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Digitization in maritime logistics — What is there and what is missing?

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Abstract: The global seaports are of pivotal importance for the world economy. Since 1990, global container traffic has grown by an average of 10% annually. Equally, the steady growth of ship sizes poses major logistical and technical problems worldwide. Given these facts, shipping and maritime logistics would largely benefit from Big Data as well as the emerging digital technologies. Apart from the many positive effects of digitization in maritime logistics with respect to efficiency, safety and energy saving, there are, however, also risks (e.g. data abuse, cybercrime). Based on a systematic literature review, this article provides an overview of the current state of digitization in maritime logistics, discusses existing problem areas, and shows potential for improvement. The results show that it is essential to capture the development potential in order to be able to benefit from the advantages. However, research is still in its initial stages, and there is a lack of theoretical and empirical work as well as explanatory approaches to appropriate recommendations for action and restructuring.

Subjects: Environment & Economics; IT Security; Hacking &; Viruses; Management of IT; Computer Engineering; Information &; Communication Technology (ICT); CommunicationTechnology

Keywords: Big Data; digitization; maritime logistics; container terminal operations, port operations

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PUBLIC INTEREST STATEMENT

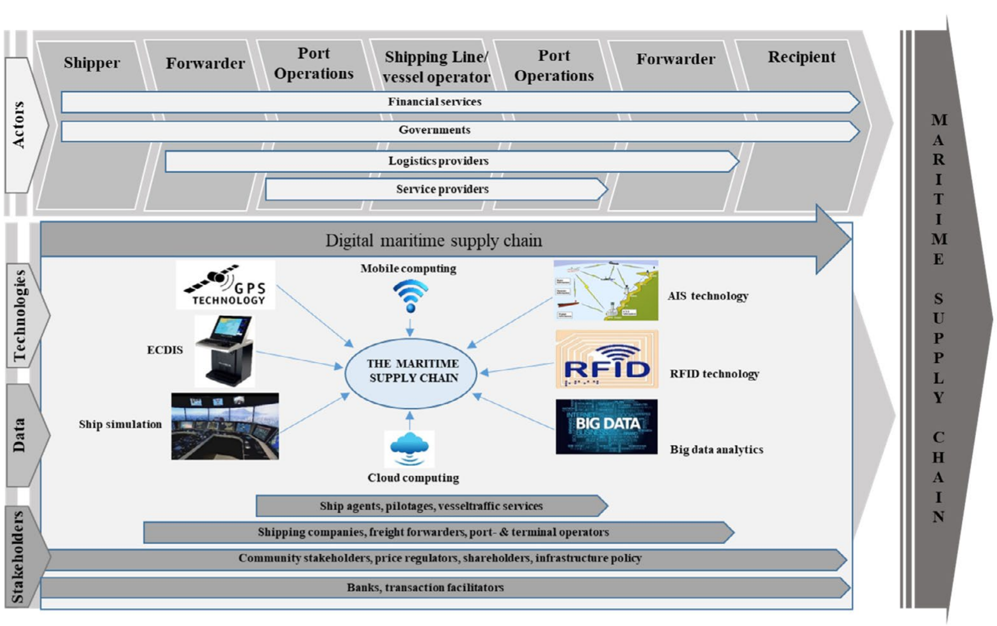
In maritime logistics, automation and digitization are constantly advancing, which noticeably affects all involved as business models and processes will change dramatically in the coming years. Against the background of the transformation process, this paper analyzes the status quo, discusses existing problem areas and identifies the arising future challenges. Furthermore, it provides recommendations for action in research and practice. A comprehensive and systematic literature analysis equally considering scientific and practical literature serves as a solid basis for this contribution. The results show that it is essential to identify the development potential in order to take full advantage of the opportunities in practice. However, research in this area is still in its initial stages. There is a lack of theoretical and empirical work as well as alternative explanatory approaches for appropriate recommendations for action and restructuring.

1. Introduction and motivation

Today, more than 90% of the world's goods transport is handled by sea. Every year around 8 million tons of goods are transported across the sea by container ships, tankers, and bulk carriers (Göpfert & Braun, 2008). While in 2013 some 9.5 billion tons of sea freight have been loaded at seaports around the world, the total capacity of the global container fleet increased to approximately 20.5 million TEU[1] in 2015 (Grote et al., 2016). Apart from the decline in 2009, which was due to the economic crisis, there has been a steady increase in the global container traffic every year. In view of the advancing globalization as well as the further progress in the containerization of general cargo transport, a further increase in container transport is expected (Fruth, 2016). Compared with the world gross domestic product and the world trade, sea trade has shown twice as fast growth in recent years. Container transport thereby accounts for less than a third, but was the fastest growing market segment within the maritime logistics sector (N.U., 2011). Maritime logistics is thus one of the key sectors for digital transformation. With its high degree of networking and its large number of interfaces, maritime logistics offers a broad range of applications for digital technologies. Therefore, digitization and logistics 4.0 provide a great potential for maritime shipping companies (Binder, 2016c). Traffic, port logistics, and just-in-time shipping will change as an electronic revolution takes shape with Big Data and the increasing networking of technologies (Berg & Hauer, 2015). Already today large amounts of data are gathered on each individual ship, although most of them still remain unused. However, given the multitude of new digital business models, data usage will inevitably change within the coming years (Fruth, 2016). The International Maritime Organization (IMO) supports the introduction of electronic data exchange from ship to ship and from land to ship, to improve the efficiency, safety, and data security of navigation and communication (Berg & Hauer, 2015). For the ports and thus for the digital linking of complete value chains in maritime logistics, there are numerous developments in the area of Global Positioning System (GPS) navigation, more accurate ship arrival times, weather data in real-time feeds, and smart container technology to name only a few of the possibilities. Likewise, there is a mathematical model currently being developed that predicts earlier and more accurately ship arrival times, based on AIS[2], weather, tide, and maritime traffic data (Kuchta, 2016).

The interaction of all actors in the maritime supply chain as well as the sequence of the related processes is shown in Figure 1.

Figure 1. Interplay of the actors of the maritime supply chain.



The actors involved include senders, logistics providers (e.g. forwarders, port and terminal operators, and shipping companies) as well as the receivers. Some of the stakeholders (e.g. senders, recipients, shipping agents, traffic control centers, port operators, but also price regulation authorities, banks and transaction brokers) use new ICT (e.g. GPS navigation, electronic seacharts (ECDIS), RFID technologies, AIS and Big Data). In this way, the actors in the maritime transport chain, e.g. terminal operator, ship brokers, tugboats, pilots and forwarders, can bundle and, in case the time of arrival changes, adapt their resources appropriately (Fruth, 2016). Further, all parties concerned, e.g. the terminal operators, can be informed about the loaded goods prior to the ships' docking. Sea containers are equipped with radio-frequency identification (RFID) chips and thus become intelligent containers. Through smart containers and a suitable networking of single information systems, it is possible to fully digitize and globally network the entire maritime transport in order to render transparent the respective processes (Berg & Hauer, 2015). All terminal vehicles, machines and devices that are involved in the transportation, loading and unloading of goods are interconnected and communicate with each other, which is enabled by means of suitable information, communication and automation technologies. Such an inclusion in higher order systems leads to cyber-physical systems (Bai, Zhang, & Shen, 2010). In the case of forward and hinterland transport, the synchronous modality is based on the idea that the optimal transport mode and route combination can be selected based on real-time information. For example, the transport of smart containers is carried out depending on the respective availability of trucks, railcars, feeder ships[3] or inland waterway vessels. Synchronous modality thus allows significant transport cost reductions and an optimum utilization of transport means while adhering to the respective delivery conditions (Lee et al. 2016). Based on the "Internet of Things" concept, machines and equipment on board ships can be equipped with sensors and transmitters that transmit performance data as well as early signs of errors to the ship computer via WiFi so that any necessary repairs or replacements of a defective system can be executed in the home port, which can save time as well as avoid considerable costs of flying technicians and parts to a ship in transit (Berg & Hauer, 2015).

In this paper, we address the following research questions (RQ):

RQ 1: What is the current status quo of digitization in maritime logistics?

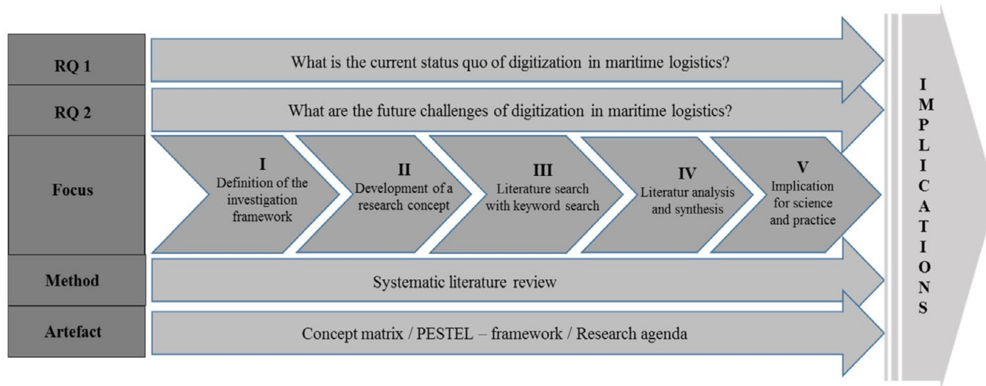
RQ 2: What are the future challenges of digitization in maritime logistics?

To answer these research questions, a systematic literature analysis is carried out in various literature databases and specialist journals with the purpose to equally capture the scientific as well as practical status quo. The contribution at hand is structured as follows: In the second section, conceptual foundations and technologies in the area of digitization in the maritime logistics are discussed in order to obtain a primary basis. The third section describes the methodological approach. In the fourth section, the results of the literature analysis are presented in a concept matrix and recommendations for research and practice are given in a PESTEL matrix. The work concludes in section 5 with a final consideration, as well as implications for science and practice.

2. Background

New technologies and concepts such as big data, cloud computing, mobile computing or self-steering processes and services are more and more penetrating the areas of social life and are becoming increasingly important in economic processes. This results in the fourth industrial revolution linked to the term industry 4.0 (Broy, 2010, p. 17 ff). Industry 4.0 focuses on the linking of industrial processes and technologies, as well as the related business processes with the new information and communication technologies (ICT) (Keller, Pütz, & Siml, 2012). As in industry, the maritime sector also provides artificial intelligence to the digitized objects by means of programmability, storage capacity, sensors, and networking, which will allow an increase in the efficiency of ship operation (Bosse & Schwientek, 2011). With AIS-log files, weather data, and fuel-sampling data, large data sources are available to the shipping industry, which can be processed using big data analyses and

Figure 2. Framework concept for systematic literature analysis (following Vom Brocke et al., 2009).



compared with other companies. In the field of maritime logistics, multimodal transport processes in the ports require an optimal networking of the individual actors who coordinate their activities in the transport chain in order to optimize traffic and goods flows (Berg & Hauer, 2015). With the use of Big Data and digital transformation, the fleet controls can be optimized, whereby costs are reduced and the environmental protection is improved. Traffic control and traffic flows can be optimized by using the ship's operating data, thereby avoiding critical situations and thus reducing the risk of accidents. All ship data, e.g. machine, aggregate, weather and cargo data, are transmitted to the onshore management in real time, who can, if necessary, enter into a direct dialog with the ship's management (Arndt, 2016). The current digital transformation is also regarded critically. Technology and information ethics ask for the gain and loss of personal and informational autonomy and the dependency of the customers on information technology and information companies. Moral and ethical problems arise, especially in the field of technology, information and economic ethics (Bendel, 2015). The digital transformation of maritime logistics is successful if the topics of data protection and data security are given a central role in the implementation strategy. The handling with digital applications and technologies does not only require competent users who are familiar with the digital innovations, but also secure systems that guarantee the protection of the company's internal infrastructure and operating systems from cyberattacks (Schweer & Sahl, 2016).

3. Research approach

The present research contribution consists of a systematic literature analysis to identify the status quo of digitization in maritime logistics. The systematic literature analysis is employed, since in scientific research it is an adequate means to determine the current state of research (Fettke, 2006). It avoids redundant investigations and leads to important contributions in the corresponding research field. The three essential characteristics of a literature analysis are: systematics, explicitness, and reproducibility. The literature analysis in this article summarizes the research work on digitization in maritime logistics. For the analysis of the relevant literature, we decided on a concept matrix based on the five-step concept described by vom Brocke et al. (cf. Figure 2).

Figure 3. Classification scheme for literature searches according to Cooper (1988).

Characteristic	Categories			
1. Focus	Research results	Research methods	Theories	Applications
2. Target	Integration	Criticism	Central aspects	
3. Perspective	Neutral representation	Representation of a position		
4. Cover	Completely	Completely and selective	Representative	Fundamental
5. Organization	Historically	Conceptually	Methodically	
6. Target group	Specialized scientists	General scientists	Practitioners	General audience

Table 1. Literature base and search results

Databases	Results	Relevant	References
EBSCOhost [(S)]	143	1	De Tugny (2016) [(1)]
Science Direct [(S)]	223	16	Lind, Hägg, Siwe, and Haraldson (2016) [(2)], An et al. (2016) [(3)], Yao Yu and ChangChuan (2011) [(4)], Haraldson (2015) [(5)], Cisic, Hadzic and Tijan (2009) [(6)], Martin-Soberon, Montfort, Sapina, Monterde, and Calduch (2014) [(7)], Bechtsis, Tsolakis, Vlachos, and Iakovou (2016) [(8)], Christiansen, Fagerholt, Nygreen, and Ronen (2013) [(9)], Sumic, Perakovic, and Jurcevic (2015) [(10)], Psaraftis (2016) [(11)], Stevens et al. (2015) [(12)], Cheng, Lai, and Sarkis (2015) [(13)], Davarzani, Fahimnia, Bell, and Sarkis (2016) [(14)], Von Lukas (2010) [(15)], Cha, Roh, and Lee (2010) [(16)], Back, Lee, Shin, and Woo (2016) [(17)]
Taylor & Francis Online [(S)]	129	5	Poulis, Poulis, and Dooley (2013) [(18)], Lee et al. (2016) [(19)], Caniels, Cleophas, and Semeijn (2016) [(20)], Chyssolouris, Makris, Xanthakis, and Mourtzis (2004) [(21)], Banomyong (2005) [(22)]
Google Scholar [(S)]	647	10	An et al. (2016) [(23)], Biccario, Annese, and de Vanuto (2014) [(24)], Diwan (2015) [(25)], Karlsson, Haraldson, and Holmberg (2015) [(26)], Min (2008) [(27)], Lam (2011) [(28)], Acciaro and Wilmsmeier (2015) [(29)], Van Leeuwen (2015) [(30)], Wuisan, van Leeuwen, and van Koppen (2012) [(31)], Sen (2016) [(32)]
SpringerLink [(S)]	3393	9	Brouer, Karsten, and Pisinger (2016) [(33)], Yang et al. (2016) [(34)], Haasis, Landwehr, Kille, and Obsadny (2014) [(35)], Isaias and Duarte Macedo (2007) [(36)], Kim, Huh, and Kim (2016) [(37)], Lee and Lee (2016) [(38)], Jiang, Chew, and Lee (2014) [(39)], Xiang (2010) [(40)], Bendel (2015) [(41)]
International Journal of Innovation and Sustainable Development [(S)]	235	0	0
European Journal of Operations Research [(S)]	49	1	Grazia Speranza (2016) [(42)]
Maritime Economics & Logistics [(S)]	425	2	Gharehgozli, Roy, and de Koster (2016) [(43)], Kim et al. (2016)[(44)]
Maritime Policy & Management [(S)]	129	5	Birtchnell (2016) [(45)], Lee, Park, and Lee (2003) [(46)], Jafari, Taghavifard, Rouhani, and Moalagh (2010) [(47)], Roumboutsos et al. (2005) [(48)], Keceli (2011) [(49)]
Asian Journal of Shipping [(S)]	156	0	0
International Journal of Shipping and Transport Logistics [(S)]	222	2	Prokop (2012) [(50)], Harder and Voß (2012) [(51)]
Asia Insurance Review [(S)]	36	1	Berg and Hauer (2015) [(52)]
THB – Deutsche Schifffahrts-Zeitung [(P)]	379	11	Fabarius (2017a) [(53)], Fabarius (2017b) [(54)], Fabarius (2017c) [(55)], Arndt (2017) [(56)], Binder (2016a) [(57)], Binder (2016b) [(58)], Binder (2017) [(59)], Binder, Oldenburg, and Breuer (2017) [(60)], Lüders (2016) [(61)], Kleinort (2017) [(62)], Germann (2017) [(63)]
Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik [(P)]	73	7	N.U. (2016a) [(64)], Bruhn (2017) [(65)], Kretschmann and Schlegel (2016) [(66)], Von Lukas (2017) [(67)], Von Lukas (2016) [(68)], Von Lukas, Staack, and Köhler (2016) [(69)], N.U. (2016b) [(70)]
DVZ – Deutsche Verkehrs-Zeitung [(P)]	341	12	Reimann (2017) [(71)], Naumann (2017a) [(72)], Granzow (2017) [(73)], De Jong (2017a) [(74)], De Jong (2017b [(75)], Naumann (2016) [(76)], Naumann and Reimann (2016) [(77)], De Jong (2016) [(78)], Zapp (2015) [(79)], Naumann (2014) [(80)], Naumann, (2017b) [(81)], Kloss (2016) [(82)]
HANSA – International Maritime Journal [(P)]	201	14	N.U. (2017) [(83)], Selzer (2017a) [(84)], Selzer (2017b) [(85)], Selzer (2017c) [(86)], Meyer (2017) [(87)], Kuster (2017) [(88)], Leira (2016) [(89)], Selzer (2016) [(90)], Meyer (2016) [(91)], Bertram (2011) [(92)], Bertram (2016) [(93)], Bertram (2017) [(94)], Bertram (2015) [(95)], Hochhaus (2011) [(96)],
Maritime Logistics Professional [(P)]	357	4	Doyle (2017) [(97)], Keefe (2017) [(98)], Keefe (2016) [(99)], Keefe (2014) [(100)],
Maritime Reporter and Engineering News [(P)]	3128	24	Muccin (2015) [(101)], Trauthwein (2017a) [(102)], Trauthwein (2017b) [(103)], Bobys (2017) [(104)], Berge (2017) [(105)], Grucza (2017) [(106)], Pekkanen (2017) [(107)], Pribyl (2016) [(108)], Segercrantz (2016a) [(109)], Muccin (2016) [(110)], Stoichevski (2016) [(111)], Haun (2015) [(112)], Segercrantz (2016b) [(113)], Hartmann and Remick (2015) [(114)], Rhodes and Soccoli (2015) [(115)], Segercrantz (2015a) [(116)], Weigel and Singleton (2014) [(117)], Bryant (2017) [(118)], Haynes (2016) [(119)], Stoichevski (2015) [(120)], Driver (2015) [(121)], Segercrantz (2015b) [(122)], Baldauf (2013) [(123)], Trauthwein (2013) [(124)]
Total relevant contributions of scientific and practical literature:		124	

The definition of the investigation framework, the development of a research concept and the literature search with keyword search are described in the section *The literature analysis as a survey method: documentation*. The analysis and synthesis of the results of the literature analysis are given in the sections *Results* and *Discussion*. Finally, limitations are discussed in the section *Conclusion* and a final *Closing Considerations and Implications for Science and Practice* are given in the last section.

3.1. Definition of scope of investigation

According to vom Brocke et al., the classification scheme for literature searches, according to Cooper (1988) with six features, is suitable as a tried-and-tested tool and is shown in Figure 3. The highlighted fields illustrate the scope of this paper. The focus lies on the identification of the available literature, shows its degree of coverage, and cites from the identified literature.

3.2. Research concept

According to the definition of the scope of the investigation, the search concept has to be explained. First, the keywords used for the search are named, then the selection of the literature databases and magazine libraries is explained and subsequently the quantitative results of the literature search are presented. The keyword search was performed in the databases EBSCOhost, ScienceDirect, Taylor & Francis Online and SpringerLink. In order to reach a wide base of literature, we completed the search through the service Scholar of the search engine Google. The EBSCO literature database was used to search for scientific journals as well as specialist magazines from maritime transport and logistics. For high-quality contributions, "A"-based journals, which are not listed in EBSCO, were considered according to VHB-Jourqual3 part ranking logistics. In addition, a supplementary manual search was carried out in the specific journals of the International Journal of Innovation and Sustainable Development, European Journal of Operations Research, Maritime Economics & Logistics, Maritime Policy & Management, Asian Journal of Shipping, International Journal of Shipping and Transport Logistics and Asia Insurance Review. Furthermore, an additional manual search was carried out for the analysis of practical literature in the following journals, newspapers and reports: Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik, DVZ – Deutsche Verkehrs-Zeitung, THB – Deutsche Schifffahrts-Zeitung, HANSA International Maritime Journal, Maritime Logistics Professional and Maritime Reporter and Engineering News. The following keyword combinations were used in the search engines of the literature databases, the specialist journals and the practical literature: <(Digital*) AND (Maritime* Logistics)>, <(Big Data) AND (Martime* Logistics)>, <(Digital*) AND (Shipping Industry) >, <(Digitalisation OR Digitalization OR Digitization) AND (Maritime* Logistics)>, <(Digital Transformation) AND (Maritime* Logistics)> as well <(Big Data) AND (Maritime*Logistics) AND (Maritime* Transportation)>. For all identified contributions from science and practice, we additionally carried out a forward and backward search, which led to three further papers. Although we specifically searched in the listed journals and magazines, in a next step we conducted an additional open Google search (forward and backward search) to broaden the search frame.

Table 1 shows the search results using all keyword combinations in the respective sources. The information in brackets behind the respective sources indicates the source of literature (P for practice and S for science).

A source is considered as relevant when it deals with digitization or transformation technologies in the maritime logistics. The review was executed by sorting the contributions by title, keywords and the abstract. After reading title and content specification, we decided whether or not we further analyze a contribution by reviewing the content or the abstract. A total of 124 contributions were identified as relevant and analyzed closer. Table 2 shows the list of publications title, grouped by major topic and subtopic(s).

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Table 2. Publications

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
De Tugny (2016) [(1)]	*Offshore Magazine*	Digital technology to transform AIMS	Automation	Digital technology
			Big Data	Transform aims
			Simulation and modelling	Technologies to transform aims
			Software	Communication technology
				AIS
				GPS-navigation
				Routeplanning
				ETA
Lind et al. (2016) [(2)]	Transportation Research Procedia – 6th Transport Research Arena	Sea Traffic Management – Beneficial for all Maritime Stakeholders	Automation	Cloud-based eBusiness
				Community stakeholders
				Automation in seaports
			Big Data	Fleet optimization
				Cloud-based eBusiness
				Transform aims
				Research to reduce emissions
				Legislation on competitive advantages
			Simulation and modelling	Technology development
				VTS
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Carlan, Sys and Vanelslander (2016) [(3)]	*Research in Transportation Business & Management*	How port community systems can contribute to port competitiveness: Developing a cost-benefit framework	Automation	Alarm system
				Research and development
			Big Data	Cloud-based eBusiness
				Competitive advantages
				Cost-benefit analysis
				Legislation on competitive advantages
			Software	Simulation and research
			Sustainable Maritime Transport	Development in supply chain
				Smart container strategies and research
Yao Yu and ChangChuan (2011) [(4)]	*Procedia Engineering*	A preliminary scheme of the online monitoring system for the ship discharging pollution at harbour based on AIS information	Automation	Alarm system
				Energy optimization
			Simulation and modelling	Development simulation
			Software	AIS

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Haraldson (2015) [5]	21st Americas Conference on Information Systems (AMCIS)	Digitalization of sea transports – enabling sustainable multi-modal transports	Automation	Alarm system
				Energy optimization
			Software	Sustainable transport models
			Sustainable Maritime Transport	Sustainable maritime transport
				Green port operations
Cisic et al. (2009) [6]	MIPRO 2009, 32nd International Convention	The ecnonomic impact of e-Business in seaport systems	Automation	Cloud-based eBusiness
			Big Data	Economic impacts
Martin-Soberon et al. (2014) [7]	*Procedia – Social and behavioral sciences*	Automation in port container terminals	Automation	Control monitoring
				Automatisation in supply chains
				Cloud-based eBusiness
				Automatisation in seaports
Bechtsis et al. (2016) [8]	*Journal of Cleaner Production*	Sustainable supply chain management in the digitalisation era: the impact of automated guided vehicles	Automation	Automatisation in seaports
				Automatisation in supply chains
				Energy optimization
			Big Data	Networking
				Sensor-chip-technology
				Impact on maritime logistics
Christiansen et al. (2013) [9]	*Europan Journal of Operations Research*	Ship routing and scheduling in the new millenium	Big Data	Fleet optimization
				Networking
				Shiptraffic
				ETA
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
			Sustainable Maritime Transport	ETA
Sumic et al. (2015) [10]	*Procedia Engineering*	Optimizing Data Traffic Route for Maritime Vessels Communications	Automation	Control monitoring
			Big Data	Fleet optimization
				Reporting
			Simulation and Modelling	VTS
Psaraftis (2016) [11]	*Transportation Research Procedia, 6th Transport Research Arena*	Green maritime logistics: the quest for win-win-solutions	Big Data	Research to reduce emissions
			Sustainable Maritime Transport	Green supply chain
				Energy efficiency
Stevens et al. (2015) [12]	*Research in Transportation Business & Management*	Is new emission legislation stimulation the implementation of sustainable and energy-efficient maritime technologies?	Automation	Energy optimization
			Big Data	Air quality
				Atmospheric environment
			Sustainable Maritime Transport	Reduction of emissions
				Green shipbuilding industry
				Emissions

(Continued)

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Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Cheng et al. (2015) [13]	*Transportation Research Part E: Logistics and Transportation Review*	Sustainability in maritime supply chains: Challenges and opportunities for theory and practice	Sustainable Maritime Transport	Green supply chain
				Energy efficiency
				Green port operations
				Research studies
Davarzani et al. (2016) [14]	*Transportation Research Part D: Transport and Environment*	Greening ports and maritime logistics: A review	Big Data	Air quality
				Atmospheric environment
			Sustainable Maritime Transport	Reduction of emissions
				Energy efficiency
				Green port operations
Von Lukas (2010) [15]	8th IFAC Conference on Control Applications in Marine Systems	Virtual and augmented reality for the maritime sector – applications and requirements	Simulation and modelling	Production processes
			Software	Simulation and research
Cha et al. (2010) [16]	*Journal of Robotics and Computer-Integrated Manufacturing*	Integrated simulation framework for the process planning of ships and offshore structures	Simulation and modelling	Optimization
				Simulation
Back et al. (2016) [17]	*International Journal of Naval Architecture and Ocean Engineering*	A study for production simulation model generation system based on data model at a shipyard	Automation	Research and development
			Simulation and modelling	Optimization
				Simulation
				Simulation studies
			Software	Simulation and research
Poulis et al. (2013) [18]	*The Service Industries Journal*	Information communication technology – innovation in a non-high technology sector: achieving competitive advantage in the shipping industry	Automation	Digital technology
			Big Data	Real-time
				Cloud computing
				Sustainable cost-reduction
				VOIP
				Competitive advantages
				Legislation on competitive advantages
			Software	Communication technology
Lee et al. (2016) [19]	*Maritime Policy & Management*	Port e-Transformation, customer satisfaction and competitiveness	Big Data	Fleet optimization
				Competitive advantages
				Legislation on competitive advantages
				Transactional data
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Caniels et al. (2016) [20]	*Maritime Policy & Management*	Implementing green supply chain practices: An empirical investigation in the shipbuilding industry	Big Data	Implementing green supply chain practices
			Sustainable Maritime Transport	Green shipbuilding industry
				Implementing
Chyssolouris et al. (2004) [21]	*International Journal of Computer Integrated Manufacturing*	Towards the Internet-based supply chain management for the ship repair industry	Automation	Supply chain management
			Software	Control systems

(Continued)

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Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Banomyong (2005) [22]	*Maritime Policy & Management*	The impact of port and trade security initiatives on maritime supply-chain management	Automation	Automatisation in supply chains
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
			Simulation and modelling	Technology development
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
An et al. (2016) [23]	22nd Americas Conference on Information Systems (AMCIS)	Configuring Value with Service-Dominant Logic: the Case of Marine Informatics Technology	Automation	Research and development
			Simulation and modelling	Simulation studies
			Sustainable Maritime Transport	Real-time tracking of global aid transports
Biccario et al. (2014) [24]	*TETHYS 2014 – Toward Emerging Technology for Harbour systems and Services*	Wireless Remote Environmental Monitoring and Control of Perishable Goods in Maritime Transportation	Automation	Cloud-based eBusiness
			Big Data	Fleet optimization
				Cloud-based eBusiness
			Software	Services for port systems
			Sustainable Maritime Transport	Smart container (RFID technology)
				Real-time control of perishable cargo
				Conditions of cargo (RFID)
				Smart container strategies and research
Diwan (2015) [25]	The International Maritime & Logistics Conference (MARLOG 4)	Cloud community in e-clusters: Towards sustainable logistics clusters	Automation	Energy optimization
			Big Data	Fleet optimization
			Sustainable Maritime Transport	Sustainable maritime transport
				Logistics clusters
Karlsson et al. (2015) [26]	21st Americas Conference on Information Systems (AMCIS)	Co-using Infrastructure for Sustainable in Maritime Transports	Automation	Energy optimization
			Big Data	Infrastructure
			Sustainable Maritime Transport	Sustainable maritime transport
				Green port operations
				Green shipbuilding industry
				Legislation infrastructure
Min (2008) [27]	IFAC Proceedings of the 17th World Congress	Automation and Control Systems Technology in Korean Shipbuilding Industry: The State of the Art and die Future Perspectives	Automation	Control system
				Research and development
			Big Data	Control systems
			Software	Control systems

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Lam (2011) (28)	*Journal of Transport Geography*	Patterns of maritime supply chains: Slot capacity analysis	Automation	Automatisation in supply chain
				Automatisation in seaports
			Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Cloud-based eBusiness
				Control systems
			Software	Control systems
Acciaro and Wilmsmeier (2015) (29)	*Research in Transportation Business & Management*	Energy efficiency in maritime logistics chains	Sustainable Maritime Transport	Green supply chain
				Green port operations
				Energy efficiency
Van Leeuwen (2015) (30)	*Ocean & Coastal Management*	The regionalization of maritime governance: Towards a polycentric governdance system for sustainable shipping in the European Union	Big Data	Air quality
				Atmospheric environment
			Sustainable Maritime Transport	Sustainable maritime transport
				Governance
Wuisan et al. (2012) (31)	*Marine Policy*	Greening international shipping through private governance: A case study of the Clean Shipping Project	Big Data	Air quality
				Atmospheric environment
			Sustainable Maritime Transport	Reduction of emissions
				Sustainable maritime transport
				Development in supply chain
				Governance
Sen (2016) (32)	Maritime Security (2nd Edition)	Cyber and Information Threats to Seaports and Ships	Risks	Cyber-attacks
				Terrorist attacks
Brouer et al. (2016) (33)	Emrouznejad, A. (ed.) Big Data Optimization: Recent Developments and Challenges	Big Data Optimization in Maritime Logistics	Big Data	Fleet optimization
				Shiptraffic
				Reporting
				ETA
				Optimization of administrative procedures
			Simulation and modelling	VTS
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
			Sustainable Maritime Transport	ETA
				Smart container strategies and research

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Yang et al. (2016) [34]	*Peer-to-Peer - Networking and Applications*	Resource allocation in cooperative cognitive radio networks towards secure communications for maritime big data systems	Big Data	Ship operating
				Machine / aggregate
				Fleet optimization
			Simulation and modelling	VTS
			Software	AIS
				GPS-navigation
				ETA
				Control systems
Haasis et al. (2014) [35]	Dethloff, J., Haasis, H. D., Koper, H., Kotzab, H., Schönberger, J. (eds.) Logistics Management	Cloud-Based eBusiness Standardization in the Maritime Supply Chain	Automation	Cloud-based eBusiness
			Big Data	Networking
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Reporting
Isaias and Duarte Macedo (2007) [36]	Smith, M. J., Salvendy, G. (eds.) Human Interface and the Management of Information	Web services as a solution for maritime port information interoperability	Automation	Cloud-based eBusiness
			Big Data	Shiptraffic
				ETA
				Web services
			Software	ETA
				Services for port systems
			Sustainable Maritime Transport	ETA
Kim, Huh et al (2016) [37]	Kim, K. J., Joukov, N. (eds.) Information Science and Applications (ICISA)	Design and Implementation of Drone for Wideband Communication and Long-range in Maritime	Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
			Simulation and Modelling	Communication
Lee and Lee (2016) [38]	Lee, P. T. W., Cullinane, K. (eds.) Dynamic Shipping and Port Development in the Globalized Economy	New Concepts in the Economics of Flow, Connection, and Fusion Technology in Maritime Logistics	Simulation and Modelling	Development in new technologies
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Jiang et al. (2014) [39]	Lee, C. Y., Meng, Q. (eds.) Handbook of Ocean Container Transport Logistics	Innovative Container Terminals to Improve Global Container Transport Chains.	Automation	Automatisation in supply chains
				Infrastructure
			Sustainable maritime transport	Smart container (RFID technology)
				Conditions of cargo (RFID)
Xiang (2010) [40]	*Marine Science & Technology in China: A Roadmap to 2050*	Status and Opportunities of Chinese Marine Science & Technology Development	Automation	Technology development
			Simulation and modelling	Technology development
				Simulation

(Continued)

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Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Bendel (2015) (41)	*HMD Praxis der Wirtschafts-informatik*	Die Industrie 4.0 aus ethischer Sicht	Risks	Loss of workplaces
				Digital ethical risks
				Social risks
Grazia Speranza (2016) (42)	*European Journal of Operations Research*	Trends in transportation and logistics	Simulation and modelling	Technology development
			Sustainable maritime transport	Energy efficiency
Gharehgozli et al. (2016) (43)	*Maritime Economics & Logistics*	Sea container terminals: New technologies and OR models	Automation	Cloud-based eBusiness
			Simulation and modelling	New port facilities
				Simulation
				Development in new technologies
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Kim et al. (2016) (44)	*Maritime Economics & Logistics*	The impact of RFID utilization and supply chain information sharing on supply performance: Focusing on the moderating role of supply chain culture	Sustainable maritime transport	Smart container (RFID technology)
				Conditions of cargo (RFID)
				Smart container strategies and research
				Real-time tracking of globald aid transports
Birtchnell (2016) (45)	*Applied Mobilities Journal*	The missing mobility: friction and freedom in the movement and digitization of cargo	Software	Cargodata
			Sustainable maritime transport	Smart container (RFID technology)
				Real-time control of perishable cargo
				Conditions of cargo (RFID)
				Smart container strategies and research
Lee et al. (2003) (46)	*Maritime Policy & Management*	A simulation study for the logistics planning of a container terminal in view of SCM	Automation	Research and development
			Simulation and Modelling	New port facilities
				Development
				Simulation studies
			Software	Simulation and research
Jafari et al. (2010) (47)	*Maritime Policy & Management*	E-commerce development experiences in world's leading container ports and offering a model for Shahid Rajaee Port	Automation	Research and development
			Simulation and Modelling	New port facilities
				Development in new technologies
				Simulaton
			Software	Simulation and research
Roumboutsos et al. (2005) (48)	*Maritime Policy & Management*	Information technology network security risk assessment and management framework for shipping companies	Big Data	Networking
				Risk assessment and management
			Risks	Data misuse
				Sabotage
				Cyber-attacks
				Terrorist attacks

(Continued)

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Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Keceli (2011) (49)	*Maritime Policy & Management*	A proposed innovation strategy for Turkish port administration policy via information technology	Automation	Automatisation in supply chains
			Big Data	Port admnistrations
			Simulation and Modelling	Innovation strategies for future port administrations
				Administrations
Prokop (2012) (50)	*International Journal of Shipping and Transport Logistics*	Smart containers and the public goods approach to supply chain security	Sustainable Maritime Transport	Green supply chain
				Smart container (RFID technology)
				Energy efficiency
				Green port operations
				Conditions of cargo (RFID)
				Real-time tracking of global aid transports
			Risks	Cyber-attacks
				Research on the risks of security of the supply chain
				Security of the supply chain
Harder and Voß (2012) (51)	*International Journal of Shipping and Transport Logistics*	A simple RFID cost model for the container shipping industry	Sustainable maritime transport	Smart container (RFID technology)
				Conditions of cargo (RFID)
				Smart container strategies and research
				Real-time tracking of global aid transports
Berg and Hauer (2015) (52)	*Asia Insurance Review*	Digitalisation in shipping and logistics	Risks	Loss of workplaces
				Digital ethical risks
				Social risks
				Abolition of workplaces
Fabarius (2017a) (53)	*THB – Deutsche Schifffahrts-Zeitung*	Maritime Wirtschaft erfindet sich neu	Automation	Automatisation in supply chains
				Supply chain management
			Big Data	Control systems
			Risks	Cyber-attacks
Fabarius (2017b) (54)	*THB – Deutsche Schifffahrts-Zeitung*	Digitale Häfen brauchen mehr Sicherheit	Risks	Cyber-attacks
				Terrorist attacks
Fabarius (2017c) (55)	*THB – Deutsche Schifffahrts-Zeitung*	Digitalisierung braucht rechtlichen Rahmen	Big Data	Legislation on competitive advantages
			Risks	Data misuse
				Security of the supply chain
Arndt (2017) (56)	*THB – Deutsche Schifffahrts-Zeitung*	Digitalisierung bedingt auch Investitionen	Big Data	Cost-benifit analysis
			Simulation and modelling	Development in new technologies
Binder (2016a) (57)	*THB – Deutsche Schifffahrts-Zeitung*	AK Küste: CyberSicherheit verbessern	Risks	Data misuse
				Security of the supply chain

(*Continued*)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Binder (2016b) (58)	*THB – Deutsche Schifffahrts-Zeitung*	VDR: Reeder packen Digitalisierung	Automation	Automatisation in supply chains
				Digital technology
			Big Data	Fleet optimization
				Control systems
			Software	Communication technology
				GPS-navigation
				Routeplanning
				ETA
Binder (2017) (59)	*THB – Deutsche Schifffahrts-Zeitung*	Chancen für smart shipping und Big Data	Big Data	Cloud-based eBusiness
				Ship operating
				Machine/Aggregate
				Sensor-chip-technology
				Impact on maritime logistics
			Simulation and Modelling	Development
				Simulation
Binder et al. (2017) (60)	*THB – Deutsche Schifffahrts-Zeitung*	Die `Tesla` der Meere wird ein Boxcarrier	Automation	Autonomous / smart shipping
			Big Data	Risk assessment and management
				Autonomous / smart shipping
Lüders (2016) (61)	*THB – Deutsche Schifffahrts-Zeitung*	Digitalisierung reduziert Kosten	Big Data	Competitive advantages
				Economic impacts
			Sustainable maritime transport	Energy efficiency
				Reduction of emissions
Kleinort (2017) (62)	*THB – Deutsche Schifffahrts-Zeitung*	Daten-Plattform für maritime Branche	Automation	Control system
				Research and development
			Big Data	Cloud-based eBusiness
				Port administration
				Web services
				Reporting
			Software	Simulation and research
Germann (2017) (63)	*THB – Deutsche Schifffahrts-Zeitung*	Schifffahrt trifft Raumfahrt	Big Data	Sensor-chip-technology
				Impact on maritime logistics
N.U. (2016a) (64)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	Prozessoptimierung durch Digitalisierung im Seehafenumschlag	Automation	Automation in seaports
			Big Data	Port admnistration
				Control systems
			Software	Services for port systems
				Cargodata
Bruhn (2017) (65)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	Maritime Wirtschaft – an der Schwelle zur autonomen Schifffahrt	Automation	Autonomous / smart shipping
			Big Data	Autonomous / smart shipping

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Kretschmann and Schlegel (2016) (66)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	Service 4.0 als Chance für die maritime Zulieferindustrie	Big Data	Ship operating
				Machine/aggregate
				Networking
				Economic impacts
			Software	Service for port systems
			Sustainable maritime transport	Green shipbuilding industry
Von Lukas (2017) (67)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	Maritime Data Space: Mehrwert durch sichere Verknüpfung von Daten	Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Economic impacts
				Infrastructure
			Simulation and modelling	Technology development
Von Lukas (2016) (68)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	Zur Rolle des Menschen in der Zukunftsvision 4.0	Automation	Cloud-based
				eBusiness
				Control monitoring
				Control system
			Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Networking
				Optimization of administrative procedures
			Simulation and modelling	Administration
				Communication
Von Lukas et al. (2016) (69)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	3D-Technologie als Grundlage für die digitale Transformation der maritimen Wirtschaft	Simulation and modelling	Simulation studies
				Production processes
				Optimization simulation
			Sustainable maritime transport	Green shipbuilding industry
			Software	
N.U. (2016b) (70)	*Schiff&Hafen – Internationale Fachzeitschrift für Schifffahrt und maritime Technik*	Technology Outlook 2025: Ausblick auf die Schifffahrt der Zukunft	Automation	Autonomous / smart shipping
			Big Data	Autonomous / smart shipping
				Sensor-chip-technology
				Impact on maritime logistics
			Sustainable maritime transport	Green supply chain
				Reduction of emissions
				Green shipbuilding industry

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Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Reimann (2017) [71]	*DVZ – Deutsche Verkehrs-Zeitung*	Ab 2020 werden Schiffe ferngesteuert	Automation	Autonomous / smart shipping
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Autonomous / smart shipping
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Naumann (2017a) [72]	*DVZ – Deutsche Verkehrs-Zeitung*	Digitale Modelle setzen sich durch	Automation	Automatisation in supply
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Control systems
			Simulation and modelling	Development in new technologies
			Sustainable maritime transport	Conditions of cargo (RFID)
Granzow (2017) [73]	*DVZ – Deutsche Verkehrs-Zeitung*	Maritime Logistik wird digitaler	Automation	Automatisation in supply chain
				Supply chain management
			Big Data	Fleet optimization
				Sensor-chip-technology
				Impact on maritime logistics
				Competitive advantages
			Software	Communication technology
			Sustainable maritime transport	Energy efficiency
De Jong (2017a) [74]	*DVZ – Deutsche Verkehrs-Zeitung*	Der Seetransport wird transparenter	Automation	Alarm system
				Control monitoring
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Reporting
			Simulation and modelling	Communication
			Sustainable maritime transport	Energy efficiency
De Jong (2017b) [75]	*DVZ – Deutsche Verkehrs-Zeitung*	Praxisnahes Projekt berechnet Schiffsankunftszeiten in Seehäfen	Big Data	Shiptraffic
				ETA
			Simulation and modelling	VTS
			Software	ETA
				AIS

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Naumann (2016) [76]	*DVZ – Deutsche Verkehrs-Zeitung*	Mehr Effizienz und Sicherheit auf See	Big Data	Networking
				Fleet optimization
				Shiptraffic
				ETA
			Simulation and modelling	VTS
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Cargodata
Naumann and Reimann (2016) [77]	*DVZ – Deutsche Verkehrs-Zeitung*	Besser planen dank Bits und Bytes	Automation	Automatisation in supply chains
				Supply chain management
				Automatisation in seaports
			Big Data	Fleet optimization
				Shiptraffic
				ETA
				Control systems
			Software	AIS
				Service for port systems
De Jong (2016) [78]	*DVZ – Deutsche Verkehrs-Zeitung*	Automatisierung an der Kaikante	Automation	Automatisation in supply chains
				Automatisation in seaports
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
			Simulation and modelling	New port facilities
				Develoment
				Simulation
Zapp (2015) [79]	*DVZ – Deutsche Verkehrs-Zeitung*	Technik ersetzt Mannschaft	Automation	Autonomous / smart shipping
				Technology development
			Big Data	Ship operating
				Machine / aggregate
				Autonomous / smart shipping
			Sustainable maritime transport	Reduction of emissions
				Energy efficiency
Naumann (2014) [80]	*DVZ – Deutsche Verkehrs-Zeitung*	Die Zukunft gehört dem Smartport	Automation	Automatisation in seaports
				Supply chain management
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Port administration
			Simulation and modelling	New port facilities
				Simulation studies
				Innovation strategies for future port administrations
			Software	Service for port systems

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Naumann (2017b) (81)	*DVZ – Deutsche Verkehrs-Zeitung*	Digitalisierung verändert Schifffahrtsbranche	Automation	Automatisation in supply chains
				Digital technology
				Supply chain management
			Big Data	Cloud-based eBusiness
				Real-time
				Cloud-computing
			Software	VOIP
				Sustainable cost-reduction
				Reporting
Kloss (2016) (82)	*DVZ – Deutsche Verkehrs-Zeitung*	Und Iris knipst am laufenden Band	Automation	Autonomous / smart shipping
				Digital technology
			Big Data	Autonomous / smart shipping
			Simulationand modelling	Development in new technologies
N.U. (2017) (83)	*HANSA – International Maritime Journal*	Schifffahrt soll mit digitalen Start-ups zusammen arbeiten	Automation	Research and development
			Big Data	Networking
				Economic impacts
			Software	Competitive advantages
Selzer (2017a) (84)	*HANSA – International Maritime Journal*	Aufbruch ins Ungewisse	Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Legislation on competitive advantages
			Sustainable Maritime Transport	Governance
			Risks	Data misuse
				Security of the supply chain
				Sabotage
Selzer (2017b) (85)	*HANSA – International Maritime Journal*	Autonomy – virtually real?	Automation	Digital technology
				Technology development
			Simulation and modelling	Production processes
			Software	
Selzer (2017c) (86)	*HANSA – International Maritime Journal*	The human factor in cyber security	Risks	Cyber-attacks
				Security of the supply chain
Meyer (2017) (87)	*HANSA – International Maritime Journal*	Neue Cyber-Allianz mit bewährter Waffe	Big Data	Reporting
				Risk assessment and management
			Risks	Data misuse
				Cyber-attacks
Kuster (2017) (88)	*HANSA – International Maritime Journal*	Intelligent durch \`smarte\` Verdrahtung	Automation	Digital technology
				Control system
			Big Data	Control systems
			Simulation and modelling	Communication
				Production processes

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Leira (2016) (89)	*HANSA – International Maritime Journal*	Neue Ära der Kommunikation auf See	Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
			Simulation and modelling	Technology development
				Communication
			Software	Communication technology
Selzer (2016) (90)	*HANSA – International Maritime Journal*	Ohne Mann und Maus	Automation	Autonomous / smart shipping
			Big Data	Autonomous / smart shipping
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Meyer (2016) (91)	*HANSA – International Maritime Journal*	DNV GL will Innovationstreiber sein	Automation	Digital technology
			Big Data	Control systems
			Simulation and modelling	Production processes
			Risks	Cyber-attacks
Bertram (2011) (92)	*HANSA – International Maritime Journal*	IT-Trends in Schiffbau und Schifffahrt	Simulation and modelling	Technology development
				Development
				Simulation
				Production processes
			Software	Control systems
			Sustainable Maritime Transport	Reduction of emissions
				Energy efficiency
Bertram (2016) (93)	*HANSA – International Maritime Journal*	Smart connected and bigger	Big Data	Sensor-chip-technology
				Impact on maritime logistics
			Simulation and modelling	Optimization simulation
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
			Sustainable Maritime Transport	Energy efficiency
Bertram (2017) (94)	*HANSA – International Maritime Journal*	Get smart! Autonomy now!	Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Internet of Things
				Virtual reality
				Autonomous / smart shipping
			Simulation and modelling	Optimization simulation

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Bertram (2015) [95]	*HANSA – International Maritime Journal*	IT for smarter ship design and operation	Big Data	Shiptraffic
				ETA
				Virtual reality
			Simulation and modelling	VTS
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
Hochhaus (2011) [96]	*HANSA – International Maritime Journal*	IT-Lösungen für die Schifffahrt	Big Data	Control systems
				Augmented reality
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Simulation and research
Doyle (2017) [97]	*Maritime Logistics Professional*	Cyber attacks threaten shipping & dominate maritime news	Risks	Cyber-attacks
Keefe (2017) [98]	*Maritime Logistics Professional*	Cloud-based global trade Management: The sky is the limit	Automation	Cloud-based eBusiness
			Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Cloud-based eBusiness
				Reporting
				Networking
			Software	Control systems
Keefe (2016) [99]	*Maritime Logistics Professional*	Cyber security: Wake up call	Risks	Cyber-attacks
				Research on the risks of security of the supply chain
Keefe (2014) [100]	*Maritime Logistics Professional*	Optimize performance via data analytics	Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Competitive advantages
			Sustainable Maritime Transport	Sustainable maritime transport
				Energy efficiency

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Muccin (2015) [101]	*Maritime Reporter and Engineering News*	Combatting maritime cyber security threats	Automation	Autonomous / smart shipping
			Big Data	Autonomous / smart shipping
				Ship operating
				Machine / aggregate
			Simulation and modelling	Technology development
				Optimization
				Simulation
			Sofware	AIS
				GPS-navigation
				Routeplanning
				ETA
				Commnication technology
			Risks	Data misuse
				Cyber attacks
Trauthwein (2017a) [102]	*Maritime Reporter and Engineering News*	Rolls-Royce blue ocean team looks to the future	Automation	Automatisation in supply chains
				Autonomous / smart shipping
				Supply chain management
			Sustainable Maritime Transport	Energy efficiency
Trauthwein (2017b) [103]	*Maritime Reporter and Engineering News*	Software solutions: Monitor & Track	Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Economic impacts
			Simulation and modelling	Technology development
				Simulation
				Optimization
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Communication technology
				Sustainable transport models
Bobys (2017) [104]	*Maritime Reporter and Engineering News*	A case for maritime cyber security capability	Risks	Data misuse
				Cyber-attacks
Berge (2017) [105]	*Maritime Reporter and Engineering News*	Maritime cyber security: Good, better & best	Big Data	Networking
			Risks	Data misuse
				Cyber-attacks
				Research on the risks of security
				of the supply chain

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Grucza (2017) (106)	*Maritime Reporter and Engineering News*	Industry 4.0 on the high seas	Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Research to reduce emissions
			Sustainable Maritime Transport	Reduction of emissions
				Energy efficiency
Pekkanen (2017) (107)	*Maritime Reporter and Engineering News*	Big Data & a level playing field	Big Data	Fleet optimization
				Sensor-chip-technology
				Impact on maritime logistics
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Shiptraffic
				ETA
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Cargodata
				Control systems
				Communication technology
			Sustainable Maritime Transport	Energy efficiency
Pribyl (2016) (108)	*Maritime Reporter and Engineering News*	Drones: Is the maritime industry ready?	Automation	Automatisation in seaports
				Research and development
				Technology development
				Control system
			Big Data	Competitive advantages
				Economic impacts
				Cost-benefit analysis
				Legislation on competitive advantages
				Infrastructure
			Risks	Security of the supply chain

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Segercrantz (2016a) (109)	*Maritime Reporter and Engineering News*	Cyber security in shipping & offshore ops	Big Data	Control systems
				Transactional data
			Simulation and modelling	Communication
			Risks	Cyber-attacks
				Sabotage
				Security of the supply chain
Muccin (2016) (110)	*Maritime Reporter and Engineering News*	Cyber world: Safer seas via phantom ships	Automation	Autonomous / smart shipping
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Control systems
				Autonomous / smart shipping
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Control systems
			Risks	Cyber-attacks
				Social risks (loss of workplaces)
				Research on the risks of security of the supply chain
Stoichevski (2016) (111)	*Maritime Reporter and Engineering News*	The `paperless` ship	Automation	Cloud-based eBusiness
				Digital technology
				Technology development
				Autonomous / smart shipping
			Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Cloud-based eBusiness
				VOIP
				Autonomous / smart shipping
			Simulation and modelling	Technology development
				Communication
				Development in new technologies
				Technologies to transform aims

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Haun (2015) [112]	*Maritime Reporter and Engineering News*	E-Procurement streamlined via the cloud	Automation	Cloud-based eBusiness
				Digital technology
			Big Data	Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Cloud-based eBusiness
				Reporting
				Web services
			Simulation and modelling	Optimization
				Simulation
				Development in new technologies
Segercrantz (2016b) [113]	*Maritime Reporter and Engineering News*	Big Data & big savings for maritime ops	Automation	Automatisation in supply chains
				Cloud-based eBusiness
				Digital technology
				Technology development
			Big Data	Sensor-chip-technology
				Impact on maritime logistics
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Cloud-based eBusiness
				Control systems
				Web services
			Simulation and modelling	Technology development
				Communication
				Development in new technologies
			Software	Communication technology
Hartmann and Remick (2015) [114]	*Maritime Reporter and Engineering News*	Cyber security & the challenge to maritime networks	Big Data	Networking
			Simulation and modelling	Communication
				Technologies to transform aims
			Software	Communication technology
			Risks	Cyber-attacks

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Rhodes and Soccoli (2015) [115]	*Maritime Reporter and Engineering News*	Big Data: Big value or big risk?	Big Data	Transform aims
				Internet of things
				VOIP
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Control systems
				Communication technology
			Risks	Cyber-attacks
				Terrorist attacks
Segercrantz (2015a) [116]	*Maritime Reporter and Engineering News*	DNV GL: `Big Data` evolving fast; LNG slower than expected	Big Data	Internet of things
				Research to reduce emissions
				Implementing green supply chain practices
			Simulation and modelling	Technology development
				Development in new technologies
			Sustainable Maritime Transport	Reduction of emissions
				Energy efficiency
				Green shipbuilding industry
Weigel and Singleton (2014) [117]	*Maritime Reporter and Engineering News*	Electronic navigation & dispute resolution: Coming of age	Simulation and modelling	Development in new technologies
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Control systems
				Simulation and research
Bryant (2017) [118]	*Maritime Reporter and Engineering News*	Balancing efficiency & security as maritime goes digital	Simulation and modelling	Development in new technologies
			Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Control systems
			Sustainable Maritime Transport	Energy efficiency
			Risks	Cyber-attacks

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Haynes (2016) [119]	*Maritime Reporter and Engineering News*	Unmanned surface vessels: From concept to service	Automation	Autonomous / smart shipping
			Big Data	Autonomous / smart shipping
				Control systems
				Research to reduce emissions
			Simulation and modelling	Production processes
				Technolologies to transform aims
				Simulation studies
			Sustainable Maritime Transport	Energy efficiency
Stoichevski (2015) [120]	*Maritime Reporter and Engineering News*	The maritime launch of Big Data	Big Data	Networking
				Sensor-chip-technology
				Impact on maritime logistics
				Reporting
				VOIP
			Simulation and modelling	Technology development
				Communication
Driver (2015) [121]	*Maritime Reporter and Engineering News*	Big IT: How fast, how far will IT drive maritime?	Big Data	Networking
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
				Internet of things
				Research to reduce emissions
				Port administration
				Competitive advantages
			Simulation and modelling	Development in new technologies-Simulation
Segercrantz (2015b) [122]	*Maritime Reporter and Engineering News*	Unmanned vessel: The future is now	Automation	Control system
				Autonomous / smart shipping
			Big Data	Autonomous / smart shipping
				Sensor-chip-technology
				Impact on maritime logistics
				Fleet optimization
			Sustainable Maritime Transport	Energy efficiency
			Risks	Cyber-attacks
				Security of the supply chain
Baldauf (2013) [123]	*Maritime Reporter and Engineering News*	Standartization for safer shipping of e-navigation & training	Software	AIS
				GPS-navigation
				Routeplanning
				ETA
				Control systems
				Communication technology
				Simulation and research

(Continued)

Table 2. (*Continued*)

Author, year of publication, reference number	Publication outlet	Publication title	Major topic	Subtopic(s)
Trauthwein (2013) (124)	*Maritime Reporter and Engineering News*	Software solutions picking up steam	Big Data	Fleet optimiziation
				Real-time
				Cloud-computing
				VOIP
				Sustainable cost-reduction
			Simulation and modelling	Technology development
				Development in new technologies
				Simulation studies
			Software	Control systems
				Communication technology
				Sustainable transport models
				AIS
				GPS-navigation
				Routeplanning
				ETA
			Sustainable maritime transport	Energy efficiency

4. Analysis

4.1. Results

The results of the literature analysis are depicted in the concept matrix in Table 3.

In the following, we assigned the publications to subject-specific clusters and analyzed them accordingly. Before explaining the defined clusters in more detail, it must be pointed out that the individual contributions do not always allow for a clear assignment, since they often refer to aspects of different clusters. Therefore, the respective thematic main focus of each contribution was decisive for its clustering.

In the practical as well as the scientific literature of the years 2003 through 2017, a total of 124 relevant contributions covering the topic of digitization in maritime logistics were identified. The publications cover a broad spectrum and show the areas in need of development. It is striking that in the analyzed literature there is no systematic literature review on digitization in maritime logistics and it must be assumed that no literature review has been carried out on this topic until now. The majority of the identified contributions (88%) stems from IS-, maritime- and management-related journals or conferences, the remaining contributions (12%) are book publications. Furthermore, 22% of the articles originate from the general transport and logistics sector, 33% are IS or management-related articles and almost half of the identified contributions (45%) stem from the maritime logistics sector. Almost all publications are written in English (98%), which is related to the fact that the keyword search in the search engines of the literature databases and trade journals was carried out in English. In addition to the search in the literature, we carried out an open Google search (forward and backward) by applying all keyword combinations. In comparison to the scientific contributions, all 72 practical contributions were published in maritime- and transport-related journals. Of these, 39 contributions (54%) were written in German, the remaining 33 contributions (46%) in English.

Furthermore, we looked at the countries of origin of the respective leading authors in the scientific literature, or rather their institutions. As to the scientific literature, there is a strong concentration of

Table 3. Stakeholders and artifacts in scope of digitization in maritime logistics

Who?	Logistics providers	Infrastructure and service providers	Maritime industries	Research and scientific community	Governments
What?	Example Reference	Example Reference	Example Reference	Example Reference	Example Reference
Automation	Control monitoring [7, 10, 68, 74]	Cloud-based eBusiness [2, 6, 7, 24, 35, 36, 43, 62, 68, 98, 111, 112, 113]	Digital Technology [1, 18, 58, 81, 82, 85, 88, 91, 111, 112, 113]	Research and development [3, 23, 46, 47, 27, 17, 62, 83, 108]	Energy optimization [4, 5, 25, 26, 8, 12]
	Alarm system [3, 4, 5, 74]	Automation in seaports [7, 8, 2, 28, 63, 77, 78, 80, 108]	Control system [27, 62, 68, 88, 108, 122] Supply chain management [21, 53, 73, 77, 80, 81, 102]	Technology development [40, 79, 85, 108, 111, 113]	Community Stakeholders [2]
	Automatisation in supply chains [39, 49, 7, 8, 22, 28, 53, 58, 72, 73, 77, 78, 81, 102, 113]		Autonomous / smart shipping [60, 65, 70, 71, 79, 82, 90, 101, 102, 110, 111, 119, 122]		Infrastructre [39]
Big Data	Ship operating, Machine/ Aggregate [34, 59, 66, 79, 101]	Cloud-based eBusiness [2, 3, 24, 28, 59, 62, 81, 98, 111, 112, 113]	Transform aims [1, 2, 115]	Optimization of administrative procedures [33, 68]	Air quality, Atmospheric environment, [12, 14, 30, 31]
	Fleet optimization [2, 19, 24, 25, 33, 34, 9, 10, 58, 73, 76, 77, 107, 122, 124]	Reporting [33, 35, 10, 62, 74, 81, 87, 98, 112, 120]	Control systems [27, 28, 53, 58, 63, 72, 77, 88, 91, 96, 109, 110, 113, 119]	Research to reduce emissions [2, 11, 105, 116, 119, 121]	Legislation on competitive advantages [2, 3, 18, 19, 55, 84, 108]
	Networking [35, 48, 8, 9, 66, 68, 76, 83, 98, 105, 114, 120, 121]	VOIP [18, 35, 37, 89, 111, 115, 120]	Implementing green supply chain practices [20, 116]	Web services [36, 62, 112, 113]	Infrastructure [26, 67, 108]
	Sensor-chip-technology, impact on maritime logistics [8, 22, 59, 63, 67, 70, 71, 72, 73, 74, 78, 80, 84, 93, 94, 100, 103, 105, 107, 110, 113, 120, 122]	Shiptraffic, ETA [33, 36, 9, 75, 76, 77, 95, 103, 107] Compet. advantages [3, 18, 19, 61, 73, 83, 100, 108, 121]	Internet of Things (IoT) [94, 115, 116, 121] Virtual Reality (VR) [94, 95]	Cost-benefit analysis [3, 56, 108]	Transactional data [19, 109]
	Real-time, cloud-computing, VOIP, sustainable cost-reduction [18, 35, 37, 28, 68, 81, 89, 98, 103, 105, 107, 111, 112, 113, 121, 124]	Port administration [49, 62, 63, 80, 121]	Augmented Reality (AR) [96]		
	Risk assessment and management [48, 60, 87]	Economic impacts [6, 61, 67, 83, 103, 108]	Autonomous / smart shipping [60, 65, 70, 71, 79, 90, 94, 101, 110, 111, 119, 122]		
Simulation and modelling	Technology development [2, 40, 42, 22, 67, 92, 101, 103, 111, 113, 116, 120, 124]	Development, Simulation [4, 40, 43, 46, 47, 59, 78, 92, 103, 121] VTS [2, 10, 33, 34, 75, 76, 95]	Production processes [15, 69, 85, 88, 91, 92, 119] Optimization, simulation [16, 17, 69, 93, 94, 101, 103, 112]	Simulation studies [23, 46, 17, 69, 80, 119, 124]	Innovation strategies for future port administrations [49, 80]
	New port facilities [43, 46, 47, 78, 80]	Administration [49, 68] Communication [37, 68, 74, 88, 89, 109, 111, 113, 114, 120]	Technologies to transform aims [1, 111, 114, 119]	Development in new technologies [38, 40, 43, 47, 56, 72, 82, 91, 101, 111, 112, 113, 117, 118, 121, 124]	
Software	AIS, GPS-Navigation, routeplanning, ETA [1, 2, 19, 33, 34, 38, 43, 9, 22, 58, 71, 76, 90, 93, 95, 96, 101, 103, 107, 110, 115, 117, 118, 123, 124]	ETA [33, 36, 9, 75, 103, 107, 118, 123] AIS [4, 75, 77, 93, 101, 103, 107, 117, 118, 123]	Control systems [27, 21, 28, 34, 92, 98, 107, 110, 115, 117, 118, 123, 124]	Simulation and research [3, 46, 47, 15, 17, 62, 96, 117, 123]	Sustainable transport models [5, 103, 124]
	Cargodata [45, 64, 76, 107, 115]	Services for port systems [24, 36, 64, 66, 77, 80]	Communicat. Technology [1, 18, 58, 73, 89, 101, 103, 107, 113, 114, 115, 123, 124]		

(Continued)

Table 3. (*Continued*)

Sustainable Maritime Transport	Reduction of emissions [12], [14], [31], [61], [70], [79], [105], [116]	Energy efficiency [11], [13], [14], [50], [61], [73], [74], [79], [93], [100], [105], [116], [118]	Energy efficiency [42], [61], [73], [74], [79], [92], [100], [102], [105], [107], [116], [118], [119], [122], [124]	Research studies [13]	Emissions [12] Legislation infrastructure [26]
	Sustainable maritime transport [5], [25], [26], [30], [31], [100]	Green port operations [5], [26], [50], [13], [14], [29]	Green shipbuilding industry [26], [20], [12], [66], [69], [70], [116]	Development in supply chain [3], [31]	Implementing [20] Energy efficiency [29]
	Green supply chain [50], [11], [13], [29], [70]	Logistics clusters [25]		Smart container strategies and research [3], [45], [24], [33], [44], [51]	Governance [30], [31], [84]
	Smart container (RFID technology) [45], [24], [39], [44], [50], [51]	ETA [9], [33], [36], [71], [75], [76], [77], [93], [95], [103]			Real-time tracking of global aid transports [23], [44], [50], [51]
	Real-time control of perishable cargo [45], [24]	Conditions of cargo (RFID) [45], [24], [39], [44], [50], [51], [72]			
Risks	Cyber-attacks [32], [48], [53], [54], [86], [87], [97], [99], [101], [104], [105], [110], [114], [115], [118], [122]	Cyber-attacks [48], [50], [32], [53], [54], [86], [87], [97], [99], [101], [104], [105], [114], [115], [118], [122]	Cyber-attacks [48], [32], [53], [54], [86], [91], [97], [99], [101], [104], [105], [109], [110], [114], [115], [118], [122]	Research on the risks of security of the supply chain [50], [99], [105], [110]	Abolition of workplaces [52]
	Data misuse [48], [55], [57], 84), [87], [101], [104], [105]	Loss of work-places [41], [52]	Social risks (loss of workplaces) [41], [52], [110]		Terrorist attacks [48], [32], [54], [115]
	Loss of workplaces [41], [52], [110]	Digital ethical risks [41], [52]	Digital ethical risks [41], [52]		Data misuse [48], [55], [57], [84]
	Digital ethical risks [41], [52]	Sabotage [48]	Sabotage [48], [109]		Security of the supply chain [50], [55], [57], [84], [86], [108], [109], [122]
	Sabotage [48], [84]				Sabotage [48], [84], [109]

authors from the EU (55%), followed by authors from Asia (31%), North America, and Australia (6%) as well as Egypt (2%). Considering the identified practical contributions, the share of authors from the EU is similarly high (62%). The remaining articles originate from North America (38%).

Given the fact that artifacts such as big data, simulation and modeling and sustainable maritime transport play an important part in the digitization of maritime logistics, and thus are equally essential for all involved stakeholders, it is comprehensible that many of the identified contributions address such artifacts as well as the corresponding ICT. It is, however, surprising that only few publications stem from the maritime industry (i.e. shipbuilding and offshore industry). From the above results, it is clear that within the scientific community the research field digitization of maritime logistics is still in its initial stage. In practice literature, the situation is different as can be seen from the following contributions: The optimization of processes in the maritime logistics chain by new technologies and the resulting reduction of costs (Lüders, 2016), the transparency of the sea transport by sensor chip technologies (De Jong, 2017a) and the autonomous navigation and the subsequent reduction in ship occupancies (Selzer, 2016) are often discussed topics. Nevertheless, the analyzed publications show a clear homogeneity regarding the benefits of digitization for maritime logistics.

Table 4. PESTEL-Matrix with recommendations for digitization in maritime logistics

Digitization in maritime logistics:		**Perspective**
Recommendations for action:		**P E S T E L**
Challenge 1:	Compliance with future stricter environmental requirements:	Environmental
The maritime logistics chain will change as a result of increasingly stringent environmental directives. The environmental directives limit the **sulfur content of bunker oil at 3.5% from January 2020 to 0.5%** (Gilbert, 2014). Since 2015, 0.1% has already been applied to areas which are particularly protected. A climate friendly and forward-looking fuel is, among other things, liquid natural gas (LNG), in its use in the long term hardly anyone will pass by (Brandt, 2016). However, when a shipping company converts to low-emission engines is an individual decision. CO2 emissions and noise can be avoided in the ports by feeding eco-friendly electricity from ashore side into the onboard network.		
Challenge 2:	Digital transformation of the maritime logistics chain + Data security and data protection	Technological
Digitization will change maritime logistics through intelligent networking of logistical processes and automation, and will contribute to **increasing efficiency** in shipping, management and service (Brouer et al., 2016), in which business models and their processes will be changing significantly in the foreseeable future: • Real-time tracking of cargo and cloud-based monitoring of ship systems are no longer a future issue (Biccario et al., 2014). • The remote controlled or fully automatic ship operation will become reality in the foreseeable future (Maluck, 2016). • Digital players will enter the market as competitors and support the digital conversion of maritime logistics with technical solutions (Brandt, 2016). The stakeholders of maritime logistics should adapt themselves to new competitors, invest in digital business models and in the future assume more tasks in the maritime supply chain in order to remain viable. Digitization will force shipping companies to deepen their service portfolios and cover the entire supply chain, not just at sea but also increasingly on land (Brandt, 2016). The growing volume of data, the demand for mobility in logistics and the exchange of information also lead to a **growing need for data security and data protection** in maritime logistics in order to prevent manipulations of sensitive systems. Existing defensive concepts (defense-in-depth models) are increasingly reaching their limits. Companies should protect their data against **unauthorized access and any kind of abuse by cloud-based user systems, access management, device management and data backup**, and make appropriate investments in IT security.		
Challenge 3:	Big Data in maritime logistics + Process optimization	Economic
The use of Big Data holds potentials and risks at the same time: • Operational planning and control processes can be improved in the maritime supply chain (Brouer et al., 2016). • Based on mathematical algorithms, based on real-time data from ship operation, ship arrival times can be predicted earlier and more accurately.In the future the stake-holders, involved in the maritime logistics chain, will be able to adjust their resource dispositions flexibly in an early stage to adapt to the ships arrival time. The **significant volume growth** in the area of container traffic, as well as other maritime transport services, **poses major challenges for the logistics chain**. The actors of the maritime logistics chain should present and model the existing processes in a process optimization software and then optimize them. In addition to the development of **meta-simulation models**, for example for container terminals in the seaports, with a discreet, event-oriented character, optimization methods from other economic sectors could also be taken into account and these would then be made use of for maritime logistics. Examples of **Lean Management**, from the further development of the term Lean Production, should be mentioned here. This creates opportunities for improving the quality of the maritime supply chain as well as increasing productivity and optimizing the process as a whole. **Ship arrival times** can be **optimized and more accurately predicted**, using new technologies as well as **reduced waiting times in ports** (Fruth, 2016). Equipped with **RFID technologies**, the **path of a product can be tracked and monitored** in a container, from the consignor to the consignee, without any gaps (Bai et al., 2010). The goods are cross linked across borders. Operating conditions and coordinates of goods can be interchanged and communicated.		

(Continued)

Table 4. (*Continued*)

Digitization in maritime logistics:		**Perspective**
Recommendations for action:		**P E S T E L**
Challenge 4:	Financial support:	Political
For years sea shipping has been in one of its most severe crises. There is no fresh capital to modernize fleets or to implement other large scale projects, because for many banks an engagement in shipping is no longer an option. In difficult times like these, many maritime companies hesitate to invest in new technologies due to high investment costs. One of the **most important challenges** is to **motivate and promote maritime companies for the introduction of new technologies**, for example through financial support measures by the Federal Ministry of Transport and Digital Infrastructure (BMVI) and through government sponsored funding programs for the maritime economy and research.		
Challenge 5:	Regulatory compliance:	Legal
The use of the AIS (Automatic Identification System) and RFID technologies requires the automated recording of personal data in some applications. When using the AIS technology, ships have a transponder on board, identify themselves among themselves, as well as with traffic control centers on land, and make **relevant static, travel related and dynamic data** clearly known. **Personal data** of the watchkeeping officer or captain are also transmitted. In these cases there are ethical and legal concerns regarding the privacy of the respective crew members. These data are available **for everyone** who has a corresponding receiver and can therefore pose a **threat to the ship and its crew members** when the ship is, for example in driving areas, affected by pirates or other criminal acts. Prior to the implementation of these technologies, restrictions on privacy and data protection should be reviewed by legislation. In addition reliable and political framework conditions, especially in the course of digitization and automation in the maritime logistics chain, are recommended so that seaports can continue to function as logistical hubs. Regulatory guidelines, on the part of the governments, could make the economic development of port cities and entire coastal regions more difficult. Uniform conditions of competition, as well as an environmental policy that would allow for future development opportunities for seaports, would be a possible approach.		
Challenge 6:	Social impact of digitization on the qualification and competencies of specialists in maritime logistics:	Social
Through the digitization and automation of many areas maritime logistics will change. **Smart-Shipping** will create **more attractive and responsible jobs onshore for the monitoring and remote maintenance of ships** (Binder, 2016c). However, the use of new technologies requires appropriate expertise and the need for advanced skills. An **increasing need for training and development in the field of new technologies will be necessary in the future**. The major challenge is therefore to create and develop new competencies, to optimize project organizations and to gain new talents. **Experience, willingness to integrate and technical knowledge** are among the most important issues that should be considered. Companies should work with their employees to develop ideas, for example on the basis of "planning games", how they can implement these things and introduce ideas for the creation of innovations. This enables effective analysis of business processes as well as the disclosure of existing improvement potentials by realizing company processes. Furthermore, interdisciplinary groups could be formed to work together to increase the efficiency of the companies.		

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In the area of new technologies and Big Data Analytics, the authors analyzed an efficiency increase in the area of ship operations, as well as an optimization of the maritime traffic through the exchange of data between ship–ship and ship–land actors and the use of ICT (Haraldson, 2015; Roumboutsos, Nikitakos, & Gritzalis, 2005). Port Community Systems (Carlan, Sys, & Vanelslander, 2016) and e-transformation systems based on IT transform and enhance the internal and external value chains as well as the transshipment activities in the ports (Lee et al., 2016). The smart, RFID-equipped container contributes to the sustainability of sea transport and significantly improves the transparency and security of international intermodal container traffic (Haraldson, 2015). In addition, RFID technologies enable the involved stakeholders to ensure a complete transparency along the entire process chain (Prokop, 2012).

Based on the AIS technology, real-time monitoring can be used to prevent pollution and protect the environment, as AIS technology optimizes maritime traffic, reduces the risk of accidents and minimizes environmental pollution (Yao Yu & ChangChuan, 2011). The fact that sustainability in the field of sea transport is a central and forward-looking theme, the actors of the entire maritime logistics chain are faced with corresponding challenges (Psaraftis, 2016; Stevens, Sys, Vanelslander, & van Hassel, 2015). The topic of cyberattacks and data misuse is also given much consideration in practical literature (Segercrantz, 2016a), as there is consensus that digitization is supposed to improve cybersecurity (Binder, 2016a) and needs a legal framework (Fabarius, 2017c).

As in other areas of the economic world, the analyzed literature shows that digitalization does not only bear chances but also risks, such as data misuse, cyberattacks as well as the loss of certain jobs for the maritime industry (Bendel, 2015; Sen, 2016), which must also be considered.

4.2. Discussion

The results indicate that research in the digitization of maritime logistics is still in its initial stages. Our wide-ranging search revealed only a small number of scientific literature and shows that digitization in the maritime logistics chain is currently being addressed and considered rather in practical than scientific literature. With regard to our research questions, we come to the following conclusion: Digitization has already reached in maritime logistics in some areas and its potential to change the maritime industry is huge. Automation and digitalization are progressing and have changed processes in ship operation and in port handling. Smart container technologies (RFID) and real-time tracking of cargo, for example, increase the transparency on the transport route from the sender to the recipient. Shipping companies are already in a position to operate their own tracking apps in the near future, where the location of the container can be determined by means of a GPS signal (Brandt, 2017). By using modern sensor chip technologies, a large number of data are already recorded at sea and analyzed onshore, which allows the optimization of process flows on board as well as in the handling in ports. Further, it reduces waiting times and costs (De Jong, 2016). The focus of the identified papers is on the optimization of ship operation and terminal transshipment procedures by means of GPS, ICT as well as closely networked stakeholders. However, the areas of sustainability, emissions reduction, use of alternative fuels, as well as the risks of cyberattacks find little consideration in the identified literature. A growing volume of data in the area of the optimization of maritime traffic, port handling operations, and smart container technologies (e.g. RFID and sensor technologies) is expected.

Digital technologies will ensure shorter waiting times for ships and faster processing at the terminal. Besides, ship crews will be able to adapt their navigation using real-time updates to weather, wind, and ocean currents, which involves reduced energy consumptions (Lee et al., 2016). In view of the MARPOL[4] guidelines on climate protection and stricter environmental requirements, the shipping companies will have to equip their fleets with more environmentally friendly marine propulsion systems in order to be able to use alternative fuels such as liquefied petroleum gas (LNG) in the future (Brandt, 2016). Although the emissions in ports are already being slightly reduced by the use of marine diesel instead of heavy oil, CO^2, nitrogen oxides, particulate matter and sulfur oxides are the main sources of the environmental pollution. To reduce such pollution, electric energy could be fed into the ship's network from onshore, which would require appropriate connections and converters (Winkel, Weddige, Johnsen, Hoen, & Papaefthimiou, 2016). Thanks to the digitization, it is further already technically possible to monitor the system ship from a central station onshore. In the future, the technical know-how will be needed rather onshore than on board of the ships (Binder, 2016c).

The digitalization in the maritime logistics sector offers a multitude of opportunities and challenges. For example, companies could take advantage of the digital transformation and position themselves on the market with applicable products, services or innovative business models (Brandt, 2017). On the whole, one can safely assume that there will be fundamental changes in ship operation and ICT. The shipping companies are assuming that, as a result of digitization, companies such as Google and Amazon will support the digital conversion of the shipping industry through technical services and will have to confront an increasing number of new competitors. Given this dramatically changing performance spectrum, also the shipping companies are forced to increasingly assume new tasks in order to remain competitive (Brandt, 2016).

As in aviation, the unmanned operation of ships is also feasible in maritime shipping. Experts predict the use of autonomous feeder ships that will transport containers on particular routes with limited reach. However, their opinions diverge as to when the first unmanned seagoing vessel will travel over the world's sea. On the industry side, it is assumed that the first autonomous ship will become a reality at the end of this decade (Maluck, 2016). According to the IT industry, however, it will still take 15 to 20 years (Kuchta, 2016). Given the high complexity of variables, many of them being unknown or difficult to predict (e.g. tide, weather, terrorism, emergency situations, increasing ship traffic), it is rather unlikely that large seagoing vessels can entirely be operated without staff (Berg & Hauer, 2015). And yet, the electronic on-board systems are in a position to take over a large part of the tasks and provide support so that the crew sizes will be further reduced (Burmeister, Bruhn, Rødseth, & Porathe, 2014).

As any networked data system, ships are also an attractive target for hacker attacks. The real-time data transmission of the smart, RFID-equipped container renders transparent the container's position, its content, and the state of goods at all times. Likewise, it can be traced whether the container was opened illegally or not. This transparency can indeed conceal immense dangers, such as criminal cyberattacks or unintentional data leaks (Berg & Hauer, 2015). The digital navigation systems of the ships could be manipulated so that they sheer off or run aground. Also a single power failure can have far-reaching consequences in a networked and digital environment (Kuchta, 2016). In maritime logistics, a large number of mostly international stakeholders are involved in transport processes. The increase in digitization and networking between ships, shipping companies, port companies, offshore installations, authorities and other communication partners onshore increase the risk of cyberattacks for all stakeholders involved. Therefore, all players in the maritime supply chain will have to ensure the best possible protection in order to ward off cyberattacks, which has to be ensured by consequently investing in the future development as well as expansion of IT security systems (Segercrantz, 2016a).

Due to the resulting logistics processes, the information requirements and the requirements for the logistical planning and control processes are high. As a result, protected and effective ICT gain in importance in maritime logistics as they contribute to increasing safety and effectiveness in maritime transport and port management (Jahn, Bosse ,& Schwientek, 2011). The results of the literature analysis indicate that the digitization of maritime logistics is still at the beginning of its development. So far, only sub areas have been investigated which hardly provide a basis for developing well-founded recommendations for the maritime logistics. For this reason, the authors propose recommendations for action that are structured in the PESTEL matrix (Kaplan & Norton, 2008) summarized in Table 4 in six dimensions (political, economic, social, technological, ecological and legal).

5. Conclusion

5.1. Limitations

Like all other scientific papers, this article also has limitations. There is thus the possibility that not all relevant articles in the selection phase were filtered by means of keywords. There are various reasons for this, e.g. the incompleteness of the defined key words, the alternative concept names in the articles and the limitation to predefined publication outlets. The categorization of the articles also requires a substantive examination and evaluation, in which a distortion by the authors' subjectivity is never completely excluded. This article, however, provides important new insights and discusses the current state of research on digitization in maritime logistics.

5.2. Closing considerations and implications for science and practice

By means of a systematic literature analysis, it is possible to cope with the confusing amount of practical and scientific literature in the research process. Research gaps can be identified on the basis of the current state of science, and the corresponding research needs can be formulated. In this article, the status quo of digitization in maritime logistics was discussed by means of a systematic literature analysis of published articles from scientifically representative trade magazines, books, web pages and conferences, with regard to content and methodology dealing with digitization in maritime logistics. To the best of our knowledge there is, up to now, no systematic literature analysis on digitization in maritime logistics, neither in maritime specialist publication outlets, nor in a VHB-ranked journal, although the research topic proved to be relevant. In the area of sustainable maritime transport aiming at the reduction of ship emissions by means of alternative ship propulsion, there is a corresponding need for development, since it is the topic of the future in sea transport with only a few publications in the scientific literature. The majority of the publications are research results in specialist journals and specific conference volumes. A large part of the publications was also found in the so called grey literature. The study and its results show that practice recognized the development potential. Nevertheless, research is still at an early stage. On the one hand, there is a lack of theoretical studies that examine in more detail the future behavior of actors in the maritime logistics chain. On the other hand, alternative explanatory approaches to recommend appropriate action and restructuring are missing. We therefore recommend to expand this research into areas where information and big data projects have already been implemented. The aim of the research in this area is to provide robust contributions to theory that are characterized by high and clear predictive power of expression and as well as theoretical interpretations. These artifacts could be achieved by methodological and theoretical triangulation.

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Notes

1. Twenty foot Equivalent Unit. Abbreviation TEU. 1 TEU corresponds to a 20-foot standard ISO container.
2. AIS = Automatic Identification System is a radio system that improves the safety and control of ship traffic by exchanging navigation and other ship data.
3. A feeder ship (from the english word to feed) is a cargo vessel specially built for container and car transportations, which acts as a supplier and distributor for large seagoing vessels and seaports.
4. Marine Pollution—International Convention for the Prevention of Marine Pollution from Ships.

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