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Digital transformation in the maritime transport sector

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ABSTRACT

In this paper, the authors perform a literature review of the drivers, success factors and barriers to digital transformation in the maritime transport sector. Previous research offering a comprehensive overview of digital transformation in the maritime transport sector is scarce. In order to fill this research gap, the authors have identified a total of 139 sources, mainly related to the drivers, success factors and barriers for digitalization and digital transformation. The analysis of the state of the art was performed, along with the analysis of the impact of digital transformation in the maritime transport sector using a number of cases. The development of innovative technologies (such as Blockchain or autonomous shipping) definitely fosters digital transformation in the maritime transport sector. The barriers which are slowing down digital transformation compared to other industries are highlighted, such as the lack of awareness of how digital transformation may affect the business, and the lack of standards and cooperation among stakeholders. The research findings fill the identified research gap, and can serve practitioners in shaping up proper strategies for successful digital transformation of organizations in the maritime transport sector.

1. Introduction

In recent years, firms in almost all industries have conducted a number of initiatives to explore new digital technologies and exploit their benefits (Matt et al., 2015). This frequently involves a transformation of key business operations and affects products, services and processes, as well as organizational structures and management concepts (Matt et al., 2015). Digital transformation (DT) causes fundamental changes in traditional business practices by the implementation and use of digital technology (Dehning et al., 2003). It exceeds changes of business processes and enables the creation of new types of organizations, brings changes in organizational culture, relationships, value creation and customer reach, as well as market position (Lucas et al., 2013). DT refers to organizational changes, caused by digital technologies, which lead to the redefinition of existing business capabilities, processes, and relationships (Dehning et al., 2003). The changes are observable in business models; in the way how organizations create, deliver and capture value (Pucihar, 2020).

DT can be defined as the process of reshaping the business models due to, and through, the adoption and use of digital technologies with the aim of creation of setting (within the organization and its environment) in which new possibilities (digital capabilities) are enabled and value is created (Jeansson & Bredmar, 2019). Integrating and exploiting new digital technologies is one of the biggest challenges that companies currently face (Hess et al., 2016). The maritime transport, an important mode of transport in international trade (Gren et al., 2020) is moving towards digitalization and DT at different speeds in the different domains (Sanchez-Gonzalez et al., 2019). Shipping, as a part of logistics chain, is a volatile industry and is in a turbulent condition due to the energy price fluctuations, technological immaturity and upcoming increases in regulations (Zaman et al., 2017).

Seaport stakeholders and enterprises in the maritime transport sector, as many enterprises in other industries, struggle with the lack of awareness, proper strategies and initiatives for successful DT (Gausdal et al., 2018; KPMG International Cooperative, 2018). The majority of contemporary research is focused either on DT of transport in general, or digitalization trends focused on the maritime transport. A lack of research and scientific papers offering a comprehensive overview of DT in the maritime transport sector is particularly pronounced. To overcome this research gap and to provide a better understanding of DT in the maritime transport sector, authors conducted a comprehensive literature review focusing on the period from 2015 to 2020 to capture

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recent research in the field of DT in the maritime transport sector, transport in general or digital transformation in general. The aim was to identify drivers, success factors and barriers for successful DT which can be applied to the maritime transport sector context. To achieve this aim, the following research questions were addressed in this study:

- What are the drivers of digital transformation which can be applied to the maritime transport sector?
- What are the success factors for digital transformation which can be applied to the maritime transport sector?
- What are the barriers to successful digital transformation which can be applied to the maritime transport sector?

After analyzing the state of the art of digitalization and DT in the maritime transport sector, the authors have identified the drivers, success factors and barriers for DT, applying them to the maritime transport sector context, and provided several cases of successful DT in the maritime transport sector. At the end, the Discussion with an emphasis of the specifics of the maritime transport sector compared to other industries in terms of DT is provided.

2. State of the art of digitalization and digital transformation in the maritime transport sector

Digitalization focuses mainly on the business process automation, operations automation, as well as on the processing of information. On the other hand, digital transformation (DT) is currently an important trend that penetrates many industrial and societal domains (Gray & Rumpe, 2017) and may be defined as the use of new digital technologies (analytics or embedded devices) to enable business improvements (e.g. improving the customer experience, streamlining processes) (Hausberg et al., 2018; Kovynyov & Mikut, 2018), (Morakanyane et al., 2017), or to innovate the business models (Hausberg et al., 2018; Gerster, 2017; Savić, 2019; Morakanyane et al., 2017) in strategic, tactical and operational terms (Saul & Gebauer 2018).

Only a small number of industry players in the maritime transport sector consider that digitalization has already changed their business significantly, whereas the companies in high-tech and in public transportation have already seen greater changes from the pressure of digitalization (Quitzau et al., 2018)(. (Sanchez-Gonzalez et al., 2019) verified the state-of-the-art of digitalization in the maritime transport and stated that digitalization currently applies to eight digital domains: "autonomous vehicles and robotics; artificial intelligence; Big Data; virtual reality, augmented and mixed reality; Internet of Things; the cloud and edge computing; digital security; 3D printing and additive engineering". Their work demonstrates that "there are domains on which almost no formal study has been done so far and concludes that there are major areas that require attention in terms of research (e.g. the use of robotics in sea transport services and the integration of the studies done on AI in the industry)".

(Fruth & Teuteberg, 2017) provided an overview of the current state of digitalization in maritime logistics and discussed the existing problem areas (e.g. lack of theoretical studies that examine in more detail the future behavior of actors in the maritime logistics chain), and showed potentials for improvement, e.g., by expanding the research into areas where information and Big Data projects have already been implemented. Proliferation of digitalization in maritime transport is most pronounced in the navigation systems, for example the concept of e-navigation and the ongoing developments within the navigation in general (Nkuna, 2017).

Shipping companies rate the importance of digitalization for their own industry according to the following: 15% consider radical industry change to be unavoidable, while 69% feel that there will be significant changes but no revolution in the industry, while a sizeable 16% consider the topic to be overrated (Quitzau et al., 2018)(. According to the PwC Norway survey (PwC Norway, 2017) that included 28 decision-makers active in ocean shipping, "the DT is set to play a key role in shipping and for shipping companies in the future and the maritime industry is now anticipating extensive digitalization processes with a great degree of certainty". Crewless shipping seems still far away, but both Norwegian and Greek shipping companies are becoming open to an idea of ships controlled from land.".

(Gausdal et al., 2018) claim that the main drivers of DT (from the Blockchain perspective only) are the intention to reduce costs, over-regulation in the maritime industry, and the large quantity of data that maritime companies process, along with the intention to increase the business effectiveness. Opposed to that, the main barriers to DT are high implementation costs, low quality of offshore Internet connections, aging decision-makers, overly technology-oriented culture, the lack of investment initiatives, the low level of modern digital technology (e.g. Blockchain) diffusion through the supply chain, and risk aversion.

Seaports play a very important role in the maritime logistics and represent important hubs in the international trade. (Heilig et al., 2017a) provided an overview of the development and state-of-the-art of DT in modern seaports in order to identify current DT potentials and barriers.

(Heilig et al., 2017b) focused on seaports, identifying three generations of DT (Transformation to Paperless Procedures; Transformation to Automated Procedures; Transformation to Smart Procedures), and analyzing the stages of respective DT.

The analysis so far has shown that there are only a few recent studies that have addressed the digitalization and DT in the maritime sector, and none of them offer a comprehensive overview of DT in the maritime transport sector. Most of these studies were focused to identify current status of digitalization, reveal managerial anticipations of DT and identify DT potentials and barriers from the perspective of collaboration in the overall supply chain, not the maritime transport in particular.

3. Research methodology

To provide a better understanding of digital transformation (DT) and to identify drivers, success factors and barriers which can be applied to the maritime transport sector, a comprehensive literature review has been conducted. The research methodology was partially adapted from (Dreyer et al., 2019). Fig. 1 shows the methodological steps of the research.

The search was carried out using six research databases: Web of Science, Scopus, AISeL, SpringerLink, Emerald Insight and Semantic Scholar. In this research, we have focused on the following keywords:

- Digital transformation
- Digital transformation AND Transport
- Digital transformation AND Maritime transport
- Digital transformation AND Maritime industry
- Digital transformation AND Shipping
- Digital transformation AND Seaport
- Digital transformation AND Port
- Business model AND Innovation AND Transport
- Business model AND Innovation AND Maritime transport

A search was performed in the aforementioned databases in order to determine whether publications contained at least one of the search terms in the title or abstract. Inclusion and exclusion criteria as well as Content analysis and Analysis of additional sources are explained in more detail in the following sub-chapters. Furthermore, snowball sampling phase was utilized to extend the set of relevant primary studies (Myllärniemi 2015).

Fig. 2 shows the literature search process, partially adapted from (Dreyer et al., 2019), and the results.

95 sources have been identified as relevant for this research. Authors have also included 12 additional sources such as the reports and thesis (this step will be further explained). Due to the lack of research related

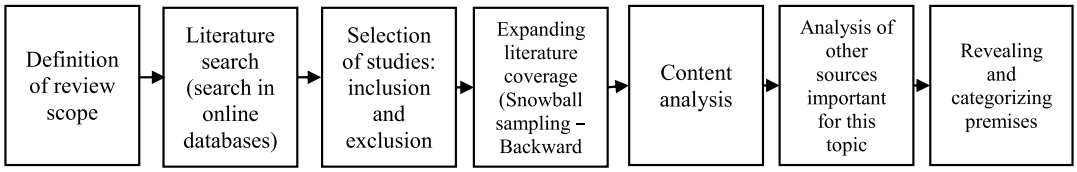

Fig. 1. Methodological steps

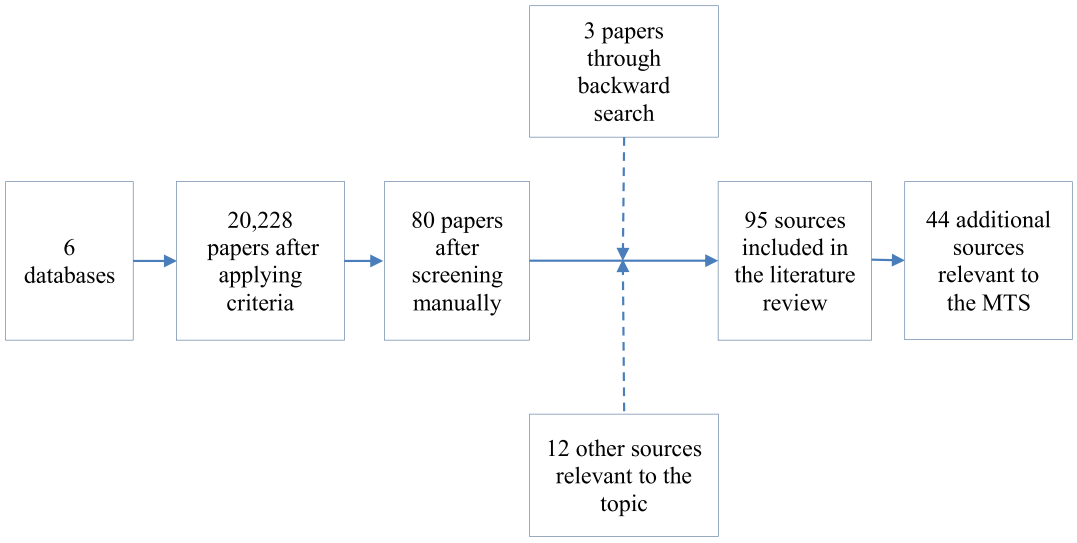

Fig. 2. Literature search process and search results

to DT in the maritime transport sector, the authors have also included additional 44 sources related to the maritime transport sector (MTS) (such as scientific papers, reports, dissertations etc.), which do not necessarily contain the selected keywords, but are related to the individual identified drivers, success factors and barriers to DT in the maritime transport sector. If the drivers, success factors and barriers to DT were identified in sources related to DT in general, the authors have further investigated additional resources related to the maritime transport sector to confirm the relevance of such drivers, success factors and barriers to the maritime transport sector.

3.1. Inclusion and exclusion criteria

Inclusion and exclusion criteria were determined to identify the most relevant articles for this topic. Due to the lack of scientific papers dealing with DT in the maritime transport sector, authors have also considered the papers dealing with DT in general and DT of the transport in general. Appendix A shows the number of hits after applying the reduction criteria for each search term found in different databases and number of sources after screening manually. As shown in Appendix A, the following limitations were used:

The search for articles was performed in six databases according to the set time limitation (2015-2020). In the Web of Science database, the search was performed in order to determine whether the publications contained at least one of the keywords in the Topic or Title. The authors limited the search to the following categories: Transport Science Technology, Computer Science, Information Systems, Management, Business, Communication, Economics, and Green Sustainable Science Technology. In the Scopus database the search was performed in order to determine whether the publications contained at least one of the selected keywords in Article title, Abstract, and Keywords. In the AISeL database, the search was performed in order to determine whether the publications contained at least one of the keywords in Abstract, Title or Subject. In the SpringerLink database, the search was performed in the following disciplines: Business and Management, Engineering, Computer Science and Economics, in order to determine whether the publications contained at least one of the keywords. In the Emerald Insight database, the search was performed in order to determine whether the publications contained at least one of the keywords in Title or Abstract. In the Semantic Scholar database, the authors limited the keyword search to the following Fields of study: Business, computer science, Engineering, Economics.

According to (Dreyer et al., 2019), in order to achieve a broad literature review, the search was not limited only to high-ranking journals and conferences. Articles that were not written in English language were excluded, in order to avoid tentative regional overrepresentation of research in the formal analysis (Dreyer et al., 2019).

3.2. Sources used in the research

In order to further overcome the research gap, authors have considered not only journal and conference papers, but have also considered book chapters, dissertations, master theses, editorial materials, reports, etc. All sources are grouped in the Table 1.

3.3. Analysis of the identified literature and other sources

The initial focus was placed on papers containing the term “digital transformation” in the title or abstract. As the goal of the research was to identify drivers, success factors and barriers, thorough analysis of the entire content of the papers had to be performed. The authors were also looking for the terms: “driver(s)”, “factor(s)” and “barrier(s)”. The main question during the search for the drivers of DT was: *Why do stakeholders in maritime transport sector decide to pursue DT?* While searching for success factors, authors were mainly led by the question: *What is needed for a successful DT?* During the search for barriers to DT, the main question was: *What prevents a successful DT?* After identifying the drivers, success factors and barriers, the importance of DT in the

Table 1
Sources used in the research

Sources used to identify drivers, success factors and barriers		Additional sources relevant to the maritime transport sector	
Journal papers	41	Journal papers	21
Conference papers	36	Conference papers	3
Dissertations	1	Dissertations	3
Editorial Materials	1	Magazine articles	2
Master theses	2	Master theses	1
Reports	7	Reports	3
Scientific series logistics at the Berlin Institute of Technology	1	Official Web Pages	5
Book chapters	5	Book chapters	3
Working papers	1	Brochures (EU Council)	1
		Invitation paper (Marshall University)	1
		Toolkit	1

maritime transport sector is demonstrated through the analysis of several cases. For that purpose, the authors have also analyzed web pages and other relevant sources related to DT in the maritime transport sector. The authors have also included additional scientific papers (which do not necessarily contain the search keywords) related to the maritime transport sector to provide a deeper insight of the maritime transport context.

4. Findings

The identified drivers, barriers and success factors of digital transformation (DT) were classified into organizational, technological and external environment context and were applied to the maritime transport sector context.

4.1. Drivers of digital transformation

Drivers can be defined as external or internal triggers that cause organizations to engage in DT (Osmundsen et al., 2018). Table 2 shows the identified drivers of DT in the maritime transport sector. In total, 76 sources have been used in this process.

Based on the literature review, 3 organizational, 2 technological and 5 external environmental drivers of DT in the maritime transport sector were identified. The following identified drivers are closely related: **new and emerging technologies, changing customer behaviors and expectations** and **competitive environment**. Due to the emergence of new digital technologies in the maritime transport sector, such as Blockchain, Internet of Things, Big Data, autonomous drones, competitive landscape and customer expectations are changing dramatically (Verhoef et al., 2019). Customer expectations for reliable, flexible, and cost-efficient transport service are increased (Raza et al., 2020) which stimulates organizations to engage into DT to stay competitive (Verhoef et al., 2019). Shipping companies have to adjust to the customer needs, offer appropriate transport services in order to achieve the most efficient and long-lasting commercial operation of its vessels (Plomaritou, Plomaritou, & Giziakis, 2011).

Regarding the **regulatory requirements**, the maritime transport sector is facing stricter environmental requirements approved by the International Maritime Organization, the European Union, and other international organizations (Gausdal et al., 2018), such as the London Convention and Protocol (LC/LP), the Hong Kong Ship Recycling Convention and Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005) of the International Convention for the Prevention of Pollution from Ships (MARPOL) (Lee et al., 2019). In order to follow the regulations, investments in technologies and collaboration and technical cooperation of involved organizations are needed (International Maritime Organization, 2020).

Processing large amounts of data, streamlining operations and **data transparency** are closely related drivers. Broad range of

Table 2
Identified drivers of digital transformation

Groups	Drivers	Sources
Drivers related to the organization itself	**Cost reduction** (9) = Organizations implement new technologies in order to simplify collaboration with other organizations, and thus reduce the cost of exchanging information and executing transactions, etc.; Leaner, more automated, and error-free processes help in cost reduction	(Gausdal et al., 2018), (Ismail et al., 2018), (North et al., 2019), (Viktorovich & Aleksandrovna, 2019), (Korpela et al., 2017), (Wei et al., 2019), (Morakanyane et al., 2017), (Henriette et al., 2015), (Korchagina et al., 2020)
	Streamlining operations (4) = Making processes more efficient and reliable, for example by improved resource planning; Improved information flows through the transport route	(Heilig et al., 2017a), (Jović et al., 2019b), (Schumann et al., 2017), (Viktorovich & Aleksandrovna, 2019)
	Shorter time delays (3) = Goods and information should pass in the required time frame; shorter waiting times for ships and faster processing at the terminal	(Junge, 2019), (Wiedenmann & Größler, 2019), (Fruth & Teuteberg, 2017)
Drivers related to technologies	**New and emerging technologies** (63) = Novel technologies open new opportunities for business transformation; at the level either of an organization or wider in the transport chain	(Digital Transport & Logistics Forum 2018), (Huang, 2018), (Heilig et al., 2017b), (Legner et al., 2017), (Shi et al., 2019), (Henriette et al., 2015), (Ismail et al., 2018), (Alt, 2019), (Verhoef et al., 2019), (Kozak-Holland and Procter, 2020), (Boneva, 2018), (Nwankpa & Roumani, 2016), (Morakanyane et al., 2017), (Quitzau et al., 2018), (Genzorova et al., 2019), (Piccinini et al., 2015), (Jović et al., 2019b), (Jeansson & Bredmar, 2019), (Fruth & Teuteberg, 2017), (Teece & Linden, 2017), (Matt et al., 2015), (Verina & Titko, 2019), (Carcary et al., 2016), (Kwon & Park, 2017), (Chinoracky & Corejova, 2019), (Peter et al., 2020), (North et al., 2019), (Agrawal et al., 2020), (Kotarba, 2018), (Henriette et al., 2016), (Fuchs & Hess, 2018), (Ponsignon et al., 2019), (Durão et al., 2019), (Mugge et al., 2020), (Kane et al., 2018), (Sehlin et al., 2019), (Malyavkina et al., 2019), (Junge, 2019), (Cichosz, 2018), (Viktorovich & Aleksandrovna, 2019), (Junge et al., 2019), (Jahn et al., 2019), (Korpela et al., 2017), (Iddris, 2018), (Sabri et al., 2018), (Wiedenmann & Größler, 2019), (Reis et al., 2018), (Sayabek et al., 2020), (Vukšič et al., 2018), (Wei et al., 2019), (Hartl & Hess, 2017), (Caputa, 2017), (Schwertner, 2017), (*continued on next page*)

Table 2 (*continued*)

Groups	Drivers	Sources
		Hausberg et al., 2019), (Vial, 2019), (Tsakalidis et al., 2020), (Pagani & Pardo, 2017), (Remane et al., 2017), (Zaman et al., 2017), (Schiavi & Behr, 2018), (Junge & Straube, 2020), (Munim et al., 2020), (Korchagina et al., 2020)
	Processing large amounts of data (6) = The ability to process large amount of data in order to increase organizations' competitiveness	(Gausdal et al., 2018), (Schumann et al., 2017), (Viktorovich & Aleksandrovna, 2019), (Iddris, 2018), (Sabri et al., 2018), (Sánchez, 2017)
Drivers related to the external environment	**Changing customer behaviors and expectations** (34) = With the emergence of new technologies, customers' expectations have increased	(Osmundsen et al., 2018), (Legner et al., 2017), (Verhoef et al., 2019), (Boneva, 2018), (Morakanyane et al., 2017), (Piccinini et al., 2015), (Hausberg et al., 2019), (Teece & Linden, 2017), (Verina & Titko, 2019), (Jeansson & Bredmar, 2019), (Alt, 2019), (Carcary et al., 2016), (Kwon & Park, 2017), (Henriette et al., 2015), (Ismail et al., 2018), (Agrawal et al., 2020), (Henriette et al., 2016), (Larjovuori et al., 2018), (Fuchs & Hess, 2018), (Ponsignon et al., 2019), (Mugge et al., 2020), (Sehlin et al., 2019), (Agushi, 2019), (Viktorovich & Aleksandrovna, 2019), (Wiedenmann & Größler, 2019), (Reis et al., 2018), (Sayabek et al., 2020), (Ivančić et al., 2019), (Leipzig et al., 2017), (Hartl & Hess, 2017), (Caputa, 2017), (Vial, 2019), (Acciaro & Sys, 2020), (Korchagina et al., 2020)
	Competitive environment (37) = Competitive environment is changing; DT may disrupt existing markets, recombine existing products and services, etc.	(Osmundsen et al., 2018), (Ismail et al., 2018), (Verhoef et al., 2019), (Boneva, 2018), (Nwankpa & Roumani, 2016), (Morakanyane et al., 2017), (Teece & Linden, 2017), (Fruth & Teuteberg, 2017), (Henriette et al., 2015), (Verina & Titko, 2019), (Jeansson & Bredmar, 2019), (Gausdal et al., 2018), (Heilig et al., 2017b), (North et al., 2019), (Adner et al., 2019), (Henriette et al., 2016), (Durão et al., 2019), (Mugge et al., 2020), (Kane et al., 2018), (Sehlin et al., 2019), (Galimova et al., 2019), (Agushi, 2019), (Cichosz, 2018), (Viktorovich & Aleksandrovna, 2019), (Junge et al., 2019), (Korpela et al., 2017), (Sabri et al., 2018), (Reis et al., 2018), (Sayabek et al., 2020), (Vukšič et al., 2018), (Hartl and Hess, 2017), (Caputa, 2017), (Schwertner, 2017), (Vial, 2019), (Acciaro & Sys, 2020), (Wang & Mileski, 2018), (Schiavi & Behr, 2018)
	Regulatory requirements (4) = Regulations imposed by international and regulatory organizations, with the intention to achieve e.g. "green" transport technologies	(Gausdal et al., 2018), (Osmundsen et al., 2018), (Tsakalidis et al., 2020), (Zaman et al., 2017)
	Improving stakeholder collaboration (4) = Improved collaboration through smooth information sharing between the involved stakeholders	(Iddris, 2018), (Sabri et al., 2018), (Wiedenmann and Größler, 2019), (Hausberg et al., 2019)
	Data transparency (2) = Providing better transparency of the transport route; the transparency at the transport route from the sender to the recipient	(Fruth & Teuteberg, 2017), (Viktorovich & Aleksandrovna, 2019)

stakeholders (such as the maritime logistics enterprises, forwarders and agents) are compelled to accept changes in the maritime transport sector and turn to more effective practices by implementing technologies that can gather and process massive amounts of information (in a cost-effective way) (Jović et al., 2019b), (Marshall University, 2019), as well as improve the stakeholder cooperation and data transparency along the transport chain.

Digitalization has also enabled more far-reaching concepts, such as the Big Data, Internet of Things, Blockchain, and cloud computing, which can provide the maritime industry with new ways to collect, process and exchange valuable data in the real time (European Council for Maritime Applied R&D, 2017).

4.2. *Success factors for digital transformation*

Success factors may be explained as elements required for achieving desired goals. Table 3 presents the identified success factors for DT in the maritime transport sector classified into three groups: success factors related to the organization itself, related to the external environment and related to technologies. In total, 84 different sources have been considered.

Based on the literature review, 13 organizational, 6 technological and 6 external environmental success factors for DT in the maritime transport sector were identified. Regarding the **actively shaping future strategies**, (Heilig et al., 2017b) state that it is essential to first evaluate competitive potentials, integrate them with the existing port IT/IS infrastructure, and align with individual processes and the port business network. However, less digitally mature organizations tend to focus more on the individual technologies (Kane et al., 2015).

With regard to **new business models**, new entries come into the market with novel and often disruptive business model, while the incumbent companies still rely on the existing business model based on their existing assets that may not be able to fulfil customer and market needs anymore (Venkatesh et al., 2019), (Mihardjo & Sasmoko, 2018). Currently, smart ports may represent the aforementioned "novel business model", in which all parts of the seaport operations and transportation are closely connected through various digital networks (Jović et al., 2019a). (Heilig et al., 2017b) claim that, in smart ports, only the

Table 3
Identified success factors for digital transformation

Groups	Success factors	Sources
Success factors related to the organization itself	**New business models** (24) = Developing new business models in order to stay competitive and generate new revenues; Smart port may also represent a new business model; Companies must develop business models that maximize innovation and effectiveness in leveraging digitalization	(Mosconi et al., 2019), (Osmundsen et al., 2018), (Legner et al., 2017), (Kutzner et al., 2018), (Fruth & Teuteberg, 2017), (Genzorova et al., 2019), (Hausberg et al., 2019), (Jović et al., 2019b), (Jeansson & Bredmar, 2019), (Teece & Linden, 2017), (Carcary et al., 2016), (Pappas et al., 2018), (Ponsignon et al., 2019), (Korpela et al., 2017), (Sabri et al., 2018), (Reis et al., 2018), (Ivančić et al., 2019), (Hartl & Hess, 2017), (Schwertner, 2017), (Verina & Titko, 2019), (Remane et al., 2017), (Schiavi & Behr, 2018), (Junge & Straube, 2020), (Korchagina et al., 2020)
	Actively shaping future strategies (50) = Actively shaping future strategies via business optimizations and investments (e.g. in employees' training, technologies), in order to overcome the obstacles and stay competitive	(Mosconi et al., 2019), (Kotarba, 2018), (Heilig et al., 2017a), (Heilig et al., 2017b), (Osmundsen et al., 2018), (Gupta, 2018), (Henriette et al., 2016), (Ismail et al., 2018), (Kane et al., 2015), (Kutzner et al., 2018), (Alt, 2019), (Verhoef et al., 2019), (Nwankpa & Roumani, 2016), (Morakanyane et al., 2017), (Teece & Linden, 2017), (Genzorova et al., 2019), (Holotiuk & Beimborn, 2017), (Matt et al., 2015), (Verina & Titko, 2019), (Carcary et al., 2016), (North et al., 2019), (Schallmo et al., 2019), (Adner et al., 2019), (Larjovuori et al., 2018), (Ponsignon et al., 2019), (Durão et al., 2019), (Mugge et al., 2020), (Kane et al., 2017), (Sehlin et al., 2019), (Galimova et al., 2019), (Moreira et al., 2018), (Agushi, 2019), (Junge et al., 2019), (Korpela et al., 2017), (Sabri et al., 2018), (Reis et al., 2018), (Sayabek et al., 2020), (Vukšič et al., 2018), (Leipzig et al., 2017), (Schwertner, 2017), (Sánchez, 2017), (Kwon & Park, 2017), (Pappas et al., 2018), (Scholz et al., 2020), (Kane et al., 2016), (Vial, 2019), (Pagani & Pardo, 2017), (Remane et al., 2017), (Wang & Mileski, 2018), (Junge & Straube, 2020)
	Clear vision (17) = A strong, clearly communicated vision shared by the entire organization	(Larjovuori et al., 2018), (Ismail et al., 2018), (Mosconi et al., 2019), (Gupta, 2018), (Zeike et al., 2019a), (Kozak-Holland and Procter, 2020), (Holotiuk & Beimborn, 2017), (Carcary et al., 2016), (Kwon & Park, 2017), (Ponsignon et al., 2019), (Mugge et al., 2020), (Kane et al., 2018), (Kane et al., 2019), (Sayabek et al., 2020), (Ivančić et al., 2019), (Schwertner, 2017), (Sánchez, 2017)
	New and dynamic capabilities (13) = Capability to design new business models; Dynamic capabilities to improve business intelligence agility and business value; Dynamic capabilities allow an organization to identify and respond to opportunities by transforming the organization, reconfiguring resources, etc.	(Mosconi et al., 2019), (Osmundsen et al., 2018), (Gupta, 2018), (Holotiuk & Beimborn, 2017), (Morakanyane et al., 2017), (Teece & Linden, 2017), (Verina & Titko, 2019), (Carcary et al., 2016), (Peter et al., 2020), (North et al., 2019), (Pappas et al., 2018), (Sánchez, 2017), (Vial, 2019)
	Cultural readiness for changes (32) = The ability to successfully respond to changes caused by the emergence of new technologies, globalization, etc.; The organizational culture must encourage risk-taking and tolerate failures to succeed	(Mosconi et al., 2019), (Osmundsen et al., 2018), (Larjovuori et al., 2018), (Ismail et al., 2018), (Holotiuk & Beimborn, 2017), (Gupta, 2018), (Kutzner et al., 2018), (Kozak-Holland and Procter, 2020), (Boneva, 2018), (Morakanyane et al., 2017), (Huang, 2018), (Teece & Linden, 2017), (Schumann et al., 2017), (Verina & Titko, 2019), (Jeansson & Bredmar, 2019), (Gausdal et al., 2018), (Peter et al., 2020), (Schallmo et al., 2019), (Henriette et al., 2016), (Pappas et al., 2018), (Ponsignon et al., 2019), (Durão et al., 2019), (Mugge et al., 2020), (Kane et al., 2017), (Kane et al., 2016), (Kane et al., 2018), (Agushi, 2019), (Junge et al., 2019), (Ivančić et al., 2019), (Leipzig et al., 2017), (Hartl & Hess, 2017), (Vial, 2019)
	Organizational agility (12) = Agility to reallocate resources, to reorganize rapidly (at the level of organization) and to detect opportunities for innovation and seize those competitive market opportunities	(Kwon & Park, 2017), (Legner et al., 2017), (Holotiuk & Beimborn, 2017), (Kozak-Holland and Procter, 2020), (Carcary et al., 2016), (Verhoef et al., 2019), (Fuchs & Hess, 2018), (Ponsignon et al., 2019), (Durão et al., 2019), (Agushi, 2019), (Hartl & Hess, 2017), (Vial, 2019)
	Organization's willingness to take risks and make decisions under uncertainty (2) = Experimenting with new, rapidly developing technologies often requires risk taking and making informed decisions under uncertainty	(Hartl & Hess, 2017), (Sánchez, 2017)
	Engagement of managers and employees (32) = Leaders have to encourage	(Osmundsen et al., 2018), (Gupta, 2018), (Legner et al., 2017), (Larjovuori et al., 2018), (Holotiuk &

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Table 3 (*continued*)

Groups	Success factors	Sources
	forward-thinking, openness, technology acceptance, entrepreneurial spirit, and a startup way of working. Employees have to be ready to cooperate, be ready to develop new skills, etc.	Beimborn, 2017), (Zeike et al., 2019a), (Zeike et al., 2019)(, (Boneva, 2018), (Teece & Linden, 2017), (Schumann et al., 2017), (Genzorova et al., 2019), (Jović et al., 2019b), (Matt et al., 2015), (Verina & Titko, 2019), (Carcary et al., 2016), (Kwon & Park, 2017), (Scholz et al., 2020), (North et al., 2019), (Henriette et al., 2016), (Kane et al., 2015), (Ponsignon et al., 2019), (Durão et al., 2019), (Kane et al., 2017), (Kane et al., 2018), (Kane et al., 2019), (Sehlin et al., 2019), (Sayabek et al., 2020), (Vukšič et al., 2018), (Sánchez, 2017), (Vial, 2019), (Remane et al., 2017), (Junge & Straube, 2020)
	Creation of new leadership roles (e.g. a chief digital officer) (1) = A chief digital officer is tasked to ensure that digital technologies are properly leveraged and aligned with the objectives of the organization	(Vial, 2019)
	Digital leadership skills/ capabilities (9) = Necessary to achieve increased performance and create competitive advantage for organizations; Seven leadership skills: openness, willingness to fail, adaptability, empathy, motivation, communication, and technological understanding	(Zeike et al., 2019a), (Carcary et al., 2016), (Peter et al., 2020), (Boneva, 2018), (Schallmo et al., 2019), (Pappas et al., 2018), (Kane et al., 2015), (Mugge et al., 2020), (Junge & Straube, 2020)
	Investing in employee and manager knowledge (25) = Changes to the structure as well as the culture of an organization lead employees to assume roles that were traditionally outside of their functions	(Gupta, 2018), (Legner et al., 2017), (Pappas et al., 2018), (Mosconi et al., 2019), (Kutzner et al., 2018), (Nkuna, 2017), (Genzorova et al., 2019), (Huang, 2018), (Henriette et al., 2015), (Verina & Titko, 2019), (Carcary et al., 2016), (Chinoracky & Corejova, 2019), (Boneva, 2018), (North et al., 2019), (Schallmo et al., 2019), (Larjovuori et al., 2018), (Kane et al., 2015), (Ponsignon et al., 2019), (Mugge et al., 2020), (Kane et al., 2018), (Junge, 2019), (Reis et al., 2018), (Ivančić et al., 2019), (Vial, 2019), (Remane et al., 2017)
	Communication within the organization (11) = The organization's intention to build internal networks for	(Carcary et al., 2016), (Heilig et al., 2017a), (Henriette et al., 2015), (Schallmo et al., 2019), (Adner et al., 2019), (Kane et al., 2015), (Ponsignon

Table 3 (*continued*)

Groups	Success factors	Sources
	knowledge and information sharing	et al., 2019), (Mugge et al., 2020), (Kane et al., 2019), (Junge et al., 2019), (Hartl & Hess, 2017)
	Cross-functional collaboration (4) = Collaboration between different functional areas of the organization	(Kane et al., 2017), (Kane et al., 2019), (Hartl & Hess, 2017), (Vial, 2019)
Success factors related to technologies	**Digital security and compliance** (4): = Enterprises are increasingly exposed to cyber-threats due to intensive use of new technologies, and must take appropriate countermeasures to ensure security	(Digital Transport & Logistics Forum 2018), (Legner et al., 2017), (Ali and Jali, 2018), (Henriette et al., 2016)
	Investing in appropriate technologies (7) = Investing in appropriate technologies according to business needs; Critical factor for creating value in business; for increasing productivity, reducing costs	(Pappas et al., 2018), (Mosconi et al., 2019), (Heilig et al., 2017b), (Schumann et al., 2017), (Gausdal et al., 2018), (Mugge et al., 2020), (Galimova et al., 2019)
	New technologies embedded in aligned business strategies and processes (6) = IT department understands the company's strategy and business	(Alt, 2019), (Kwon & Park, 2017), (North et al., 2019), (Mosconi et al., 2019), (Moreira et al., 2018), (Schwertner, 2017)
	Compatibility, integration and interoperability of ICT and systems (1) = Integration of ICT systems improves data exchange, business planning and management	(Schumann et al., 2017)
	Integration between multiple information platforms (3) = Enabling smoother exchange of information and documents	(Korpela et al., 2017), (Iddris, 2018), (Schumann et al., 2017)
	Development of business process connectivity and standards (3) = For integrating business processes along the transport route	(Korpela et al., 2017), (Iddris, 2018), (Wiedenmann & Größler, 2019)
Success factors related to the external environment	**Mutual trust between the organization, its leadership, members and external partners** (1) = A key for an increasingly digitalized working environment	(Hartl & Hess, 2017)
	Understanding stakeholder needs and their expectations (1) = Implementing new technologies to increase collaboration along the transport route and to meet	(Fruth & Teuteberg, 2017)

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Table 3 (*continued*)

Groups	Success factors	Sources
	stakeholders' expectations (reduced delays, timely and accurate information)	
	Customer and partner engagement and collaboration (30) = An optimal networking of the individual actors who coordinate their activities in the transport chain in order to optimize traffic and goods flows	(Legner et al., 2017), (Kutzner et al., 2018), (Piccinini et al., 2015), (Jović et al., 2019b), (Jeansson & Bredmar, 2019), (Teece & Linden, 2017), (Matt et al., 2015), (Carcary et al., 2016), (Heilig et al., 2017a), (Henriette et al., 2015), (Boneva, 2018), (Agrawal et al., 2020), (Kotarba, 2018), (Larjovuori et al., 2018), (Mugge et al., 2020), (Kane et al., 2018), (Sehlin et al., 2019), (Galimova et al., 2019), (Cichosz, 2018), (Viktorovich & Aleksandrovna, 2019), (Korpela et al., 2017), (Iddris, 2018), (Sabri et al., 2018), (Ivančić et al., 2019), (Caputa, 2017), (Schwertner, 2017), (Sánchez, 2017), (Holotiuk & Beimborn, 2017), (Fruth & Teuteberg, 2017), (Pagani & Pardo, 2017)
	Inter-organizational data and knowledge exchange (i.e. across organization boundaries) (5) = The organizations' positive stance towards teamwork, cross-functional collaboration, and readiness for cooperation with external partners (e.g. customers)	(Junge et al., 2019), (Wiedenmann & Größler, 2019), (Hartl & Hess, 2017), (Schwertner, 2017), (Vial, 2019)
	Government/policy-makers support (4) = Financial help given by the government/policy makers	(Digital Transport & Logistics Forum 2018), (Jeansson & Bredmar, 2019), (Legner et al., 2017), (Lavikka et al., 2017)
	Adequate regulation (2) = Rules made by the government or other authorities, encouraging DT	(Digital Transport & Logistics Forum 2018), (Hanna, 2018)

integration of different solutions enables the adequate redesign of business processes.

Clear vision was considered to be either the prerequisite or the first step of the DT (Larjovuori et al., 2018). The importance of clear vision may be shown through the case of Port of Rotterdam: "We continually improve the port of Rotterdam to make it the safest, most efficient and most sustainable port in the world…", "…we are also strengthening the competitive position of the Netherlands." (Port of Rotterdam, 2019c). Indeed, the port area is constantly in development, maintaining Rotterdam's position as the world's leading port" (Port of Rotterdam, 2019a). The necessity for a clear vision can be demonstrated through the Maersk (the Danish shipping company responsible for 18% of container trade in the world) case as well. "Maersk is delivering on the vision in which DT and technological rationalization become the backbone of delivering a seamless, end-to-end experience for its customers." (Maersk, 2019a).

In order to realize the vision and further accelerate DT, CMA CGM Group is introducing services such as smart containers which provide notifications in case of humidity or an abnormal rise in temperature (CMA CGM GROUP 2018). Their vision, among others, focuses on customers as well, proving that the changing customer behaviors and expectations are the primary drivers of DT.

New and dynamic capabilities can be defined as "an organization's ways of responding in a rapidly changing environment" (Bleady et al., 2018). (Kuo et al., 2017) claim that in an uncertain environment, with increasingly higher costs and risks, container shipping companies need to focus on dynamic capabilities to renew and adjust their management strategies.

Regarding the **engagement of managers and employees** and **investing in employee and manager knowledge**, senior managers of organizations in the maritime transport sector should effectively develop incentives and encourage employees and invest in their knowledge, as these factors affect the organizational agility (Maymand & Mollaei, 2014). For example, developing new devices for data processing and validating the collected data in the maritime transport sector is labour intensive and requires technological knowledge in analytics, statistics and software modelling (Koga, 2015; Jović et al., 2020).

In regard to **cultural readiness for changes** and **organization's willingness to take risks and make decisions under uncertainty**, leaders in the maritime transport sector need to build a supportive culture that embraces collaboration, risk taking, and experimentation (Kane et al., 2017). Cultural values crucial for DT success are: openness towards change, customer-centricity or willingness to learn (Hartl & Hess, 2017).

With regard to customer and partner engagement and collaboration and inter-organizational data and knowledge exchange (i.e. across organization boundaries), collaboration may help the stakeholders of the port processes to reduce logistics costs through faster information flow, aiming to deliver the cargo faster, to enable the flow of goods, to save time necessary for the completion of business processes and finally, to boost economic growth (Tijan et al., 2012). For example, the Port of Rotterdam plays a decisive part in the process of DT through the cooperation with clients, business partners and digital platforms in order to make Rotterdam a hotspot for the development of the most promising digital innovations; they are also investing in new digital infrastructure that can help create the right conditions for extensive digitalisation etc. (Port of Rotterdam, 2019b). The Maritime and Port Authority of Singapore launched the Smart Port Challenge 2017 to encourage start-up and organizations collaboration, pushing DT into the industry, harnessing technologies to add value to the maritime logistics chain, also collaborating with the Port of Rotterdam in the same kind of endeavor" (Czachorowski et al., 2019). However, according to (Chandra & van Hillegersberg, 2018), collaborations need formal governance to address members' concerns about who owns the data, how the data is protected, and who can access the data. In order to achieve successful collaboration, mutual trust between the organizations, their leadership and members, as well as the organizations' trust in their external partners are necessary.

In order to **understand stakeholder needs and their expectations**, some of the stakeholders (e.g. senders, recipients, shipping agents) use new technologies. In this way, the actors in the maritime transport chain, e.g. terminal operators, ship brokers and forwarders, can bundle and, in case the time of arrival changes, adapt their resources appropriately (Fruth & Teuteberg, 2017). In order to meet the rising customer expectations and to stay ahead of the competition, it is necessary to **invest in appropriate technologies**, as the overall port operation services can be enhanced by moving to a paperless environment and providing a valuable and relevant solution that completely restructures the manual process of documents exchange among the port community members (Attia, 2016).

The following identified success factors are related to technologies: new technologies embedded in aligned business strategies and processes; compatibility, integration and interoperability of ICT and systems; integration between multiple information platforms as well as development of business process connectivity and standards. Integration

of existing information systems and data sources as well as more intelligent use of data may help to improve planning, controlling, and management of intra- and inter-organizational operations in the maritime transport sector (Heilig et al., 2017a). Paperless and standardized communication is a prerequisite not only for effective maritime transport operations involving many stakeholders but also for improving the integration, coordination, and performance of the supply chain (Heilig & Voß, 2017). Furthermore, security and transparency must be built in the technology and processes at all levels in the maritime transport sector. It is important that used solutions allow easy audit trail, logging of activities and using some innovative new technologies to assure the proof of authenticity (digital signature or Blockchain).

Government/policy-makers support relates to governments, transport ministries and port authorities that play an important role in DT of the maritime transport sector. It is necessary that governments envision and articulate future development scenarios, maintain frequent consultation with the stakeholders and encourage the stakeholders to invest with confidence in projects that support DT in the maritime transport sector (World Bank Group, 2007).

4.3. Barriers to successful digital transformation

In addition to drivers and success factors, authors have identified the barriers to DT in the maritime transport sector as well (also known as dysfunctional factors (Dehning et al., 2003). Challenges may arise collectively and form barriers that substantially hinder the progress of the DT process. Such barriers require explicit and extensive coping actions that go beyond the mitigation of individual issues (Fuchs & Hess, 2018). In total, 16 barriers were identified using 36 sources (Table 4).

Based on the literature review, 10 organizational, 4 technological and 2 external environmental barriers to DT were identified. One of the identified barriers is **heterogeneous organization structures and lack of cultural integration**. Lack of effective organizational culture and poor cultural integration within the organization affect the organization performance and cause the loss of productivity (Tedla, 2016). According to (Theotokas, 2007), the business culture creates a unified "front" of all institutions in the case of tramp shipping, allowing the handling of a crisis at the right moment through a common reaction, which would not be possible without vision, strategy, direction and capabilities to change.

Less digitally mature organizations tend to focus on individual technologies and have **technology-oriented culture only** (Kane et al., 2015). The Port of Rotterdam has successfully digitally transformed its seaport operations by recognizing the benefits of new and emerging technologies. However, the Port of Rotterdam does not focus only on the technologies themselves, but on a clear vision and the collaboration between the stakeholders.

An increasing number of enterprises in the maritime transport sector are offering high-technology solutions to optimize ship operations (in regard to the optimum speed, fuel consumption), or to facilitate collaboration and communication between stakeholders (Jović et al., 2020). Necessary technical modifications depend on the state of existing technologies used in an organization and must be adapted according to the needs of the organization. It usually implies a major upgrade or replacement of the working tools, applications and underlying infrastructure, leading to **high investment/implementation costs** and **high implementation risks and lack of clarity about the pay-off from the investments in emerging technologies**.

Maritime transport may suffer from a **lack of digital skills and qualified labour force**, a problem that is expected to increase in the future because the emergence of new technologies requires additional skill sets, and technological knowledge. Adequate human resources need to be ensured through the cooperation between universities and the private sector (by investing in knowledge, new study and training programs, etc.) for further development and implementation of technologies in the maritime transport sector (Jović et al., 2020; Koga, 2015).

Table 4
Identified barriers to successful digital transformation

Groups	Barriers	Sources
Barriers related to the organization itself	**Heterogeneous organization structures and lack of cultural integration** (2) = Inert organizational cultures preventing DT	(Kozak-Holland and Procter, 2020), (Hartl & Hess, 2017)
	Lack of awareness of how DT may affect the business of organizations (4) = Due to lack of awareness and understanding, organizations do not assess the resources and do not invest in resources by which DT can be achieved	(Boneva, 2018), (Piccinini et al., 2015), (North et al., 2019), (Durão et al., 2019)
	Technology-oriented culture (2) = Digital technologies alone provide little value to an organization without the alignment with the business strategy	(Gausdal et al., 2018), (Vial, 2019)
	Lack of capabilities to change (3) = Leads to a slower DT	(Mosconi et al., 2019), (Gupta, 2018), (Kane et al., 2016)
	Lack of digital skills and qualified labor force (8) = Due to the emergence of new technologies, the labor force is not able to use new technologies properly and to take full advantages of the new technologies; Lack of digital skills and qualified labor force will slow down the DT	(Mosconi et al., 2019), (Fuchs & Hess, 2018), (Agrawal et al., 2020), (Kane et al., 2016), (Sehlin et al., 2019), (Agushi, 2019), (Leipzig et al., 2017), (Munim et al., 2020)
	Employees' and managers' resistance to change (18) = The resistance that employees can demonstrate when disruptive technologies are introduced in the organization: Resistance can be classified as being systemic (cognitive) or behavioral (emotional), where systemic implies the lack of information, skills, knowledge, etc. and behavioral implies the assumptions, perceptions and reactions	(Gupta, 2018), (Kozak-Holland and Procter, 2020), (Matt et al., 2015), (Jeansson & Bredmar, 2019), (Ismail et al., 2018), (Henriette et al., 2016), (Durão et al., 2019), (Mugge et al., 2020), (Sehlin et al., 2019), (Agushi, 2019), (Junge et al., 2019), (Sayabek et al., 2020), (Leipzig et al., 2017), (Gausdal et al., 2018), (Agrawal et al., 2020), (Fuchs & Hess, 2018), (Vial, 2019), (Acciaro & Sys, 2020)
	Lack of employees' and managers' motivation (4) = Negative attitudes and opinions of the organization members who are involved in the DT	(Fuchs & Hess, 2018), (Teece & Linden, 2017), (Verina & Titko, 2019), (Sehlin et al., 2019)
	Lack of vision, strategy and direction (13) = Some organizations do not know in which direction they should lead their digital strategy	(Jeansson & Bredmar, 2019), (Ismail et al., 2018), (Ntsako Nkuna, 2017), (North et al., 2019), (Schallmo et al., 2019), (Kane et al., 2015), (Durão et al., 2019), (Kane et al., 2016), (Agushi, 2019), (Sayabek et al., 2020), (Mosconi et al., 2019), (

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Table 4 (*continued*)

Groups	Barriers	Sources
		Gupta, 2018), (Heilig et al., 2017b)
	Lack of coordination and collaboration (2) = Problematic coordination with other business units; at the organizational level	(Fuchs & Hess, 2018), (Acciaro & Sys, 2020)
	Lack of investment and initiatives (4) = No investments related to digitalization or low level of investment in digital initiatives; Lack of cultural and organizational transformation leads to the lack of investments in new technologies and digital initiatives	(Digital Transport & Logistics Forum 2018), (Gausdal et al., 2018), (North et al., 2019), (Durão et al., 2019)
Barriers related to technologies	**The existence of heterogeneous and independent information systems and lack of standards** (2) = Heterogeneous, non-integrated information systems prevent the successful DT	(Schumann et al., 2017), (Tsakalidis et al., 2020)
	Decreased levels of cyber security (especially in the area of digital operations) and resilience (6) = All players in the maritime supply chain have not ensured the best possible protection in order to ward off cyberattacks; As the digital technologies are rapidly changing, information security must evolve at the same pace	(Nkuna, 2017), (Fruth & Teuteberg, 2017), (Agrawal et al., 2020), (Kane et al., 2015), (Junge et al., 2019), (Tsakalidis et al., 2020)
	High investment/ implementation costs (5) = Not all companies chose to digitalize their business due to significant investment/ implementation costs	(Gausdal et al., 2018), (Agrawal et al., 2020), (Leipzig et al., 2017), (Mosconi et al., 2019), (Acciaro & Sys, 2020)
	High implementation risks of emerging technologies and return on investment (ROI) concerns (2) = High risk of implementing a radical change in an unknown field such as digitalization or DT	(Leipzig et al., 2017), (Agrawal et al., 2020)
Barriers related to the external environment	**Lack of industry specific guidelines** (1) = As a result, companies lack a clear vision about what to transform first: internal operations, customer relationships or business models	(Agrawal et al., 2020)
	Missing or inadequate regulations (1) = The regulations in maritime transport sector are often specific for each country, and the question is whether it is possible to introduce a particular technology or business model	(Marija Jović, 2019)

Regarding the **employees' and managers' resistance to change** as well as the **lack of employees' and managers' motivation**, a need arises for the repeated training of employees and managers in order to successfully utilize the technologies or services in the maritime transport sector. Furthermore, resistance of employees and managers to collaborate may present an obstacle in preparations for the imminent change.

Decreased levels of cyber security (especially in the area of digital operations) and resilience are additionally identified barriers. The stakeholders in the maritime transport sector might be unwilling to use the information systems because of skepticism regarding data security (Treppte, 2011). Besides, the stakeholders should ensure both proactive and reactive protection such as threat scanning and perimeter defenses that sift through data streams in real-time searching for security threats and anomalies.

The existence of heterogeneous and independent information systems and lack of standards may represent a large barrier to DT. According to CLECAT, "in recent years, many authorities and business communities have developed their own solutions to exchange information digitally. However, even though they were created with the best intentions, these individual initiatives have led to a multitude of non-interoperable IT solutions". The joint blockchain initiative Tradelens (Maersk and IBM) is an example which highlights the importance of collaboration among stakeholders and building common standards (as lack of standards in one of the barriers for DT) (Maersk, 2019b).

5. Discussion

A summary model of the aforementioned drivers, factors and barriers for digital transformation (DT) in the maritime transport sector identified in this study is presented in Fig. 3. and discussed in detail below. In this model, the identified drivers foster DT in the maritime transport sector and success factors enable/facilitate DT in the maritime transport sector. On the other hand, the identified barriers inhibit the successful DT in the maritime transport sector.

One of the main drivers of DT in the maritime transport sector is **cost reduction** and it mostly refers to reducing costs of exchanging information and executing transactions. **Streamlining operations** (improving of resources planning and information flows) is directly related to **shorter time delays, streamlining operations, processing large amounts of data, improving stakeholder collaboration** and **data transparency**. Unnecessary bottlenecks result from a large number of uncoordinated stakeholders, non-transparent data, and numerous transactions and documentation processes (mostly paper-based). Stricter environmental requirements in the maritime transport sector may also act as a driver for digital transformation. For example, if incoming ships are provided with the real-time information on availability of the berths in seaports, their navigation speed can be adjusted, shortening the waiting time at the seaport and reducing the volume of emissions at the berth and during the voyage. In this way, digital transformation enables the **regulatory requirements** to be met.

The drivers **new and emerging technologies, changing customer behaviors and expectations** and **competitive environment** are also closely related. The emergence of new digital technologies dramatically changes the competitive landscape and customer expectations. Customers demand reliable, flexible, and cost-efficient transport services stimulating the maritime transport sector companies to engage into DT in order to remain competitive. The crucial phase of the DT is not only the digitalization of the business processes, but also a gradual removal of

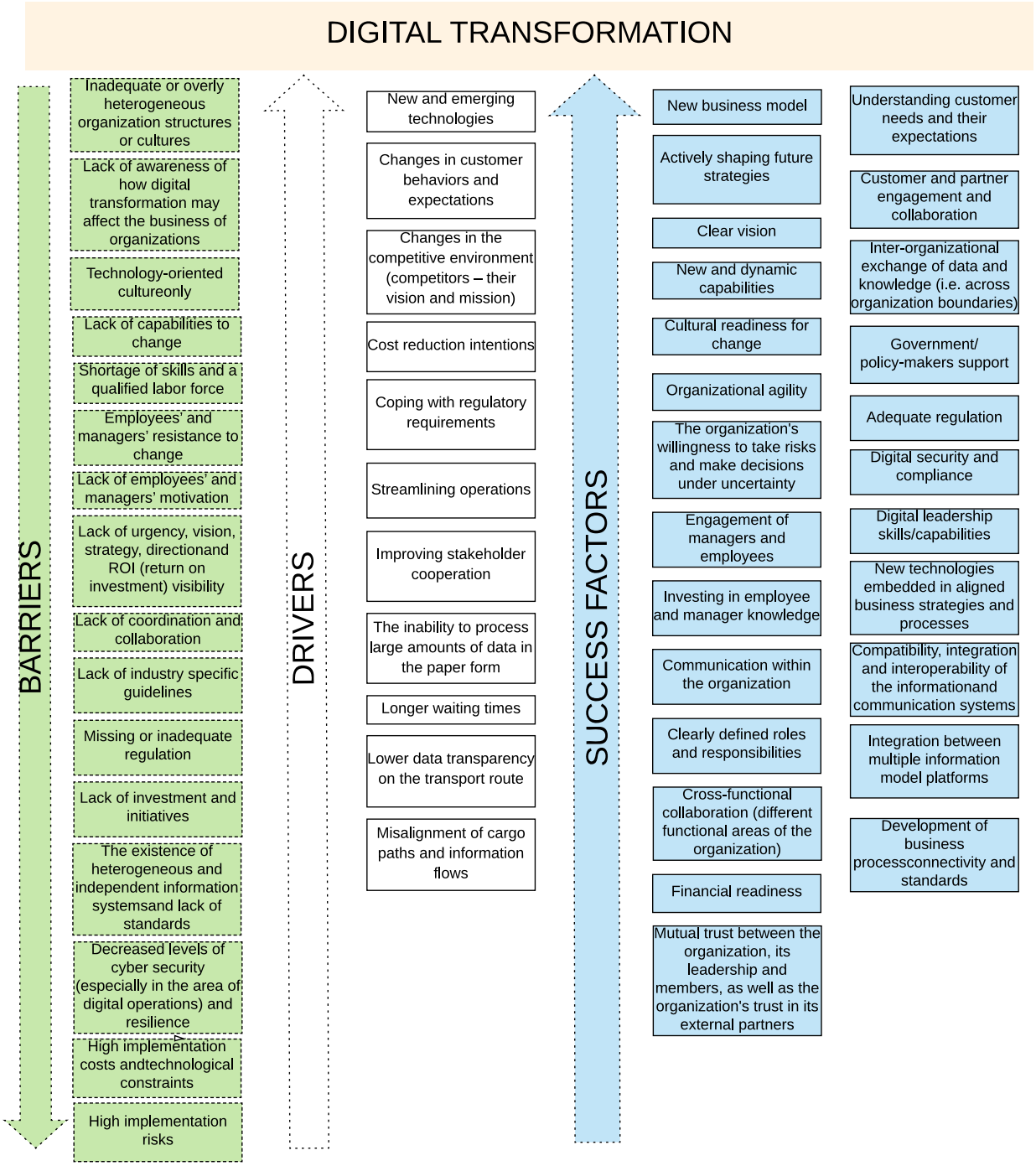

Fig. 3. Model of drivers, success factors and barriers affecting digital transformation in the maritime transport sector

the outdated business and management processes that are often compartmentalized and highly fragmented. **New business models** are necessary for maximizing innovation and effectiveness in fostering digitalization. The competitive potential should be assessed before **shaping future strategies** which should be focused towards the harmonization. The DT should not only be oriented towards the technology implementation, as the **technology-oriented culture** (without considering other factors) represents one of the main barriers. It must be based on the aligned business and digital strategy of an organization.

The stakeholders should successfully respond to a rapidly changing environment and recognize opportunities and minimize threats which can be defined as **cultural readiness for changes. New and dynamic capabilities** should allow the maritime transport sector organizations to identify the opportunities and to respond to them by organizational transformation. The **engagement of managers and employees** and **investing in employee and manager knowledge** are the important success factors since the new technologies (which requires technological knowledge) emerge rapidly. **Customer and partner engagement and collaboration**, together with **inter-organizational data and knowledge exchange**, may help the stakeholders to reduce costs through smoother information flow.

Stakeholder collaboration may be the most important challenge for the maritime transport sector, because the successful DT in the maritime transport sector should not only focus on the individual needs, but also on the external environment that is more difficult to predict and control. **Government/policy-makers support** can also encourage the

stakeholders to invest in the projects that support DT in the maritime transport sector. Since the stakeholders are often reluctant to digitally transform their business, there is a need for constant education about the benefits of DT, but also for the quantification of benefits that can be clearly presented to the decision-makers.

Technological success factors for the DT are closely related. **Compatibility, integration and interoperability of ICT and systems** as well as the **development of business process connectivity and standards** are the prerequisite for the undisturbed data exchange, but **digital security** and **data transparency** are imperative in all technologies and processes at all levels in the maritime transport sector. However, the stakeholders might be unwilling to integrate their information systems because of the skepticism regarding **data and information security**, and may also be **reluctant to collaborate**, continuing to use their **independent information systems**.

In regard to DT, the maritime transport sector is specific compared to the other sectors: the management usually takes a conservative approach, and the resources are often limited. Although the technologies such as the Blockchain or the autonomous shipping foster DT in the maritime transport sector, **the lack of awareness of how DT may positively affect the business** as well as **employees' and managers' resistance to change** is pronounced. The paper documents exchanged between the stakeholders in the maritime transport sector still slow down the business processes and incur higher costs.

6. Conclusions

In the maritime transport sector, transport enterprises and seaport stakeholders are at different stages of their DT journey. While the highly digitalized seaports and enterprises (such as, for example, port of Rotterdam and Singapore) may be observed as the most successful examples of digital transformation (DT), on the other hand many other seaports, seaport stakeholders and enterprises along the maritime supply chains are lagging behind.

The motivation for this research stems from the lack of existing research focused on DT in the maritime transport sector. The existing studies do not provide a comprehensive overview of the current situation, and successful cases or drivers and impediments of DT in the maritime transport sector. To fill these gaps, this research aims to identify the success factors, drivers and barriers for DT which can be applied to the maritime transport sector context. For that purpose, the authors conducted a comprehensive literature review.

The contribution of this study is twofold. First, the results of the study enrich the body of knowledge in the field of digitalization and DT which can be applied to the maritime transport sector. The overview of the identified drivers, success factors and barriers offer other researchers an introduction to the investigated field and may provide a baseline towards the future research design. Due to the lack of research in the field, further studies will be necessary to gain deeper insights into how to design successful DT and apply it to the maritime transport sector. Secondly, the understanding of drivers fostering DT, the success factors facilitating and enabling DT as well as being aware of barriers to the DT can help the practitioners in shaping their DT strategies. In addition, the paper also provides an initial overview of DT in the maritime transport sector, that could also be beneficial for researchers as well as practitioners.

As this research is limited to the literature review, which revealed that not many DT studies exist in the maritime transport sector, the future studies should empirically examine the situation in the field. While in depth case studies will serve as a basis for deeper understanding of the successful and failed DT projects, quantitative approaches with surveys will offer an opportunity for the generalization of understandings.

Along with that, the proposed research questions, or venues for future research in the field of DT in the maritime transport sector that should contribute to academic knowledge and practitioners' understandings are the following:

- What are the activities and actions needed for successful DT, that should be undertaken by enterprises in the maritime transport sector presently at lower levels of digital trends adoption, considering their achieved level of development, available resources and capabilities, and cultural readiness for change?
- Is there a difference, and to what extent, between the SMEs and the larger enterprises in terms of adapting to the changes caused by the emerging technologies, and the changes in competitive landscape of the maritime transport sector?
- What is the government's role in DS in the maritime transport sector?

This comprehensive literature review presents a fundamental basis for the planned future research in DT in the maritime transport sector, in order to gain a deeper understanding of how the maritime transport stakeholders cope with the market and digital/technology changes and challenges. A literature review facilitates identifying the research gaps and provides an overview of the current body of knowledge. However, the authors deem it necessary to conduct further empirical analysis of the maritime transport stakeholders to gain comprehensive understanding of the ongoing activities and to design proper guidelines, strategies and solutions for faster, wider and more successful DT of the maritime transport sector.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.techfore.2021.120879.

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