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*Published in:*

Journal of International Technology and Information Management

*DOI:*

[10.58729/1941-6679.1583](https://doi.org/10.58729/1941-6679.1583)

Published: 01/01/2024

*Document Version*

Final published version

*Document License*

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[Link to publication](#)

*Please cite the original version:*

Chen, Y., Tsvetkova, A., Edelman, K., Wahlström, I., Heikkilä, M., & Hellström, M. (2024). How does Digitalisation Transform Business Models in Ropax Ports? A Multi-Site Study of Port Authorities. *Journal of International Technology and Information Management*, 32(1). <https://doi.org/10.58729/1941-6679.1583>

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# How does Digitalisation Transform Business Models in Ropax Ports? A Multi-Site Study of Port Authorities

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## How does Digitalisation Transform Business Models in RoPax Ports? A Multi-Site Study of Port Authorities

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### ABSTRACT

*This article investigates the relationship between digitalisation and business model changes in RoPax ports. The study is based on six RoPax ports in Northern Europe, examining their digitalisation efforts and the resulting changes in their business models, leading to further digital transformation. The paper offers insights by reviewing relevant literature on digitalisation's role in business model innovation and its application in ports. The findings reveal that digitalisation supports relevant business model changes concerning port operation integration within logistics chains, communication, documentation flow, and cargo flow optimisation. However, exploring digitalisation's potential for diversifying value propositions is*

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*still limited. Most digitalisation efforts enhance existing operations through automation, monitoring, and decision-making support. The study contributes to understanding port business models and offers practical implications for RoPax ports' digital transformation.*

**Keywords:** port authority, business model innovation, digitalisation

## INTRODUCTION

In recent years, digitalization has become critical for business development. Digitalization refers to applying digital technologies and data in work (Ritter and Pedersen, 2020), such as changing business models and providing new value propositions and value-producing opportunities (Gartner, 2023). Digitalization leads to digital transformation (DT), referring to the organizational-level integration of digital technology, bringing changes in organization structure, process, and business models (Gray et al., 2015; Kraus et al., 2022).

Maritime transport accounts for over 80% of the international trade volume (United Nations Conference on Trade and Development, 2022). Short-sea shipping has a particular strategic role for the European Union in reducing carbon-dioxide emissions and it has set a target to increase inland waterway and short-sea shipping traffic by 25 % (European Commission, 2011; European Court of Auditors, 2023). Exploiting digital technologies is considered disruptive in maritime logistics due to its potential for optimizing processes and integrating numerous (Heikkilä et al., 2022; Tsvetkova et al., 2021). However, compared to other industries, fewer studies covered DT in maritime logistics.

Ports are logistics hubs that could renew their business models through digital technologies, resulting in reduced shipping emissions (Haraldson et al., 2021) and improved efficiency. Ports authorities (PAs) – companies that manage ports – are increasingly seen as ecosystem integrators or orchestrators (Caballini et al., 2009), making them critical in leading DT (Tijan et al., 2021b; von Malmborg, 2004). Proposals for how ports operate have been emerging, advocating for technological development and business model innovation (BMI) (Verhoeven, 2010). We consider digitalization as the antecedent of DT, which can trigger BMI and prepare for a larger-scale evolution. Previous research focused limitedly on this aspect. Hence, this study aims at addressing the research gap, and draw connections between BMI and digitalization.

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This paper contributes to DT research by exploring the relationship between digitalization and business model changes in logistics. Our study is based on six RoPax ports in Northern Europe. These ports handle roll-on and roll-off vessels, that can carry vehicles and passengers. Due to low regional logistics intermodality, these ports serve as road continuation. RoPax is the primary regional transport method due to its short port turnaround time. However, these ports gained limited research attention and could benefit from digitalization differently compared to container ports that have been extensively studied considering digitalization (Brümmerstedt et al., 2017; Port of Rotterdam, 2023).

The paper is structured as follows. The next section reviews the literature on digitalization's role in BMI; the literature addresses ports BMI and digitalization. We then present the methodology: case construction, data collection, and analysis. Section 4 presents our findings regarding the drivers for changing port business models, the changes themselves, and digitalization efforts at ports. Section 5 discusses the results and corresponding implications. Section 6 concludes the study's contributions and limitations.

## LITERATURE REVIEW

### *Business Model Innovation*

Business models are 'stories that explain how enterprises work' (Magretta, 2002). Scholars have proposed frameworks for business models, among the most mentioned, there are value proposition, revenue model, processes for delivering value, cost structure, resources, and capabilities (Afuah and Tucci, 2003; Chesbrough and Rosenbloom, 2002; Teece, 2010; Zott et al., 2011). More specifically, a business model defines how a company delivers value to customers, encourages them to pay for that value, and generates profit from those payments (Teece, 2010).

Drawing from previous conceptualizations and considering maritime logistics' resource intensity, we choose to focus on the four elements of a business model as Johnson et al. (2008) proposed: 1) value proposition; 2) profit formula; 3) key resources; and 4) key processes. The customer value proposition and profit formula define how value is created for the customer and the focal company, while resources and processes describe how the value is delivered.

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Accordingly, BMI is defined as novel and non-trivial alterations to a business model's key elements (Foss and Saebi, 2017). Thus, BMI is distinct from product and process innovation (Latifi et al., 2021), enabling firms to attain competitive advantages through value logic reconfiguration in dynamic business environments (Parida et al., 2019) or ecosystems (Hellström et al., 2015; Lingens et al., 2022; Tsvetkova et al., 2014).

### ***Digitalization, Digital Transformation and Business Model Innovation***

Digital technologies' widespread adoption has become one of the key drivers and enablers of BMI at the firm level (Holmström et al., 2019; van Tonder et al., 2020). Digitalization and its impacts on business models have been extensively explored (Bourreau et al., 2012; Caputo et al., 2021). Van Tonder et al. (2020) mentioned in their paper that firms can digitally transform their business model elements for BMI. Caputo et al. (2021) note that new business models' proliferation is characterized by digital innovations. In addition, digitalization and BMI are context-specific (Kamalaldin et al., 2021), and there are multiple business models based on digitalization.

The alignment of technological development with business strategy is essential to success (Tripathi, 2022). Airbnb, Netflix, Spotify and Uber are examples of companies which have transformed whole industries with digital platform-based business models and matching strategies (Kavadias et al., 2016; Rayna and Striukova, 2016). Digitalization enables competitive advantages for firms and DT. The latter one also brings opportunities for BMI changes to cross multiple industries, ecosystems (Kamalaldin et al., 2021; Leminen et al., 2020; Sjödin et al., 2020) or even at the global value chains level (Leão and da Silva, 2021). Brunner et al. (2021) identified digital leadership competences, such as strategic architecture design of DT process and business plan development.

However, while BMI is often necessary to reap digitalization's benefits, some incumbent firms are underprepared for digitalization (Parida et al., 2019). Thus, it is necessary to expand existing research and explore digitalization's role in BMI in empirical contexts that are less prone to digitalization.

### ***Business Model of Port Authorities***

Ports are areas with maritime and hinterland access that have developed into logistics centers (Van der Lugt and De Langen, 2007). PA is often a public-owned company responsible for managing and developing the port area, with its income primarily derived from port dues and land rent, functioning as a landlord. Landlord

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PAs are tasked with balancing public and private interests (World Bank, 2007), as tenants in ports usually comprise private companies involved in port operations or logistics activities (Van der Lugt and De Langen, 2007).

A PA's business model depends on diverse factors, which influence their decision-making (Haraldson et al., 2021). Intrinsic factors can include its traffic profile, cargo typologies, hinterlands, existing facilities, and infrastructural conditions (Burns, 2014, p. 22; Paixão Casaca and Lyridis, 2022). Extrinsic factors are equally important, encompassing technological, geopolitical, and demographic aspects (Vonck et al., 2021). Given this complex landscape, the competitiveness of PAs' hinges on their ability to effectively contextualize themselves within relevant ecosystems.

Research has emphasized the need to expand the PA role to create more value, moving away from traditional business models such as landlord, regulator, and operator (Hollen et al., 2015; Notteboom et al., 2022; Rönty et al., 2011). Scholars have highlighted the importance of PAs' initiatives concerning digitalization (Tijan et al., 2021b). Gonzalez et al. (2018) reviewed sustainable hinterland measures implemented by PAs, demonstrating their influence extension beyond sea logistics. Furthermore, Verhoeven (2010), based on an extensive literature review of PA's functions, suggested that PAs could adopt diverse roles in facilitating business activities, including coordination and resolution of collective action issues within and beyond the port area.

With the advent of 'smart ports', there are emerging opportunities to create additional value through data-based services and data-driven business models. However, there is a scarcity of studies addressing this specific issue. The available research mainly focuses on the relevance of digitalization for the PA's business model and the corresponding changes in the business ecosystem (Henríquez et al., 2022; Hirata et al., 2022), also examining the benefits and challenges of digitalization, as discussed in the following section.

### ***Port Digitalization: State of Art***

Over recent decades, port operations have evolved several times: paperless procedures, partially automated processes, and today's smart intermodal transportation (Heilig et al., 2017b). Although extensive studies on port digitalization are available, most studies are based within the context of container ports (Haezendonck and Langenus, 2019; Heikkilä et al., 2022; Henríquez et al., 2022). Ports with other traffic profiles, e.g., RoPax, are scarcely studied.



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Digitalization challenges for these ports unfold from several perspectives: shifting business perspectives (Hirata et al., 2022), system incompatibilities, organizational resistance to new digital tools, security threats, scarce resources, and knowledge scarcity (Brunila et al., 2021; Inkinen et al., 2019; Tijan et al., 2021a). Previous research assessed digital technologies' benefits and challenges, but few studies address the relationship between port digitalization and business model changes (Henríquez et al., 2022; Hirata et al., 2022; Inkinen et al., 2021).

Following Heilig et al. (2017a), we stress that digitalization is not a goal but a pathway to benefit from digital technologies. We approach digitalization as a driver and means for BMI. We explore this relationship using RoPax ports as a case study. Moreover, these technologies create digital affordances, that is, 'what an individual or organization with a particular purpose can do with a technology' (Autio et al., 2018), and thus affect PA's business model.

## METHODOLOGY

### *Research Design*

For addressing the research question and RoPax port's empirical set-up, the research is designed as a multi-site case study (Creswell and Poth, 2016), where the RoPax port is considered a case, studied at several sites. Like a multiple case study, which enables comparison (Gibbert et al., 2008; Gioia et al., 2013), the case is compared among sites with the possibility for cross-site generalizations, enabling a context-embedded understanding of the phenomenon (Audet and d'Amboise, 2001; Yin, 2018).

Due to a lack of theoretical background and empirical study on RoPax ports (see section 0), we follow an abductive approach, pursuing the iterative matching and simultaneous evolution between theoretical and empirical observations (Dubois and Gadde, 2002). Our research targets capturing relationships between digitalization and business model change. A cross-site comparison enables variation identification within the same case (Creswell and Poth, 2016).

Six RoPax ports in four Northern European countries were studied. All ports offer liner traffic operated by at least two shipping companies to several international destinations. These ports were selected based on similar characteristics, e.g., ownership structure, a high share of short-sea shipping traffic, and business model.

The ports operate in countries characterized as being at a high level of national digital infrastructure readiness, integration, and adoption.

### *Data Sources*

Data collection timeframe was from August 2022 to April 2023. The primary data is based on semi-structured interviews with PAs, and the secondary data originates from desktop studies related to the case ports.

For secondary data, we reviewed press releases, publications, statistics, and strategic and project reports related to case PAs. These data supported us in structuring interview topics regarding business model transitions and adapting PA's perspective.

The primary data collection commenced with a workshop where three representatives from PA Beta participated, lasting about two hours (see **Table 1**).

**Table 1: Ports' Characteristics**

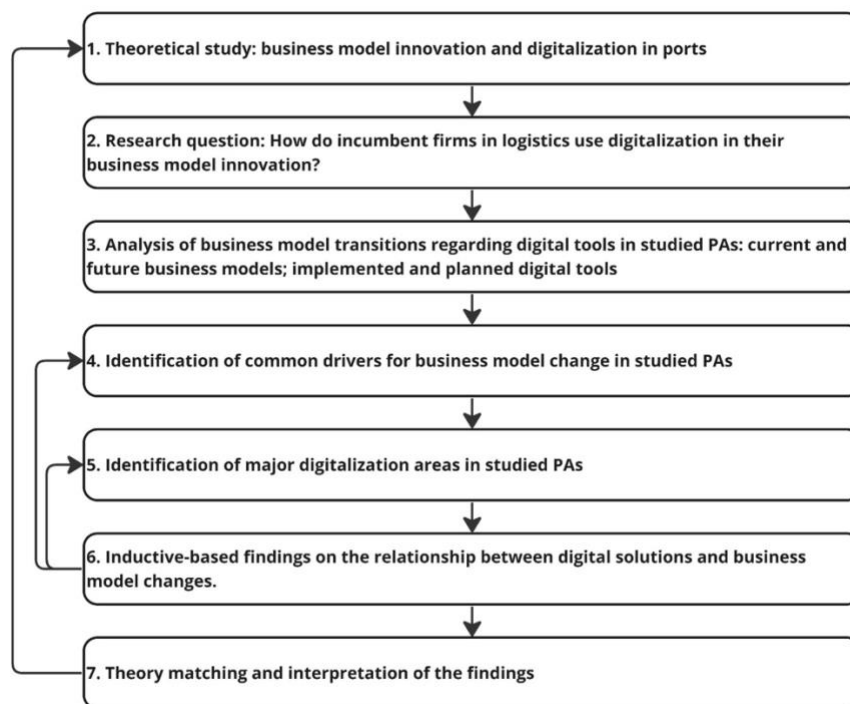
<b>PA</b>	<b>Traffic profile</b>	<b>Interviewees' roles</b>	<b>Data format</b>
<b>Alpha</b>	Cargo and passenger	Port Development Strategist	Interview
<b>Beta</b>	Cargo and passenger	Technical Director Operation Manager IT Specialist	Workshop and interview
<b>Gamma</b>	Cargo and passenger	Head of Business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

We started by identifying their current business model and continued the discussion on potential future business models and activities aligning with drivers for business development. We followed a similar logic for individual interviews with other case PAs, with an average duration of one hour. However, the nature of individual interviews differs from the workshop, we invited interviewees to define current

business models and then identified the main drivers for business model changes. For each port, one or more managerial-level representatives attended the interviews. The interviews were recorded, transcribed, and documented. Table 1 presents the studied ports' characteristics.

### *Data Analysis*

Data analysis followed the deductive category application and further inductive category development (Mayring, 2004), which can be labelled as a directed approach to content analysis to support or extend the theory (Hsieh and Shannon, 2005). The labels were later compared to existing theories regarding business model evolution, ecosystem, and literature related to port business models. The abductive iteration involves identifying mismatched empirical-theoretical concepts, which were further discussed and studied. Figure 1 illustrates the research process.



**Figure 1: Research process steps.**

Three researchers first analyzed research data independently, which included interview transcripts and secondary data to reach reliable category development. The second analytical phase consisted of comparing first-phase analytical results

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with the entire research team, namely drivers for BMI, allowing a more concise categorization by merging and revisiting interview transcripts.

The study's credibility was strengthened through various measures. The researchers aimed for transparent research process reporting (Roulston, 2014). Furthermore, triangulation was employed for data collection and analysis by comparing and combining observations from diverse data sources (Archibald, 2016). A collaborative approach to data analysis could incorporate a range of perspectives into the process (Cornish et al., 2013), enhancing the trustworthiness.

## FINDINGS

### *Drivers for Business Model Change in RoPax Ports*

Over the decades, the business model 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 operations of wheeled commercial vehicles (trucks, trailers), private cars, and passenger transportation. The case ports have short vessel turnaround times, and low cargo standardization and are further challenged by passenger transportation services.

We identified numerous factors affecting RoPax ports' business models and grouped them into three categories: environmental, economic, and social drivers (aligning with the well-known sustainability dimensions), as Table 2 lists.

Today's maritime environmental regulations are associated with climate goals (Gifford et al., 2021; Vonck et al., 2021) and constitute one of the key drivers affecting RoPax PAs. These technologies aim at tracing and reducing emissions by port operations or logistic activities, such as emission detection sensors within the port areas. As discussed in section 0, PAs increasingly engage in the development of alternative fuel infrastructure. Moreover, they acknowledge the importance of striving for zero emissions logistics. As one interviewee stated:

*Even if all vessels are connected to shore power whilst calling at the port, that will not suffice. We, as PA, also need to work with shipping lines on how to eliminate emissions when vessels are sailing in and out of the port.*

In addition to regular maintenance, PAs face growing pressures to adapt infrastructure to increasing trade volumes and vessel sizes, while co-existence with expanding cities is also a concern. Hence, PAs have increased their intentions of contextualizing port activities within supply chain level. For example, by implementing technologies for enhancing communication with truck companies and the city. Several interviewed PAs mentioned ongoing or planned port area rearrangement, entailing digital and physical measures:

*We have identified a trend of cargo goods moving/relocating out of the cities, whilst passenger traffic dominates in the city centers close to local attractions.*

**Table 2: Drivers of business model changes in studied RoPax ports**

Drivers	Drivers of business model change	Alfa	Beta	Gamma	Delta	Epsilon	Zeta
<b>Environmental</b>	Reducing the environmental impact of shipping operations	x	x	x	x	x	x
	Increasing cargo traffic		x		x	x	
<b>Economic</b>	Increasing vessel sizes	x			x		
	Space limitations in ports		x		x	x	x
	Developing port infrastructure, ensuring smooth operations, cargo and passenger flows	x	x	x			x
	Passengers as important	x	x	x	x	x	x

	customers for the PA					
	Need to retain shipping companies as customers and attract new ones	x	x	x	x	x
	Requirements from logistic chain actors to increase digitalization	x		x		
	Goal for higher infrastructure utilization rate		x	x	x	
<b>Social</b>	Port-city integration	x	x	x	x	x
	Safety and security	x	x	x	x	

Most case ports are near urban areas, and the port-city symbiosis is changing, especially in high passenger volume ports. Hence, PAs start seeking for technological solution for solving these challenges. However, both parties’ interests lie in the collaborative port-city integration agenda to turn the port area into a leisure area for residents:

*With expanding cities, integrating the port and city needs to benefit both parties in terms of efficient land use.*

***Changes in Business Models of RoPax Ports***

Traditionally, a PA’s value proposition is providing infrastructure, facilities, and vessel services, enabling safe, efficient, and timely port calls and smooth traffic. A RoPax PA’s primary income derives from vessel, passenger, and cargo fees and facility rentals. Conversely, the main expenditures are human resources costs and land leases.

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A PA's strategic renewal is largely driven by the drivers described in Section 4.1 and manifested in their business model changes. Following inductive category development, we could identify several recurring topics.

The most radical change concerns port activities' in-depth integration with the logistics chain. Because significant efficiency gains require overall logistics chain collaboration. As an interviewee mentioned:

*Even providing cargo online check-in, as a port, we can only be a role model by showing that we are digitalizing the road freight sector, nothing more...Online check-in needs shipping operators' initiative. The port can only provide the gate system, which is already there.*

Increased integration with the logistics chain is also crucial for reducing shipping's environmental impact (see section 0). Moreover, ports have gradually shifted to electrified equipment and machinery, greener fuels, and energy-efficient infrastructure. Several PAs have implemented or planned green incentives for customers, e.g., pricing based on vessels' environmental index. However, the analysis also shows that incentivizing 'green' customers may be challenging if the PA does not have any contact with land logistics companies, which are shipping lines' customers. These companies do not consider themselves relevant in encouraging passengers to opt for sustainable choices.

Green corridors are zero-emission technology-supported logistics routes (Joeris et al., 2021), which can be considered another important initiative for shipping emission reduction; PAs play a key role in establishing those corridors. In this vein, several PAs plan to establish alternative fuel infrastructure. PAs rearrange existing business processes to pursue efficient resource usage and business growth. Both processes strive to optimize the usage of existing facilities to benefit the public. New terminals are increasingly moving towards joint terminals, where PAs offer infrastructure to be shared by several shipping lines. However, the perceived benefit does not necessarily come without challenges. An interviewee provided insight related to space planning:

*The new (joint) terminal will have spatial capacity constraints; hence, underground space will be exploited rather than taking up vast areas or constructing parking lots.*

The case ports often serve as seasonal destinations for cruise lines. Several PAs highlighted the potential of exploiting terminals as event venues during low seasons.

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Moreover, several PAs are taking over ownership of the new passenger terminals. Traditionally, shipping lines and port operators are RoPax PA's customers, while passengers and road haulage companies are shipping lines' customers. The terminal ownership transition leads to business model changes, to ensure new customers' satisfaction, e.g., passengers. A PA explained that despite the passengers are not PAs' customers, they still share responsibilities for service quality:

*... on the passenger side, they want a seamless journey. It doesn't matter who provides the service, but for the passenger, it has to be seamless.*

The findings indicate that the most critical business model changes concern efficiency improvement, achieved through key processes and resources alternations. These changes are internal to an organization. Regarding more efficient land use, many PAs are trying to separate passenger and cargo services geographically. Operation automation increases the efficiency, safety, and security of manual activities, enhancing workers' occupational conditions and safety (section 0).

Finally, ensuring safety and security, one of PA's primary responsibilities, is even more critical given the extended scope of ports' activities.

The changes in the business models of RoPax PAs discussed above are listed in Table 3 and are common for the two or more ports we studied and concern changes in the business model elements (Johnson et al., 2008): value proposition, profit formula, key processes, and key resources. Naturally, changes in one element bring secondary effects. Hence, we mark the main and secondary changes in the PA's business model elements and indicate drivers for these changes in the business model.

We could observe that most changes relate to value delivery, i.e., to the key resources and processes (Johnson et al., 2008). These changes can be attributed to the challenges and resistance associated with deviating from the traditional landlord business model, which heavily relies on infrastructure investments and land allocation to achieve PA's strategic goals (Hollen et al., 2015). However, RoPax ports are characterized by low traffic intramodality; thus, the efficient traffic flows define their competitive advantage, resulting in key process alterations. Limited changes concern value propositions and profit formulas; changes are mainly related to further exploitation of existing infrastructure or new infrastructure investment.



**Table 3: The analysis of the impact of changes on the business model of PAs**

		Type of business drivers	Key resources	Key processes	Value proposition	Profit formula
<b>Integration in logistics and supply chain</b>	Enhanced communication	Economic Environmental	***	++*		+
	Digitalization facilitator	Economic Environmental	+	+	++	
<b>Environmental impact reduction</b>	Engagement in developing alternative fuel infrastructure	Environmental	++		+	
	Green incentives for port users	Environmental			+	++
<b>Expansion of business</b>	Alternative use of port infrastructure	Economic Social	+	+	++	+
	New offerings for passengers	Economic			++	+
	Ownership and operation of passenger terminals	Economic	++	+		+
<b>Efficiency improvement</b>	More efficient use of port infrastructure	Economic Environmental	++	+		
	Geographical separation of cargo and passenger flows	Economic Social		++		
<b>Social sustainability</b>	Expanded safety and security measures	Social		++		
	Human work rationalization	Social Economic	+	++		

\*: ++ refers to main change; \*\*: + refers to secondary change.

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### *Digitalization Efforts at RoPax Ports*

The digitalization level of the interviewed RoPax ports varied remarkably, depending on customer profiles, ecosystem configurations, connectivity, and the port's development stage. All PAs recognized areas where digitalization could improve competitiveness, safety and security, operational efficiency, and stakeholder communication, even if they did not have a digitalization strategy in place. However, the more unclear matter concerns the benefits of digitalization investment and relevant operational costs. One PA stated:

*A central thing is how digitalization can favorably impact operations or costs.*

Furthermore, the digitalization of logistics chains has been increasingly pressuring PAs to adopt new technologies. Several interviewees mentioned PA's importance in enabling logistics chain digitalization and DT. Hence, we recognized four distinct strategic areas where digitalization was implemented or planned in the RoPax port.

First, several digital solutions concern interorganizational data sharing. PAs are introducing digital solutions to strengthen communication. More ambitious solutions spanning entire logistics chains were less often mentioned. These include traffic optimization beyond ports, which supports developing intelligent logistics chains and smart infrastructure, e.g., supporting autonomous trucks and sensor-embedded roads leading to the port. These solutions can be collectively called intelligent transport systems (European Commission, 2023) aimed at improved efficiency and sustainability.

Second, digital solutions could lower ports' environmental impact. The extant environmental regulations in shipping constitute one of the key development areas in RoPax ports. PAs have progressively shifted to greener fuels and energy-efficient infrastructure. Hence, most interviewees mentioned upcoming investments in monitoring air quality and managing onshore energy consumption.

Third, landlord PAs focus on digital solutions for infrastructure management. The case PAs increasingly face pressures on infrastructure rearrangement in response to growing trade volumes and vessel sizes. Apart from conventional maintenance work, they started exploiting data for infrastructure maintenance. The case PAs have shown interest in digital twins, e.g., building information models for new terminals. However, it is necessary to assess these solutions' advantages, as one of the interviewees concluded:

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*...you need to be able to optimize something with the digital twin that is hard to optimize without it (digital twin).*

Fourth, considering a larger-scale DT, space limitation, intensified traffic flows, and co-existence with expanding cities are growing concerns, driving ports to seek digital solutions. PAs are pressured to adopt digital technologies for overall logistics chain digitalization, for example, intelligent traffic management.

Finally, PAs have developed digital solutions to help monitor and manage security, contributing to one of RoPax PA's key activities. Table 4 presents the implemented and planned digital solutions in RoPax ports. We also analyze how these solutions contribute to the business model changes discussed in section 0. PAs predominantly invest in digital solutions to enhance operational efficiency. For instance, automation reduces the costs associated with manual operations and human labor. The latter also contributes to social sustainability by improving occupational safety.

PAs also implement solutions related to green transition, allowing monitoring, and reducing operations emissions. However, despite understanding the need to extend the emission responsibility scope, the implemented solutions remain within the terminals.

Digital solutions that enable data sharing and optimization at the logistics chain level. For example, digitalization alongside the logistics chain can produce cargo and traffic situation data and enable port operation integration in logistics chains. However, we did not observe digital solutions that would support PA's business expansion, such as new value propositions or activities, as discussed in section 0.

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

Digitalization areas	Digital solutions	Contribution to business model change				
		Integration in logistics chains	Environmental impact reduction	Business expansion	Efficiency improvement	Social sustainability
<b>Data sharing and coordination among port stakeholders</b>	Intelligent supply chain	x	x		x	
	Communication and procedures among port actors	x			x	
	Intelligent transport systems	x			x	
<b>Green transition</b>	Monitoring emissions and air quality		x			x
	Monitoring and optimizing energy use		x			
	Energy management for onshore power supply		x			x
<b>Infrastructure management</b>	Digitizing port infrastructure data				x	

	Infrastructure use management		X	
<b>Enhanced cargo, passenger, and vessel flow</b>	Automated check-in for passengers and vehicles		X	
	Intelligent traffic management		X	
	Automooring		X	X
	Digital buoys/fairways	X	X	
<b>Safety and security</b>	Security monitoring and management		X	X

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## DISCUSSION

### *Digitalization in changing RoPax ports' business models*

The changes in the business model explored in this study range from operational improvements supported by digitalization to more profound alterations to PA's role in the maritime logistics ecosystem enabled by digitalization. As discussed in section 4.2, ports are logistics nodes, their performance can influence the overall logistics' environmental impact and transportation efficiency (Wahlström et al., 2022). This study shows that digitalization enables logistics chain integration (Gonzalez Aregall et al., 2018) through improved communication, prediction, and optimization, impacting a PA's key processes and resources (Baiyere et al., 2020). As ports could become digital hubs (Watson et al., 2021), the PAs case showed difficulties in developing digital infrastructure and hiring personnel with relevant knowledge.

Our findings reveal other significant aspects in the development of PA business models formulating new values beyond the landlord model. These include activities such as passenger terminal operation or innovative infrastructure exploitation, resulting in the creation of new value propositions and customer bases. This finding corresponds to the renaissance port concept mentioned by Verhoeven (2010), in which PAs ensure competitiveness by creating value for stakeholders other than customers, such as shipping companies and terminal operators. For the PAs, these stakeholders include passengers, municipalities, and even citizens.

Aligning with Hollen et al. (2015), several PAs would remain as landlord ports but explore new activities to create value for critical actors. In this case, digitalization integrates interorganizational activities, increases traffic flow transparency, and helps trace emissions – the information basis for decision-making by PAs and other logistics actors. Thus, digitalization can enable reconfiguring value logic in the business ecosystem, which PAs are part of, and lead to DT and BMI (Parida et al., 2019).

Concurrently, we observed that instead of BMI, PAs opted for incremental landlord business model changes through new resource acquisition and processes. This corresponds to earlier studies (Vejvar et al., 2018), confirming that PAs are bound by institutional pressures and prefer solutions that provide immediate payoffs.

### *How can digitalization be embedded in strategic business model renewal?*

Our study shows that despite that several PAs are preparing for their digitalization strategies, they implement solutions without a strategic approach. The current digitalization process is fragmented which leads to a 'digitalised mess'. For example, short-term project-derived solutions mentioned in section **Error! Reference source not found.**, do not contribute strategically to PA's business development.

Conversely, PA's digital knowledge scarcity prolongs their decision-making. The lack of conceptual framework on smart port hinders further implementation (Karaś, 2022). For instance, several PAs mentioned their concerns about the uncertain return of digital technologies investment. This situation echoes previous studies, which also identified that

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the maritime transport sector lacks awareness of how DT may affect their business (Tijan et al., 2021a).

Relating digitalization to business models and strategic planning requires specific knowledge and resources. In this vein, several PAs created new job positions for coordinating digitalization in long-term strategic plans. Thus, this shows that digitalization leads to DT, reshaping organizational structure as observed in other studies (Karanja and Rosso, 2017; Kraus et al., 2022; Tijan et al., 2021a).

Digitalization aids PAs in several ways for improving infrastructure management and port operation coordination. First, PA could facilitate digitalization and communication between organizations. Second, several solutions, such as automated check-in could support PAs in affecting the activities outside of the terminal. Hence, digitalization could lead PAs to new value propositions, such as becoming digital infrastructure owners.

### ***Implications***

The findings provide insights to practitioners (e.g., PAs, digital solution providers) for understanding how digitalization influences PAs' business models. RoPax PAs could position themselves by contextualizing digital solutions in their long-term strategies. In addition, opportunities and challenges for port digitalization were also mentioned in this study. Digital solution providers could comprehend PAs' value priorities and decision-making criteria, which could support their technological development.

Policymakers may also find this study valuable, especially regarding port city integration, sustainable seafront, and port development. Considering that PAs are adapting organizational structure, resources, and strategic plans in pursuing DT, policymakers could aid in ensuring that this transformation also leads to greener maritime logistics.

Education and research play a crucial role in the future development of ports, particularly concerning knowledge of digital technology and interdisciplinary collaboration. Educational institutes could further prepare future talents by providing expertise in supply chain management, industrial management, and innovation management.

## **CONCLUSIONS**

This article highlights digitalization's role in enabling changes in RoPax ports' business models, contributing to port business model research (Gonzalez Aregall et al., 2018; Hollen et al., 2015; Tijan et al., 2021a; Verhoeven, 2010). The study offers insights into a relatively understudied area of RoPax port digitalization. The findings suggest that digitalization could support profound changes in RoPax PA business models related to logistics chain integration, such as communication and traffic optimization. However, business model innovations, such as value proposition expansion have not yet tapped into digitalization. Most digitalization efforts remain at improving the current operations through automation, monitoring, and supporting decision-making.

This article presents how digitalization drives business model changes in RoPax ports. The findings highlight variations among RoPax ports in integrating digitalization into their business models. However, future research could explore factors influencing these differences, such as ports' ownership structure, resources, and ecosystem configuration, enabling an in-depth knowledge of the variations within RoPax ports. The case ports are in Northern Europe, resulting in the geographical limitations of this study. Future research could take a longitudinal approach to depict business model evolution with digitalization.

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### **Acknowledgement**

The work was conducted in the framework of the SMARTER project with financial support from Business Finland (ref. 41740/31/2020)