

This is an electronic reprint of the original article. This reprint may differ from the original in pagination and typographic detail.

The Role of Digitalisation in Changing the Business Models in Logistics: Case of RoPax Ports

Chen, Yiran; Tsvetkova, Anastasia; Edelman, Kristel ; Wahlström, Irina; Heikkilä, Marikka; Hellström, Magnus

Published in:

36th Bled eConference – Digital Economy and Society: The Balancing Act for Digital Innovation in Times of Instability: June 25 – 28, 2023, Bled, Slovenia, Conference Proceedings

DOI:

[10.18690/um.fov.4.2023](https://doi.org/10.18690/um.fov.4.2023)

Published: 26/06/2023

Document Version

Final published version

Document License

CC BY

[Link to publication](#)

Please cite the original version:

Chen, Y., Tsvetkova, A., Edelman, K., Wahlström, I., Heikkilä, M., & Hellström, M. (2023). The Role of Digitalisation in Changing the Business Models in Logistics: Case of RoPax Ports. In A. Pucihar, M. Kljajić Borštnar, R. Bons, G. Ongena, M. Heikkilä, & D. Vidmar (Eds.), 36th Bled eConference – Digital Economy and Society: The Balancing Act for Digital Innovation in Times of Instability: June 25 – 28, 2023, Bled, Slovenia, Conference Proceedings University of Maribor Press. <https://doi.org/10.18690/um.fov.4.2023>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

THE ROLE OF DIGITALISATION IN CHANGING THE BUSINESS MODELS IN LOGISTICS: CASE OF ROPAX PORTS

YIRAN CHEN,¹ ANASTASIA TSVETKOVA,²

KRISTEL EDELMAN,² IRINA WAHLSTRÖM,¹

MARIKKA HEIKKILÄ,² MAGNUS HELLSTRÖM^{1,3}

¹ Åbo Akademi University, Laboratory of Industrial Management, Turku, Finland
yiran.chen@abo.fi, anastasia.tsvetkova@abo.fi, Irina.wahlstrom@abo.fi

² University of Turku, Centre for Collaborative Research, Turku, Finland
kristel.edelman@utu.fi, marikka.heikkila@utu.fi

³ University of Agder, Department of Working Life and Innovation, Kristiansand, Norway
magnus.hellstrom@abo.fi

This article explores digitalisation's potential to change traditional business models in the context of RoPax (roll-on, roll-off passenger vessels) ports in four Northern European countries. The study examines digitalisation's role in addressing business model change drivers, focusing on the perspective of port authorities (PAs). While digitalisation slowly affects operations at RoPax ports and PAs' business models, the research data exhibits no radical business model innovation. Instead, the findings indicate that PAs introduce new digitalisation and business activities, potentially leading to business model renewal. However, the current digitalisation is inefficient, as technology providers lack an in-depth understanding of the port business and its ecosystem, and PAs have scarce knowledge of digitalisation's business impact. The article concludes that connecting digitalisation strongly to the business model and strategic renewal is the way to overcome this challenge.

Keywords:

port
authority,
business
model,
maritime,
digitalisation

1 Introduction

Sea logistics is known for being among the slowest to adopt digital technologies (Acciaro et al., 2018; Transport Intelligence, 2019) and relies heavily on old communication and data exchange methods. However, digitalisation is considered a disruptive driver in the industry due to the opportunities for optimising logistics and integrating actors involved in transportation chains (Tsvetkova et al., 2021). The potential benefits of aggregating and analysing data on maritime transportation are vast (Watson et al., 2021), and various digital solutions are being implemented or developed (Brümmerstedt et al., 2017; Tijan, Jović, Aksentijević, et al., 2021; Tsvetkova et al., 2021).

As critical links in sea logistics and other transport modes, ports can renew their business models through digitalisation, reducing shipping emissions (Haraldson et al., 2021) and improving supply chain efficiency. Ports have already been conceptualised as ecosystems (de Langen, 2021; Haraldson et al., 2021; Watson et al., 2021), and port authorities (PAs) are increasingly seen as ecosystem integrators or orchestrators (Caballini et al., 2009), making their critical role in leading digital transformation undisputable (von Malmberg, 2004). Passenger ports also have high public interest and are often public enterprises that local municipalities fully or partly own, making them an interesting public–private collaboration platform. They play a key role in transport digitalization and sustainable transitioning in maritime transportation (Damman & Steen, 2021; Del Giudice et al., 2021).

This article explores digitalisation’s potential to change incumbent business models in a highly institutionalised, asset-heavy industry. Six RoPax (roll-on, roll-off passenger vessels) ports in four Northern European countries, handling both vehicle and passenger transportation, were interviewed on their digitalisation efforts and goals. Due to low regional transport intermodality, these ports can be seen as a continuation of road networks and can benefit from digitalisation differently than mega container ports, which have been extensively studied in light of digitalisation (Brümmerstedt et al., 2017; Port of Rotterdam, 2023).

The current study provides insight into the digitalisation process and business model innovation from PAs’ perspective. Thus, our research question is, “How do incumbent firms in logistics use digitalisation in their business model innovation?”

To answer this, we explore the drivers for business model innovation in the chosen context and understand the general directions for business model change in RoPax ports. Then, we pinpoint digitalisation's role in addressing those drivers through business model innovation.

2 Literature Review

2.1 Digitalisation's Role in Changing Business Models

Business model innovation (BMI) has been defined as the designed, novel, and non-trivial changes to the key elements of a company's business model and architecture linking these elements (Foss & Saebi, 2017). The widespread diffusion of digital technologies has become one of the key drivers and enablers of BMI at the firm level (Holmström et al., 2019). Exploiting digital technologies through innovative business models has been distinguished from innovation in which new technologies are developed within the product innovation process (Caputo et al., 2021; Cozzolino et al., 2018). Furthermore, digitalisation grants opportunities for BMI beyond firm-level changes to cross multiple industries and ecosystems (Kamalaldin et al., 2021; Leminen et al., 2020; Sjödin et al., 2020).

The conceptual relationship between digitalisation and corresponding changes in business models has been extensively explored (Caputo et al., 2021); studies of digitalisation in different industrial contexts show that digitalisation and BMI is context-dependent (Benghozi & Salvador, 2015; Kamalaldin et al., 2021; Vendrell-Herrero et al., 2017). Caputo et al. (2021) note that the proliferation of new business models characterised by a high degree of digital innovation has concerned innovative and traditional sectors, which are not characterised by high degrees of technological investment. Furthermore, while BMI is often necessary to reap digitalisation's benefits, most incumbent firms across industries are ill-prepared to benefit from digital transformation (Parida et al., 2019).

Digitalisation in the maritime industry is considered slow (Acciaro et al., 2018; Transport Intelligence, 2019). Nevertheless, indications show that digitalisation in the maritime sector can change the relationships among the supply chain actors, restructure the ecosystems, and create an opportunity for new business models or

changes in incumbent business models (Fruth & Teuteberg, 2017; Heikkilä et al., 2022; Tijan et al., 2021 a; Tsvetkova et al., 2021).

2.2 Business Model Innovation and Digitalisation in Ports

Ports are areas with maritime and hinterland access that have developed into logistics hubs (Van der Lugt & De Langen, 2007). Ports are managed by PAs, that often operate as landlords (World Bank, 2007). In most cases, a PA is a publicly owned company by a local municipality or state and manages and develops the port area, with income mainly based on land rent and port dues. Tenants in a port are often companies involved in port operations or logistics activities (Van der Lugt & De Langen, 2007). Thus, landlord PAs aim to balance between public (PA, municipality) and private (port industry) interests (World bank, 2007). Regulation and business environment alternations drive changes in ownership of PAs (Notteboom et al., 2022; Rönty et al., 2011), pressures come from numerous actors, such as NGOs; governments; municipalities (Verhoeven, 2010); and business partners and customers, such as logistic companies, cargo owners, and passengers (Notteboom et al., 2022, Chapter 4.1).

Furthermore, a PA's business model depends on numerous other factors, such as its traffic profile, typologies of cargo and passenger, location, existing facilities, and infrastructural conditions (Burns, 2014, p. 22; Paixão Casaca & Lyridis, 2022). Environmental, technological, geographical, and demographic changes also drive today PAs' business model evolution (Vonck et al., 2021). The mentioned factors influence a PA's strategic decision-making (Haraldson et al., 2021). Given such a changing landscape, the strategic responses are, for example, becoming full-fledged partners in the logistics chain, restricting a port's role to supporting activities or entirely disappearing from the scene (Heaver et al., 2010).

Digitalisation offers new opportunities for a PA's BMI. Scholars proved the importance of PAs' initiatives when it comes to digitalisation, considering different types of port governments models (Tijan, Jović, Panjako, et al., 2021). However, limited studies have addressed the relevance of digitalisation, the PA's business model, and ecosystem changes (Henríquez et al., 2022; Hirata et al., 2022). A major focus on port digitalisation has been set in mega and large container ports (Haezendonck & Langenus, 2019; Henríquez et al., 2022). Ports with other traffic

profiles, such as RoPax ports, are scarcely reviewed. Compared to mega and large container ports, these ports are limited regarding resources and investments (Del Giudice et al., 2021; Inkinen et al., 2019; von Malmborg, 2004) and face challenges on understanding digitalisation's influence on strategic business development (Inkinen et al., 2019).

Thus, our study complements the current research agenda's gap and focus on digitalisation in RoPax ports.

3 Methodology

3.1 Research Design

The theoretical gap and emerging status of port digitalisation led researchers to adapt qualitative research with a multi-site case study approach (Creswell, 2007), where the RoPax port is considered a case studied in the diverse sites where these ports are located. A multi-site case study enables the understanding of a specific phenomenon that is merged into the context, adding to the phenomenon's complexity (Audet & d'Amboise, 2001; Gillham, 2000; Yin, 2018). Similarly, to a multiple case study, which enables comparison (Eisenhardt & Graebner, 2007; Gibbert et al., 2008; Gioia et al., 2013), the case is compared between sites with the possibility for cross-site generalisations. This comparison aims to enhance understanding digitalisation in relationship with business models in RoPax ports.

RoPax ports gained scarce research attention (see section 2.2), our ultimate research interests are commonalities in use of digitalisation. Our research logic takes an abductive approach, pursuing the iterative matching and simultaneous evolution between theories and empirical observations (Dubois & Gadde, 2002). By applying cross-site comparison (Creswell, 2007), this research approach enables identifying variations within the same case.

3.2 Selection of Sites

The study includes six RoPax ports in four Northern European countries. Each port offers regular liner traffic operated by at least two shipping lines to more than one international destination port. The ports and countries were chosen based on generic

similarities such as a common trading area, ownership base, high share of short shipping services, business model and culture, and high level of national digital infrastructure readiness, integration, and adaption.

3.3 Data Collection and Analysis

The primary research data was collected with semi-structured interviews conducted with PAs, with an average duration of one hour. Secondary data served as foundation for drafting interview topics regarding business model transitions from a PA's perspective, which comprises press releases, publications, statistics, and strategic and project reports related to PAs' development. Drivers for business model, ecosystem, and activity changes were discussed during the interviews. For each selected port, one or more managerial-level representatives joined a discussion of selected topics. The interviews were recorded, transcribed, and documented. Table 1 presents the case ports' characteristics.

Table 1: Ports' Characteristics

PA	Traffic profile	Interviewees' roles	Data format
Alpha	Cargo + Passenger	Port Development Strategist	Interview
Beta	Cargo + Passenger	Technical Director Operation Manager IT Specialist	Workshop and interview
Gamma	Cargo + Passenger	Head of Business Development	Interview
Delta	Cargo+ Passenger	Development Manager	Interview
Epsilon	Passenger-dominated	Business Development	Interview
Zeta	Cargo + Passenger	Chief Operations Officer	Interview

Data analysis followed the deductive category application and further inductive category development (Mayring, 2004), which can be labelled a directed approach to content analysis aimed to support or extend the theory (Hsieh & Shannon, 2005). The labels were later compared to existing theories regarding BMI, digitalisation, and literature related to port business models. The abductive iteration involves identifying mismatched empirical-theoretical concepts, which were further studied by aligning with other theoretical explanations.

Three researchers independently analysed the interview transcripts and secondary data to attain reliable categorisation and identified content pertinent to one of the topics defined in the analysis framework. All researchers then compared notes and agreed on the categories within each topic by merging some of them and revisiting the original texts in case of dissimilarities in identified drivers or enablers for BMI.

4 Findings

4.1 Drivers for Business Model Change in RoPax Ports

Over the recent decades, combining short-sea passenger and cargo transportation has become an established and common transport concept (Marcadon, 1998). RoPax vessel design is based on roll-on and roll-off features, enabling efficient loading and unloading of wheeled commercial vehicles (trucks, trailers) and passenger cars and the capability to accommodate passengers. The case ports have short vessel turnaround times, low cargo standardisation, and are further challenged by additional services passenger transportation.

The analysis of the interviews indicates that managing and combining the flows and services of cargo and passengers leads to several specific challenges, all leading to digitalisation opportunities. On the passenger side, typical challenges are related, for instance, to non-integrated information on transport connections and services as well as crowding and queuing in the passenger terminal. Conversely, the multimodal transport chain is hampered by uncoordinated road traffic pulses and congestion at ship arrivals and departures inside the port, associated urban area, and its main approach roads. This problem is less likely to diminish with expanding residential and recreational urban areas and the associated shrinkage of the port areas. Furthermore, the vessels are likely to grow in cargo capacity, further worsening the overcrowding of the road network, while traffic jams give rise to idling and unnecessary emissions (Wahlström et al., 2022).

Further, passenger transportation forms a vital revenue source for the shipping company and the PA. Several PAs mentioned the detrimental effects of trade shocks, such as the one caused by the COVID-19 pandemic, taking passenger transportation to a total standstill, impacting shipping services availability and, in most cases,

dramatic plunges in PAs' revenues with potentially long-term consequences and challenges to retain the main customers' regular fleet capacity.

4.2 Changes in the Business Models of RoPax Ports

Traditionally, RoPax ports' principal customer base comprises shipping lines and port operators. Other relevant actors encompass various authorities and land-based passenger and cargo transporting companies.

Meanwhile, passengers and road haulage companies are shipping lines' main customers. A RoPax PA's primary income derives from vessel, passenger, and cargo fees and the rental income of facilities. Conversely, the main expenditures typically include human resources costs and land leases paid to the municipality. A RoPax PA's value proposition is providing required infrastructure, facilities, and quay-side vessel services, enabling safe, efficient, and timely port calls and smooth cargo and passenger flows.

A PA's strategic renewal is largely driven by the drivers mentioned in 4.1, and manifested in changes in their business models to a varied degree. Following our inductive approach, we identified several recurring topics. The changes in the RoPax PAs' business models (see Table 2) are common for two or more studied ports and concern changes in value-creating activities, earning logic, revenue streams, and key partnerships, using resources for value creation.

As presented in the table, the most radical change concerns the ***business expansion*** and ***further integration in logistics and supply chain***. With the construction of new passenger terminals, several PAs are taking over the ownership of passenger terminals. Combined with the increasing perception of passengers as PA's customers, the ownership transition of the terminal premises brings many changes to the business models, such as new value propositions for passengers and new activities to ensure customer satisfaction. In addition, PAs are also searching for new values for existing facilities, such as using terminal buildings as a venue outside of traditional port operation use.

Table 2: Changes in PAs' Business Models

		Alpha	Beta	Gamma	Delta	Epsilon	Zeta
Business expansion	New values of port facilities		x	x		x	
	New offerings for passengers		x	x	x		
	Ownership and operation of passenger terminals		x			x	
Integration in logistics and supply chain	Enhanced communication	x	x	x	x		
	Enabler of digitalisation by other port actors		x	x			
Environmental impact reduction	Green incentives for port users	x	x			x	x
	Alternative fuel infrastructure	x			x	x	x
Efficiency improvement	Cargo and passenger flows separation					x	x
	Increased facility utilisation rate	x	x	x	x	x	x
Social responsibility	Decreased human work		x		x		
	Expanding safety and security measures		x		x		

Further integration with other actors enables optimised supply and logistics chains. This entails enhanced communication of port activities and service offering for diverse logistics actors. It is worth highlighting that PAs could also become enablers and integrators of logistics chains digitalisation, as mentioned by several interviewees. Because ports are critical transport hubs that could affect the overall logistics performance.

Increased integration with other logistics actors is also crucial for *reducing shipping's environmental impact*. There was a discussion with PA Alpha that a port's emission mitigation scope should be extended to achieve overall logistics emission reduction. Several PAs have implemented or plan to implement green incentives for its customers, such as pricing models and rebates based on the visiting vessel's environmental performance. Green corridors are considered another important initiative for shipping emission reduction; PAs play a key role in establishing those. In this vein, several PAs are planning to develop alternative fuel infrastructure.

PAs focus on **efficiency improvement** to retain competitive, enhance and maximise the utilisation rate of port infrastructure and assets, including facilities, warehouses, quays etc. Thus, automating various processes is high on the agenda. Many RoPax ports, located close to city centres, face increasing threat of space limitations, and hence a potential solution would be to geographically separate and relocate potential non-wheeled cargo from RoPax associated passenger and cargo services. Automation in operations rationalises and increases the efficiency, safety and security of various manual activities and processes, hence optimising, the workers' work conditions and safety as part of PA's *social responsibility*.

4.3 Digitalisation Efforts at RoPax Ports

We see different efforts and digital tools applied in ports. Our analysis indicates that PAs who have or are about to establish their digitalisation strategies or roadmaps are actively contributing to the understanding of how digitalisation could support their business activities, enabling the avoidance of a "digitalised mess", as one of the interviewees mentioned, and prioritising various ongoing and upcoming digitalisation projects.

In general, we recognised four distinct strategic areas where digitalisation was implemented or planned in the RoPax ports:

1. **Infrastructure management:** This is the traditional focus of landlord PAs. Apart from regular maintenance work, the PAs growingly face the pressure of adjusting and upgrading infrastructure in response to growing trade volumes and vessel capacities. The case PAs had developed digital solutions to help monitor and manage security in the ports. Furthermore, they

increasingly utilise port infrastructure data to improve maintenance and facility services. PAs also showed interest in developing digital twins of the port infrastructure.

2. **Traffic fluency:** Space limitation and co-existence with expanding port cities is a growing concern, driving PAs to search for automated and digitalised solutions, ensuring smooth passenger and cargo flows, efficient operations, and timely port calls. The digitalisation degree of the case PAs varied markedly. However, digitalising logistics and supply chains has increasingly pressured PAs to adopt new technologies, such as automated check-in for passengers and vehicles.
3. **Green transition:** Today, the environmental regulation of the shipping industry together with national climate goals constitutes one of the key development areas in RoPax ports. PAs have progressively shifted to electrified equipment and machinery, greener fuels, and more energy-saving infrastructure to reduce the environmental impact. Berthing vessels have been the leading emitter of carbon dioxide and other air pollutants. Hence, installing and investing in automooring and an onshore power supply have occurred in most of the interviewed ports.
4. **Data sharing between port-operation-related organisations:** PAs are introducing new digital solutions to strengthen communication, electronic trade documents sharing, customs clearance, and integration with other supply chain actors. More ambitious solutions that span across entire supply chains were mentioned, however less often. These solutions aim at improved efficiency and sustainability, amongst others.

The above digitalisation areas are summarized in Table 3.

Table 3: Major Digitalisation Areas

	Alpha	Beta	Gamma	Delta	Epsilon	Zeta
1) Improved infrastructure management						
Security monitoring and management	x	x	x	x	x	x
Digitising infrastructure data	x		x		x	
Infrastructure use management			x			
2) Enhanced traffic fluency						
Automated check-in (passengers)	x	x	x	x	x	x
Automated check-in (vehicles)		x	x			x
Intelligent traffic management	x		x	x		
Digital buoys/fairways	x					
Autonomous vehicles	x					
3) Green transition						
Monitoring emissions and air quality		x	x			
Monitoring and optimising energy use	x		x	x		
Automoorings	x	x	x	x		
4) Data sharing between port-operation-related organisations						
Communication and procedures among port actors	x	x	x	x	x	x
Intelligent supply chain			x			

5 Discussion

The findings affirm that digitalisation gradually affects RoPax port's operations and business models. At the beginning of the study, we expected digitalisation to drive PAs to innovate their business models. However, the data illustrated that PAs are introducing new digitalisation and business activities, potentially leading to business model renewal. However, no radical business model innovations were identified. For instance, PA's value proposition remains the same, as most of the case ports would remain landlord ports (World Bank, 2007) also in future. Thus, the discussion focuses on drivers for business model changes and how digitalisation supports these changes rather than business model innovations.

Although some PAs implemented strategies or roadmaps for enabling the creation of a more holistic view of digitalisation. The current digitalisation is fragmented and may cause a "digitalised mess" (see section 4.3). If PAs digitalise without

contextualising strategically, the actual digitalisation benefit would be limited. For example, many solutions mentioned in section 4.3 are short-term project outcomes that are not part of a PA's strategic plan.

Conversely, PAs may have limited knowledge of how digitalisation may impact and improve their efficiency and business performance, potentially prolonging the decision-making process. For instance, several PAs mentioned the inability to comprehend the true advantages that solutions such as a digital twin would bring, especially as the development and implementation are perceived to require significant resources, whilst the application's benefits may remain undisclosed.

This situation echoes previous studies on the maritime transport sector that emphasise there is a *“lack of awareness of how digital transformation may affect the business”* (Tijan, Jović, Aksentijević, et al., 2021). As the interview analysis shows, for overcoming this challenge, job positions and responsibilities are established for developing digitalisation roadmaps and embedding digitalisation in strategic planning based on individual business development needs. We could observe that connecting digitalisation with business development needs could contribute for PA's strategic business model renewal, such as acquiring relevant knowledge or planning digitalisation in a long-term context.

Despite the “digitised mess” (see Section 4.3), digitalisation enables and drives several prominent business model changes for the case PAs, namely, supporting the formation of green logistic chains or becoming a digital infrastructure owner.

Besides the more ‘physical’ (as opposed to digital) activities, such as developing alternative fuel infrastructure, ports provide awareness of emissions and pollution from port operations through monitoring solutions and communication with other logistic actors. Improving passenger and cargo flow efficiency through avoiding unnecessary idling, could also reduce emissions. PAs naturally achieve further integration with other actors alongside the logistic chain.

Digitalisation aids this goal in several ways. Firstly, PA could facilitate digitalising documentation and information sharing between organisations. Secondly, several optimisation solutions, such as automated check-in and flow of passengers and vehicles and intelligent traffic management, support PAs in affecting the activities beyond a RoPax terminal to enhance port operations efficiency.

PAs could also be a central digital infrastructure provider for other organisations to improve port operations performance. In line with Hollen et al. (2015), we argue that RoPax ports seemingly explore complementary roles and activities in pursuing creating strategic value as landlord ports, i.e., the value for critical actors. Digitalisation integrates interorganisational logistic activities, increases traffic flow transparency, and trace emissions – the information basis for decision-making by PAs and other logistics actors. Digital solutions like autonomous roads and intelligent supply chains also contribute to expanding the role of ports in the hinterland of logistics chains (Gonzalez Aregall et al., 2018).

In Table 4, we present the digital solutions implemented or planned to be implemented in studied RoPax ports. We also analysed digital solutions' contribution (see section 4.3) to the business model changes discussed in section 4.2. Not surprisingly, PAs predominantly invest in digital solutions that allow to increase operation efficiency. These solutions mainly concern automation in the pursuit reduction of port operations' time and costs, but also to decrease human work, thereby also addressing the changes related to social sustainability.

6 Conclusion

We contribute to the literature on the business models of ports by explicating digitalisation's role in aiding changes in the business models of RoPax ports. We also contribute empirically with an account of digitalisation efforts in RoPax ports, which are less studied in the literature on digitalisation in ports and sea logistics.

The study has several limitations. First, it focuses on a limited geographic context of Northern Europe. Further, although the change in business models is studied by discussing the current business models of ports and foreseeing changes in their business model, a more longitudinal study would be beneficial to uncover the business model evolution in this context.

Table 4: Types of Digital Solutions Planned and Implemented by RoPax PAs and Main Digitalisation Areas

<i>Digitalisation areas</i>	<i>Digital solutions</i>	<i>Contribution to business model change</i>				
		Business expansion	Integration in logistics chains	Environmental impact reduction	Efficiency improvement	Social sustainability
Improved infrastructure management	Security monitoring and management				x	x
	Digitising port infrastructure data					
	Infrastructure use management				x	
Enhanced traffic fluency	Automated check-in for passengers and vehicles				x	
	Intelligent traffic management				x	
	Digital buoys/fairways		x		x	
	Autonomous vehicles		x		x	
Green transition	Monitoring emissions and air quality			x		x
	Monitoring and optimising energy use			x		
	Automoorings				x	x
Data sharing between port-operation-related organisations	Communication and procedures among port actors		x		x	
	Intelligent supply chain		x	x	x	

References

- Acciaro, M., Ferrari, C., Lam, J. S. L., Macario, R., Roumboutsos, A., Sys, C., Tei, A., & Vanelander, T. (2018). Are the innovation processes in seaport terminal operations successful? 787–802.
- Audet, J., & d'Amboise, G. (2001). The Multi-Site Study: An Innovative Research Methodology. The Qualitative Report, 6(2), 1–18.
- Benghozi, P. J., & Salvador, E. (2015). How and where the R&D takes place in creative industries? Digital investment strategies of the book publishing sector*, 28(5), 568–582.

- Brümmerstedt, K., Fiedler, R., Flitsch, V., Jahn, C., Roreger, H., Sarpong, B., Saxe, S., & Scharfenberg, B. (2017). *Digitalization of Seaports - Visions of the Future* (C. Jahn, S. Saxe, & Fraunhofer CML, Eds.; p. 168). Fraunhofer Verlag.
- Burns, M. G. (2014). *Port management and operations*. CRC Press.
- Caballini, C., Carpaneto, L., & Parola, F. (2009). Italian port authorities approaching the post-reform: The Ligurian Case (pp. 191–207).
- Caputo, A., Pizzi, S., Pellegrini, M. M., & Dabić, M. (2021). Digitalization and business models: Where are we going? A science map of the field. *Journal of Business Research*, 123, 489–501.
- Cozzolino, A., Verona, G., & Rothaermel, F. T. (2018). Unpacking the Disruption Process: New Technology, Business Models, and Incumbent Adaptation. *Journal of Management Studies*, 55(7).
- Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*, 2nd ed. Sage Publications, Inc.
- Damman, S., & Steen, M. (2021). A socio-technical perspective on the scope for ports to enable energy transition. *Transportation Research Part D: Transport and Environment*, 91, 102691.
- de Langen, P. W. (2021). Seaports as Clusters of Economic Activities. In *International Encyclopedia of Transportation* (pp. 310–315). Elsevier.
- del Giudice, M., di Vaio, A., Hassan, R., & Palladino, R. (2021). Digitalization and new technologies for sustainable business models at the ship–port interface: a bibliometric analysis. 49(3), 410–446.
- Dubois, A., & Gadde, L. E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, 55(7), 553–560.
- Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50(1), 25–32.
- Foss, N. J., & Saebi, T. (2017). Fifteen Years of Research on Business Model Innovation: How Far Have We Come, and Where Should We Go? *Journal of Management*, 43(1).
- Fruth, M., & Teuteberg, F. (2017). Digitization in maritime logistics—What is there and what is missing? *Cogent Business and Management*, 4(1).
- Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study? *Strategic Management Journal*, 29(13), 1465–1474.
- Gillham, B. (2000). *Case study research methods*. Bloomsbury Publishing.
- Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods*, 16(1), 15–31.
- Gonzalez Aregall, M., Bergqvist, R., & Monios, J. (2018). A global review of the hinterland dimension of green port strategies. *Transportation Research Part D: Transport and Environment*, 59, 23–34.
- Haezendonck, E., & Langenus, M. (2019). Integrated ports clusters and competitive advantage in an extended resource pool for the Antwerp Seaport. *Maritime Policy and Management*, 46(1), 74–91.
- Haraldson, S., Lind, M., Breitenbach, S., Croston, J. C., Karlsson, M., & Hirt, G. (2021). The Port as a Set of Socio-technical Systems: A Multi-organisational View. In *Maritime Informatics* (pp. 47–63).
- Heaver, T., Meersman, H., Moglia, F., & van de Voorde, E. (2010). Do mergers and alliances influence European shipping and port competition? 363–373.
- Heikkilä, M., Saarni, J., & Saurama, A. (2022). Innovation in Smart Ports: Future Directions of Digitalization in Container Ports. *Journal of Marine Science and Engineering*, 10(12).
- Henríquez, R., Martínez de Osés, F. X., & Martínez Marín, J. E. (2022). Technological drivers of seaports' business model innovation: An exploratory case study on the port of Barcelona. *Research in Transportation Business & Management*, 43, 100803.
- Hirata, E., Watanabe, D., & Lambrou, M. (2022). *Shipping Digitalization and Automation for the Smart Port. Supply Chain - Recent Advances and New Perspectives in the Industry 4.0 Era* [Working Title].

- Hollen, R. M. A., van den Bosch, F. A. J., & Volberda, H. W. (2015). Strategic levers of port authorities for industrial ecosystem development. *Maritime Economics and Logistics*, 17(1), 79–96.
- Holmström, J., Holweg, M., Lawson, B., Pil, F. K., & Wagner, S. M. (2019). The digitalization of operations and supply chain management: Theoretical and methodological implications. *Journal of Operations Management*, 65(8), 728–734.
- Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277–1288.
- Inkinen, T., Helminen, R., & Saarikoski, J. (2019). Port digitalization with open data: Challenges, opportunities, and integrations. *Journal of Open Innovation: Technology, Market, and Complexity*, 5(2).
- Kamalaldin, A., Sjödin, D., Hullova, D., & Parida, V. (2021). Configuring ecosystem strategies for digitally enabled process innovation: A framework for equipment suppliers in the process industries. *Technovation*, 105, 102250.
- Leminen, S., Rajahonka, M., Wendelin, R., & Westerlund, M. (2020). Industrial internet of things business models in the machine-to-machine context. *Industrial Marketing Management*, 84, 298–311.
- Marcadon, J. (1998). L'évolution récente de l'activité maritime et portuaire dans les pays de la Baltique (Recent evolution of the maritime and port activity in the Baltic states). *Bulletin de l'Association de Géographes Français*, 75(4), 428–436.
- Mayring, P. (2004). Qualitative content analysis. *A Companion to Qualitative Research*, 1(2), 159–176.
- Notteboom, T., Pallis, A., & Rodrigue, J.-P. (2022). Port Economics, Management and Policy. In *Port Economics, Management and Policy*. Routledge.
- Paixão Casaca, A. C., & Lyridis, D. v. (2022). Guest Editorial: Port Business and Green Innovation. *Maritime Business Review*, 7(1), 2–4.
- Parida, V., Sjödin, D., & Reim, W. (2019). Reviewing literature on digitalization, business model innovation, and sustainable industry: Past achievements and future promises. In *Sustainability (Switzerland)* (Vol. 11, Issue 2). MDPI.
- Port of Rotterdam. (2023, Feb 12). Smart shipping process. <https://www.portofrotterdam.com/en/to-do-port/futureland/smart-shipping-process>
- Rönty, J., Nokkala, M., & Finnälä, K. (2011). Port ownership and governance models in Finland Development needs & future challenges. In VTT Technical Research Centre of Finland.
- Sjödin, D., Parida, V., Jovanovic, M., & Visnjic, I. (2020). Value creation and value capture alignment in business model innovation: A process view on outcome - based business models. *Journal of Product Innovation Management*, 37(2), 158–183.
- Tijan, E., Jović, M., Aksentijević, S., & Pucihar, A. (2021). Digital transformation in the maritime transport sector. *Technological Forecasting and Social Change*, 170, 120879.
- Tijan, E., Jović, M., Panjako, A., & Žgaljić, D. (2021). The Role of Port Authority in Port Governance and Port Community System Implementation. *Sustainability* 2021, Vol. 13, Page 2795, 13(5), 2795.
- Transport Intelligence. (2019). *Global Freight Forwarding 2019*.
- Tsvetkova, A., Gustafsson, M., & Wikström, K. (2021). Digitalizing maritime transport: digital innovation as a catalyzer of sustainable transformation. *A Modern Guide to the Digitalization of Infrastructure*, 123–148.
- van der Lugt, L., & de Langen, P. W. (2007). Port authority strategy: beyond the landlord—a conceptual approach. *Proceedings of the 2007 IAME Conference*.
- Vendrell-Herrero, F., Myrthianos, V., Parry, G., & Bustinza, O. F. (2017). Digital dark matter within product service systems. *Competitiveness Review*, 27(1), 62–79.
- Verhoeven, P. (2010). A review of port authority functions: towards a renaissance? 37(3), 247–270.
- von Malmberg, F. (2004). Networking for knowledge transfer: Towards an understanding of local authority roles in regional industrial ecosystem management.
- Vonck, I., Camphuijsen, R., & Jongejan, J. (2021). Europe's ports at the crossroads of transitions A Deloitte and ESPO Study.

- Wahlström, I., Hellström, M., Tsvetkova, A., & Chen, Y. (2022). Greening Ferry Ports by Truck Flow Optimisation. *Baltic Transport Journal*.
- Watson, R. T., Lind, M., Liesa, F., & Delmeire, N. (2021). Shipping: A Self-Organising Ecosystem. In *Maritime Informatics* (Issue 2020, pp. 13–32).
- World Bank. (2007). *Port Reform Tool Kit*.
- Yin, R. K. (2018). *Case study research and applications: design and methods* (Sixth edit). Sage.