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# SYNCHROMODALITY AS A PROSPECTIVE DIGITALIZATION SCHEME FOR FREIGHT LOGISTICS

A pre-study report



TRAFIKVERKET

Published by  
**World Maritime University**

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This scholarly investigation was commissioned by Trafikverket (in English: Swedish Transport Administration – STA) to work collaboratively with Sjöfartsverket (in English: Swedish Maritime Administration – SMA) and various logistics companies and shippers in and around Sweden.

The study necessary for this report was conducted by a World Maritime University research team comprising Dong-Wook Song (Principal Investigator), Gang Chen, and Satya Sahoo (Co-Investigators). Ajay Deshmukh and Marie Urfels supported the team as Research Assistants.

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<b>AI</b>	Artificial Intelligence
<b>ALICE</b>	Alliance for Logistics Innovation through Collaboration in Europe
<b>API</b>	Application Programming Interface
<b>B2B</b>	Business-to-Business business model
<b>B2C</b>	Business-to-Consumer business model
<b>DoI</b>	Diffusion of Innovation
<b>EGS</b>	European Gateway Services
<b>EU</b>	European Union
<b>GPS</b>	Global Positioning System
<b>ICT</b>	Information and Communication Technologies
<b>IT</b>	Information Technology
<b>ITS</b>	Intelligent Transport System
<b>LSPs</b>	Logistics Service Providers
<b>RORO</b>	Roll-on/Roll-off
<b>SLR</b>	Systematic Literature Review
<b>TAM</b>	Technology Acceptance Model
<b>3PL</b>	Third-Party Logistics
<b>5G</b>	Fifth-generation technology standard for broadband cellular networks

## ACKNOWLEDGMENTS

The World Maritime University (WMU) would like to express its sincere gratitude to the Swedish Transport Administration (STA) for providing the financial support that made this report possible. This research would not have been possible without their interest and encouragement to pursue this topic.

We would like to express our sincere appreciation to Stena Line, Stena Terminal, Baltreiss SIA, Lundby Container Service, Kappahl, Tetra Pak, the Chalmers University of Technology, the Swedish Maritime Administration (SMA) for their generous support, which made this pre-study report possible.

Without their contributions and willingness to participate in the discussion sessions, this report would not have been completed. In particular, we would like to extend our thanks to Niclas Mårtensson, Markus Lindbom, Muhammad A. Samad, Björn Möllerström, Jacob Koch-Nielsen, Patrik Almqvist, Mathias Sjölin, Anders Claesson, Elger Postma, David Lundqvist, Kristian Malm, Violeta Roso, Ceren Altuntas Vural, Ulf Siwe, Jennie Larsson, and Aleksejs Denisovs for their availability, valuable insights, and contributions to the discussions. Their inputs were critical to the success of this pre-study report.



## EXECUTIVE SUMMARY

Freight logistics face pressing challenges, such as the lack of timely information exchange between different transport modes, various operational inefficiencies, and the environmental externalities of freight transport. To address these issues, the industry requires innovation and digital transformation, with the concept of synchromodality emerging as a prospective solution. Synchromodality could enable seamless switching between transport modes during shipment and promote efficient cooperation between various modes by improving visibility and flexibility in transport processes, resulting in cost and emission reductions. Despite the potential benefits of synchromodality, digital fusion in the freight logistics sector faces numerous barriers. These obstacles include the lack of common digital standards, insufficient digital data storage, poor real-time data transmission, the absence of integrated planning systems, interoperability of transport infrastructure, and a general lack of trust among stakeholders.

This study aims to revisit the concept of synchromodality from a freight logistics perspective by identifying its key constructs, such as inter-organizational integration, operational visibility, and operational flexibility. In addition, the study proposes a Synchromodality Maturity Model for logistics service providers to gauge their digitalization progress. The model consists of three synchromodal capabilities (Integration, Operational Visibility, and Operational Flexibility) and four maturity stages - Fragmented Cooperative Network, Dyadic Coordinative Partnership, Extensive Coopetitive Ecosystem, and Fully Collaborative Synchromodality.

Case studies on Roll-on/Roll-off logistics in Sweden were conducted to assess the digitalization level and prospects of the logistics

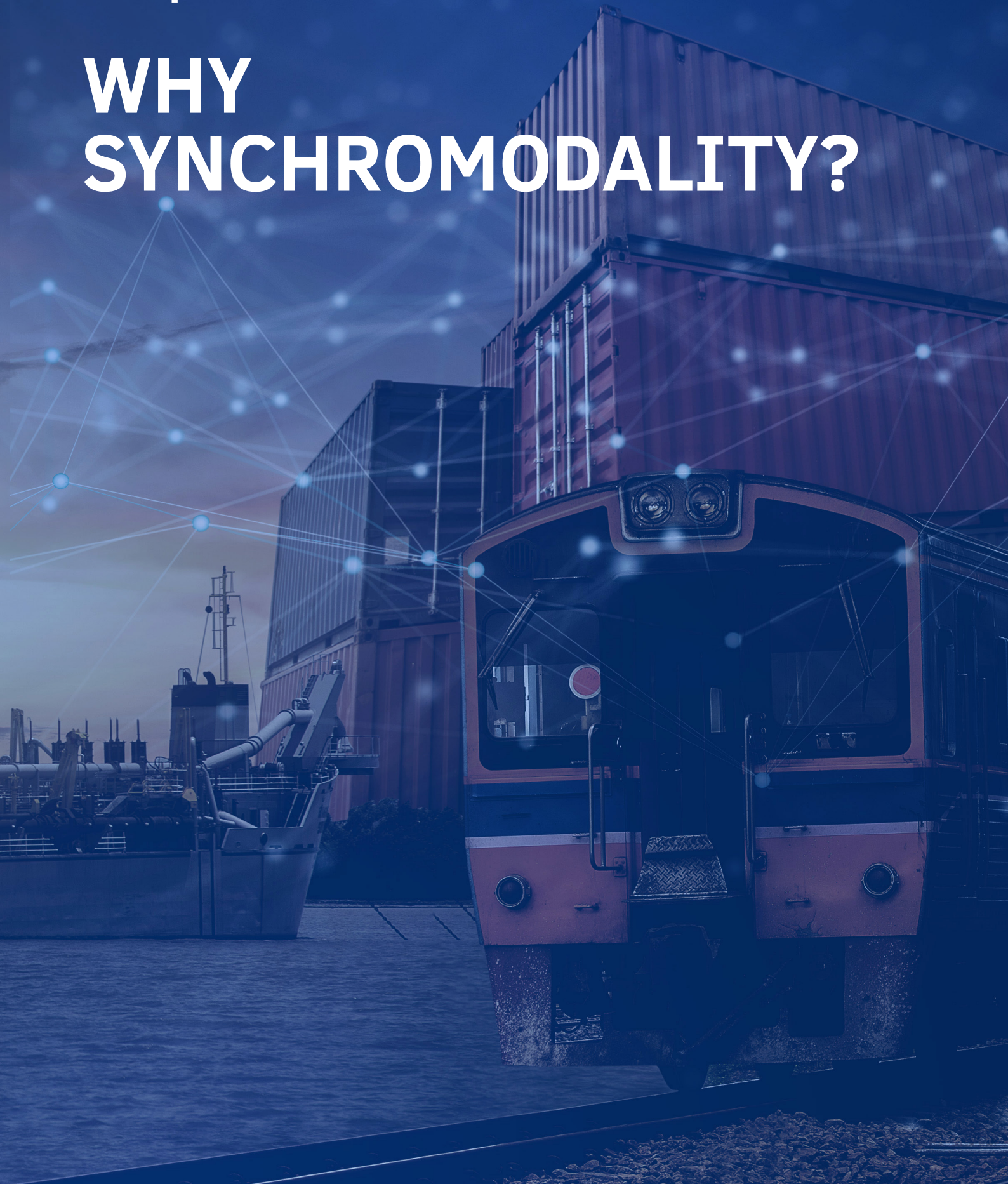
chain toward achieving synchromodality. The analysis reveals that most industry players are transitioning from Stage-1 Fragmented Cooperative Networks to Stage-2 Dyadic Coordinative Partnerships of maturity, primarily due to weak visibility capabilities and limited ecosystem platforms. The sector also grapples with challenges related to digitalization, insufficient human resources, and a lack of operational flexibility at the system level.

The findings of this study offer some policy implications to policymakers and industry players. It indicates the needs to emphasize digital infrastructure investment, to promote data standardization, and to foster public-private partnerships. It would be relevant for industry players to develop a value-adding-focused strategy, foster a culture of collaboration, embrace digitalization, invest in human capital, implement a data-driven approach, optimize transport modes and routes, improve communication and collaboration, implement real-time tracking and monitoring, adopt a flexible approach, standardize data and communication protocols, and develop performance metrics and key performance indicators.

By guiding and consolidating efforts along these directions, the freight logistics industry can move towards achieving synchromodality, which in turn will optimize transportation operations, reduce costs, and enhance overall sustainability. To provide further theoretical support, future research could investigate the implementation of synchromodality across different segments of the logistics value chain, assess the effectiveness of existing policies and regulations, and identify best practices for promoting collaboration among various stakeholders within the industry.

## Chapter I

# WHY SYNCHROMODALITY?





## CHAPTER I: WHY SYNCHROMODALITY?

The freight logistics industry has seen significant changes in recent years as it has worked to meet the growing demand for cargo transportation across the world. This development has been driven partly by technological standardization and inter-organizational integration on the supply side, leading to the establishment of a global intermodal network. One example of this trend is the use of mega-size container ships, which has helped to reduce unit costs and prices through economies of scale. Despite these advancements, there remain significant challenges in the freight logistics system that impact the smooth flow of cargo. The lack of timely information exchange leads to delays and inefficiencies in physical cargo flows. Cargo transportation routes are typically fixed beforehand, with little flexibility after dispatching. The cargo loaded into containers or trailers is generally treated as homogenous boxes during the handling processes, which improves efficiency but can limit service differentiation. However, recent events, such as geopolitical tensions, COVID-19, and even the blockage of the Suez Canal by the Ever Given ship, highlight the need for a more integrated and efficient freight logistics system that considers both physical cargo flows and information flows.

The implementation of digital technologies has the potential to resolve the aforementioned challenges. Digitalization can help streamline information flow and increase flexibility of transportation routes, leading to a more effective and efficient freight logistics system. The freight logistics industry is benefiting from the rapid advancement of digital technologies, as shipping companies, ports, logistics companies, and emerging logistics information providers are all implementing new digital solutions to improve their operations. Policymakers can play a significant role in strategically adapting to the technological development of the freight logistics

system, by providing a structured framework to logistics service providers (LSPs) and shippers for conceptualizing digitalization development. Therefore, it is urgent to address this issue through collaboration between academia, industry experts, and policymakers.

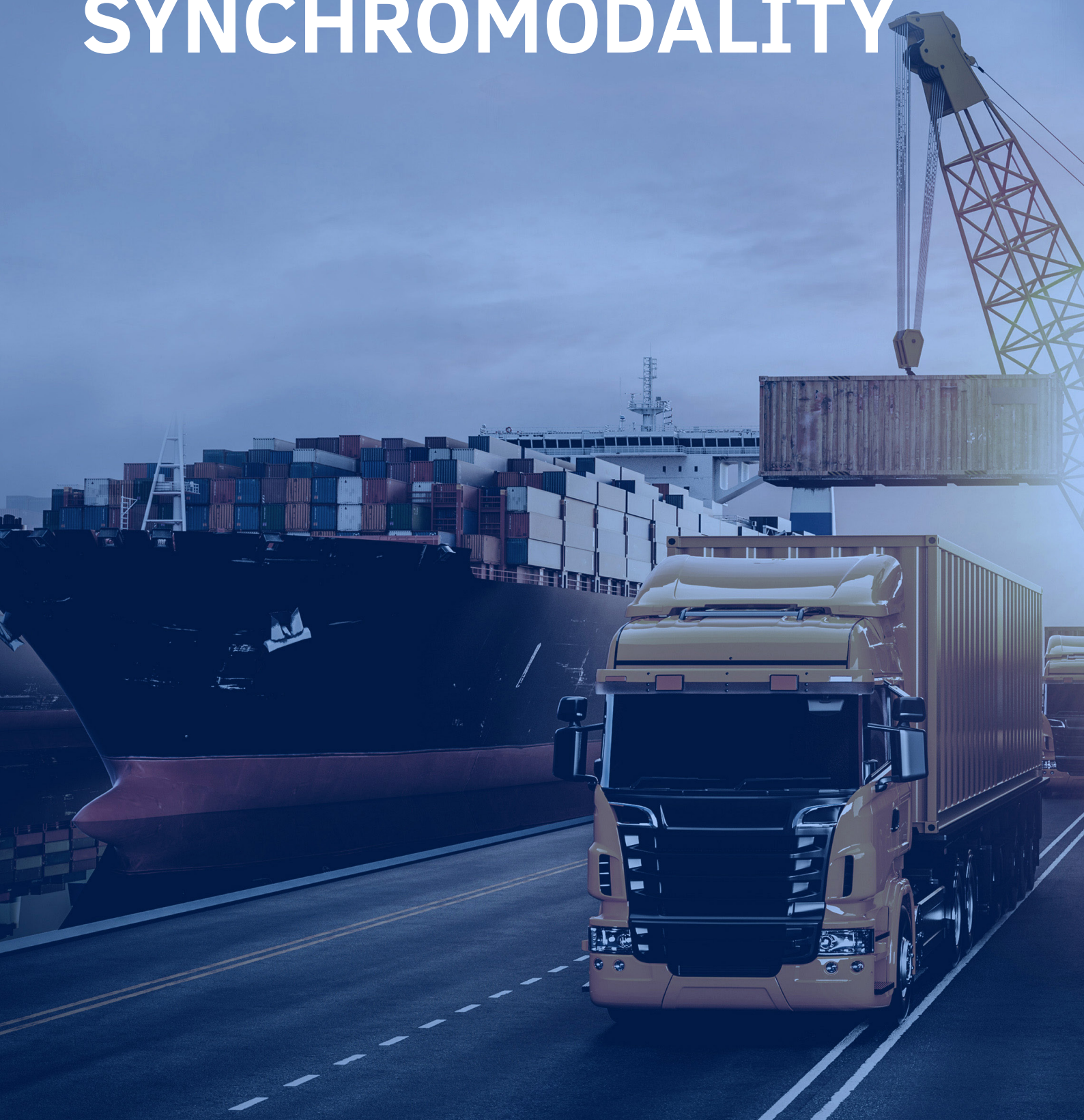
Synchromodality is a relatively new concept in the freight transport industry that is attracting attention for its potential to enhance efficiency and sustainability. Originating in the Netherlands as an evolution of intermodal transport concepts, synchromodality aims to provide more sustainable and flexible transportation services by optimizing the use of available resources and minimizing waste. It emphasizes the synchronization of physical resources, business processes, and the parallel use of transport modes. The concept proposes that cargo can be transported more efficiently by synchronizing different modes of transportation, such as trucks, trains, and ships, to optimally utilize available resources. Currently, research on synchromodality is limited to container logistics, with a focus on container port operations due to their significant economic scale in hinterland discharging. There is growing interest in exploring its potential application in other sectors of freight logistics. Although there is currently no universal understanding of the concept among researchers, it is generally considered to have the potential to conceptualize the evolution of freight logistics. The concept promotes real-time information exchange, which can improve visibility and control over the transportation process, resulting in better customer service and increased trust between stakeholders. The potential benefits of synchromodality include increased operational efficiency, improved sustainability, and enhanced customer satisfaction. By optimizing the use of available resources, synchromodality can help reduce transportation costs, improve delivery times, and minimize carbon emissions.

The research aims to facilitate the development of digitalization in the freight logistics industry by examining the concept of synchronomodality in the context of Roll-on/Roll-off (RORO) logistics. RORO logistics is crucial in the Swedish transportation system and the Baltic Sea Region. To begin the research, a literature review on the conceptual study of synchronomodality was conducted, and subsequently, a situation analysis of the current industry status was carried out through in-depth interviews. The aim of this pre-study is to validate the concept of synchronomodality as a potential digitalization scheme for the RORO logistics sector. If the concept is validated, full-scale research will be necessary to comprehensively investigate its relevance, implementation opportunities, and challenges with respect to the RORO logistics sector.

The research seeks to understand how synchronomodality can be implemented in RORO logistics to achieve more flexible and sustainable transportation services through the synchronization of physical resources, business processes, and the parallel use of transport modes. Ultimately, the goal of this research is to provide strategic guidance to the industry and policymakers to enhance the digital transformation of the freight logistics industry. By doing so, the research will contribute to the overall development of a more efficient and resilient freight logistics system that meets the demands of the industry and supports regional growth.

## Chapter II

# PERSPECTIVES ON SYNCHROMODALITY





# CHAPTER II: PERSPECTIVES ON SYNCHROMODALITY

## 2.1. INTRODUCTION

Freight logistics plays a crucial role in the smooth transport of materials and finished products in supply chains. Today, our inter-modal freight system is characterized by the combination of four modes of transport: Waterway, Rail, Road, and Air. This combination undoubtedly offers customers cost advantages when sourcing materials from different locations in the global supply chain (SteadieSeifi et al., 2014). However, operational efficiency and effectiveness can still be questioned. In fact, transport services are provided in the form of predefined routes and modes connecting origin and destination, and there is little real-time coordination between these modes. Even advance intimation between modes is often not given in a timely manner, leading to disruptions when unforeseen situations arise during transport. Furthermore, the environmental impact of freight transport, especially by trucks, has been a public concern for decades. The more environmentally friendly modes (such as rail, inland waterways, and short sea shipping) are generally considered less flexible, less frequent, and slower, and therefore less reliable (Acero et al., 2022). Despite the use of a unit load and intensive policy efforts, a modal shift has remained modest at best (Dong et al., 2018), clearly reflecting that road transport still accounts for 77.4% of transport in the EU (Eurostats, 2022). It is, therefore, clear that modal shift and comprehensive decarbonization of the transport sector are still a long way off.

Innovation is deemed necessary to address the current challenges in the freight logistics industry. Similar to other industries, freight logistics is currently undergoing a digital transformation, with technological advances such as artificial intelligence (AI) and

machine learning, 5G, blockchain, distributed ledger technology, pervasive computing, data analytics, and immersive technology developing at an unprecedented pace (Wang and Sarkis, 2021). These advances are disrupting traditional freight logistics practices, a disruption accelerated by the COVID-19 pandemic. On the one hand, consumers have become accustomed to ubiquitous access to information, which has changed their behavior and therefore demands for transportation services (Wang and Sarkis, 2021). On the other hand, service providers are increasingly using digital technologies, either reactively or proactively, to support innovative management of logistics operations. This is often accompanied by significant changes within and between organizations, including changes in operations, product/service offerings, business models, inter-organizational relationships, and industry leadership.

If digitalization leads to greater use of both traditional and new information systems, it can increase efficiency and effectiveness in freight logistics. However, the industry lacks digital integration at intra- and inter-organizational levels. Common challenges include the lack of common digital standards, insufficient digital data storage, and poor real-time data transmission (Wang and Sarkis, 2021). There is also a lack of integrated planning systems, interoperability of transport infrastructure (Hofman, 2015), trust between stakeholders (Kurapati et al., 2017), and most importantly, platforms for data exchange (Hofman, 2014; Singh et al., 2018). Without real-time situational data, stakeholders cannot adequately plan transport or respond to unexpected events in the supply chain, such as strikes, congestion,



and weather conditions (Riessen et al., 2015; Lin et al., 2016). Addressing these issues is crucial to reaping the potential benefits of digitalization in the freight logistics industry.

Given the existing problems in the freight logistics industry, digitalization can offer many benefits, including technological advances, seamless mobility between different modes of transport and a more integrated global freight logistics ecosystem. LSPs can gain a competitive advantage over their rivals, and the sustainability of freight transport can be improved in terms of environmental, physical, economic, and social aspects (Wang and Sarkis, 2021). The Alliance for Logistics Innovation through Collaboration in Europe (ALICE) (ALICE, 2014; Punte et al., 2019) recommends the concept of synchromodality as an innovative way to increase the share of sustainable transport modes —this concept basically involves an integrated view of freight transport that includes all available transport modes and combines them in a highly flexible way. Although recommended as a promising transport concept by ALICE, Dutch policy documents published in 2010 were the first to mention ‘synchromodality’ as a new transport strategy (Lu, 2014).

The broader concept of synchromodality can be seen as a further development of multimodal and intermodal transport. This is because multimodal transport is generally understood as the combined use of several modes of transport in order to reduce transport costs and times (Bontekoning et al., 2004); intermodal transport is the successive use of different modes of transport on a single route in order to transport a single unit of freight (e.g., a container) on that freight route (Macharis and Bontekoning, 2004). Synchromodality, according to the current definition, is characterized by the ability to switch freely between modes at a given point in time during the transport of a shipment (Dong et al., 2018). Achieving such

flexibility requires efficient and responsive cooperation between the different transport modes, which could be possible in a highly digitally integrated transport system. Many benefits are expected from synchromodality, including (i) parallel use of different transport modes (Pfoser et al., 2016), (ii) reduced costs and carbon emissions (Zhang and Pel, 2016; Prandtetter, 2016), (iii) improved visibility (ALICE, 2014), and (iv) flexible, sustainable transport processes with lower costs and higher service levels (Roth et al., 2013).

As a conceptual innovation in freight transport, synchromodality has yet to be fully established and implemented in industrial practice (Acero et al., 2022). While the concept was mainly discussed from an LSP point of view, little attention was paid to the shipper's point of view. Notwithstanding this, the concept of synchromodality has recently been discussed from a supply chain perspective. Scholars argued that synchronization of different transport modes is only possible when all parties in the supply chain come together (Reis, 2015). Moreover, in all previous transport concepts - from unimodal to intermodal - shippers were less involved in decision-making compared to LSPs, and their [internal] activities were less integrated with other supply chain actors. Therefore, some researchers have argued that in a new transport system (i.e., synchromodality), shippers' activities, such as inventory control, should also be synchronized with transport activities (Dong et al., 2018).

To achieve this level of synchronization, all participants in the logistics chain must cooperate and collaborate with each other at a high level. They undoubtedly need to exchange real-time information. However, the current state of data exchange mechanisms is very limited, even among LSPs. Many small companies (e.g., lorry operators) still work with traditional paper-based systems, and some transport companies prefer to use their own software to manage their

operations without sharing data with other stakeholders. These practices distort the flow of information in transport and hinder visibility throughout the supply chain.

In industrial practices, the concept of sychromodality is tested in two different cases. The first case comes from the Port of Rotterdam, which acted as an orchestrator to achieve sychromodality in hinterland unloading by using real-time information from different modes of transport (Zhang and Pel, 2016). As Song and Panayides (2008) mention, ports that provide more efficient hinterland connectivity due to the productivity, efficiency, and reliability of intermodal connectivity and interoperability add value to shippers and consignees. This particular case could be considered 'actor-centric' sychromodality, where an actor in the supply chain takes the initiative to synchronize transport operations based on real-time information. In this case, the port has a dominant position and sufficient economic scale to reap the benefits of cost reduction and capacity utilization. In the second case, real-time visibility platforms, such as Project 44, use a telematics network connected

to electronic devices to track shipments across multiple countries to provide customers with real-time visibility of the supply chain. Such a platform, as an 'outsider' to the supply chain (in this case, an information technology company), collects real-time information from all parties involved and offers a tailored transport solution depending on the situation.

The aforementioned examples clearly reflect that the concept of sychromodality is still at an early stage of development and that there is no consensus among scholars on its definition and scope. Some studies consider sychromodality as a pure transport concept, an evolution of the intermodal and multimodal transport system, while others consider it as a new transport concept that allows shippers to become an integral part of the future freight logistics system alongside LSPs. Furthermore, various studies have discussed sychromodality from either an actor-centric or outsider perspective. Overall, these different conceptual views have led to a knowledge gap in understanding sychromodality. This project aims to fill this gap by answering the following research questions:

**(A)** *What are the different current perspectives on sychromodality?*

**(a1)** *What are the definitions of the different perspectives of sychromodality?*

**(a2)** *How do these perspectives differ from each other?*

**(B)** *What are the different constructs involved in the sychromodality transport system? How can the concept be redefined to comprehensively capture its essence and critical elements?*

Section 2.2 conducts a comprehensive literature review to understand the various perspectives on the concept of sychromodality, while section 2.3 intends to provide a working definition for sychromodality from a freight logistics perspective. Lastly, section 2.4 provides concluding remarks and points out some gaps in the literature for future research.

## 2.2. PERSPECTIVES ON SYNCHROMODALITY

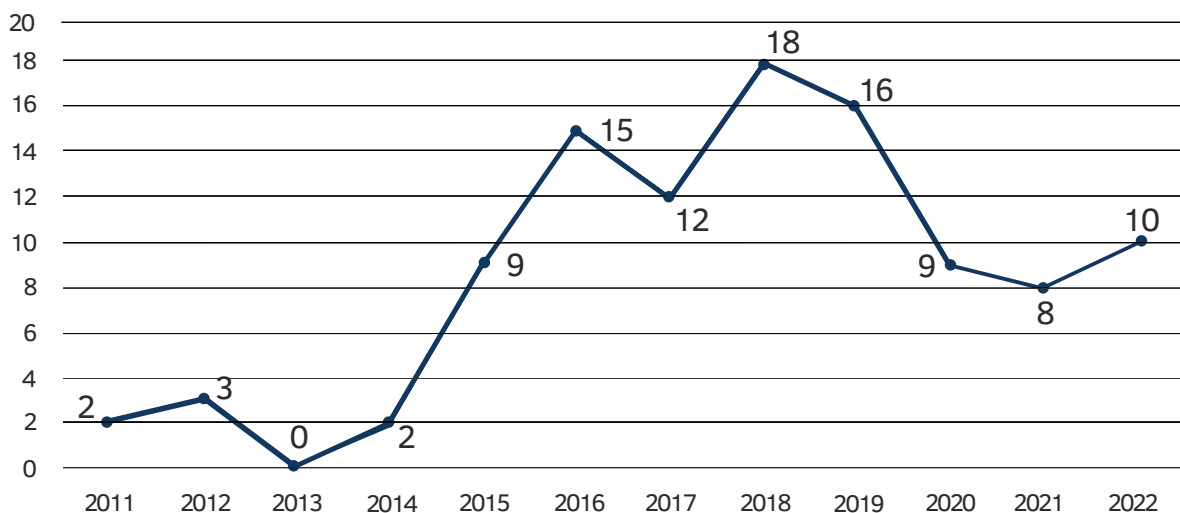
To answer the first research question and the two sub-questions above, we conduct a literature review following the process suggested by Saenz and Koufteros (2015). This process involves five steps: formulating the research question, searching for existing articles, selecting and evaluating the articles, conducting a content analysis, and presenting the results. In the first step, we searched for relevant literature by searching titles and abstracts with keywords such as 'synchronmodality' and 'synchronmodal traffic' in three major databases: Web of Science, Scopus, and Science Direct. These databases were chosen for their comprehensive coverage of the literature on this topic.

### DESCRIPTIVE ANALYSIS

The search phase yielded 119 publications. As can be seen in Figure 1, the majority of articles were published between 2015 and 2019. While there are a number of reviews

on intermodal transport research, e.g., Macharis and Bontekoning (2004), Meixell and Norbis (2008), Caris et al. (2008), Reis et al. (2013), SteadieSeifi et al. (2014), and Agamez-Arias and Moyano-Fuentes (2017), almost none of them address the field of synchronmodality. Nevertheless, there have been some conceptual elaborations on synchronmodality in recent years. For example, Pfoser et al. (2021) study on synchronmodality freight transport, Riessen et al. (2015) focus on synchronmodality in relation to the specific case of European Gateway Services in Rotterdam, de Juncker et al., (2017) address the mathematical planning problem of synchronmodality, Ambra et al. (2019) explain the differentiation of synchronmodality and the associated vision of the physical internet, and Giusti et al. (2019) discuss the critical success factors of synchronmodality and the corresponding technologies. Synergies within research on synchronmodal transport are explored to provide a sound and comprehensive overview of the topic.

**FIGURE 1:** Number of publications per year on synchronmodality



Source: Drawn by authors

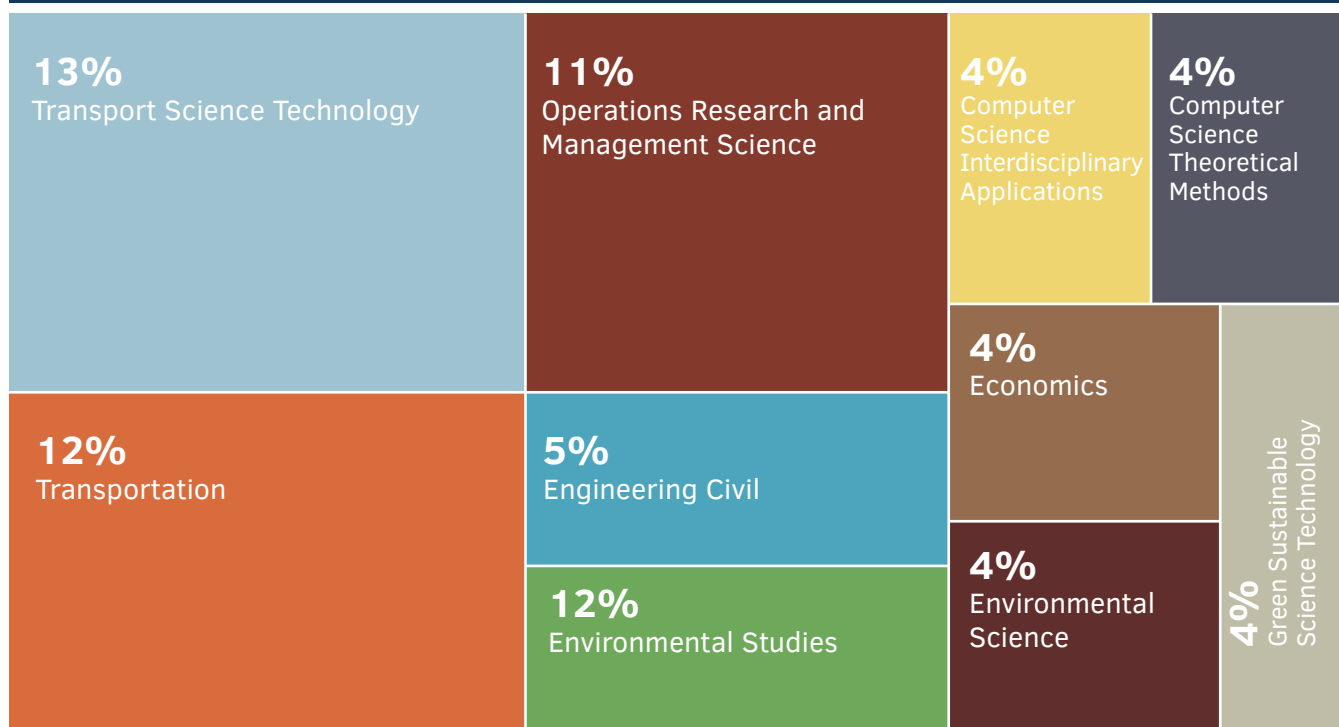
Figure 2 presents the distribution of scientific publications across different fields, revealing that Transport Science Technology (13%), Transportation (12%), and Operations Research and Management Science (11%) have the highest number of published articles. On the other hand, Environmental Science and Civil Engineering have a comparatively lower number of publications, at around 5%. Meanwhile, Computer Science Interdisciplinary Applications, Economics, Environmental Science, Computer Science Theoretical Methods, and Green Sustainable Science Technology have even fewer publications, at approximately 4% each. Notably, the field of law and politics has published very few articles on the topic of synchronomodality, which stands out as a significant gap in the literature.

Initially developed in the Netherlands, Dutch researchers have predominantly studied the concept of synchronomodality. Nonetheless, the increasing number of researchers from various countries who are now exploring synchronomodality indicates a growing global

interest in the concept. In fact, studies on synchronomodality are now being conducted on several continents outside Europe, including Asia, Africa, and North and South America. This shift illustrates that synchronomodality is not solely a Dutch vision but a concept that is gaining worldwide recognition. Although the initial research on synchronomodality focused mainly on the Netherlands and other parts of Europe, and other parts of Europe, which is to be expected given its origins, almost 70 articles on synchronomodality have been published in these regions alone (Pfooser et al., 2021).

The existing research on the concept of synchronomodality can be categorized into two primary areas: (a) the conceptual refinement of synchronomodality, in which researchers strive to define the mechanisms distinguishing synchronomodality from other transport concepts, identify its critical success factors, and examine the barriers to its implementation; and (b) the 'transport route planning problem' associated with synchronomodality, marked by the capacity of synchronomodal

**FIGURE 2:** Publication on Synchronomodality in different fields



Source: Modified from Web of Science (2022)



transport to address uncertainties in strategic and tactical transport matters (Delbart et al., 2021). This involves real-time planning of integrated transport networks to achieve sychromodality (Riessen et al., 2015) and the classification of transport issues that can be resolved through sychromodal approaches (De Juncker et al., 2017). Nearly all of the articles reviewed highlight some benefits of sychromodality, such as enhanced visibility of the transport network, increased flexibility for various stakeholders, and improved efficiency within the transport network.

The discussion on sychromodality has recently entered the realm of the supply chain. This is because sychromodality as a concept has some fundamentally new features compared to other existing transport systems, such as real-time switching and collaboration between stakeholders, and consequently can improve supply chain flexibility and resource utilization. Sychromodality thus transcends the boundaries of transport research and requires a supply chain perspective (Giusti et al., 2019). Likewise, another group of researchers suggested that the critical functions in the supply chain, such as inventory control and production, could also be integrated into the choice of modality within the sychromodal transport system (Acero et al., 2022; Dong et al., 2018). Although research on sychromodality from a supply chain perspective lags somewhat behind that of the transport network, recent articles published in respected journals emphasize the importance of incorporating sychromodality into the supply chain.

The concept of sychromodality is presently approached from either the transport or supply chain perspective. Although both approaches have their respective advantages and disadvantages, each has limitations. Applying sychromodality to the multimodal or intermodal transport network could involve actors from other transport systems

and represents a step forward. Meanwhile, applying sychromodality to the supply chain could require a paradigm shift and the synchronization of different stakeholders at different levels. Ultimately, sychromodality needs to reach the supply chain level, but in practice, it needs to arrive at the freight logistics level first. However, there is currently a lack of discussion on this in both academia and the industry. This is because freight logistics is where the physical distribution of goods takes place. In other words, sychromodality must also encompass upstream functions of logistics, such as warehousing, distribution planning, and order fulfillment. Therefore, before exploring sychromodality from the perspective of freight logistics, it is crucial to delve into the current perspectives of sychromodality in detail.

The concept of sychromodality is a relatively new and developing approach in the transport and logistics industry. It is currently viewed from either a transport or supply chain perspective, with each perspective having its own advantages and limitations. Applying sychromodality to the multimodal or intermodal transport network represents a significant step forward as it involves integrating different transport systems and actors. On the other hand, applying sychromodality to the supply chain requires a significant paradigm shift and the synchronization of different stakeholders at different levels. Even though the ultimate goal of sychromodality is to reach the supply chain level, it is essential first to achieve it at the freight logistics level. Freight logistics involves the physical distribution of goods and includes upstream functions such as warehousing, distribution planning, and order processing. Therefore, sychromodality must also encompass these functions to achieve a fully synchronized and efficient supply chain. Despite the importance of sychromodality in the transport and supply chain, its application to freight logistics is currently not sufficiently

discussed in both academia and industry. It is crucial to thoroughly understand the different perspectives of sychromodality before we explore its potential in the freight

logistics industry. In this way, we can take full advantage of sychromodality and pave the way for a more sustainable and flexible door-to-door supply chain in the future.

### 2.2.1. TRANSPORT PERSPECTIVE

The concept of sychromodality was first introduced in the Netherlands by Tavasszy et al. (2010), who defined it as the "synchronization of physical resources, business processes, and parallel use of modes in a mode-free manner to provide shippers with a more flexible and sustainable way to transport goods" (Agbo et al., 2017). However, there is currently no unified understanding of the concept among researchers. While some scholars define sychromodality from a transportation perspective as a structured, efficient, and synchronized combination of modes, others view the concept from a supply chain perspective, emphasizing the synchronization and integration of different actors and stakeholders to achieve flexibility and responsiveness to changing market demands. In addition, some scholars suggest that the sychromodal [transportation] approach can dynamically adjust the mode based on real-time information from stakeholders, customers, and the logistics network (Acero et al., 2022). Given the different perspectives on sychromodality, it is necessary to consider each perspective in detail.

From a transportation perspective, sychromodality is considered a natural evolution of the intermodal transportation system. Research in this area has focused mainly on transportation management and planning, with the goal of creating a more collaborative and flexible transportation network that can switch between modes in real-time based on available resources. Qualitative research has played a significant role in introducing various constructs of sychromodality from the transportation perspective. For example, Pfoser et al. (2021) identified

four key aspects that distinguish sychromodality from traditional transportation systems: (i) switching between modes in real time, (ii) integrated transportation network planning, (iii) horizontal cooperation between different modes, and (iv) mode-independent booking. These elements are essential to ensure flexibility and efficiency in transportation operations and to make LSP services more environmentally friendly.

From the transport point of view, the configuration of a sychromodal system is often a popular research objective and is mainly evaluated using quantitative methods (Rentschler et al., 2022). It is often assumed that (1) shippers' demands are given in terms of cost, duration, and/or sustainability requirements, and (2) modes can be flexibly switched according to the latest traffic information, such as traffic demand and congestion (Lin et al., 2016). These sychromodal transportation modeling problems can be classified (De Juncker et al., 2017), and an optimal solution can be obtained with a suitable optimization approach. Some researchers strongly emphasize the uncertainties in transportation planning and operations (Delbart et al., 2021; Riessen et al., 2015; SteadieSeifi et al., 2014) and use different algorithms to deal with the uncertainty at tactical, strategic, and operational levels. These quantitative studies typically assume that information is shared between all stakeholders in real-time, which is often a challenge in current industry practice. Overall, the transportation perspective of sychromodality highlights the importance of collaboration and flexibility in transportation planning and

and management. The adoption of synchromodality is seen as a necessary step toward sustainable and efficient transportation operations, with real-time switching between modes being a key feature of this approach.

In pilot tests, the Port of Rotterdam has experimented with synchromodality in its European Gateway Services (EGS) for unloading containers in the hinterland. This system selects the most efficient and sustainable mode of transport for each cargo based on real-time information. In this way, an efficient synchromodal transport system has been established, albeit within a well-defined geographical area and organizational unit, without covering all land/hinterland transport operations (Bruemmerstedt et al., 2017). It should be noted, however, that competition between different LSPs did not

play a role in this pilot. Instead, LSPs were organized through vertical integration with the port, and the port acted as an orchestrator that shared real-time information with other LSPs. This model is referred to as "agent-centric" synchromodality (De Juncker, 2017). While the pilot test conducted by the Port of Rotterdam demonstrated the potential benefits of synchromodality from a transportation perspective, further testing and development are needed to extend this system to all land/hinterland operations and to incorporate competition between different LSPs. Nevertheless, using real-time information and selecting the most efficient and sustainable mode for each freight is a promising step towards greater efficiency and lower environmental impact in the transportation industry.

### 2.2.2. SUPPLY CHAIN PERSPECTIVE

Although the concept of synchromodality has been extensively discussed from a transportation perspective, a group of researchers have argued against limiting the concept to transportation network planning and proposed a different concept of synchromodality at the supply chain level (Giusti et al., 2019). They argue that synchromodality is the provision of efficient, reliable, flexible, and sustainable services through the coordination and cooperation of actors and the synchronization of operations within one or more supply chains, driven by information and communication technologies (ICTs) and intelligent transportation system technologies (ITS). Their main argument is that the synchronization of modes alone is not sufficient to achieve optimal transportation costs and times. Therefore, all actors involved in supply chains must come together on a common platform and exchange real-time information to achieve optimal results.

Therefore, a concept of synchromodality has been developed that incorporates the supply chain perspective (Dong et al., 2018) and goes beyond the synchronization of multimodal modes to include other supply chain decisions, such as inventory control and production. This extended synchronization can bring significant benefits to individual shippers and the supply chain as a whole. Following this logic, synchromodality can be defined from a supply chain perspective as "a multimodal strategy that incorporates flexible mode choice into shippers' management of supply chain processes" Some case studies have shown that synchronizing key aspects of a shipper's operations, such as inventory control, for door-to-door delivery, can not only reduce overall logistics costs but also significantly reduce [greenhouse gas] emissions. However, research in this area is still limited.

### 2.2.3. AN OVERLOOKED PERSPECTIVE: FREIGHT LOGISTICS

From the above discussion, it appears that the concept of sychromodality is currently viewed from either a transportation or supply chain perspective. Although transportation is a component of the supply chain in a broader context, the concept of sychromodality in academia may have skipped the freight logistics stage as it directly moves toward the supply chain level. In general, freight logistics systems encompass a range of processes, technologies, and infrastructures involved in moving and storing goods from one location to another. These systems typically encompass a variety of activities, including transportation planning and scheduling, inventory management, warehousing, packaging, and distribution. In recent years, various freight logistics systems have emerged, all aiming to deliver products cost-effectively, reliably, in good condition, and with minimal environmental impact. However, as the distance between supplier and end customer increases, ensuring uninterrupted door-to-door delivery in a multi-partner supply chain becomes increasingly difficult. The integration of sychromodality at the freight logistics level could provide a solution to this challenge by enabling the synchronization of different stakeholders at different levels and facilitating the efficient and flexible use of different transport modes.

Moreover, it is imperative to discuss the concept of sychromodality at the supply chain level, but in practice, the discussion must first arrive at the freight logistics level. After all, freight logistics is the actual process through which the physical distribution of goods takes place. Thus, in order to create visibility (in a practical sense) throughout the supply chain network, real-time information from all logistics nodes is equally necessary.

In summary, the concept of sychromodality needs to incorporate upstream logistics functions such as warehousing, distribution planning, order processing, and transportation to increase visibility and flexibility throughout the supply chain.

The freight logistics sector faces numerous challenges, such as the lack of integrated transportation networks (Xu et al., 2015), interconnected digital infrastructures (Hofman, 2015), cooperative planning systems (De Juncker et al., 2018), and data exchange mechanisms (Singh et al., 2014). These challenges have hindered the adoption of "real-time transportation planning" and led to a lack of visibility and flexibility in freight logistics systems. Sychromodal transportation represents a potential solution to overcome these challenges and improve visibility and flexibility in the supply chain. By addressing the challenges facing freight logistics, sychromodality could lead to more efficient and sustainable freight transportation that benefits both the transport industry and the environment. Therefore, studying sychromodal transportation from a freight logistics perspective is crucial. Although various conceptual frameworks for sychromodal transportation have been proposed in recent years, the construction and mechanisms of the concept are not yet fully understood. To define sychromodality from a freight logistics perspective, all previous constructs of sychromodal transportation must be considered. This will allow for a more comprehensive understanding of the concept and its potential applications in freight logistics.



2.3. SYNCHROMODALITY IN CONCEPT

2.3.1. PURPOSE AND METHOD

To improve the understanding of synchronmodality, we conducted a systematic literature review (SLR) to answer the second research question, that is, *What are the different constructs involved in the synchronmodality transport system? And how can the concept be redefined to comprehensively capture its essence and key elements?* In general, conducting an SLR is intended to organize and categorize the intellectual

territory of a particular field, evaluate it, and develop the existing body of knowledge (Denyer and Tranfield, 2009). SLRs are widely used in business, logistics, and supply chain research, especially in developing conceptual frameworks or creating new definitions of a concept (Durach et al., 2017), which in this case is the definition of synchronmodality from a new perspective.

2.3.2. DECONSTRUCT EXISTING DEFINITIONS

Although synchronmodality is a relatively new concept, it has various definitions in the literature. However, there is a lack of consensus on what the core constructs of synchronmodality are. Many articles have focused on technical solutions for optimization in transportation engineering without thoroughly

discussing its conceptual framework. Due to the inter-LSP nature of synchronmodality, we have focused on the articles related to inter-organizational topics and excluded those on intra-organizational topics. Table 1 presents a list of relevant definitions that we have identified.

TABLE 1: Existing Definitions of Synchronmodality	
ARTICLE	DEFINITION
Alice (2014)	a service that enables decisions about modes and routing to be made as late as possible at the individual shipment level through informed and flexible planning, booking and management
Xu, Cao, Jia and Zang (2015)	synchronmodal freight transportation involves a structured, efficient, and synchronized combination of two or more transportation modes
Riessen, Negenborn and Dekker (2015)	a tool for creating the most efficient and sustainable transportation plan for end-to-end shipments by using different modes (and routes)
Mes and Iacob (2016)	transport services that offer the opportunity to improve inland transportation services in terms of sustainability, costs, and quality
Pfoser, Treiblmaier, and Schauer (2016)	an evolution of inter- and co-modal transport concepts, where stakeholders in the transport chain actively interact within a cooperative network to flexibly plan transport processes and to be able to switch in real-time between transport modes tailored to available resources

Behdani, Fan, Wiegman and Zuidwijk (2016)	an integrated view of planning using different transport modes to provide flexibility in handling transport demand
Tavasszy, Behdani and Konings (2017)	a planning and management of different modalities to provide flexibility in handling transport demand
Singh et al. (2018)	an integration platform for logistics that provides access to third-party real-time data and supports dynamic planning and information services ... targets the flexible allocation of cargo to transport modes and routes in order to achieve a better balance of cost, performance, and service levels.
Alons-Hoen, Somers and Duin (2019)	the transport of goods (without changing the loading unit) in which real-time changes can be made with regard to the flexible and sustainable use of different transport modes in a network; the logistics service provider is in control in order to offer optimized integrated solutions for all parties.
Khakdaman, Rezaei and Tavasszy (2020)	'synchronized inter-modality' where LSPs have the flexibility to make real-time decisions about switching between transportation modes and routes, in response to demand variations and resource/network availabilities
Acero, Saenz and Luzzini (2022)	a multimodal transportation planning system, wherein the different agents involved in the supply chain work in an integrated and flexible way that enables them to dynamically adapt the transport mode they use based on real-time information from stakeholders, customers, and the logistics network
Pfoser et al., (2021)	four mechanisms ... differentiate synchromodality from other transport concepts: real-time switching, integrated network planning, horizontal collaboration, and mode-free booking.

The definitions in Table 1 are summarized following a systematic approach to reduce a large amount of textual data to its essence in a unifying structure. The generic 'contextual conditions - mechanisms - outcome' structure of Pawson and Tilley (1997) is used here because it is an established approach that has been widely applied in SLR analysis. Moreover, the structure is general enough to serve as a basis for analyzing broad and diverse definitions (Hanelt et al., 2021).

First, each of these definitions is broken down into the structure shown in Table 2. It is worth noting that some elements do not represent a consensus among the definitions and have therefore been removed and crossed out. For example, mode-free booking implies that a customer must give up their right to choose a mode in order to give

the LSP the flexibility to change modes. This view seems to stem from an LSP perspective, possibly inherited from intermodality, where dominant LSPs have the power to control the direction of transportation system development (e.g., mega-size of container ships). This intent can also be seen in some articles that unilaterally advocate 'flexible freight sharing among modes and routes', assuming that the other side would be convinced of progress. We believe that synchromodality does not require customers to give up their rights and that mode-independent booking should be an option for them, not a hard requirement on the part of an LSP. We believe the other two elements, multimodality, and intermodality, are dispensable because synchromodality could logically take place between the same modes (e.g., roadways and roadways), especially when considering inventory and warehousing from a freight logistics perspective.

Second, similar elements are grouped, and a text box frames each group in Table 2 as a potential construct of sychromodality. We also introduce additional elements to complement the existing ones, which are indicated by an underline. Data standards are necessary for the development of data exchange platforms and are of utmost urgency in current industry practice but are not explicitly highlighted in these definitions. Therefore, we introduce them along with digital connectivity and data exchange platforms. Similarly, inter-LSP strategic coordination to align common strategic goals is added to the group with inter-LSP collaboration and integrated network planning because sychromodality can only be initiated by LSPs coordinating together at the strategic level; these elements elaborate on how LSPs integrate with each other at an inter-organization level, and hence could be summarized as integration. Finally, customer-added value is introduced to encapsulate the individually introduced values.

The obtained elements in Table 2 suggest that, in the current literature, sychromodality is primarily an operational-level concept, and needs to be initiated through strategic coordination between stakeholders. The groups of elements in the table could be considered candidates for constructing a comprehensive concept of sychromodality. Three of the groups represent the contextual conditions: information exchange platform, demand variations, and cooperative network. They have already been unanimously acknowledged in the literature, despite some contested elements to be further discussed. In the mechanism category, the three groups, i.e., *integration*, *visibility*, and *flexibility*, are the key constructs that distinguish sychromodality from other modality concepts. The last category presents two expected outcomes of sychromodality: *resource utilization* and *adding value to customers*.

**TABLE 2: Deconstruction of Existing Definitions**

CONTEXTUAL CONDITIONS That form the basis of sychromodality	MECHANISMS That link contextual conditions with outcomes	OUTCOMES Consequences of sychromodality for logistics performance
<div> <u>Data standards</u> Digital connectivity Data exchange platform </div> <div> Demand variations End-to-End logistics <i>Mode free booking</i> </div> <div> Cooperative network <u>Multimodality</u> <u>Intermodality</u> </div>	<div>Visibility</div> <div>Flexibility Real-time switching</div> <div>Inter-LSP strategic coordination Integrated network planning Structured mode synchronization Inter-LSP collaboration</div>	<div>Resource utilization Cost effectiveness</div> <div><u>Added customer value</u> Efficiency Sustainability Service quality</div>

### 2.3.3. DEFINING SYNCHROMODALITY

The potential constructs presented above provide a solid basis for defining sychromodality from a freight logistics perspective. In

a broader sense, sychromodality is an evolved version of earlier transportation systems, more deeply integrated to increase

operational visibility and flexibility in the logistics chain, and thus more efficient and effective. Therefore, the concept can be defined as follows: *Synchromodality is an operational concept applicable to freight logistics for the purpose of adding value to customers by organizing and utilizing resources in an effective and efficient way, that can be achieved through facilitating integration amongst stakeholders along the logistics chain and enhancing their operational visibility and flexibility.* To achieve synchromodal operations on this scale, all participants must be harmoniously 'integrated' at different levels. Only then can each participant in the chain gain a better overview of operations and make flexible decisions to provide added value to its customers, including logistics costs, transportation time, service reliability, and system resilience. It is important to note that the scope and extent of added value should be defined by individual customers. Therefore, customizable logistics services for heterogeneous customer requirements will be necessary for synchromodal freight logistics.

This definition of synchronization states that real-time information in the freight logistics system should be available in commonly accepted digital formats and accessible to relevant stakeholders. This can introduce real-time flexibility in optimizing transportation choices (Acero et al., 2022), allowing LSPs and other decision-makers to autonomously and dynamically choose the optimal mix. To translate the available data into efficient and effective decisions, stakeholders need to go beyond information sharing and design a dedicated transportation system based on integrated network planning that can increase stakeholder visibility and enable timely mode switching based on real-time information from other stakeholders (Dong et al., 2018; Acero et al., 2022).

In the following subsections, we elaborate on the key constructs in the new definition of synchromodality.



## INTEGRATION

In the context of managing inter-organizational relationships, integration broadly refers to the coordination, cooperation, and collaboration of processes between organizations. Since synchromodality is based on inter-organizational relationships between different actors, it is necessary to examine *integration* in the context of *coordination*, *cooperation*, and *collaboration*.

Coordination between organizations involves several organizations operating in a consortium, jointly setting common goals, and treating the organizational 'goal' as a single entity (Castaner and Oliveira, 2020). Coordination also involves attitudes, behaviors, and outcomes associated with deliberating, negotiating, and agreeing on a common goal. Conversely, cooperation refers to attitudes, behaviors, and outcomes associated with implementing a common goal. Notably, coordination is not limited to cases where partners cooperate physically or virtually or communicate bilaterally. For instance, in the health sector, organizations can coordinate with each other to ban the use of certain hazardous chemicals that can have far-reaching side effects. In such cases, organizations do not necessarily need to work together to achieve these goals but engage individually within their own organizations to achieve a common goal. Coordination is a vital aspect of supply chain management as it helps to align the goals of different organizations in the chain, leading to improved efficiency, reduced costs, and increased sustainability.

Therefore, in order to establish a synchromodal logistics system, LSPs must first coordinate to define the common goals. For example, the stakeholders may set a common goal of offering a service option of changing destination for en route cargo. They must then discuss and decide how to cooperate in sharing resources to achieve



the goal. Resource sharing may involve tangible resources, such as transport facilities, equipment, warehouses, and IT infrastructure, as well as intangible resources such as databases, patents, copyrights, trademarks, knowledge, and experience. The degree of cooperation between stakeholders controls the degree of operational visibility within the logistics chain, which in turn affects operational flexibility, and ultimately determines the performance of the synchromodal transport system (Castaner and Oliveira, 2020). Greater coordination and cooperation are expected to create more value for customers.

In addition, *collaboration* refers to attitudes, behaviors, and outcomes related to an organization's voluntary support in achieving common goals or a private goal of its partner. Voluntary support can enhance trust and increase reciprocity and commitment in inter-organizational relationships (Das and Teng, 2000). Another motivation could be to gain a reputation as a good partner and thereby attract new partners in the marketplace (Williamson, 1993). Under synchromodality, larger stakeholders can support smaller partners with infrastructures such as IT, databases, and/or digital technologies, as well as expertise to increase their efficiency, which may ultimately lead to greater efficiency of the entire chain.

### OPERATIONAL VISIBILITY

Visibility is a critical aspect of logistics and supply chain management. It refers to the extent to which an actor has access to timely and accurate information that is relevant or useful to its business (Barratt, 2011; Barratt and Oke, 2007). Visibility of demand and supply information across the logistics chain enables the system to achieve higher levels of customer service and mitigate the risk of potential disruptions. The quality of visibility is closely related to the accessibility,

accuracy, and usefulness of information to stakeholders in conducting their business (Barratt and Oke, 2007). However, information biases such as lateness, incompleteness, and untruthfulness can significantly affect stakeholder visibility and lead to reduced operational flexibility. To avoid such distortions, creating a harmonized digital process integration among stakeholders in a synchromodal logistics system is necessary. Such integration would ensure that stakeholders have access to timely and accurate information, leading to improved visibility, increased operational flexibility, and increased efficiency throughout the logistics chain. Through the use of digital technologies, stakeholders can seamlessly share data, collaborate more effectively, and make informed decisions based on real-time information. This enables better coordinated and more efficient use of transport modes and leads to more sustainable and environmentally friendly freight transport.

### OPERATIONAL FLEXIBILITY

In the literature, *operational flexibility* is described as the ability of an actor to deploy its resources quickly and efficiently to respond to changing market conditions (Sethi and Sethi, 1990; Gerwin, 1993; Upton, 1994). The visibility of the freight logistics chain determines the extent to which an actor deploys its resources in response to changing circumstances. In the context of synchromodality, operational flexibility can therefore be defined as the extent to which a LSP is able to offer a range of service alternatives to other stakeholders in a timely manner by mobilizing its resources and/or capacity in response to changing market situations.

Operational flexibility to switch freely between modes in unforeseen situations is necessary. For example, a container originally destined for intermodal rail transport may be switched to direct truck transport at

certain terminals if intermodal rail transport is delayed or if there are urgent replenishment deliveries. If inventories at the destination are sufficiently high, in-transit shipments can also be slowed down. In such a situation with good operational visibility,

the appropriate LSPs can provide operational flexibility by chaining modes at multiple nodes along the route or changing the route to meet cost and service level requirements without compromising value to the end customer.

## 2.4. DISCUSSION

Sychromodality is a very practical topic addressed primarily in applied research, so basic conceptual constructs are insufficient to understand it in a broader sense. However, using basic constructs is critical to developing conceptual and theoretical frameworks that lead to knowledge production (Handfield and Melnyk, 1998). Therefore, identifying foundational constructs is critical to the development of sychromodality into a mature scientific concept. This study examined the different perspectives on sychromodality (transportation vs. supply chain), extracted fundamental constructs from existing studies, and then redefined the concept from a freight logistics perspective.

This research aims to provide guidance for LSP digitalization efforts and related policy decisions. The literature shows that there are several barriers to such digitalization developments. First, digitization - the conversion of data into computer-readable formats, a prerequisite for digitalization - is not yet fully realized in the industry, with manual and non-digital processes still common, resulting in broken data chains

and poor connectivity. Second, the industry lacks standards and protocols for capturing and sharing data. Even if a standard is adopted, its adoption could be challenging for some stakeholders for whom it does not provide clear benefits (Vairetti et al., 2019). Third, developing a standard or protocol into an inclusive platform can be costly for stakeholders with insufficient economic scale. Moreover, because such a platform is a public infrastructure, it can often be difficult to find volunteers to lead and invest in it (Boullauazan et al., 2022). Fourth, the security and reliability of digital platforms remain a major concern for stakeholders, and a lack of trust is also a significant barrier to the widespread adoption of sychromodal transport (Tsertou et al., 2016). Lastly, a lack of ICT capacity and insufficient human resources are other barriers that cannot be ignored (Boullauazan et al., 2022).

These challenges require a coherent strategic response to address them, but this topic is still in its infancy. Therefore, significant research efforts are needed in both empirical and conceptual studies.

- Currently, the EGS project in the port of Rotterdam is the only meaningful empirical case available on sychromodality. It is the main practical example on which many recent studies are based. The Netherlands is known for being a high-performing logistics country and a pioneer in sustainable freight transport (Rashidi and Cullinane, 2019). To further promote the adoption of sychromodality, successful business cases need to be reported to mobilize potential users. It would be beneficial to have more publications on practical demonstrations and business cases of sychromodality from different countries, especially from those with different policy frameworks.

- As far as integration is concerned, an important question for LSP managers is how to organize horizontal integration and digital network orchestration in a synchronomodal logistics system. Different models have been proposed, but there is no practical evidence regarding which model works best or is preferred by LSPs. Further research is needed to identify the most suitable models for various types of logistics chains.

- At the organizational level, there needs to be more discussion about the digital platforms (including common data standards and protocols) that are feasible for all stakeholders in a logistics chain to achieve door-to-door synchronomodality. In relation to this, the role and impact of the orchestrator structure need investigation, for example, through comparison with the traditional transport orchestrator structure. Additionally, research is needed to identify ways to overcome the barriers to the adoption of digital platforms, such as the lack of trust, concerns about security and reliability, and inadequate ICT capabilities and human resources.

The inclusion of synchronomodality in European Union policy roadmaps, as discussed by Zijm and Klumpp in 2016, indicates strong political support for this approach. However, the existing literature lacks a comprehensive policy framework for synchronomodal transportation networks, highlighting a need for further research to contribute to policy efforts. Developing recommendations and policy implications that facilitate the effective implementation of synchronomodality is essential. For example, it would be valuable to study the impact of different policies in different sectors, such as road transport, inland waterways, and rail transport, on the adoption of synchronomodality.

With the growing interest in synchronomodality globally and the political attention it has received in Europe, this innovative concept is expected to play a vital role in achieving sustainability goals and mitigating the negative impacts of freight transport, as highlighted by Kotzab and Unseld in 2018. However, whether the term "synchronomodality" will eventually gain widespread acceptance to describe this integrated and optimized approach to freight logistics remains to be seen.



## Chapter III

# SITUATION ANALYSIS OF RORO FREIGHT LOGISTICS IN SWEDEN: A CASE STUDY





## CHAPTER III: SITUATION ANALYSIS OF RORO FREIGHT LOGISTICS IN SWEDEN: A CASE STUDY

### 3.1. INTRODUCTION

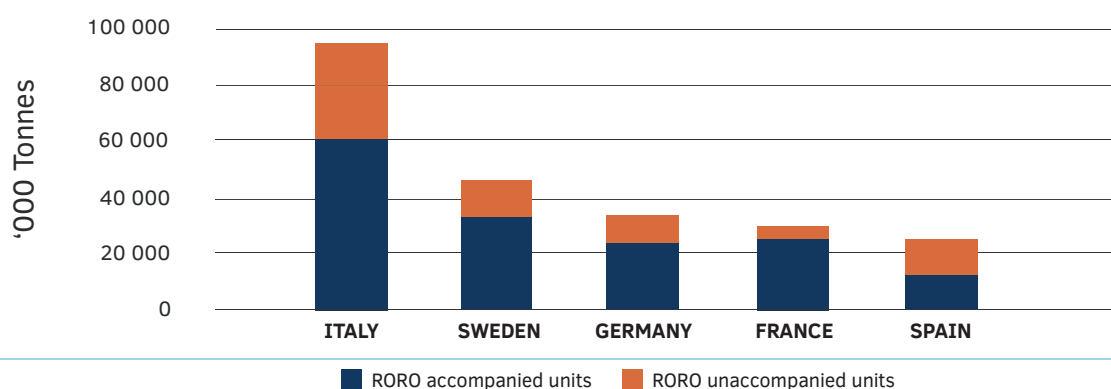
As stated earlier, there is a growing interest in synchronomodality in both academia and industry, but currently, it is limited to the container sector. Despite the existing literature, there is still a lack of strategic models that can conceptualize digitalization as an evolutionary process towards synchronomodality. This absence of a framework makes it challenging to guide policymakers on digitalization strategy. However, the definition of synchronomodality presented in Section 3.3 can serve as a conceptual foundation for measuring the digitalization progress of individual LSPs, with synchronomodality as the ultimate goal.

In this chapter, we aim to derive a maturity model of synchronomodality based on the definition and apply it to a case study of the RORO logistics chain in Sweden. Our goal is to map the current status of stakeholders along the RORO logistics chain in terms of digital maturity and their ability to meet shippers' digital service requirements. This study aims to assist their long-term digitalization development based on future logistics concepts.

Why did we choose RORO logistics as the focus of the study? While synchronomodality

has been studied and pilot-tested in the container sector, it has yet to be explored in the RORO sector. This is because there are significant differences between the two sectors, such as competing modes of transportation and the dominant position of ports, requiring proper validation from a sector-by-sector approach before generalizing results. Therefore, it is necessary to study RORO logistics as a separate case to understand the potential of digitalization in this sector. Moreover, RORO is a crucial transport mode for the economies in Sweden and the Baltic Sea region. Given the extensive coastline of Sweden, the country has developed a large-scale RORO logistical network to connect its hinterland with neighboring countries. In fact, in 2022, Sweden ranked as the second-largest RORO cargo-handling country in Europe (Eurostat, 2022), as shown in Figure 3. Additionally, Sweden is a leading country in producing and utilizing digital technologies (OECD, 2018). To support the digital transformation of RORO logistics in the Baltic Sea region and other parts of the world, it is essential to assess Sweden's digital maturity towards synchronomodality. Therefore, this study conducts a situation analysis in Sweden to assess the current state of digitalization in RORO logistics.

**FIGURE 3:** Top 5 European Countries by RORO Cargo Volume (in '000 tonnes)



Source: Eurostat (2022)

A RORO logistics system is an intermodal network where multiple LSPs collaborate to transport shippers' cargo in trailers between sea and different modes, such as road and rail. These routes usually serve regional transport demands over short distances and face strong competition from roadways, and sometimes railways.

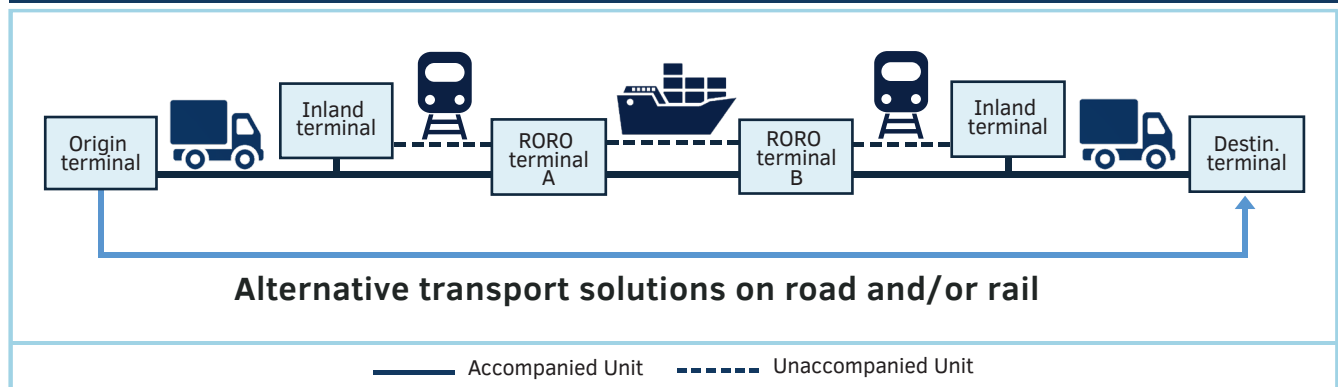
Figure 4 presents a schematic diagram of a RORO logistics chain, which moves cargo from the origin to the destination. In this chain, road transport is used for the first and last mile, and accompanied trailers can drive onto the ferry, while unaccompanied units arrive by road or rail and are loaded onto the ferry by port stevedores. Upon arrival, accompanied trailers proceed to the final destination, while unaccompanied units are either picked up by a driver or continue on the railway to an inland terminal before completing the last mile by roadway.

In this business, shippers have multiple LSPs to choose from, and some LSPs provide

intermodal solutions to their customers in partnership with LSPs of other modes. However, in recent times, LSPs that collaborate with each other, such as RORO and railway, often compete for the same demand.

The rest of this chapter is organized into two main sections. Section 3.2 outlines the development of a synchromodal maturity model, which includes details on the model's design and the application method. This section provides a comprehensive overview of the model's construction and explains how it can be used to assess the level of synchromodality maturity in LSPs. Section 3.3 focuses on the application of the proposed model to a case study. This section discusses the synchromodality maturity levels of each player involved in the logistics chain and examines the findings in detail. The case study helps to illustrate how the model can be used in a practical setting to assess the digital maturity of LSPs and identify areas for improvement.

**FIGURE 4: A Schematic Diagram of RORO Logistic Chain**



Source: Drawn by the authors

## 3.2. DEVELOPING A SYNCHROMODAL MATURITY MODEL

The concept of maturity models originated in the software development field (Boullauzan et al., 2022) and has proven to be a valuable tool for assessing an organization's current situation and identifying opportunities for

change. Hundreds of such models have been developed in the IT management field (Becker et al., 2009), and their use is increasingly being adopted in other fields as well (Boullauzan et al., 2022).

A maturity model typically consists of a sequence of maturity levels for a class of objects, representing an anticipated, desired, or typical evolution path of those objects in discrete stages (Becker et al., 2009). The bottom stage usually characterizes an organization with limited capabilities in the domain under consideration. The second stage is defined by more structured processes, but these are not yet established standards within the industry. In the third phase, the processes become established as organizational standards, although not all industry stakeholders may have adopted them yet. The fourth stage depicts the highest level of maturity, with organizational standards and institutionalized processes integrated across stakeholders. The fifth stage is the optimization stage, where effectively managed processes are continuously improved.

As the focus of this pre-study is to map the capabilities of stakeholders along the RORO logistics chain, we have developed a maturity model that focuses on the first four stages. The optimization stage (fifth stage) falls beyond the scope of this study and will be explored in the continuation study.

Given the cooperative relations between LSPs, there is a need to develop a maturity model at the inter-organizational level to measure their progression as a whole towards synchronomodality. As recommended by Becker et al. (2009), the first step in the methodology should be to review existing models to ensure that the proposed model integrates existing knowledge. However, in the literature, only one conference paper presents a maturity model developed on synchronomodality. Alons-Hoen et al. (2021) attempted to determine the general level of

synchronomodal maturity for LSPs in the Netherlands and Belgium by evaluating aspects of their operations, such as execution of transport, pricing, data exchange, and decision-making power. In our opinion, these aspects are useful for describing the outcomes of business model development but not for measuring the key capabilities that enable LSPs to pursue synchronomodality. Furthermore, their model does not fully reflect the common conceptual elements of synchronomodality in the literature, as revealed in Section 2.3.2.

Additionally, other maturity models in transport logistics address different issues, such as smart port maturity (Boullauazan et al., 2022), where the model design has reference values, but its domain focus is different from this study. Therefore, the existing knowledge in the literature is limited, and there is a need to develop a new synchronomodal maturity model that focuses specifically on LSPs' capabilities at the inter-organizational level.

To adhere to design science research guidelines (Mettler, 2010), it is important to identify the target audience for the maturity model to tailor it to their specific needs. For this study, the maturity model should be applicable for measuring the digitalization progression of LSPs towards synchronomodality at the strategic level. The target audience should be industry leaders and policy-makers who primarily influence digitalization strategies in RORO logistics. The maturity model should focus on organizations with interest in the capabilities required for synchronomodal development. Therefore, we have developed this maturity model based on the definition of synchronomodality presented in Section 2.3.3.

### 3.2.1. TAXONOMY OF MATURITY MODEL

The proposed maturity model taxonomy (or classification system) consists of three synchromodal capabilities and four maturity stages. The synchromodal capabilities are defined according to the definition of

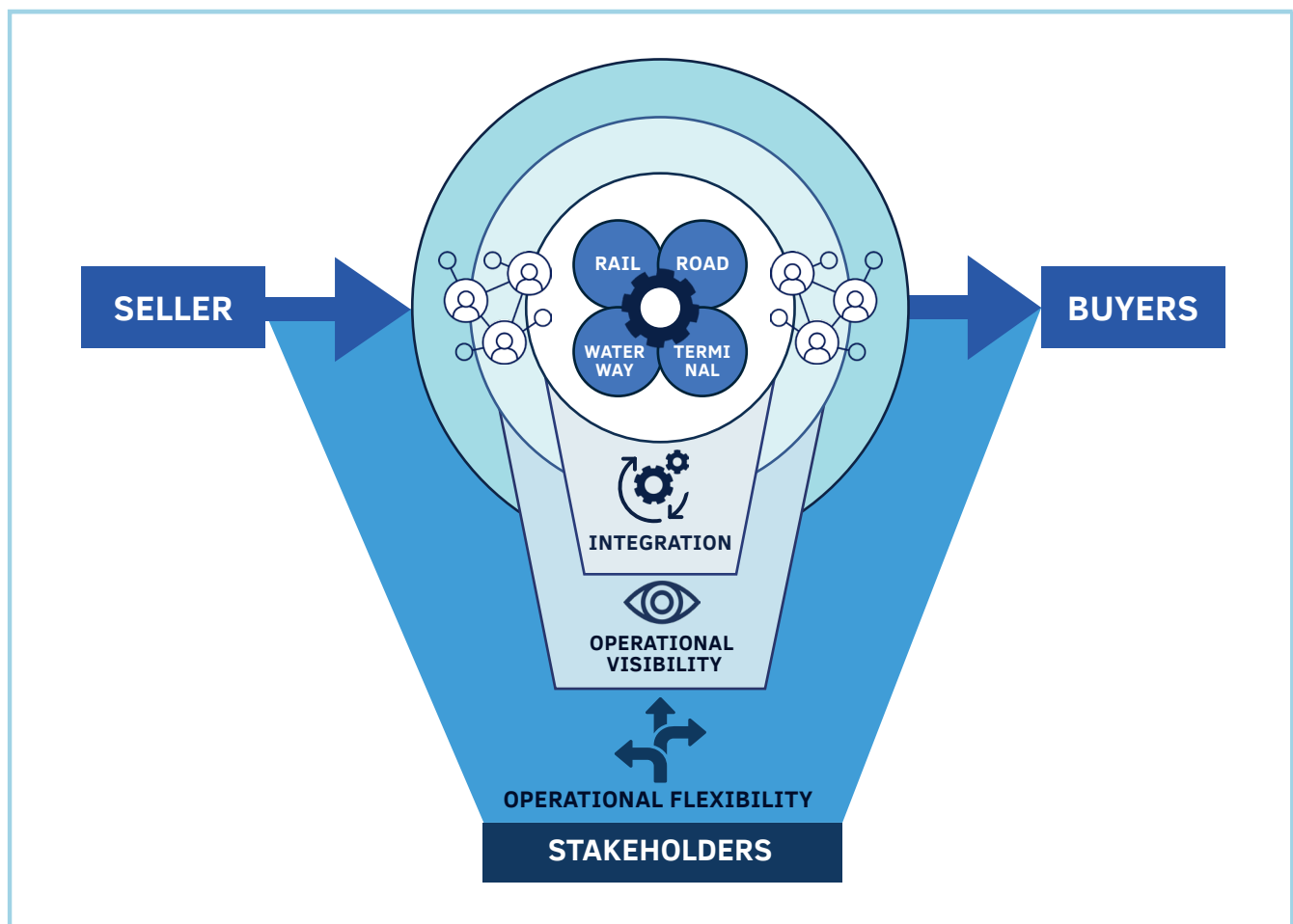
synchromodality in Section 2.3.3, where *Integration*, *Operational Visibility*, and *Operational Flexibility* can be extracted as key capabilities. These capabilities and the maturity stages are discussed in detail in the following.

#### CAPABILITY DOMAINS OF THE MATURITY MODEL

In the journey towards digitalization and synchromodality, LSPs must develop the necessary capabilities to synchronize different transport modes in partnership to meet their customers' logistical needs. As outlined in Section 2.3.2, eight element groups

have been identified from existing literature. Among these, Integration, Operational Visibility, and Operational Flexibility under the mechanism category are capability-related, while the other element groups are of the context- or outcome-type.

**FIGURE 5:** Capability domains of Synchromodality in logistics service



Source: Drawn by authors





**Integration** here refers to stakeholder coordination, cooperation, and/or collaboration in the context of inter-organizational relations management. According to Castaner and Oliveira (2020), *coordination* is defined as the joint setting of common goals by several organizations operating in a consortium, and can be described in terms of the attitudes, behaviors, and outcomes related to deliberating, negotiating, and agreeing on a common goal. They further define *cooperation* as the attitudes, behaviors, and outcomes related to implementing a common goal in their daily operations, and *collaboration* as the attitudes, behaviors, and outcomes related to the voluntary assistance of an organization in achieving common goals or a private goal of its partner. All three terms can be evaluated in terms of scope and depth, to measure the degree of inter-organizational integration.



**Operational Visibility** refers to the extent to which an organization has access to timely and accurate digital

information related to logistics demand and supply, subject to information distortion. Distortions may occur in the form of information delay, incompleteness, and occasionally untruthfulness, impacting on the stakeholders down the chain from the information source. It can be measured in terms of scope (accessibility of information from sources in terms of distance, as well as its usefulness) and depth (quality of information from different sources).



**Operational Flexibility** refers to the ability of an organization to provide stakeholders with a range of service alternatives in a timely manner by mobilizing resources and capacities efficiently in response to changing market situations. Some relevant characteristics include resource control, resource mobility, service innovation, service substitutability, and contract restrictiveness. Flexibility can be measured in terms of scope (coverage of service ranges) and depth (the degree of involved partnerships).

### 3.2.2. DEVELOPMENT STAGES OF THE MATURITY MODEL

Based on the above three key synchromodal capabilities, we can partition the digitalization development of an organization or network into four stages. Each stage is explained below.

**Fragmented Cooperative Network** is the initial stage characterized by individual LSPs that are capable of cooperating with each other at a minimal level to fulfill customer transport demand, without any further strategic level coordination or voluntary collaboration. In other words, they primarily focus on optimizing their individual activities in silos, with no operational visibility outside of their organization. This lack of coordination is often characterized by a lack of data

standards, ICT platforms, real-time data exchange, and operational flexibility.

The second stage of the cooperative network is characterized by a **Dyadic Coordinative Partnership**. Recognizing the importance of strategic coordination, individual LSPs begin to strengthen communication and gradually establish partnerships to align their strategic goals. At this stage, LSPs often focus on data exchange and operational visibility. However, the scope of the partnerships is often limited, resulting in finite visibility with high information distortions, such as low data quality and long time lags. This level of visibility is insufficient to enable operational flexibility.

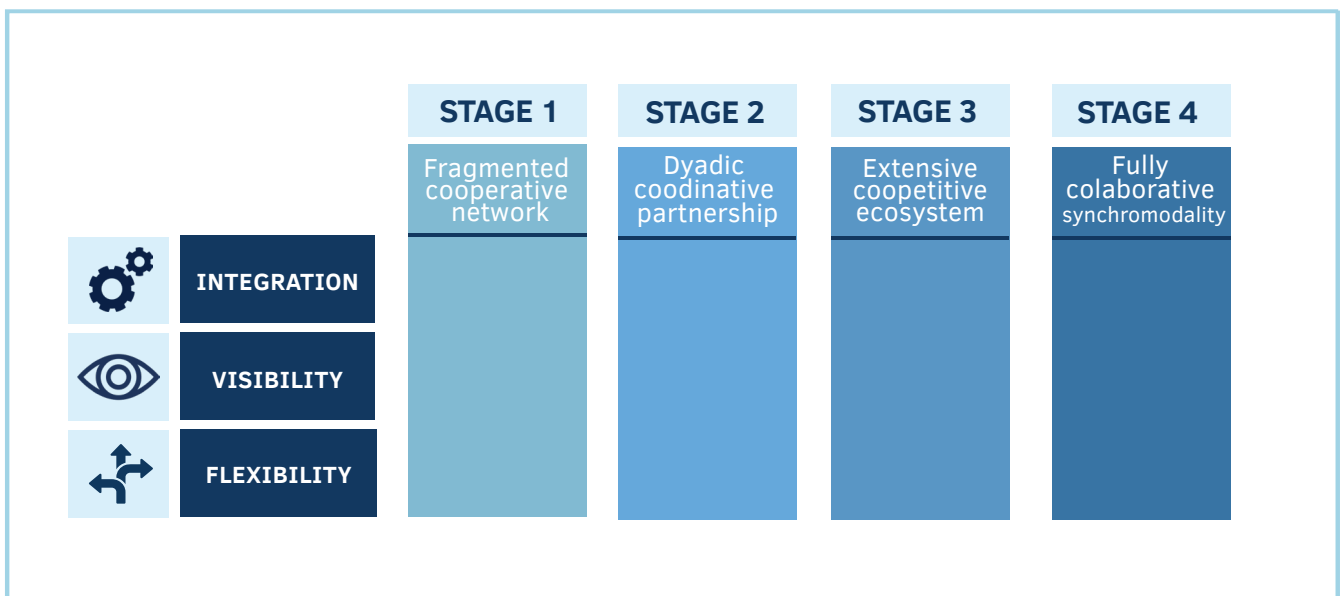
The establishment of an **Extensive Coopetitive Ecosystem** characterizes the third stage. LSPs build stronger coordinative relationships with multiple partners in the network and establish integrative platforms for data exchange within the ecosystem. This allows LSPs to gain increased visibility with medium distortion, meaning medium data quality and time lag. Additionally, the partners can compete with each other, and extensive coopetition becomes a defining feature of this stage. LSPs can offer operational flexibility to their stakeholders at a medium level, which means they have full resource control and a high number of alternatives, but providing alternatives may have a time lag due to data distortion.

The final stage of the cooperative network is the **Fully Collaborative Synchromodality** stage, which has the highest degree of synchromodality based on the capability of

the players. LSPs and shippers can coordinate their strategic goals within the ecosystem and collaborate voluntarily to achieve their partners' common or private goals. They cooperate with high visibility and low distortion, meaning high data quality in real time, as all players are integrated within the ecosystem. This further facilitates a high level of flexibility on a network level, meaning that LSPs can offer full resource control and a full level of alternatives in real time. At this phase, resources are almost fully utilized in normal situations, and different customer demand requirements can be sufficiently differentiated and fulfilled.

This four-stage model, as shown in Figure 6, indicates a sequential progression toward greater levels of integration, visibility, and flexibility, which are fundamental synchromodal capabilities to be developed by LSPs and shippers.

**FIGURE 6: Synchromodality Maturity Model**



Source: Drawn by authors

### 3.3. APPLYING SYNCHROMODALITY MATURITY MODEL TO RORO FREIGHT LOGISTICS

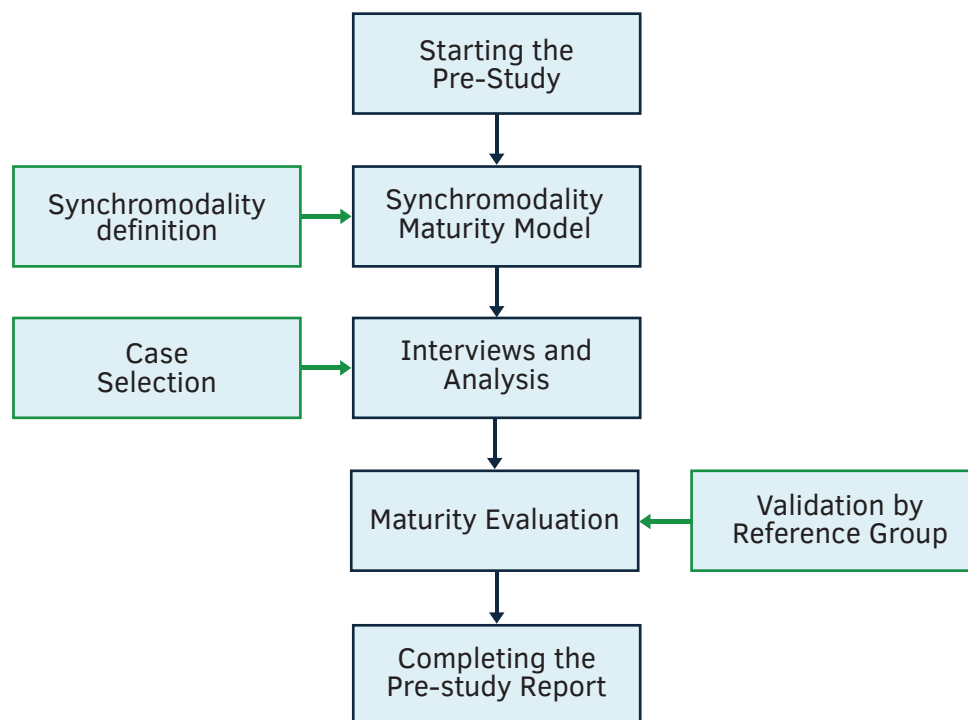
The maturity model is applied in a situation analysis where representative companies are selected, in this case, in the RORO logistics industry in Sweden. The entire process is depicted as a flowchart in Figure 7, and the steps include selecting relevant industry conducting interviews with the selected actors, and analyzing the obtained data. The findings are validated through a reference group of industry experts.

To select cases, we collaborate with a prominent RORO company operating in the area, and through their network, we engage with key industry actors, including a terminal operator, a RORO shipping company, a forwarder company, and a global third-party logistics service provider (3PL). Additionally, we interview two shippers who utilize logistics services that traverse the RORO network.

In the interview step, we develop open-ended questions for each element of the maturity model to assess the digitalization level and conduct semi-structured interviews with each case company. This approach enables us to comprehensively understand the digitalization prospects and hurdles in RORO freight logistics.

The interview data obtained is analyzed using the content analysis method. First, we transcribe the audio recordings of the interviews and then group the initial codes into larger themes based on their recurrence and significance in connection with the maturity model. This approach enables us to gain insights into each case company's viewpoint regarding their digitalization towards synchronomodality.

**FIGURE 7:** Maturity Model Application Process



Source: Drawn by authors

Then, the observations are categorized into Stages 1 to 4 of the maturity model. Additionally, to assess the integration, visibility, and flexibility capabilities of the entire RORO logistics chain, we analyze the data both at an individual company level and from the perspective of the entire logistics chain.

Finally, we validate our findings through a reference group meeting that involves stakeholders, academic partners, and

policymakers. This group offers constructive feedback to enhance the accuracy and quality of the results. Additionally, the reference group assesses the significance, practicality, and excellence of the proposed maturity model through an iterative process, which involves refining the model over multiple iterations. The results presented in this report will be refined and updated in the final version.

**TABLE 3:** List of Interviewed Case Companies

INTERVIEWEES	CHARACTERISTICS
Shipper A	Shipper A has production facilities in Asia and Europe. The finished goods are transported to the warehouse in Scandinavia. All products are destined for sale in Northern Europe. The shipper manages inbound and outbound logistics on its own.
Shipper B	Shipper B has production facilities, warehouses and customers across the globe, including Scandinavia. It has three main supply chains: base material, packaging material, and finished goods. Shipper B manages the entire operations of its supply chains.
Freight Forwarder and 3PL	Global warehousing and logistics operator.
Freight Forwarder	The freight forwarder provides intermodal solutions from the Baltic states to Scandinavia and mainland.
RORO Shipping Line	One of Europe's largest RORO and RoPax ferry companies.
Terminal Operator	The terminal operator of the interviewed ferry company in one of Sweden's largest RORO ports.

### 3.3.1. INDIVIDUAL PLAYER DESCRIPTION

This section describes each case company with a particular focus on digitalization-related opportunities and challenges they face in the Baltic Sea region. The description aims to help (i) analyze the current state of digitalization in the industry (from both direct and indirect sources) and (ii) estimate their need (if any) for synchromodality, to provide inputs for the maturity evaluation of individual stakeholders in the next section.



#### Shipper

Shipper A and Shipper B both have extensive networks beyond Europe. Shipper A serves B2C customers, while Shipper B focuses on a B2B market. Both shippers prioritize control of their logistics operations to ensure visibility and efficiency of cargo flow. They manage their logistics processes internally and outsource transportation, and LSPs are selected based primarily on price, time, and environmental factors.



Shipper A has worked with a single shipping line over years for inbound logistics from factories in Asia; for their European markets they typically choose an LSP for each geographic region to cover both inbound and outbound logistics. The data exchange with these LSPs are sometimes based on email and spreadsheets. They have created various in-house systems to handle logistics operations, but communication gaps exist between internal departments and also with LSPs. The lack of integration between the different systems often causes issues with visibility and efficiency, e.g., delays, therefore they try to integrate the systems. One alternative solution they would consider is to adopt an order management system offered by a main LSP, which can replace some of their segregated existing system. However, the solution is exclusive, meaning Shipper A will have to rely on that LSP, and it will be costly when they switch to another LSP. Therefore, they are keen to explore the possibility of having LSPs integrate with their system with sufficiently low switching cost. Given the fast pace of new technologies and their limited internal resources, Shipper A is interested in off-the-shelf IT solutions based on common and open standards, but it is challenging to find a suitable one in the market.

Shipper B has streamlined supply chain management by integrating internal and external processes into a unified system for managing three distinct supply chains. Transportation mode and provider are selected based on shipment type, geographic location, transportation cost, and transportation time. They use spot bidding or two-year contracts to select transportation providers based on specific needs, and have integrated a selected number of providers meeting their requirements. Larger volume LSPs are connected with the shipper's system via API, while smaller volume LSPs are not. The result is a more efficient and cost-effective supply chain management system. Despite having strong integration with LSPs, Shipper B still faces challenges in obtaining real-time visibility over

its logistics chain. The company struggles to track freight and respond to uncertainties, due to limited and delayed information provided by scanner-based visibility systems. While the visibility providers can offer valuable information, they are limited by their access to data and cannot always provide a complete view of the logistics chain. Deploying IoT devices to track every unit is costly and not feasible for every shipment.

In general, both shippers share a common goal of improving the efficiency of their operations through strategic integration, enhanced visibility, and flexible options to handle operational uncertainties. In other words, they desire a synchromodal logistics service; however, the market and LSPs have yet to offer optimal solutions that fully meet their demands for visibility and flexibility. LSPs have been slow to provide advanced solutions with real-time visibility and flexibility, prompting both shippers to rely on their own management to explore new possibilities rather than depending solely on LSPs.



### Freight forwarder

Freight forwarders handle transportation and warehousing services, as well as manage the flow of goods and information in the supply chain. Two freight forwarders were interviewed separately in this study, including one regional player focusing on the European market and one global player having a well-established reputation as a forwarder and 3PL worldwide. In the freight forwarder business, an IT system is necessary to manage cargo flows, track changes in operations, and coordinate with multiple stakeholders. Large providers can afford the resources to develop and/or implement digital systems for themselves. Cumulated data and real-time information are recognized as having value to multiple parties, and can be shared with customers and other stakeholders, even competitors, if requested by the customer. This information

sharing can come with a fee, to cover the substantial costs of data collection.

Smaller freight forwarders, due to economies of scale, may rely on manual processes such as whiteboards or spreadsheets and communication through email or phone calls, which limits operational efficiency. This was the case for the small freight forwarder that we interviewed; as the company grew, an IT system was needed to enhance efficiency and reduce errors; thus, they developed one system in-house to receive real-time GPS information from trailers. Other information, such as loading and unloading times at port, still requires collaboration with other stakeholders because it is not automated.

Freight forwarders face some common challenges related to digital systems. First of all, data quality (especially manually updated data) often depends on the willingness and ability of individual staff members, such as drivers and port personnel, to provide accurate digital information; delays and incomplete data are often experienced in practice. Moreover, competition and lack of trust among LSPs can impede information sharing, limiting visibility throughout the supply chain. Stakeholders prefer working with their own platform to maintain control, but rely on obtaining information from others. However, this requires advanced technologies that enable automation and real-time data transfer between systems. For example, the interviewed freight forwarder and RORO ferry company have expressed a willingness to share information, but the absence of system integration impedes automation. A collaborative approach could help overcome these challenges by promoting data standards across different platforms. This would require enhancing data security measures and creating a reliable and secure data-sharing environment to facilitate automation and real-time data sharing.



## Rail operator<sup>1</sup>

European rail companies play a crucial role in freight logistics, as they can transport large volumes of goods and have extensive networks. However, operating across borders presents challenges due to the high costs of investing in specialized trains that can run in all countries. Consequently, rail operators often need to coordinate and collaborate to expand their cross-border operations.

The lack of collaboration and system integration among LSPs limit operational visibility on a network level for rail operators. Currently, rail connections are manually booked through the rail operator's web portal, leading to uncertainties regarding delays and arrival times. Additionally, limited rail network capacity and long-term planning make it challenging for LSPs to expand intermodal services and respond to short-term changes in demand. Shortage of human resources and high investment costs also complicate expansion efforts.

The extensive rail connections compete directly with the RORO logistics network, resulting in decreased demand for rail and ferry intermodal services between Sweden and mainland Europe. This reduction in rail ferries and limited mainland connections has reduced the flexibility of rail solutions at a network level between Scandinavia and mainland Europe. Therefore, any uncertainties on the main route to and from Europe can significantly impact the efficient flow of goods to and from Sweden.



## RORO shipping line

The interviewed RORO line has an extensive network connecting European ports, roads, and rail. It transports primarily road freight from all the ports, and some rail freight

<sup>1</sup> This observation is based on indirect sources.

from the ports with a rail connection. The internal booking system is highly digitalized, leveraging API connections, web interfaces, and apps to facilitate 94% of its bookings. Of these, 70% are made via a web portal or app, while 24% are made via system-to-system connections with larger freight forwarders. All these bookings are registered on their in-house booking platform, which enables automating most pre- and post-booking processes and sharing with customers in a timely manner. On the other hand, the ship operations, particularly loading and unloading, still rely on manual work, generating insufficient data to improve the operational efficiency. Digitization is not easy due to the low level of standardization of RORO equipment, but can be manageable as digital technologies become more mature and affordable.

Another operational challenge stems from uncertainties about cargo arrivals and cancellations. This limits efficiency and incurs revenue loss if slots remain empty due to unexpected no-shows. Although introducing fees for no-shows could potentially reduce last minute cancellations, it could also restrict demand at a system level. Sharing arrival times in advance by the shippers (e.g., through truck GPS position or geo-fencing), if possible, will bring significant benefits to improve the operational efficiency and flexibility, but in reality it is still very difficult.

The rail freight services, named as an 'inter-modal solution' in the shipping line, is a strategic direction due to its sustainability advantage. Currently, it accounts for 6% of total bookings. They spend significant efforts to develop more intermodal services by partnering with rail operators. However, it is challenging to collaborate in improving operational visibility and flexibility, due to a lack of digital integration with rail operators. The communication of booking changes or train delays is done manually through email or notifications, often resulting in short notice. Improved visibility is particularly

critical for planning during high-demand periods with limited deck capacity, where delayed train units can be challenging to manage. To resolve this problem, the RORO line is working on new technological tools to set up system-to-system connections, aiming to provide better visibility to customers and offer more flexible services.



### Terminal operator

The terminal operator is essential in connecting stakeholders, including RORO ferries, freight forwarders, rail companies, end customers, and port authorities. They are closely linked with the ferry operator, often owned by a RORO line or highly integrated in one way or another. However, in practical operations, their cooperation with the stakeholders is not always efficient due to significant information distortion in the RORO logistics chain. Despite being a vital link between stakeholders, they do not receive real-time information on the arrival times of trucking or rail units. Manual sharing of information between the port authority and terminal operator contributes to further distortion. They receive increasing responsibility for managing cargo units within port boundaries due to the growing demand for transporting unaccompanied units. However, limited land availability at port presents operational challenges, requiring timely pickup of units by carriers. Terminal operators lack information on carrier arrival times at the destination port and must follow up manually. Implementing a digital system providing real-time information on unit arrivals and pickups would improve efficiency and enhance customer experience.

### 3.3.2. MATURITY OF INDIVIDUAL PLAYERS

Following the interviews, we evaluate the synchromodal maturity of each player using the maturity model taxonomy detailed in Section 3.2.1. The results are depicted in Figure 8, visually representing the synchromodal maturity levels of various player categories and highlighting areas for improvement in the RORO logistics sector. The position of an orange dot in the figure represents the capability score of a player, while the green arrow indicates the maturity stage the player is progressing towards. We plot the average scores for player categories with two case companies to present a general overview of the sector.

Based on their integration and visibility capabilities, the shipper category is transitioning from Stage 1 to Stage 2. Shippers desire to coordinate their supply chain and collaborate with LSPs and can do so with individual LSPs when the necessary IT systems are in place. However, their inability to effectively exchange information along the supply chain limits their ability to achieve the desired level of visibility. It is worth mentioning that the flexibility capability is not evaluated in this study, as shippers are customers and do not need to provide flexibility to LSPs. There may be expectations of flexibility from their customers, but that falls outside the scope of this study.

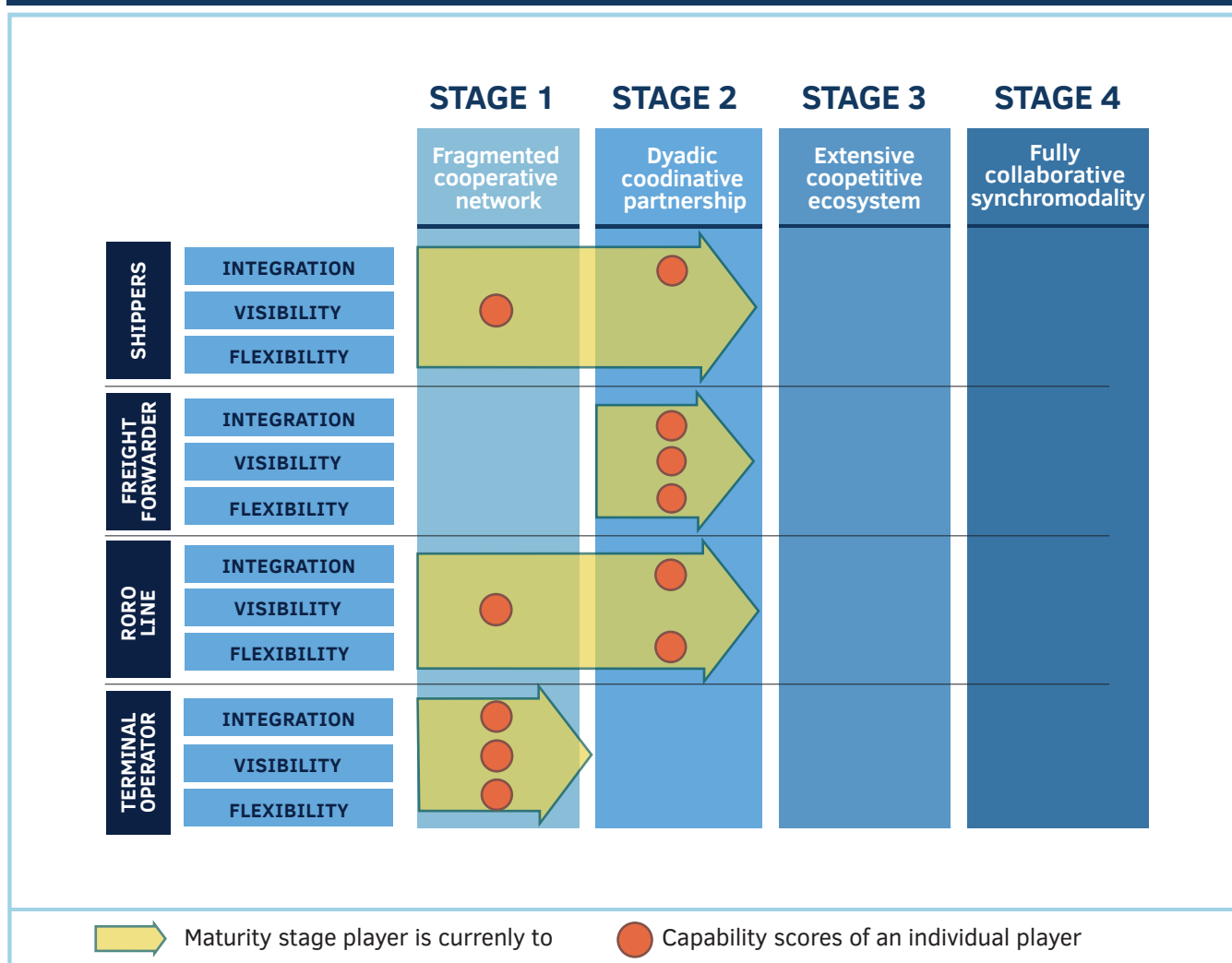
Freight forwarders, including 3PL providers, prioritize integration as they are responsible for managing the entire transportation process. The ability to coordinate and collaborate with stakeholders is crucial for their success in the industry and is typically applied in a dyadic relationship, as connecting a customer with a cooperative partner is not seen as beneficial for maintaining market share. With regards to visibility, medium and large-sized freight forwarders are capable of collecting relevant information about market conditions and operational status in a timely manner through

system-to-system information exchange or by tracking equipment status using sensors, although occasional distortions in information may occur. Smaller companies tend to be less digitally integrated and exchange information via email or phone calls. The information they gather is primarily for internal use but can be shared with external stakeholders for a fee. Thanks to their information advantage and integrative network, freight forwarders have the potential to improve their ability to offer alternative services and solutions. Based on these capabilities, they are positioned at Stage 2 of maturity.

RORO shipping lines possess strong integration capabilities, which are essential for maintaining competitiveness against roadways and railways. They must coordinate with stakeholders to align strategic goals and use advanced IT systems to achieve those goals efficiently. However, their visibility is not as extensive as that of freight forwarders, due to the limited information shared by stakeholders in a timely manner, as outlined in Section 3.3.1. Despite limited visibility, they still strive to offer flexibility to customers, such as free bookings and fee-free cancellations, which they typically provide at their own expense. If they can improve their visibility, they would be fully positioned at Stage 2 of maturity.

Finally, terminal operators are positioned at Stage 1 of maturity because many of them are closely integrated with RORO lines. This indicates that they do not require significant integration or flexibility capabilities, allowing them to collaborate effectively with stakeholders. Their operations are frequently performed by stevedores manually, with limited digital support, which restricts their visibility capabilities.



**FIGURE 8:** Output of synchromodal maturity scale

Source: Drawn by authors

In summary, most players in the RORO logistics sector tend to coordinate with their immediate stakeholders in a dyadic relationship rather than in a broader ecosystem platform. This is either due to the lack of individual capability to establish such a platform or because they are wary of competing with other LSP partners. Overall, they are progressing from Stage 1 to Stage 2 according to the synchromodal maturity model, primarily due to their weak visibility capabilities, which are prevalent in this sector.

To illustrate the issue of limited visibility, Table 4 provides several examples of how data sharing among stakeholders results in differing levels of visibility (high, medium, low, or none) due to various degrees of distortion within a RORO logistics chain. For instance, while a freight forwarder can monitor the real-time location of a truck through GPS, this information is not shared with any other stakeholders. Terminal operators and RORO lines remain uninformed about the estimated arrival time of a unit until it is checked in at the terminal gate, and shippers are not promptly notified about the completion status of a load. Moreover, no stakeholders achieve high visibility unless they are the original source

**TABLE 4:** Visibility examples in a RORO logistics chain

INFORMATION IN TARGET	SHIPPER	FORWARDER	RORO LINE	TERMINAL	RAIL
Real-time location of truck					
Arrival time of truck					
Dimension of trailer					
Arrival time of ferry					
Discharging time of unaccompanied units					
Arrival time of train					

= Origin of data source / high visibility
  = Medium visibility
  = Low visibility
  = No visibility

Source: Drawn by authors

The above analysis reveals some challenges in the current sector.

- The RORO logistics system grapples with varying degrees of digitalization and fragmented IT platforms, which impede digital connectivity among stakeholders. Larger operators have embraced more advanced digital systems with API connections, while smaller companies often lag behind in digitalization. This disparity reflects the high cost of digitalization and the potential unequal distribution of benefits among stakeholders, leading to information distortion for all parties and, most notably, poor data quality. Establishing common standards to facilitate real-time data sharing among stakeholders could prove beneficial. As such, it is crucial to pinpoint shared digitalization goals through collaborative strategic planning, thoroughly evaluate the value and relevance of digital connectivity based on stakeholders' needs, and offer suitable incentives to promote adoption. In this context, some technology service providers have developed vehicle tracking systems to assist smaller LSPs in gathering positional data and sharing it with customers on their behalf. While this can effectively supplement an LSP's service system, LSPs must continue to enhance their internal visibility capabilities.

- Insufficient human resources can pose a major obstacle for companies looking to digitalize and integrate with others. In order to address these challenges, it is crucial to communicate the potential benefits of adopting digital tools and common standards to all stakeholders and provide appropriate incentives to encourage their adoption. For example, user-friendly and cost-effective applications based on common standards can enable resource sharing and facilitate the integration of digital systems among stakeholders of varying sizes and capabilities.

- Finally, the industry faces a shortage of operational flexibility at the system level. At present, companies can only provide flexible services at their own cost. For instance, RORO ferry operators might waive fees for cancellations or no-shows, but these perks predominantly apply to first-tier stakeholders rather than second- or third-tier ones. The dyadic integration between stakeholders poses a significant limitation in introducing system-level flexibility that would benefit all parties involved. To tackle this challenge, increased coordination and collaboration among stakeholders are necessary to create an integrated and adaptable system that more effectively addresses the needs of all participants.



Chapter IV

# CONCLUDING REMARKS





## CHAPTER IV: CONCLUDING REMARKS

This chapter summarizes the findings from the preceding literature review and situational analysis, and discusses the challenges when implementing synchromodality within the RORO logistics sector in the Baltic Sea Region. In doing so, it does also make a few key policy implications, derived from these findings, and put forward a few areas for further and more detailed exploration and research in a manner to support the

necessary (or more preciously required) transition to be made by the industry towards "synchromodal" freight logistics. Doing this exercise will certainly generate value to all the stakeholders by effectively and efficiently utilizing limited resources to get them better prepared for future freight transport and logistics, while reducing transportation costs and enhancing environmental friendliness

### 4.1. KEY FINDINGS

The current trend of digitalization in the global economy has the potential to transform the RORO logistics industry. Despite the growing interest from industry stakeholders, policymakers, and academia in the new concept of "synchromodality", which is generally regarded as having the potential to revolutionize the freight logistics industry, there is still limited academic research and no universal consensus among researchers and industry practitioners. The systematic literature review reveals some key capabilities that are required for developing synchromodality, i.e., *integration*, *visibility*, and *flexibility*. In the digitalization journey toward synchromodality, LSPs must develop these necessary capabilities to implement the synchronization of different transport modes in partnership to add customer value. Building upon this capability dimension, we suggest a Synchromodality

Maturity Model to assess the current digitalization level of the industry stakeholders, including shippers and LSPs. This model could potentially serve as a useful framework for guiding policymaking on digitalization strategy.

In the industry practice, few pilot studies have examined the relevance of synchromodality in freight logistics. They are limited in scope, mainly focusing on the concept adoption in the container sector from a port perspective. Due to significant differences between the container and RORO sectors, it is necessary to study the latter separately. In-depth interviews with freight logistics stakeholders were conducted and analyzed using the proposed maturity model. The obtained results unfold the current situation in the Baltic Sea Region.

#### A. Fragmented Data Flows Along Logistics Chains

Market players are all obstructed by the lack of internal and external visibility. LSPs often find themselves not recording all internal data, even for optimizing their own system processes. Without such data sources, sharing data with relevant stakeholders is impossible. For example, cargo (un)loading and stowage onboard are often not fully

recorded in a digital format, resulting in information delays to the truck drivers; it might occur from time to time that equipment is forgotten somewhere. Recording such data is often challenging due to the lack of data standards, e.g., the format and position of trailer number. Thus, particular technical solutions need to be developed.

Investment in digitization can be costly, and large LSPs might be able to afford it, but smaller LSPs have to evaluate the cost and benefits. Some smaller shippers still rely on paper and pencil, which is sufficient for their

size, but results in a broken data chain. Some 3rd party information service providers are entering the market, trying to fill the digital gaps. It can help facilitate certain data flows, particularly cargo tracking.

## **B. Scanty Integration Among Stakeholders in Logistics Ecosystems**

Under market competition, most logistics players are eager to enhance their integration capabilities at the inter-organizational level. This involves strategically coordinating with stakeholders to identify common goals and working together to implement them. However, most integration efforts currently take the form of dyadic relationships, which may not always be the most effective approach for clarifying a common development direction for freight digitalization. In contrast, RORO terminal operators do not feel the requirement of strong integration as they are deeply integrated into or with a RORO line.

The LSPs and shippers are currently positioned at Stage 2 of the synchromodality maturity model, which is characterized by dyadic coordinative partnerships. This highlights the pressing need for enhanced visibility in the RORO logistics sector in the Baltic Sea region. Therefore, it is imperative to develop effective policies that incentivize the necessary efforts and investments and clearly demonstrate the benefits for the entire industry and economy.

## **C. Asset Utilization Focused Business**

Many LSPs emphasize on asset utilization, and develop their IT systems for this purpose. For example, a digital booking system capable of processing all orders in an automated way is of high importance. This indicates that RORO LSPs still focus on the conventional intermodal logic – further integrating the transportation system for cost efficiency, rather than adding customer values. These two logics show different directions of developing business, and both are necessary for synchromodality.

Additionally, it is observed that LSPs prioritize intermodal transport, which involves using multiple modes of transportation (rail, road, sea, etc.) due to its advantage in environmental sustainability. In comparison, adding value for the customers by creating an integrated transportation system is less emphasized. To achieve synchromodality, LSPs must focus on both conventional intermodal transport and integrating the transportation system. The former improves efficiency in transporting goods across different modes of transportation, while the latter creates added value for the customer by optimizing the transportation process and enhancing the customer experience.

## 4.2. POLICY IMPLICATIONS

The above findings reveal some managerial and policy implications on RORO logistics.

### A. Enhancing Digital Infrastructure for LSPs in the Digital Age

It is worthwhile to prioritize digitization, which is a prerequisite for digitalization, as it has not been fully realized in the industry, and many processes still rely on manual methods. In numerous cases, LSPs do not record sufficient data, necessitating a Data Strategy to specify the necessary data elements and how to collect and store them.

The lack of visibility caused by the absence of data standards and exchange channels is a major obstacle for all market players in logistics. This restricts their flexibility capabilities, and offering flexible services within individual capacity can be very expensive

for LSPs. To overcome the cost barrier of digital investment, technical support may be required, especially for smaller LSPs. Policymakers can play a key role in supporting investments in digital infrastructure.

Advanced digital technologies can enable real-time tracking and monitoring of shipments, improving logistics operations' efficiency. Investing in digital infrastructure can lead to greater visibility, flexibility, and efficiency in logistics operations. Therefore, policymakers need to support investments in digital infrastructure, especially for smaller LSPs, to promote the adoption of digital technologies in the logistics industry.

### B. Cultivating Collaboration Among LSPs for Enhanced Integration

As the logistics industry continues to evolve, there is an increasing need for LSPs to enhance the integration of a freight logistics ecosystem. This entails collaborating with all stakeholders in the logistics value chain, such as shippers, carriers, and technology providers, to identify common goals and coordinate efforts to achieve them. By doing so, LSPs can move towards Stage 4 of synchronomodality maturity, which involves a more comprehensive and dynamic collaboration among stakeholders for the entire freight logistics chain.

A synchronomodal logistics ecosystem functions as a cohesive and interdependent system, with stakeholders working in tandem to optimize the transportation of goods. This requires a high level of coordination, data sharing, and communication. As policymakers serve as neutral stakeholders

in this situation, they could encourage data standardization and communication protocols among stakeholders. By adopting common standards for data exchange, policymakers can facilitate seamless communication and promote integration among stakeholders. With digital technology, the Internet of Things (IoT), big data storage, and data processing into useful information using artificial intelligence and machine learning, logistics operations can be managed and monitored more effectively.

To accomplish Stage 4, LSPs need to be proactive in developing and implementing digitalization strategies that enable them to connect and collaborate with other stakeholders in the ecosystem. This may involve investing in new technologies, developing new business models, and establishing new partnerships and alliances. Ultimately, the

successful implementation of these strategies will enable LSPs to provide more efficient and effective logistics services that

meet the evolving needs of their customers and the broader logistics industry.

### **C. Boosting Customer Value for Improved Services**

As digitalization disrupts the logistics industry, LSPs will need to transform business models, by optimizing their value proposition and redefining target customers and even the range of services. Such potential disruptions are still to be observed in the sector, as well as the changes in firm capabilities and key interfirm relationships in extended business networks.

For this purpose, it is crucial to understand customer needs, particularly in visibility

and flexibility. Currently, more and more customers demand visibility, to obtain real-time status updates on their cargo, and LSPs have begun to enhance this capability by either developing an in-house tracking system or relying on third-party technology service providers. A deep understanding of this need will help LSPs better transform their business model and support the authority to develop an effective policy for industry development.

## **4.3. EXPANDING THE HORIZON: AREAS FOR FURTHER EXPLORATION**

Prior to transforming the aforementioned implications into practically implementable action lines, the researchers in this report would consider it worthy doing a more-detailed and wider-scoped exploration and examination with the following areas:

### **A. Towards Enhancing Digital Infrastructure for Greater Freight Logistics Services**

A LSP generates a vast amount of data, which can be used to improve operations and enhance customer experience by itself and also its cooperating LSPs, for the sake of shippers. Considering data as new fuel, individual LSPs can be reluctant to share data with each other when there are no clear win-win benefits. To overcome this obstacle, it is important to measure the operational performance improvement of the overall logistics chain given optimal data flows. This can support policymakers to identify the worthy data flow bottlenecks and design effective policy to incentivize LSPs to share necessary data. Such a policy can compose the digital infrastructure as a soft element.

In this regard, there is a large knowledge gap in the freight logistics literature. For example, what challenges exist to develop digital infrastructures in RORO logistics? How to solve the challenges with effective incentivization for LSPs? What elements should be considered as key digital infrastructure for the industry and public interests? Meanwhile, with the fast development of digital technologies such as the Internet of Things (IoT), and artificial intelligence (AI), there is a need to explore how these technologies can be utilized by individual LSPs, and also integrated into logistics digital infrastructure shared by LSPs.



Currently the main digital development in the RORO logistics sector is around visibility, and there is limited understanding about related challenges. For example, how to technically enable and economically motivate LSPs and related stakeholders to

collect and share the needed data? In practice, some 3rd party information technology providers enter the market and provide data exchange services, which helps improve visibility to some extent, but not solving all the digitization issues.

## **B. Towards Striving for Seamless Integration of All Stakeholders in Freight Logistics Chains**

LSPs and shippers are increasingly looking to collaborate and integrate with other players in the logistics chain to streamline operations and increase efficiency. However, there are still uncertainties about the potential risks and challenges involved in such integration, which limits stakeholders from pursuing this path. To address this issue, it is essential for industry players to better understand both the potential benefit and risks associated with integration in the freight logistics chain. In this aspect, policy-makers can act as the enabler, suggesting a framework to the logistics players, indicating the areas/scope of integration, and how to measure the risk and rewards associated with the integration. In addition, they could provide resources such as human knowledge, initial capital requirements, and digital infrastructure to facilitate research and innovation aimed at promoting integration between logistics players.

Sweden's open and liberal approach to business makes it imperative to encourage LSPs to pursue integration for economic growth. To achieve this, it is essential to understand the opportunities for vertical and horizontal integration between LSPs, along with the potential benefits and uncertainties. Additionally, identifying the relevant counter-players in the freight logistics chain with whom a player should consider integrating is crucial. As these integrations typically involve B2B contracts, it is vital to consider the parameters needed for

efficient business negotiations that result in sustainable, long-term commitments between players.

To successfully design and implement a market mechanism promoting integration between logistics players, future research must explore various market-based approaches that align the interests of individual players with the goals of the industry as a whole. Research could investigate different incentive structures, pricing models, and other mechanisms that encourage integration and support the development of more integrated logistics chains. By leveraging the value of data and asset sharing, logistics players can create a more seamless and integrated logistics ecosystem that delivers value for all stakeholders. Ultimately, a market mechanism promoting integration could unlock significant benefits for the freight logistics industry, including improved efficiency, reduced costs, and better customer experience. By working together and embracing the potential of integration, logistics players can create a more connected and efficient logistics ecosystem. This will require a collaborative approach that brings together all stakeholders to design and implement innovative solutions that drive the industry forward. With a shared commitment to integration and collaboration, the freight logistics industry in Sweden can become a model for efficiency and innovation.

## C. Towards Facilitating Technology Adoption in Freight Logistics Network

Digital technologies have a potential to transform the logistics industry as a whole, and individual LSPs need to adapt and modernize their system considering the level of technologies adopted by others players in their logistics network. Many questions exist regarding the upstream and downstream effects of the use of new concepts and technologies on overall supply chain sustainability. This is especially relevant to seaports interfacing different transport modes and carriers. How do the seaports respond to the demands that are emerging in the logistics chain due to digitalization of transport?

To address this topic in the context of logistics network, we can start at the individual level. In the literature, Change Management has appeared as a key success factor for digitalization; future research needs to look at the ways to craft and implement an appropriate Change Management strategy as a part of the adaptation to digitalization. Established tools such as the Technology Acceptance Model (TAM) or Diffusion of Innovation (DoI) could provide interesting insights.

TAM models how users accept and use new technology, while DoI approach has been historically proven to impact the adoption rates of innovations. It is important to consider adoption rates of these new concepts because long-term impact of any proven solutions requires scalability, i.e., adoption upstream and downstream in the supply chain. Both approaches could facilitate further analysis that would enlighten ways to mitigate the barriers.

Besides digital technologies, adopting a customer-centric approach that puts the customer at the center of logistics services is also helpful to improve service quality and customer experience. Future research can explore how LSPs can leverage digital technologies to provide more flexible or tailor-made, on-demand logistics services and improve customer value. Environmental wise, there might be both carbon contributing and carbon reducing processes in the supply chain resulting from the modernization initiatives from LSPs, particularly seaports. The impact of port modernization on overall end-to-end supply chain needs further investigation.

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