation of organisational strategic knowledge management is generally based on Bratianu (2022), with additional references specified where relevant. Strategic thinking is inherently future-oriented, and its core elements are uncertainty and the absence of knowledge. Therefore, it must be complemented with imagination

and creativity. Moreover, an organisation's strategies aim to bridge the knowledge gap between known and unknown.

Past, present and future. Time is a complex construct, and several theories emphasise the interplay between past, present and future in the process of knowledge creation and management (e.g. Nonaka & Takeuchi, 1995; Vygotsky, 1978). In line with this, Bratianu (ibid) argues that strategies should seek to reduce the gap between knowledge of the current situation and desired future state. Understanding the past involves interpreting previous events and their consequences, while imagination can help compensating for the absence of knowledge and reduce uncertainty. Risk management – by considering the potential effects of decisions – aims to exert some control over potential outcomes through using foresight and scenario thinking:

> *"By designing many probable futures, we can learn how to reduce uncertainty and the absence of knowledge – how to "create" knowledge and move faster from the state of known-knowns toward unknown-unknowns." (Bratianu, 2022)*

Generic knowledge strategies are assumed to be designed and implemented in any organisation in accordance with specific needs and dynamic capabilities. One of the perspectives presented is Dalkir's (2005) *Known-Unknown Matrix*, which outlines various knowledge states(see Figure 1. The knowledge states encompass both explicit knowledge (rational and conscious) and tacit (implicit, emotional or spiritual) knowledge.

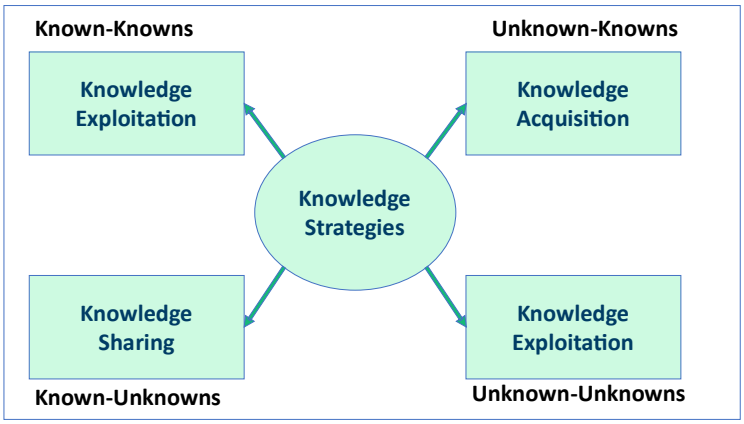

Figure 1: Generic Knowledge Strategies

Explicit knowledge is primarily associated with *known-knowns* and *unknown-knowns*. In contrast, *known-unknowns* and *unknown-unknowns* may involve both explicit and tacit knowledge. Bratianu argues that, since tacit knowledge is acquired through direct experience and processed by our cognitive conscious, *known-unknowns* reflect situations where we possess incomplete knowledge about the future. Furthermore, *unknown-unknown* represent events that are entirely unforeseen and cannot be anticipated.

Strategic approaches to each of the four knowledge states may differ: (1) *Knowledge Exploration* is a recommended management strategy for addressing known-knowns – knowledge embedded in for example an organisation's procedures, regulations or culture. Relevant management tools and processes include the integration of existing knowledge; codification which involves transforming knowledge into messages (often language-based) that can be understood across the organisation; and creation of knowledge maps to identify bottlenecks and prevent knowledge loss. These maps may distinguish between operational and strategic knowledge management. (2) *Knowledge Acquisition* strategies are suitable for addressing unknown-knowns, such as lack of knowledge about available resources. To identify what knowledge is missing, organizations can implement processes such as establishing learning networks or capturing knowledge from current and departing employees. (3) A *Knowledge Sharing* strategy is recommended for known-unknowns, when complete knowledge is distributed among different actors or individuals). Bratianu emphasizes that knowledge sharing is a central aspect of knowledge management, aiming to bridge the gap between individual and the organisational knowledge. Constituting individual knowledge with application and values can enhance innovation. This strategy should foster a supporting culture and a climate of trust. Management tools to facilitate this include training programs and Communities of Practice (eighter in-person or online). Lastly, (4) a *Knowledge Exploration* strategy may be used in face of innovations and knowledge absence. Identification of unknown-unknowns includes to imagine problems and possible solutions. Exploration processes include knowledge creation at the individual, team, and organisational levels. These strategies may assist managers to explore new knowledge alternatives

along main trends in e.g. science, technology, and economics. Bratianu describes that knowledge dynamics as a continuous interaction between rational, emotional, and spiritual fields, and argues that learning involves the integrated functioning of the total organism – thinking, feeling, perceiving, and behaving. In addition to rational knowledge, innovations today are also based on non-rational forms of knowledge including intuition and emotional insight.

2.2 Resilience

Resilience represents a proactive management, offering principles for handling both normal operations and unexpected events. To support future transformation in response to technological and societal changes, resilience emphasizes the design and maintenance of systems that can withstand, adapt to, and rapidly recover from disruptions. This approach is particularly relevant in complex and critical systems – such as aviation, healthcare, transportation, and information technology, where reliability and security are essential.

Management levels. Like strategic management theories, resilience perspectives aim to reduce the gap between the current and the desired state. In resilience terminology, this is often framed as the distinction between *Work-as-Done* (WAD) and *Work-as-Imagined* (WAI). WAD relates to work is actually done, while WAI describes how work is prescribed through management systems, regulations and standards. WAI typically reflects strategic-level management — what designers, managers, and authorities believe is or should be happening. WAD pertains to operational-level management.

Temporal insight. Understanding the past, present and future is essential for managing both foreseen and unforeseen events. Over the past decades the resilience concept has gained increasingly attention in scientific literature, resulting in numerous definitions (Stene & Skuggevik, 2024). The definition adopted in the MARMAN project is:

> *"A system is resilient if it can adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions" (Hollnagel, 2019).*

Some resilient approaches limit the focus to rebound capabilities, i.e. how a system recover from disrupting or traumatic events and returns to previous or normal activities. The emphasise is not on the rebound period itself, but rather on the capabilities and resources were present prior to the disruption (Woods, 2015). Measuring resilience in terms of rebound capabilities includes analysing how the system has adapted to past disruptions and changes. Consequently, the focus is placed on knowledge of past events, rather than on anticipating future ones.

However, it can be argued that after socio-technical systems rarely return to the exact pre-event state (bounce back) but instead undergo transformation to something different (bounce forward). In this view, understanding historical events is important but so is also recognizing *current* challenges and anticipating *future* trends —both of which are essential for identifying, updating and developing critical competences (Stene & Skuggevik, 2024). Resilience also involves mechanisms of transformation (Rocchetta, 2024), referring to the system's adaptive capacity to reorganize its structure or function in anticipation of, or in response to, destabilizing shocks. In addition to the ability to recover, this also includes the ability of its industrial and technological structure to evolve by creating an innovative growth path.

Further, it's important to distinguish between two related concepts – resilience and robustness (Woods, 2015). The term *robustness* refers to systems that are designed to effectively handle known failure modes. *Resilience*, on the other hand, describes how well the system also can handle troubles that were not foreseeable by the designer. You can think of robustness as being able to deal well with *known unknowns*, and resilience as being able to deal well with *unknown unknowns*. Foresight studies, trend-analysis and scenario design may be used to gather knowledge about potential future outcomes.

In addition to foreseen (known-unknowns) and unforeseen events (unknown-unknowns), resilience performance should cover competences to handle future normal variations (known-knowns) and vulnerability (unknown-knowns). The latter are related to risks and brittleness. Resilience should strive to minimize system vulnerability. Potential management measures may be to create arenas for experience transfer between relevant actors or stakeholders, e.g. networks, Community of Practices, workshopsor education.

Woods argues that a key characteristic of resilient system performance is *adaptive capacity* — the ability to adjust functions, including the ability to adapt to *future* surprises across multiple cycles of change. Resilient

performance, therefore, implies a dynamic approach: the ability to modify in response to situational changes and to adapt the performance as the situation evolves.

Hollnagel (2009) proposed four cornerstones regarding key abilities of organisational resilient performance, both for learning from historical events and detecting future anomalies:

- *Learn* – Knowing what has happened – To analyse and understand both successful and unsuccessful past events. An organisation adopts a plan for continuous learning, including analysis, communication and sharing of reflections regarding reasons for performance.
- *Anticipate* – Knowing what to expect – To look far ahead in time to identify events that need to be prevented from occurring. The organisation looks at the future and performs safety assessment with methods able to account for emerging phenomena.
- *Monitor* – Knowing what to look for – To understand when a situation, in the short term, is becoming to get critical and therefore start preparing for it. An organisation defines meaningful indicators and performs measurements of significant changes.
- *Respond* – Knowing what to do – To detect that something has happened, to recognise the relevance, and to respond to it. An organisation defines a set of critical events and allocates appropriate resources (competence, technology etc.) to respond if they occur.

3. Method

This study explores the significance of ports as nodes in a transport system through a qualitative approach, based on semi-structured interviews conducted in spring 2025 with seven significant port stakeholders in Norway. The interviews cover three main themes: (1) The current situation, including roles, responsibilities and coordination of plans and practices; (2) New technologies and increased automation in ports or terminals, including transition challenges and mitigation measures; and (3) Two future scenarios – climate changes and geopolitical instability – that may impact transport systems and regional communities.

The informants were contacted by e-mail informing about the project and an invitation to participate. Those who responded positively were subsequently contacted by phone to provide further details about the purpose of the interview and main topics, as well as to schedule the interview.

Each interview lasted between 60 to 90 minutes. Microsoft Teams was used both for dialogue and recording. Two interviewers were present at each session: one led the conservation, while the other took notes and ensured relevant follow-up questions.

The interview themes were used to structure the transcript and guide the initial coding process. The two theoretical perspectives – strategic knowledge management and resilience – were then applied to organise the findings and analyse the participant's statements.

4. Results

The structure of this chapter is according to the main themes.

4.1 Status – Multimodal Traffic and Transport Management

(A) Current maritime operations – How is the transportation from sea and from land to the port? Most Norwegian ports act as both infrastructure owners and logistic providers, investing in terminal equipment and port area development. However, coordination between onshore and offshore operations – such as between vessels, cranes, terminal operators, shipping companies – is generally limited. Most port directors are unaware of the total transportation cost through the terminal, although they are familiar with the crane service costs.

(B) Multimodal operations – Are the transport logistics of different modalities and actors coordinated? Ports serve as nodes in the transport chain and may constitute several modalities (sea, road, rain, air). A political goal is to shift more freight from road to sea or rail. Improved information sharing between actors at sea, in port, and on land is seen as beneficial, as is greater use of European transport corridors. Some ports participate in R&D projects, innovations initiatives and demonstration pilots to support port development. One interviewee described offering route planning services for individuals, aiming to create a seamless multimodal transport system.

(C) Integrated planning – How is transport coordinated within the port and with external transport systems? Ports lacking a comprehensive overview may face operational challenges. While involved actors often have their own operational plans, these may diverge. There is a strong need for coordination in planning large

infrastructure projects, such as terminals and roads. Some ports, as infrastructure owners, have outsourced the transport operations. They are planning for future electrification, including docking systems and cargo handling logistics. Efforts are being made to involve both internal and external operational managers in workshops and pilot projects related to strategical port development. However, strategical planning can be difficult to coordinate due to fragmented or insufficient knowledge. Political ambitions also influence definitions of visions and goals – for example a zero-emission vision affect prioritizing electrification, docking infrastructure, and automated transport.

(D) Handling of disturbances, threats or unforeseen events – Do ports have management strategies to prepare for and to respond to disturbances? Several informants highlighted challenges related to ownership and financial constraints. Ports often compete for national-level, strategic investments. Additionally, as most ports are municipality owned, investment decisions must be balanced against other local priorities such as healthcare or education. Ports also have limited influence over investments in other critical infrastructures – such as roads and hospitals – which may be owned by different agencies, neighbouring municipalities, or the state.

There are significant variations between ports. Some have established crisis teams and maintain dialogue and training exercises with local stakeholders as the military, fire and rescue, and water suppliers. These ports have emergency plans in place for identified threats, such as fire and collisions within the terminal area. However, they do not always fully account for the nature of hazardous goods being transported. Some informants argue that proactive evacuation plans should be developed whenever new potential hazardous products or services are introduces. In addition to workers, these plans should include local residents and fleet managers – both at sea and on land.

One company offering transport route service operates an operational control centre that manage all public transport in the area. This centre collaborates closely with traffic managers from rail and road networks, as well as with the police, fire and rescue services.

4.2 Ports as Critical Nodes

4.2.1 Improvements

Compared to today's practise – What aspects have the largest improvement potentials? A key area identified by all stakeholders is the need for better *coordination* between actors to avoid silo-thinking. This includes collaboration across the entire logistic chains - from large to small scale actors – such as cooperation between ports, ship operators and shipping companies. It also involves engaging local area agencies, citizens and end users as well as fostering collaboration between infrastructure owners and terminal operators.

Innovation topics are linked to several areas, including management structures and governance models, information and data sharing through digital platforms, city development and integrations addressing challenges faced by end users, regulations of transport, standards for digital data exchange, electrification and docking infrastructure .

4.2.2 Challenges related to future digitalisation, new technology and increasing automation

(A) Future trends and changes. Digitalisation will imply more automation of port operations and management. This includes exchange of information and data related to transport demands, port capacity, resource available, time slots, schedules, request for assistance. Automation aims to reduce costs improving operational effectivity and orchestration across transport modes. However, the use of digital platforms also includes cyber risks and may complicate the coordination of transport to and from the port.

The role of managers will shift from manual tasks to greater reliance on digital platforms, tools and automated processes. Mobility patterns will change, with new actors and new roles emerging, and more tasks transferred to control centres. Control centres will be used to manage, support and monitor traffic and transport operations. Thus, the managers will need to have insight in data sharing, knowledge of coordination between actors, standards and regulations, and technical tools supporting decisions.

(B) Measures to manage vulnerability. It is argued that greater emphasise must be placed on digitalisation, electrification and climate neutral solutions. Key measures include ensuring robust backup functions, as well as standardising and regulating of new products and services. Continuous development of legislation, aligned with global changes is also recommended.

To reduce silo thinking, increased collaboration between actors in the transport value chain is essential. Alternative routes and multimodal transport systems could include coordination between ports, costal administration and traffic surveillance .

Bridging the gap between strategic and operational management is highlighted as a critical need. One measure may be to identify potential hazards and What-If scenarios.

To be prepared for future changes, two of the interviewed agencies have established a department dedicated to R&D and innovation. Others are actively participating in pilot projects and demos international at international, national and local.

(C) Transition of knowledge management. Knowledge is emphasized as one key component. One important aspect is *knowledge sharing* of past, current and upcoming events. This can be facilitated through various arenas such as meetings, working groups, or digital information channels. Another aspect is to develop *new competence* by sharing information and knowledge. Relevant arenas may be training, pilots or demos, workshops, or meetings.

It is argued that the transformation will be successive, step-by-step, including both changes of procedures, people and technology. This requires change in expertise, training and exercises. Management will benefit from increased use of scenario planning to prepare and to adequately respond to changes. This includes coordinating ongoing activities, prioritizing between alternative solutions and procedures, and engaging in joint planning of investments, standards and legislation.

Integrated planning can be achieved when strategical managers come together and discuss shared visions, goals, ambitions and risks.

4.3 Scenario Planning

In the context of scenario planning, handling of both known and unknown events are important. This section presents reflections on two scenarios – climate change and geopolitical instability. Both may have huge impact on transport in general and in a regional context. The interviews explored whether these scenarios influence planning and preparedness, as well as coordination of regional actors and activities.

4.3.1 Climate change and natural hazards

Most relevant hazards affecting ports are flooding and extreme rain and snow-falls, followed by heavy wind affecting the tide. Harbours are considered critical infrastructures in the supply chain, and effective coordination across stakeholders, transport modes and actors is important. If one port is attacked, others must be prepared to support or take over transport.

Regional planning and scenario coordination are crucial and should involve a wide range of actors, infrastructure owners (as ports), road authorities, citizens, municipalities and county council, urban planners, emergency agencies, in addition to service providers of public transport, city bikes and car sharing. To reduce vulnerability, transport providers must conduct individually risk analysis and assessments.

There must be a strong focus on the sustainability of key critical functions as electricity, water and fuel. Emergency preparedness is important and should include learning from past events, e.g. chaos caused by heavy snowfall within a few hours. One example mentioned is how local actors together planned for future incidents using What-if scenarios - clarifying who does what, in what order, and which locations should be prioritized.

Defined scenarios should serve as the basis for pilots, demos and emergency training. Participation and dialogue with affected actors in preparation and execution should be emphasized. In some cases, significant time has been invested on surveys and outreach activities involving district committees, politicians, school and kindergarten visits.

4.3.2 Geopolitical instability

Ports are important geopolitical locations, serving as key nodes connecting different transport modes, logistic corridors and transport networks. Thus, ports may become targets in the event of war. The role is to ensure supply safety, maintaining safety and preparedness for major accidents, protecting industrial infrastructure, and providing information to users and the public.

Although planning for war scenario is increasingly relevant, such plans are generally not yet fully developed. Scenario planning should include potential hazards, risk and vulnerability analysis, the port’s role as digital node,

alternative routes and corridors, inter-port collaboration, multimodal transport, handling of dangerous goods, emergency preparedness and responsiveness, as well as clearly defined roles and responsibilities. Potential hazards identified are damage to electricity and water supplies, management system and communication infrastructure, as well as fire and leakage of hazardous fluids or gasses. Security policy is challenging today, as ports may be vulnerable, cyberattacks from hostile nations. Key actors in planning and emergency exercises include the military sector, Coastal Authority, Norwegian Directorate for Civil Protection, local emergency services, municipal authorities, infrastructure owners, tele suppliers, industry and citizens.

5. Discussion

Knowledge strategies are often linked to organizational outcomes and implemented within an organization. In the context of Multimodal Traffic Management, strategies should include inter-organisational outcomes – particularly the synchronizing of management systems (Stene & Skuggevik, 2024).

5.1 Can the Theoretical Perspectives – Strategic Knowledge Management and Resilience – Facilitate Port Development and Management??

Table 1 presents examples of port management practices categorized according to strategic knowledge management and resilience perspectives. The examples are based on tools and processes recommended by the participants in this study. Overall, the theories provide a useful framework for identifying potential measures, depending on the port's current level of knowledge and insight.

Knowledge exploitation supports a holistic ecosystem insight of current management. The findings indicate a significant potential for ports to optimize port operations, improve coordination with regional actors, and enhance multimodal transport and network efficiency. Management strategies may include knowledge mapping, identification of current practices and planning measures, and the use of historical data from successes and failures – such as experiences with changes, accidents, exercises and training.

Knowledge acquisition includes identification of future gaps, risks and vulnerabilities. Ports are recognized as critical nodes within a transport network. The results suggest that management can be improved through collaboration and integration of planning, including a shared understanding of knowledge and needs and interaction between actors.

The two latter strategies – *Knowledge sharing* and *Knowledge exploitation* - are more strongly characterized by uncertainty and the absence of prior knowledge. These, strategies require a degree of imagination and foresight. The findings highlight that scenario thinking, training, integrated planning, experimentations and innovations are essential management tools in this context.

Table 1: Strategic knowledge management and examples of resilient and strategic port management

Dimensions	Strategy	Examples of resilient and strategic port management
Known-Knowns **(Existing procedures, regulations, culture)**	*Knowledge Exploitation* (Messages, knowledge maps)	*Use historical data* from successes and failures related to changes, accidents, exercises and training *Map existing transport corridors and networks* in the logistic value chain to improve efficiency and reduce cost *Planning*: Consider future changes in *normal variation* of practise and management due to global trends as digitalisation
Unknown-Knowns **(Available resources)**	*Knowledge Acquisition* (Learning networks, knowledge capturing of individuals)	*Dynamic planning:* Involve internal and external actors to identify potential vulnerabilities and coordinate plans. Use experts to supplement specialized knowledge *Invite relevant multimodal* stakeholders to workshops, seminars etc *Research:* Map and get an overview of standards, legislation and potential local resources and actors
Known-Unknowns **(Knowledge distributed on different individuals)**	*Knowledge Sharing* (Training programs, CoP, Meetings)	*Meetings, workshops or seminars* to share expertise and experiences within and across actors *Digital platforms for information and data sharing* to ensure open access and identification of knowledge gaps *CoP* enables coordination of plans for and investments in critical infrastructures *Emergency plans and trainings:* regular practicing and coordination

Dimensions	Strategy	Examples of resilient and strategic port management
Unknown-Unknowns **(Knowledge absence)**	*Knowledge Exploitation* (Knowledge creation, explore new alternatives)	*Innovation and experimentation:* Participate in R&D, pilots and demos to prepare implementation of new knowledge, management, technology *Scenario planning:* to prepare and respond to future changes, events, and disasters *Control centres* may be considered to ensure collaboration and coordination of different actors

5.2 Is Theory a Significant Basis for Scenario Planning of Future Changes, Events, and Disasters?

The interviews underscore that knowledge is a key component in preparing for future changes, and that scenario thinking is vital for responding effectively to uncertainties. The theorical perspectives applied in this study take a proactive approach, emphasising the identification of potential futures alternatives. Past, present and anticipated knowledge is used in development of scenarios, foresight studies, and trend analysis. Dynamical planning enables the systematic collection, analysis, and dissemination of knowledge.

Furthermore, the two perspectives complement each other and together provide a comprehensive framework. They support the identification of potential future scenarios and the development of strategies to address them. While resilience perspectives are typically multi-disciplinary, strategic management theory offers more detailed guidance on specific measures related to leadership and decision-making. The four knowledge strategies offer a structured way to categorize relevant tools measures and procedures. In complex cases, the framework helps clarify which types of management strategies are appropriate for different challenges, events and scenarios (depending on the degree of insight available. Resilience theory supports scenario planning by emphasizing the importance of flexibility, redundancy, and adaptive capacity. It encourages the development of contingency plans and the ability to pivot quickly in response to foreseen and unforeseen events.

Innovation is described by Bratianu (2022) as a complex, nonlinear, and interactive process with many unknowns and unexpected outcomes. He argues that innovation is a dynamic design and decision-making process involving a series of risks and actors, and that it requires a new managerial philosophy - one that embraces open innovation, knowledge co-creation, strategic learning, and scenario thinking. The findings of this study support this view, indicating that innovation is essential for preparing future operations and managing transformation processes. Innovations may stem from known trends (as digital transformation), or more unknown challenges like natural hazards or geopolitical instability. In all cases, innovation may involve the development of new or changed processes, standards and digital platforms for communication and date sharing.

6. Conclusions

This study suggests that the perspectives of resilience and knowledge management can significantly support port development and the management of global trends and future challenges. Knowledge strategies may assist ports managers in strengthening preparedness and responsiveness to future changes, events, and disasters. The four knowledge strategies provide a useful framework for categorising, analysing and identifying knowledge needs in both in current context and in relation to future scenarios.

The findings also highlight a need for increased coordination between actors, integrated planning emerges as a key area that should be emphasized and further exploited in future research and innovation efforts. Today, traffic and transport management operate in silos within each mode (sea, road, rail, air), which limits the potential for holistic and resilient solutions.

Acknowledgements

The authors acknowledge the Norwegian Research Council projects MARMAN (324726 - FORSKER21).

Ethics and AI declaration: Ethical clearance for the research referred to in this paper was not needed. However, the informants are anonymized. No relevant AI tools are used to develop this paper.

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