Digital technologies and business opportunities for logistics centres in maritime supply chains

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Abstract

The study investigates how the adoption of emerging digital technologies can provide valuable business opportunities for logistics centres in maritime supply chains. For this purpose, a systematic literature review (SLR) of prior academic studies addressing this topic is performed. The review unveils the current lack of a comprehensive framework to assess the impact of digital technologies on transport and maritime logistics, bringing insights for a promising research agenda. The paper proposes an ad-hoc conceptual framework for disentangling relevant business opportunities which originates from the adoption of cutting-edge digital technologies for each type of logistics centres. The main business benefits for logistics infrastructures which manage cargo flows in maritime supply chains (MSCs) are identified and discussed. The results suggest alternative strategic options for innovating logistics chains and increase the competitiveness of various cargo logistics centres. Managerial and marketing implications for both academics and practitioners are discussed in-depth.

Keywords: logistics centres; maritime supply chain; digital technologies; business opportunities; digital innovation.

1. Introduction

Digital innovation is shaping the architecture of maritime supply chains (Carlan et al., 2017; Cariou, 2018). Operational efficiency and costs reduction as well as strengthening of decision-making process and stakeholder relationship management (SRM) are just some of the business benefits that digital technologies of Industry 4.0 offer to logistics centres embedded in maritime supply chains (MSCs), including port terminals, distribution centres, intermodal terminals and dry ports (Lee et al., 2016; Haddud et al., 2017; Heilig and Voß, 2017; Arunachalam et al., 2018). Among the most promising technologies, scholars agree that IoT platforms, cloud computing and blockchain will be potentially disruptive for the sector (Cariou, 2018). Their implementation enables to unbundle information flows from related physical cargo flows and to digitally share data among the actors involved in MSCs (Bruque Camara et al., 2015; Molano et al., 2017). This promotes a collaborative attitude and supports the creation of wider logistics networks (Abdel-Basset et al., 2018). Digital technologies also ensure the effective storage of manufacturing goods and commodities both in port terminals and hinterland logistics centres, reducing transit times and maximizing cargo value (Wamba et al., 2008; Du and Bergqvist, 2010; De Langen, and Douma, 2010). Furthermore, logistics service providers (LSPs) benefit from these innovations because they can extend the array and quality of ancillary services ensured to vehicles, firms and people (Higgins et al., 2012; Büyüközkan and Göçer, 2018).

Recent studies have investigated the key drivers of logistics centres' attractiveness (see e.g., Notteboom et al., 2017). Carlan et al. (2017) emphasize the growing relevance of information and communication technologies' infrastructural endowment (e.g., electronic data interchange, applications for monitoring of vehicles and cargo, and for supporting cargo flows), which significantly contribute to the competitiveness of maritime-related logistics centres. ICT systems, and promptly digital technologies, generate valuable business opportunities for both service differentiation and cost saving in various logistics activities, including cargo handling, warehouse management, track and trace operations, sales activities, safety and security and payment methods (Marchet et al., 2009; De Langen and Douma, 2010; Cariou, 2018). Additionally, they facilitate the collaboration among the heterogeneous actors of MSCs, fostering networking and marketing as well as stakeholder relationship management (Bellingkrodt and Wallenburg, 2013; Abdel-Basset et al., 2018).

Based on above considerations, many scholars recognize the beneficial effects of digital technologies on logistics centres' business model and strategies (see e.g., Carlan et al., 2017; Cariou, 2018). However, the implications are not the same for every logistics nodes which are thus called to identify the most suitable innovations for their business. Previous studies, indeed, outline different typologies of logistics centres embedded in MSCs according to their features and distinctive key success factors (Rimienė and Grundey, 2007; Higgins et al., 2012; Notteboom et al., 2017). Consequently, an array of heterogeneous opportunities and threats emerge from the combination of different digital technologies with each typology of logistics centre.

Although the complex and multifaceted nature of (maritime-related) logistics centres constitutes a valuable empirical domain for assessing the prominent trajectories of digital innovation, only few managerial studies have investigated how digital technologies of Industry 4.0 are shaping the competitive environment of MSCs. In this vein, most academic papers mainly address engineering and technical issues, leaving several rooms for further research along with a managerial or marketing perspective (Bellingkrodt and Wallenburg, 2013; Cariou, 2018; Arunachalam et al., 2018).

In light with the above, the objective of the paper is twofold:

- **Research Objective 1 (RO1)**. To perform a systematic literature review (SLR) of academic papers addressing the adoption of emerging digital technologies by the logistics centres of MSCs to comprehend the state of the art.
- **Research Objective 2 (RO2)**. To identify the main business benefits emerging from the literature review and to assess managerial and marketing opportunities for the different typologies of logistics centres in MSCs.

The SLR examines more than 100 academic papers published in leading international journals of port and maritime management (e.g., Maritime Policy & Management and Research in Transportation Business and Management), transport and logistics (e.g., Transportation Research Part E: Logistics and Transportation Review and Journal of Business Logistics), supply chain management (e.g., Supply Chain Management), innovation and computer science (e.g., Journal of Manufacturing Technology Management and Transportation Research, Part C: Emerging Technologies). Then, both managerial and marketing opportunities are explored through the application of an original conceptual framework, grounding on the theoretical construct of the Abell's matrix (1980). The conceptual framework enables to disentangle these potential business benefits combing the most promising digital technologies for the industry with the different typologies of logistics centres in MSCs.

The paper is structured as follows. Section 2 defines the theoretical foundations of the study. First, it provides a taxonomy and a description of the logistics centres embedded in MSCs according to the functional criterion of Notteboom et al. (2017). Second, the most promising digital technologies of Industry 4.0 for maritime logistics are debated and commented. Section 3 outlines the proposed multi-layered conceptual framework based on the Abell's matrix (1980). Moreover, it describes the methodology applied to perform the SLR and the sample of selected papers. In Section 4, the results of the study are reported, also proposing an application of the multi-layered conceptual framework.

Finally, Section 5 addresses the managerial implications of the study before drawing further academic research avenues and concluding.

2. Theoretical foundations

2.1. Logistics centres of maritime supply chains: definition and taxonomy

Logistics centres are pivotal nodes in MSCs because they perform and facilitate all the activities related to transport, logistics and goods distribution (Notteboom and Rodrigue, 2005; Flämig and Hesse, 2011). Given the ongoing globalisation and the rise of cargo flows, logistics centres are no longer considered only facilitators of the transportation system, but also generators of economic growth and business opportunities (Notteboom and Rodrigue, 2005). This evolutionary process along with the emergence of additional services has made harder to classify these infrastructures through a univocal criterion (Rimienė and Grundey, 2007; Higgins et al., 2012). For the objective of the study we use the overarching taxonomy proposed by Notteboom at al. (2017) which relies on the primary function of logistics centres within MSCs. It consists of three typologies, as follows: (i) logistics centres focused on storage, deposit and warehousing; (ii) logistics centres focused on cargo transloading and rapid transit; (iii) logistics centres focused on VAS and soft/light manufacturing. This taxonomy turns out to be particularly suitable to investigate the impact of digital technologies on each typology of logistics centres because it captures their intrinsic nature and role within the MSC. Accordingly, a summary of the main features and characteristics of all three typologies is detailed below.

Logistics centres of the first typology rely on basic facilities characterised by a low/medium level of infrastructural and managerial complexity. Warehouses and deposits represent buffering nodes of logistics network. They support the inventory management of suppliers, producers and customers of the supply chain (Higgins et al., 2012). When it comes to the maritime domain, this typology includes, among others, container yards/inland container depots, that provide primary services related to storage, cleaning, maintenance and repair of empty containers, and distribution centres, which combine cargo storage activities with handling functions. Distribution centres collect and split shipments from different origins and, then, send cargo toward various destinations, supporting the organisation of transport and logistics network. For this purpose, they require suitable ICT platforms aiming at managing the multitude of orders and related physical and information flows (Kia et al., 2003).

The second typology (i.e. logistics centres focused on cargo transloading and rapid transit) stresses the reduction of timing requested for completing the long-haul transports, by receiving and dispatching goods in the fastest way. Relatedly, the monomodal or intermodal nature of these logistics services significantly affect transport efficiency, especially when they are embedded in MSCs (Flämig and Hesse, 2011). Monomodal or multimodal nodes include, among others, inland (freight) terminals and intra-modal gateways which are normally specialised in a certain commodity chain (e.g. perishable goods, value-added products or time-sensitive goods). They are primarily focused on reaching major economies of scale, providing basic transloading services (Notteboom et al., 2017). Conversely, intermodal terminals deal with road-and-rail logistics services based on a single-plant facility (Rimienė and Grundey, 2007). This category also includes port terminals that are pivotal nodes for the entire MSC (see e.g., Keceli, 2011). Given the expansion of the international commercial trade and due to the reconfiguration of continental distribution systems (Notteboom and Rodrigue, 2005), intermodal terminals such as dry ports are acquiring a critical role in MSCs. They can relieve ports from the lack of available storage area and, thus, from risks related to queuing and bottlenecks of maritime cargo flows.

The last typology of logistics centres includes logistics centres focused on the provision of value-added services and soft/light manufacturing to goods, vehicles, firms and people (Du and Bergqvist, 2010). On the basis of their characteristics and business models, Notteboom et al. (2017) identify two main sub-typologies: (i) freight village and (ii) special zones. A freight village is the hub of various national and international transport and logistics activities which are carried out by different operators (Rimienė and Grundey, 2007). The availability of public facilities and equipment, managed on a common-user base, constitutes a valuable precondition for this type of logistics centres (Du and Bergqvist, 2010). Freight villages consist of agglomeration of co-localised logistics operators that offer complementary and auxiliary services to logistics actors. They are becoming fundamental within complex maritime-related supply chains. Among them, distriparks cover a pivotal role in the MSC since they are directly connected with seaport terminals (Notteboom et al., 2017). When it comes to special zones, they are generally large areas characterised by favourable regulations addressed to stimulate co-location of logistics infrastructure, manufacturers and LSPs. In particular, special zones are used by central or regional governments to foster international trade and to attract foreign investments, especially in the port area.

2.2. Emerging digital technologies in maritime logistics

Digital innovation has reshaped the rules of the maritime logistics industry (Carlan et al., 2017; Cariou, 2018). The implementation of new digital technologies and automated systems, indeed, is improving productivity, labour working conditions, quality of strategic plans and communication strategies of MSC actors (Lee et al, 2015; Molano et al., 2017; Büyüközkan and Göçer, 2018; Notteboom and Vitellaro, 2019). The digitisation journey is already underway and both scholars and practitioners believe it will accelerate in the next years ahead (Molano et al. 2017). In this perspective, a study of PwC (2016) reports the industry is investing approximately 5% of annual revenue in new digital technologies to innovate the business and make the MSC more competitive.

According to leading academic papers (Lee et al, 2015; Molano et al., 2017; Carlan et al., 2017; Cariou, 2018; Büyüközkan and Göçer, 2018) and reports by consulting firms (Deloitte, 2015; PwC, 2016), the most promising digital technologies for MSCs are the following: 3D printing (3DP), Human Machine Interface (HMI), augmented reality (AR), Automated Systems (ASs), Big Data Analytics (BDA), Blockchain Technology (BT), Cloud Computing (CC), Internet of Things (IoT), Location Detection technologies (LDs), Mobile devices (MDs), Multilevel Customer Interaction (MCI), Customer Profiling (CP) and Smart Sensors (SSs).

Although some of debated technologies are still under development and currently stand for only prototypes (e.g., AR and 3DP), IoT, CC, LDs and BDA have proven to be more mature for the maritime logistics industry (Haddud et al., 2017; Cariou, 2018; Büyüközkan and Göçer, 2018). IoT is a global infrastructure which enables advanced services by interconnecting physical and virtual things as well as humans through interoperable information and communication technologies (Bassi et al., 2013). Physical devices, such as mobile phones, machines and smart sensors, are constantly connected with humans and working environment, improving the performance of logistics companies (Ganesan et al., 2016). Moreover, IoT allows to monitor every cargo handling and operation within logistics centres aiming at taking prompt actions to solve accidents or bottlenecks (Haddud et al., 2017).

When it comes to CC, it enables authorized users to simultaneously access online platform from different devices (e.g., mobile phones, tablets, laptops, and workstations) and enjoy real-time services, such as networks, servers, storage, applications. CC is also designed to be elastic and scalable for meeting instantly the demand needs. These characteristics have determined a rapid growth of cloud technology within the logistics industry (Bruque Camara et al., 2015). Relatedly, LSPs can use online platform services and tools to organize cargo handling, transportation, freight forwarding, customs clearance, warehousing, and finally distribution activities. The explosion of e-commerce in China and western countries contributes to the wide diffusion of this technology (Hsiao, 2008). The fragmentation of shipping activities, which are no longer linked to a specific time and/or location, require, indeed, additional coordination activities.

LDs are included among the first digital innovations introduced in the business (De Langen and Douma, 2010; Abdel-Basset et al., 2018). They monitor the geographic position of individuals, vehicles and cargo through electronic devices, including smartphones and laptop computers. In this perspective, LDs support logistics centres in all procurement and storage activities, by reducing the time required to find the goods inside the warehouse as well as to prepare items for dispatching. In addition, location data related to vehicles and cargo flows, provide valuable insights to logistics centre managers when assuming strategic decisions (James, 2004).

The ongoing digitisation process, indeed, has been improving the relevance of data for logistics industry (Arunachalam et al., 2018). Nowadays, data management appears pivotal for demand forecasting, improving inventory planning, warehouse management and distribution system (Vásquez Rojas et al., 2018). In this vein, not only do logistic centres get the opportunity to increase their management flexibility, but also, they can develop the competences to meet rapidly customers' requirements. Hence, BD offers logistics centres the opportunity to enhance the efficiency and the quality of their services, in terms of both customer experience and service customisation (Arunachalam et al., 2018; Büyüközkan and Göçer, 2018).

[Figure 1 near here]

In conclusion, Figure 1 summarises some of the main applications of enabling digital technologies in logistics centres' activities, i.e. marketing and sales, operations, warehouse and logistics handling, network and connectivity, and billing and payment (Cariou, 2018; Büyüközkan and Göçer, 2018).

3. Data and methodology

3.1. Conceptual framework

Although academics and practitioners agree on the most promising digital technologies for maritime logistics in the next future, a deeper analysis is required to go further their features and expectations and to disentangle the main business opportunities for logistics centres of MSCs.

In his outstanding work, Abell (1980) proposes a three-dimensional model (i.e., Abell's matrix) to analyse the strategic planning process of the business. The author argues a business can be outlined in three dimensions, respectively customer groups, customer needs and technologies, that describe how the firm meets the requirements of its customers. Each combination of these dimensions (i.e., strategic business unit) highlights the competitive scope and the extent of the business opportunities related to firm's strategy. In this perspective, Abell's theoretical approach turns out to be suitable to address the objective of the paper.

[Figure 2 near here]

Figure 2 shows our theoretical approach based on Abell's matrix (1980). We consider logistics centres as "customers" of new potential digital technologies, whereas the dimension "technologies" turns into "digital technologies" referring to the main innovations of Industry 4.0 addressed to maritime logistics. Finally, the dimension "customer needs" is adapted to identify the prominent categories of potential business benefits sought by logistics centres when introducing new technologies in their operations and processes.

According to these theoretical premises, we develop a multi-layered conceptual framework (Figure 3). On the X-axis we outline three-layers referring to the taxonomy of logistics centres illustrated in sub-section 2.1, namely (i) logistics centres focused on storage, deposit and warehousing, (ii) logistics centres focused on cargo transloading and rapid transit, and (iii) logistics centres focused on VAS and soft/light manufacturing. In line with sub-section 2.2, on the Y-axis are reported the 13 prominent digital technologies that are expected to shape the maritime logistics industry.

[Figure 3 near here]

Finally, on the Z-axis we draw *i* categories of theoretical business benefits originating from digital technologies. Since prior academic contributions have not proposed yet an overarching taxonomy of business benefits, the number of categories ranges from 1 to *i,* where *i* is the infinite number of potential benefits recognisable. Therefore, after reviewing academic literature we address this gap by suggesting an original taxonomy of business benefits to be reported in our conceptual framework.

3.2. Systematic literature review

In line with RO1 and RO2, the paper carries out a systematic review of academic literature performing a three-stage procedure divided in (i) planning, (ii) execution and (iii) reporting (Tranfield et al., 2003; Crossan and Apaydin, 2010).

The planning stage defines the boundaries of review. For this purpose, we use Scopus database (provided by Elsevier) as research engine to select the most promising academic papers. In addition, to ensure homogeneity and consistency, conference papers, books and PhD dissertations are excluded from the sample. In the second stage (i.e. execution), the paper defines the initial selection criteria. We perform ad-hoc queries using different string of words in the research engine of Scopus (Elsevier). Relatedly, we define four groups of search terms, which include several alternative key words, as follows:

i. the type of logistics centre related to MSCs (e.g., "port terminal", "logistics centre", "distribution centre" and "intermodal terminal");
ii. the innovative dimension of the digital technology investigated (e.g., incremental vs. disruptive);
iii. the 13 most promising digital technologies for the maritime logistics industry (see, the detailed list in sub-section 2.2); in this case, we adopt diverse synonyms and abbreviations to be sure to capture the selected technologies (e.g., "internet of things" and "IoT");

iv. the managerial and marketing dimensions (e.g., “customer”, “user” and “marketing”).

As a result, seventy queries are performed, driving to a first sample of 392 papers potentially relevant for the study, published on 227 academic journals, which cover 27-year timeframe (1991-2018). The high number of sources proves the heterogeneity of academic perspectives applicable to this novel and cutting-edge topic which is growingly debated by scholars and experts from various fields of research including, e.g., business and management, economics, engineering, computer sciences, social sciences, environmental sciences and energy. For strengthening the consistency of the sample, we further screen selected papers according to three additional parameters: (a) the actual pertinence to the research topic, (b) the scientific impact on future research, and (c) the year of publication. As regards the latter parameter, we narrow the timeframe to 10 years, from 2007 to 2018 (first quarter), in order to select the most novel papers concerning digital innovation. All the authors scrutinize each of the 392 sample papers’ abstract and they individually assign the label “pertinent” only to those papers that meet the three parameters. Abstracts that do not receive at least three “pertinent” labels are eliminated from the sample. Consequently, 116 papers are defined as “pertinent” for the objective of the study. Then, the authors entirely read the papers of this shortlist and replicate the aforementioned label assignment procedure. As a result, the final sample consists of 44 papers, published in 29 international journals (Table 1) from 2007 to 2018 (first quarter).

[Table 1 near here]

To conclude the second stage of the SLR, we carefully classify and systematize selected papers according to the following dimensions: authors' name, journal, year of publication, main topics, theoretical perspective (if applicable), paper type (e.g., conceptual paper, qualitative or quantitative research paper, etc.), method (e.g. theory building, multiple case study, regression model, etc.), temporal coverage and logistic centre typology/sub-typology. Moreover, we report the digital technologies and related business benefits which arise from each sample paper.

The last stage of the SLR (i.e. reporting) consists of the results reported in Section 4.

4. Results

4.1. Mainstream research in academia and literature gaps

Consistent with RO1, we first debate the most significant issues emerging from the SLR, which offers valuable insights into current academic knowledge on the adoption of emerging digital technologies in logistics centres of MSCs.

Firstly, the paper examines the temporal distribution of selected papers (Figure 4). The sample covers a period of 11 years, drawing the attention to the novelty and the cutting-edge nature of the research. In particular, 18 out of 44 (41%) studies were published in the last two years, unveiling the increasing attention of scholars on this topic.

[Figure 4 near here]

When it comes to the analysis of paper type and research methods (Table 2), the sample papers are predominantly conceptual or qualitative studies.

[Table 2 near here]

In detail, 38.6% of the selected studies are conceptual papers (17), including 13 new conceptual frameworks and 4 theory building approaches. Qualitative research papers (27.3% of the sample) consistent of single and multiple case studies (respectively, 9 and 3 papers), which are particularly relevant for the analysis since they report empirical evidence of digital technologies in logistics domain. As regards quantitative research papers (25.0%), it appears as a heterogeneous category: structural equation modelling (4 papers), regression model (2), costs/benefits analysis (1) and simulation model (1) are just some of the methodologies applied in this category. What emerges is the lack of this kind of papers in literature since they can considerably foster academic knowledge by making use of the impressive quantity and quality of available data concerning logistics flows in MSCs. Finally, literature review papers are rather scarce (only 4 cases, 9.1% of the sample). It suggests the urgency for additional efforts in systematizing past research in order to pave the ground for future studies on the use of emerging digital technologies in logistics and supply chain domain.

Many authors propose alternative models and theories for investigating some of the potential implications related to the adoption of emerging digital technologies by logistics centres. This result stresses once again the originality and the novelty of the present research topic. The examination of theoretical perspectives (Table 3) shows that the supply chain management perspective (SCM) is the dominant paradigm within sample papers (27.3%), see among others the study on hinterland chain coordination (i.e. De Langen and Douma, 2010). Other relevant research streams for the objective of the present study are innovation theories (18.2%), e.g., business model innovation theory (2 papers), and managerial theories which proposes alternative strategic management lens for investigating the phenomenon, i.e. knowledge based-view, resource based-view, etc. To conclude, 11 papers (25.0%) do not refer to a specific stream of theory.

[Table 3 near here]

The SLR provides interesting insights concerning the type of logistics centres debated in the selected papers (Table 4). Nearly half of the sample papers investigate the use of emerging digital technologies in storage and warehousing centres (45.5%), especially in distribution centres (22.7%). The special interest for these facilities comes from the greater complexity in the management of logistics flows, given the presence of thousands of parcels with multiple O/D (origin/destination) combinations. Moreover, the abundance of papers grounding on SCM perspective and the use of LDs and related technologies in warehouses feed the research in this field. As regards logistics centres focus on cargo transloading and rapid transit (31.8%), they are essentially represented by port terminals (27.3%), stressing their relevance for the competitiveness of the whole maritime chain. This figure is not surprising since the relevance of ICT and electronic logistics management systems for supporting port terminals' activities as well as administrative and custom clearance procedures (Mondragon et al., 2012; Lee et al., 2016).

[Table 4 near here]

Rather unexpectedly, the outcomes underline a lack of papers examining logistics centres focused on value added services (VAS) and soft/light manufacturing (only 2 papers). Given the complex nature of this typology of logistics centres and the role play by the related managing entities as business orchestrators of the whole MSC (Notteboom et al., 2017), this gap is quite surprising. These logistics entities, in fact, represent the most relevant field for investigating prominent trajectories of technological innovations in logistics, considering the number of business actors involved in various stages of the MSC and the positive effects new digital technologies are expected to generate for innovating their business model. Relatedly, new digital technologies, not only contribute to make the logistic platforms more efficient, but also have a positively impact on service differentiation.

In line with RO1, the study examines to what extent selected emerging digital technologies are debated in the sample papers. Figure 5 reports a longitudinal analysis related to the number of mentions the selected digital technologies have received in the sample papers. The year of mention refers to the year of publication of the 44 papers. Accordingly, each digital technology can receive 44 mentions maximum (see, the last column), whereas the total mentions of every single year (see, the last row) varies depending on the number of published papers in that year (see, Figure 4).

[Figure 5 near here]

What emerges from the analysis is 70.5% of the papers deals with LDs, whereas BDA, SSs, and CC are addressed by more than half of the sample papers. These figures prove the relevance of abovementioned innovations for the growth and transformation of the MSC. Conversely, BT, AR and 3DP are rather neglected and do not appear enough mature for the business.

4.2. Business benefits of digital technologies

Consistent with RO2, sample papers are further examined to identify major business benefits for logistics centres of the MSC, originating from the adoption and diffusion of digital technologies. The study stresses on potential managerial and marketing opportunities that enable these logistics centres to innovate their business model and improve the competitiveness of the whole MSC. For this purpose, we create three ad-hoc categories to bundle the heterogeneous business benefits detected in the second stage of the SLR, namely "efficiency", "service differentiation & SRM", and "strategic management". Table 5 reports the results of this analysis.

[Table 5 near here]

The category "efficiency" grounds on two main benefits, respectively operational efficiency (61% of sample papers marked with the "efficiency" category) and costs reduction (39%). Notably, 28 sample papers (64%) debate logistics centres' efficiency gains, showing the high interest of academics in investigating to what extent digital technologies can improve the efficiency of logistics operations. In this perspective, advance HMI, big data analytics and IoT systems can support logistics firms in optimizing physical resources allocation and asset utilization (Mondragon et al., 2012; Haddud et al., 2017). Ganesan et al. (2016) assert the adoption of IoT platforms in logistics centres improve the level of efficiency in cargo handling operations as well as of safety and security. De Langen and Douma (2010) claim track and trace devices support logistics centres in reducing gate congestion and other bottlenecks throughout the MSC since they are constantly informed about the localisation of cargo. Radio-frequency identification (RFID) represents also one of the most debated and diffused technology in maritime logistics due to its low expense compared to the significant reduction of logistics costs it can generate, especially those related to warehouse inventory (Cheng at al., 2017). In addition, the diffusion of cloud computing and integrated information systems across the MSC enables to reduce inventory costs, thanks to a more accurate demand forecasting (Bruque Camara et al., 2015). Regarding cost reduction benefits, the implementation of automated system (e.g., Automated Storage/Retrieval System) by warehouses and distribution centres, may substantially reduce the overall labour costs (Hu and Chang, 2010). Moreover, automation has proven to drastically reduce the costs of container terminals, especially for the decrease in number of required dock workers and the enhancement of the overall operational efficiency (Notteboom and Vitellaro, 2019).

The “service differentiation and SRM” category ranks second (45% of the sample papers). The most debated benefit in this category is networking and information sharing systems (60%). Academics and practitioner agree that the collaboration with key trading partners or customers require a strong relationship of trust based on information sharing (Huong

Tran et al., 2016). Bellingkrodt and Wallenburg (2013) argue digital technologies are expected to create wider and more embedded networks of players belonging to the MSC. In this vein, LDs and digital networks (e.g., IoT) may improve shipping, receiving and put-away processes, thanks to a higher level of information sharing and synchronization among MSC actors (Wamba et al., 2008). In this perspective, emerging digital technologies are introducing a new way to overcome the "vertical silos" approach of traditional ICT systems adopted by logistics centres, encouraging the collaboration with other stakeholders aiming at promoting an innovative value proposition (Kubler et al., 2017). LDs and IoT, indeed, allow customers to control the status of the freight, improving their satisfaction with the service provided (Cheng at al., 2017). These benefits are crucial for MSCs since digital exchange of information can accelerate transport and logistics activities. When it comes to personalisation and customer relationship management (CRM) benefits (30%), digital technologies contribute to enhance business-to-business relationships in downstream markets, overcoming vendor management inventory (VMI) approaches (Cariou, 2018). In this perspective, Choi end Sethi (2010) propose an innovative supply chain system aiming at improving the VMI of logistics centres as well as at developing a more collaborative relationship with the customers. Moreover, port terminals that undertake the e-transformation and adopt innovative ICT systems to communicate with the stakeholders (Lee et al., 2016), may gain the loyalty and trust of their direct clients (e.g., shipping lines, shippers and freight-forwarders). This leads to a higher level of customer satisfaction, by lifting-up the competitiveness on the MSC. Finally, disintermediation benefits (10%) consist of direct communication among MSC actors via IT systems, removing intermediaries between logistics centres and their stakeholder and, thus, increasing B2B relationships (Abdel-Basset et al., 2018).

Papers categorised as “strategic management” (34% of the sample) focus on the use of emerging digital technologies to support strategic decision (53% of the papers in this category), to make the business model and related activities more flexible and scalable (27%), and, finally, to create a sustainable and smart distribution system (20%). Haddud et al. (2017) suggest new digital technologies may support the strategic planning process of logistics centres for some of their core business activities (e.g. marketing and sales, warehousing and logistics handling and operations). They ensure information accessibility and data sharing with selected stakeholders of the MSC, facilitating the process of data gathering and decision-making (Wamba et al., 2008). In particular, Vásquez Rojas et al. (2018) highlight the importance of text mining and data analysis to transform textual information of various sources into strategic data. Over the last years, the amount of information logistics centres are called to manage have been significantly increasing, especially in the MSC (Heilig and Voß, 2017). Therefore, digital tools are pivotal to explore data and support strategic and operational decision-making, especially for unexpected changing market conditions (Marchet et al., 2009). When it comes to flexibility and scalability benefits (27%), cloud computing and IoT platforms ensure a certain level of operational flexibility, which constitutes a valuable competitive advantage for logistics centres since they operate in a business characterized by high levels of uncertainty (De Langen and Douma, 2010). In this perspective, digital technologies allow to manage large volume of data which increase scalability and adaptability of the services provided by logistics centres (Arunachalam et al., 2018). Other sample papers investigate innovative solutions for distribution network models. For example, Castillo et al. (2018) introduce a smart distribution system based on “crowdsourced delivery agents” for last mile deliveries. This kind of options exploits digital technologies to stimulate B2B relationships as well as social interactions across the MSC by making use of digital technologies and platforms.

Finally, we draw the three categories of business benefits (i.e., Efficiency, Service differentiation & SRM and Strategic management) on the Z-axis of our proposed multi-layered conceptual framework (see, Figure 3). In line with RO2, we use this framework to assess the business opportunities for each typology of logistics centres within MSCs which result from the adoption of investigated digital technologies. Figure 6 reports an empirical application of the conceptual framework for the three most debated digital technologies (i.e., LDs, BDA, and SSs). The colour intensity of each combination denotes the potential positive effects of digital technologies on logistics centres’ business model according to scholars' contributions. In this regard, location and detection technologies as well as big data analytics and advanced algorithms are expected to have a huge impact on the level of operational efficiency in both logistics centres focus on storage, deposit and warehousing and cargo transloading and rapid transit. Moreover, they may significantly support these typologies of logistics centres in strategic decision-making process and stakeholder relationship management. On the other hand, smart sensors unveil a general low contribution to the business model of logistics companies, excluding deposits and warehouses. Surprisingly, according to extant literature, all three technologies are expected to not affect logistics centres focus on VAS and soft/light manufacturing, especially big data analytics and advanced algorithms that should have the potentialities to foster this kind of activities instead.

[Figure 6 near here]

5. Conclusions

The paper provides valuable outcomes for both academics and practitioners. Adapting Abell's theoretical model to the investigated empirical domain, the study adds to the extant literature by shedding lights on the main business benefits which originate from the adoption of new digital technologies of Industry 4.0 by each typology of logistics centres of MSCs.

The results of the SLR demonstrate the lack of an overarching analytical framework capable to identify and classify business benefits and opportunities of digital innovation in MSCs. Prior studies focus mainly on the relevance of operational efficiency issues and thus a more comprehensive theoretical framework is required to include strategic and managerial dimensions. Therefore, the paper suggests a first taxonomy of business benefits which cargo logistics centres in MSCs can leverage on, stressing managerial and marketing opportunities. In particular, “efficiency”, “service differentiation & SRM”, and support of “strategic management process” are identified as the main categories of business benefits.

The proposed multi-layered conceptual framework, which combines logistics centres, digital technologies and business benefits, identifies potential managerial and marketing opportunities for each typology of logistics centre after the adoption of the investigated technologies. The results underline digital technologies are definitively expected to improve the operational efficiency of logistics centres acting as deposits and warehouses (e.g., LDs may significantly reduce gate congestion and other bottlenecks throughout the MSC). Moreover, they can support the strategic decision-making process and the management of relationships with stakeholders. Digital technologies, indeed, provide logistics centres the opportunity to widen their networks and to improve the collaboration with MSC actors.

Despite the paper deals with a critical issue for the competitiveness of logistics centres, it still suffers some inherent limitations. First, the literature review provides valuable insights on the most established digital technologies in the maritime logistics domain, suggesting viable opportunities for logistics centres' managers to innovate their business. However, only a handful of emerging digital technologies are deeply scrutinized by scholars, including among others, LDs, BDA and SSs. A large group of innovations (e.g., IoT, BT, MDs and HMI) appears still underexplored or neglected, offering promising future research fields.

Second, the paper explores managerial and marketing opportunities for cargo logistics centres in MSCs. These leaves rooms for further studies on other typologies of logistics infrastructures (e.g., airports, rail stations, etc) and specific traffic flows. Next research, indeed, may scrutinize logistics centres called to manage predominantly passenger flows. In this empirical context, different digital technologies (e.g. augmented realty) may provide unprecedented or unexpected business opportunities related to people services.

Finally, most of investigated technologies, especially BT, require a close collaboration among MSC actors in order to support their development (Bavassano et al., 2020). The highly competitive environment of MSCs, which result in weak ties among the players and the poor attitude to cooperate, may restrain the interactive learning process as well as slow down the adoption and diffusion of digital technologies across logistics networks.

Therefore, further studies are expected to investigate these barriers and find solutions to accelerate the adoption of digital innovations in maritime logistics. Moreover, they may stretch out the number of business benefits for logistics centres to strengthen the proposed conceptual framework and the scrutiny of managerial and marketing opportunities.

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Table 1. Journals included in the final sample of selected papers

Source title	*No. of papers*
International Journal of Production Economics	6
Journal of Business Logistics	3
Maritime Policy & Management	2
Information Technology and Management	2
IEEE Access	2
International Journal of Physical Distribution and Logistics Management	2
Industrial Management and Data Systems	2
Transportation Research Part E: Logistics and Transportation Review	2
Information Systems Frontiers	2
International Journal of Engineering Business Management	2
Journal of Manufacturing Technology Management	1
Technological Forecasting and Social Change	1
NETNOMICS: Economic Research and Electronic Networking	1
International Journal of Transport Economics	1
Flexible Services and Manufacturing Journal	1
Research in Transportation Economics	1
International Journal of Advanced Manufacturing Technology	1
Electronic Markets	1
International Journal of Distributed Sensor Networks	1
Indian Journal of Science and Technology	1
Advanced Engineering Informatics	1
Research in Transportation Business and Management	1
International Journal of Logistics Management	1
Supply Chain Management	1
Future Generation Computer Systems	1
Transportation Research Part C: Emerging Technologies	1
Computers and Operations Research	1
Expert Systems with Applications	1
International Journal of Retail and Distribution Management	1
Overall sample	44

Source: Authors' own elaboration

Table 2. Paper type and research methods.

Paper type and methods	*No. of papers*	*% on the sample*
Conceptual paper	*17*	*38,6%*
Conceptual framework	13	*29,5%*
Theory building	4	*9,1%*
Research paper (qualitative)	*12*	*27,3%*
Single case study	9	*20,5%*
Multiple case study	3	*6,8%*
Research paper (quantitative)	*11*	*25,0%*
Structural Equation Modelling (SEM)	4	*9,1%*
Regression model	2	*4,5%*
SIRS epidemic model-deterministic and stochastic models	1	*2,3%*
Discrete event simulation	1	*2,3%*
Costs/Benefits analysis	1	*2,3%*
Casual Loop Diagram & System Dynamics	1	*2,3%*
Simulation models (controlled arrival method)	1	*2,3%*
Literature review	*4*	*9,1%*
Systematic literature review	2	*4,5%*
Literature review	2	*4,5%*
Overall sample	*44*	*100,0%*

Source: Authors' elaboration

Table 3. Theoretical perspectives in the sample papers

Theoretical perspectives groups	*No. of papers*	*% on the sample*
SCM perspective	*12*	*27,3%*
SCM perspective	8	*18,2%*
Information Systems (IS)	3	*6,8%*
Hinterland chain coordination	1	*2,3%*
Innovation theories	*8*	*18,2%*
Innovation theory	4	*9,1%*
Business Model Innovation Theory	2	*4,5%*
Technology Adoption Model (TAM)	2	*4,5%*
Computer science theories	*3*	*6,8%*
Computer science theory	1	*2,3%*
System Dinamics	1	*2,3%*
Information technology (IT) & business process re-engineering (BPR)	1	*2,3%*
Contingency theory	*3*	*6,8%*
KBV and RBV	*3*	*6,8%*
RBV	2	*4,5%*
KBV	1	*2,3%*
Other theories	*4*	*9,1%*
Simulation & optimization approaches	1	*2,3%*
Trust theory	1	*2,3%*
Game theory	1	*2,3%*
Inductive theory building approach	1	*2,3%*
NA	*11*	*25,0%*
Overall sample	*44*	*100,0%*

Source: Authors' elaboration

Table 4. Logistics centres' types & subtypes

Logistic centres' type/subtypes	*No. of papers*	*% on the sample*
Storage & warehousing	*20*	*45,5%*
Distribution centre	10	*22,7%*
Warehouse	9	*20,5%*
All	1	*2,3%*
Cargo transloading & Rapid transit	*14*	*31,8%*
Port terminal	12	*27,3%*
All	2	*4,5%*
VAS & soft/light manufacturing	*2*	*4,5%*
Logistic platform	1	*2,3%*
All	1	*2,3%*
Other	*8*	*18,2%*
Overall sample	*44*	*100,0%*

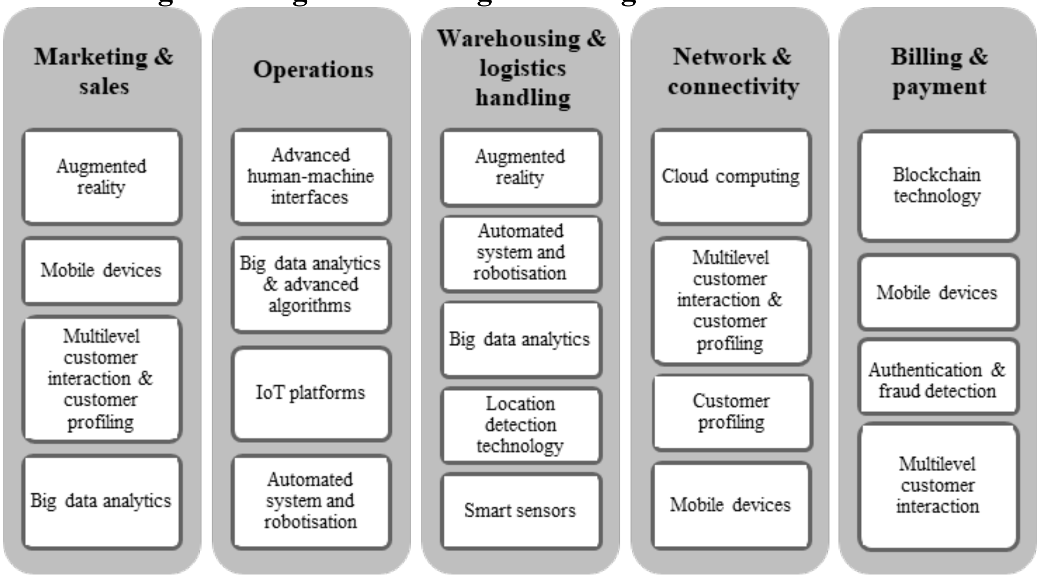
Source: Authors' elaboration

Table 5. Business benefits for logistics centres within the maritime supply chain

Category	***Main digital technologies***	***% on sample***	***Business benefits***	***% on category***
Efficiency	Location detection technologies, smart sensors, cloud computing, IoT, automated systems and HMI	64%	Operational efficiency	61%
			Costs reduction	39%
Service differentiation & SRM	Big data analytics, smart sensors, IoT, mobile devices and HMI	45%	Networking & information sharing	60%
			Personalisation & CRM	30%
			Disintermediation	10%
Strategic management	Location detection technologies, big data analytics, IoT and cloud computing	34%	Support of strategic decision	53%
			Flexibility & scalability	27%
			Sustainability & smart distribution system	20%

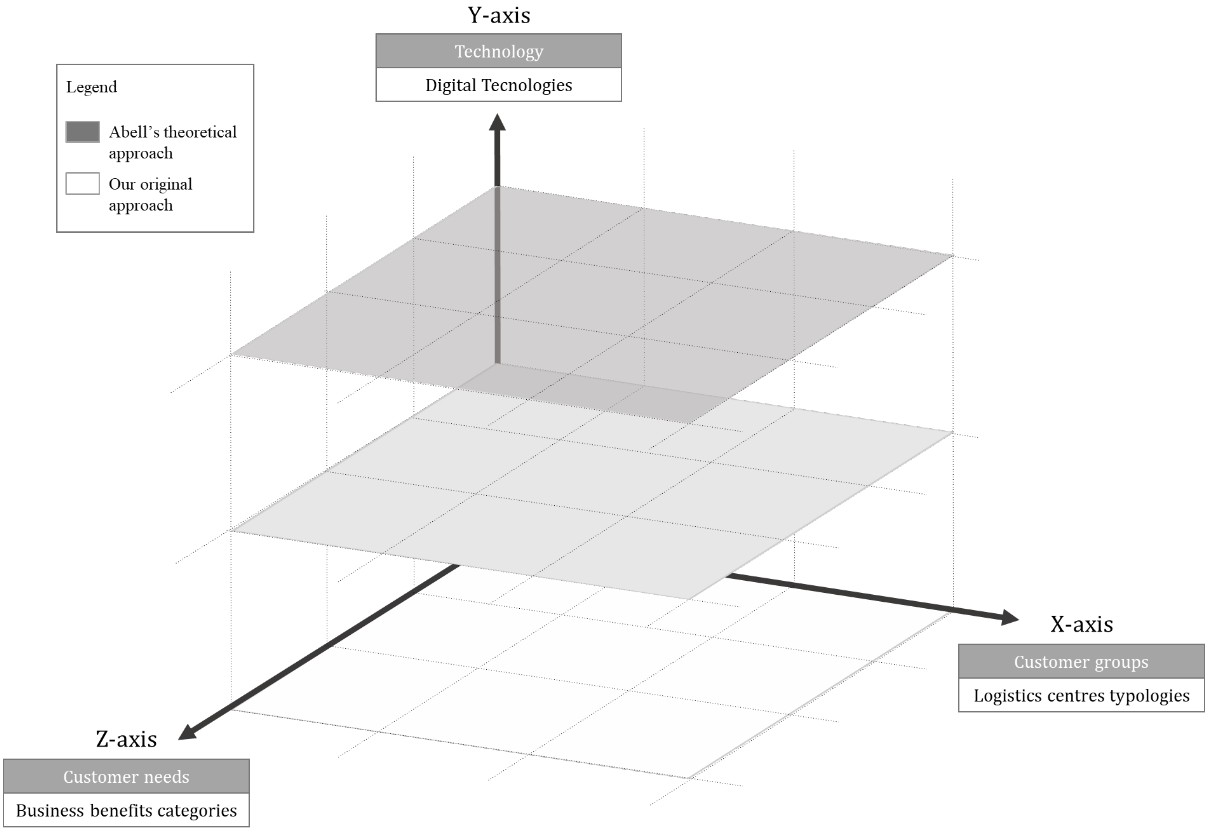
Source: Authors' elaboration

Figure 1. Digital technologies and logistics centres' activities



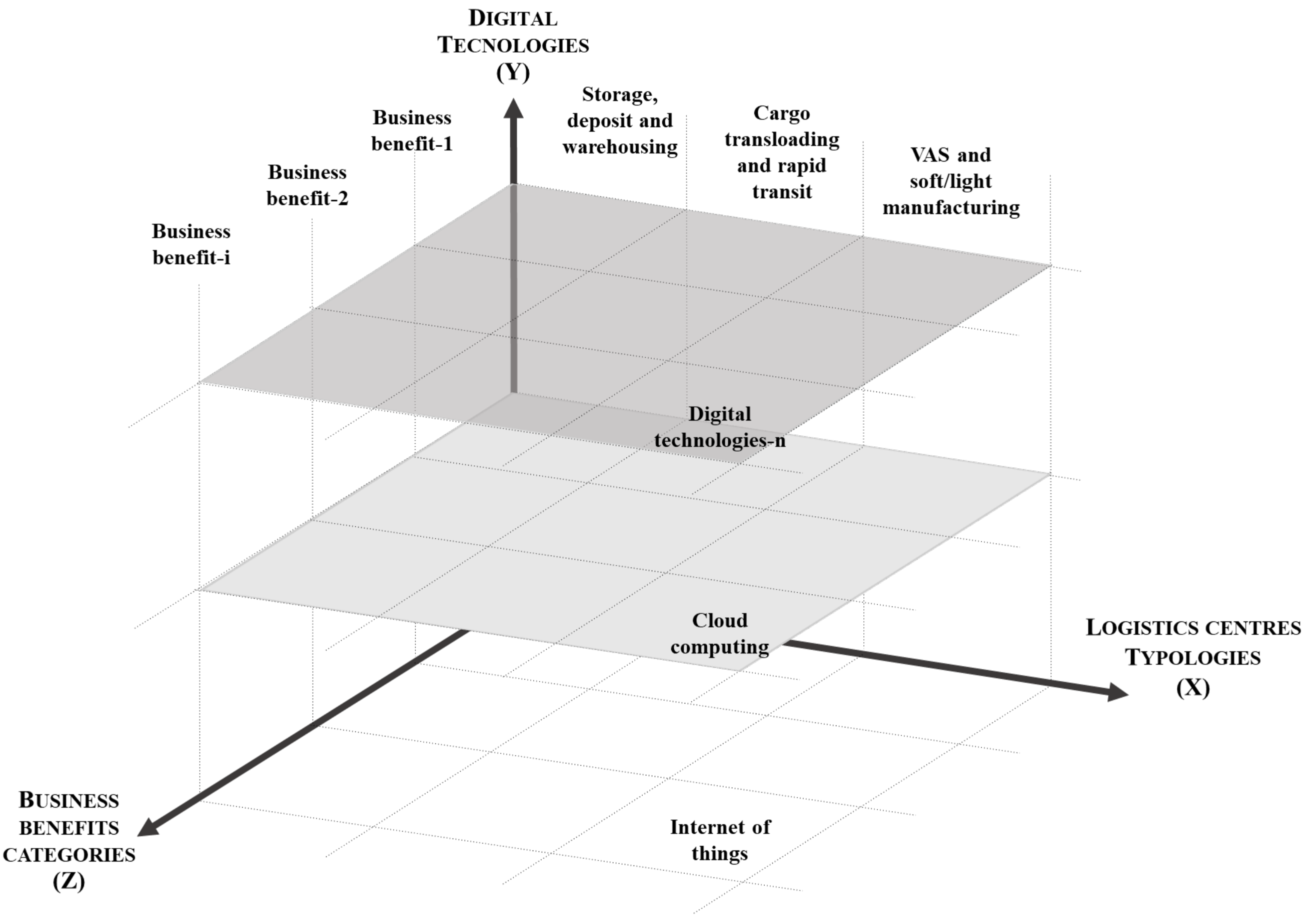
Source: authors' own elaboration

Figure 2. The theoretical approach.



Source: authors' own elaboration

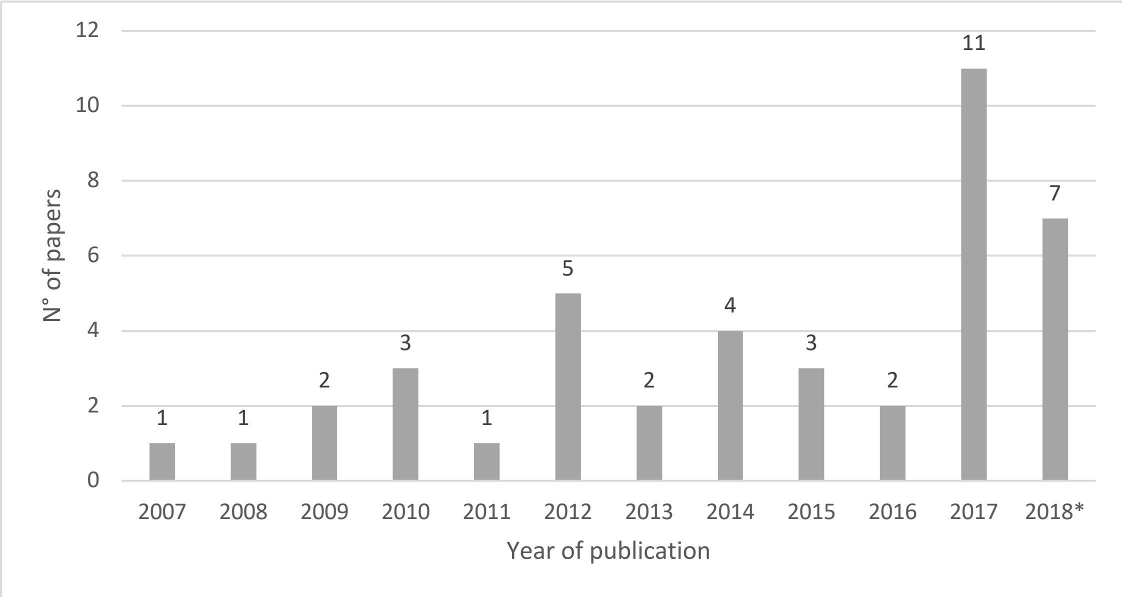
Figure 3. The multi-layered conceptual framework[1]



Source: authors' own elaboration

[1] We scrutinised 13 digital technologies (n = 13), see sub-section 2.2 for more details.

Figure 4. Temporal distribution of the sample papers



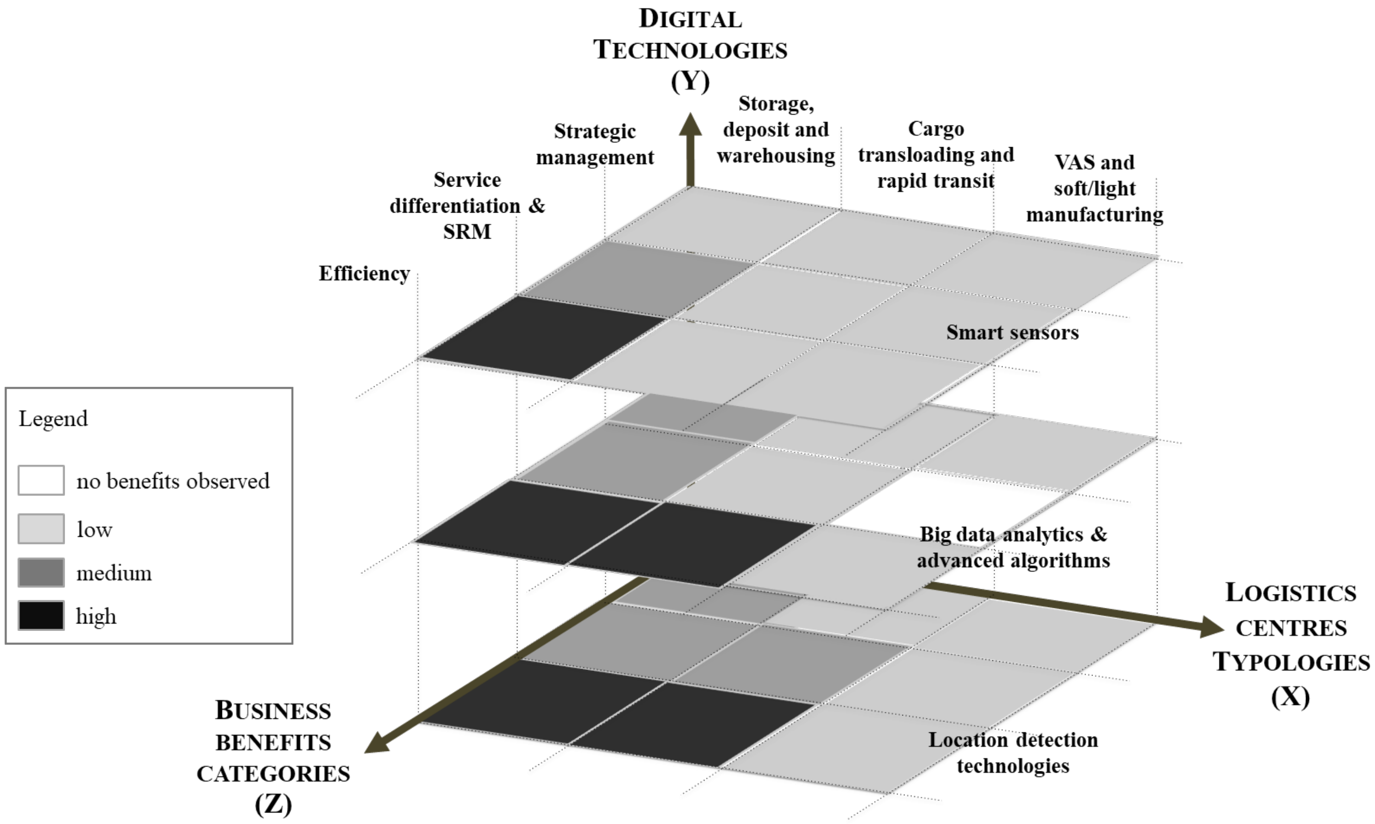
Source: Authors' elaboration

Figure 5. Number of mentions of digital technologies in literature: a longitudinal analysis.

		Year of mention												
		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Overall
Digital technologies	Location detection technologies	1	1	2	3	0	5	1	2	3	2	8	3	31
	Big data analytics & advanced algorithms	0	1	0	1	1	3	0	3	3	2	6	5	25
	Smart sensors	1	1	1	2	0	5	0	1	2	2	8	2	25
	Cloud computing	0	1	1	0	0	1	0	4	2	1	7	4	21
	IoT platforms	0	1	1	0	0	2	0	2	2	1	8	1	18
	Mobile devices	0	0	1	1	0	3	0	2	1	0	6	2	16
	Automated system and robotisation	1	1	1	2	1	3	0	1	1	1	4	0	16
	Advanced human-machine interfaces	0	1	0	0	0	1	0	2	2	2	5	0	13
	Multilevel customer interaction & customer profiling	0	0	1	1	1	1	1	1	1	0	3	0	10
	Authentication & Fraud detection	0	0	0	1	0	0	1	1	1	0	3	1	8
	Blockchain technologies	0	0	0	0	0	0	0	0	0	1	0	0	1
	Augmented reality/wearables	0	0	0	0	0	0	0	0	0	0	1	0	1
	3D printing	0	0	0	0	0	0	0	0	0	0	0	0	0
	Overall	3	7	8	11	2	24	3	18	18	12	59	18	

Source: Authors' elaboration

Figure 6. An application of the multi-layered conceptual framework.



Source: Authors' elaboration