Empowering freight transportation through Logistics 4.0: a maturity model for value creation

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Abstract: Logistics 4.0 is a recognized lever for improving efficiency, effectiveness and sustainability in logistics processes. Of these, the increasingly complex area of transport plays a key role in companies, as it directly impacts costs and service level. This paper investigates how Logistics 4.0 affects the design and configuration of the transportation process, so that companies can exploit the related benefits and create value. Using a systematic literature review, this study provides a framework for Logistics 4.0 in transportation, which includes the process dimensions to be taken into account when designing such a process. A maturity model complements the framework, which presents the configuration options for each process dimension in an evolutionary path from low to high implementation level. This paper is original in that it takes a novel process perspective, crucial for supporting the implementation of Logistics 4.0 in transportation, and discusses the associated opportunities for companies.

Keywords: logistics 4.0; transportation; systematic literature review; conceptual framework; maturity model

1. Introduction

Market globalization, the growth of e-commerce, evermore challenging customer requirements and increased attention towards sustainability are some of the factors that trigger the need for flexible, adaptive and cost-effective logistics and supply chain solutions capable of keeping pace with the stakeholders' current requirements (Winkelhaus and Grosse 2020). This complexity can only be managed effectively through new and breakthrough organizational and technical solutions (Oleśków-Szłapka and Stachowiak 2019). The concept of Logistics 4.0 was inspired by the new paradigm of the Fourth Industrial Revolution and enabled by new technologies. Logistics processes should make strong use of automation, data sharing and data analytics to support decision making processes and maximize a company's ability to compete on service, speed, reliability and cost, thereby improving the efficiency and sustainability of its global operations and the delivery service (Tang and Veelenturf 2019).

The opportunities brought about by Logistics 4.0 have heightened academic interest in the topic, opening a new research area. While the opportunities stemming from Industry 4.0 have been widely explored in manufacturing processes (Culot et al. 2020), further research is needed to study their application in the logistics field in general (Hofmann and Rüsch 2017). Logistics 4.0 concepts must be clearly understood and harmonized if they are to be disseminated in companies where logistics are far from reaching maturity (Kucukaltan et al. 2020). To the best of the authors' knowledge, previous literature has focused on specific aspects only or on conceptual investigations into Logistics 4.0 design principles, overlooking the application of these design principles to logistics processes. Specific examples of such studies include the organizational enablers required to operate efficiently in a Logistics 4.0 context (Barreto, Amaral and Pereira 2017), the application of 4.0 to specific logistics management tactics, such as route scheduling for parcel delivery (Lee, Kang and Prabhu 2016) and path decision methods (Zhang 2018a). Furthermore, knowledge on Logistics 4.0 has been logically arranged in several recently published literature reviews (Winkelhaus and Grosse 2020). Ben-Daya, Hassini and Bahroun (2019) have discussed about the role of the internet of things (IoT) and its impact on supply chain management. Garay-Rondero et al. (2019) have set Industry 4.0 definitions for logistics and supply chains and related conceptual models. Winkelhaus and Grosse (2020) have proposed a conceptual framework of Logistics 4.0 adapted from the technology, organization and environment (TOE) model, together with an overview of existing solutions and technologies for Logistics 4.0. Yavas and Ozkan-Ozen (2020) have covered the concept of Industry 4.0 in the context of logistics centres. Lastly, Fatorachian and Kazemi (2020) have devised a framework for potential impacts on performance in supply chain processes. It appears, however, that a process perspective has never been taken into account in any of these contributions. A process view is needed to define a proper path for implementing the fourth industrial paradigm within logistics processes, such that organizations can understand how to adopt and apply Logistics 4.0 and how to seize the related emerging opportunities (Hofmann and Rüsch 2017). In other words, although the concepts relating to Industry 4.0 and Logistics 4.0 have been widely discussed in the literature, it is not clear how the Industry 4.0 design principles can be applied to a specific logistics process and, more in detail, how they affect the design and the configuration of the process in question.

Within the wider sphere of logistics processes, transport plays a crucial role; with increasing distances, companies are intensifying their use of transportation to fulfil their customers' demand (Villarreal et al. 2017). Transport is a significant component of the total logistics cost and, at the same, it is a source of value and competitive advantage, as it impacts directly on cost efficiency, service level and sustainability (Crainic and Laporte 1997; Klumpp 2018). Additionally, managing transport systems is a complex task that involves many stakeholders, different ownership of assets and coordination among key actors, i.e. shippers, freight operators and receivers (Chopra and Meindl 2007). The opportunities offered by Logistics 4.0 and new advanced technologies could help companies handle the ensuing greater management complexity, and improve performance within their transport processes by increasing cost efficiency and service level, attained through greater visibility and flexibility. Companies can also achieve sustainability outcomes by reducing their carbon emissions and improving resource efficiency (Harris, Wang and Wang 2015; Pathak, Thakur and Rahman 2019). These opportunities stemming from applying Industry 4.0 in the transportation process have, however, been overlooked (Lamba and Singh 2017; Strandhagen et al. 2017; Govindan et al. 2018), a factor that has determined the present study with its focus on the freight transportation process (hereafter transportation process).

The purpose of this paper is to clarify how Logistics 4.0 affects the design and configuration of transportation processes, after first defining how Logistics 4.0 changes the settings and characteristics of the transportation processes themselves, thereby enabling companies to reap the related benefits and creating value. The research questions investigated in this study are the following:

> RQ1: What are the process dimensions that need to be considered in order to integrate Logistics 4.0 design principles within the transportation process?
>
> RQ2: How can the transportation process be configured towards the implementation of Logistics 4.0 and so create value?

Hence, this research strengthens the theoretical base of Industry 4.0 principles applied to logistics by adopting a process perspective. The research questions are addressed through a systematic literature review. Literature reviews on this topic could be crucial from both a theoretical and practical perspective to support advances in appropriate strategies and practices. In particular, a conceptual framework will be proposed to identify the process dimensions to be considered when designing a Logistics 4.0 transportation process. Besides, a maturity model will enrich the framework, which will present configuration options for the Logistics 4.0 transportation process, from low to high level of implementation for each process dimension. The opportunities for companies located at the different levels of implementation will then be discussed.

The remainder of the paper is organized as follows. The next section provides an overview of the relevant literature (Section 2), followed by a description of the research method (Section 3). In Section 4, after a descriptive analysis of the selected contributions, a conceptual framework for Logistics 4.0 in transportation is described, with the design principles and the dimensions affected by each. The maturity model containing the configuration options for the Logistics 4.0 process follows. The conclusions are lastly drawn, identifying the limitations of the study, with suggestions concerning the directions for future research.

2. Theoretical background

2.1. Supply Chain 4.0 and Logistics 4.0

Industry 4.0 is concerned with the development and integration of digital technologies into business processes, connecting physical assets and relative information into cyber-physical systems (CPS) (Ghadge et al. 2020). By linking real with virtual objects through information networks that bring together digital and physical systems, CPS communicate and cooperate with each other and with humans in real-time via the internet, thereby enabling decentralized decisions. CPS encompass all digital technologies currently pushing 4.0 development, e.g. IoT, cloud computing, big data and artificial intelligence (AI). These technologies enable physical processes to be combined with digital data analysis and computation, improving execution and decision making and ultimately supporting decentralized autonomous decisions (Garay-Rondero et al. 2019).

Supply chains play a central role in the transition to Industry 4.0. The socio-technical transformations that the fourth industrial paradigm is bringing to supply chains has been termed Supply Chain 4.0 (Barata 2021). Supported by the introduction of new technologies, Supply Chain 4.0 deals with the creation of new business models and the redesign of existing business processes to improve supply chain performance (Frederico et al. 2019), thus offering the opportunity to pursue sustainable economic, environmental and social supply chain objectives (Birkel and Müller 2021). Supply Chain 4.0 'is not only "a state" of technology maturity, but also a long-term transformation process with different generations of stakeholders' (Barata 2021, 7). While closely related, differences exist between Industry 4.0, Supply Chain 4.0 and Logistics 4.0, depending on the scope of each paradigm. In Industry 4.0, manufacturing processes are the target of digital transformation, while Supply Chain 4.0 refers to supply chain networks and supply chain processes as a whole, including, for example, the digitalization of planning, sourcing and delivery processes (Frederico et al. 2019).

Logistics 4.0 is essentially the application of fourth industrial revolution concepts to logistics operations (Barreto, Amaral and Pereira 2017). Although there is no common agreement on the term (Hofmann and Rüsch 2017), most authors link Logistics 4.0 to the introduction of the CPS concept to logistics processes (Barreto, Amaral and Pereira 2017; Hofmann and Rüsch 2017; Facchini et al. 2020). The changes that CPS bring to traditional logistics processes affect both the physical flow and the flow of logistics-related information (Hofmann and Rüsch 2017), leading to the development of autonomous systems, whose behaviour is affected by the changing environment and the neighbourhood actors and subsystems (Facchini et al. 2020). While decisions are taken at an individual, decentralized level, CPS-enabled interactions can produce consistent performance among the various actors involved, and can help the processes themselves to improve, encouraging higher efficiency in costs and resources, and improving visibility and reliability (Winkelhaus and Grosse 2020).

The existing literature conceptualizes Logistics 4.0 into four building blocks. The first concerns the digital technologies that underpin the implementation of CPS in logistics processes. The second relates to logistics processes, these being all the logistics activities involved in managing the movement and storage of materials and associated information, and in delivering finished products of the right quality to end customers at the appropriate service level and the lowest possible cost (Barreto, Amaral, and Pereira 2017; Strandhagen et al. 2017). The third building block relates to design principles, which were introduced in Industry 4.0 literature and enable the transition towards the 4.0 paradigm; they define how the process should be designed in order to achieve the improvement in performance expected as a consequence of adopting CPS, through the integration of technology. The fourth and last is performance, in terms of resource efficiency, costs, visibility, reliability, flexibility and reduction in carbon emissions (Hofmann and Rüsch 2017; Tang and Veelenturf 2019; Winkelhaus and Grosse 2020).

Different authors have focused their research effort on the role played by digital technologies in shaping Logistics 4.0 (Chen and Zhao 2019; Zhang 2018b; Tang and Veelenturf 2019; Culot et al. 2020; Seyedghorban et al. 2020; Winkelhaus and Grosse 2020). They have pointed out that Logistics 4.0, similarly to Industry 4.0, 'is not about a single breakthrough technology but comprises several "tech ingredients" that are still evolving into new enabling technologies by convergence and mutual combination' (Culot et al. 2020, 5). Moreover, Culot et al. (2020) and Seyedghorban et al. (2020) have argued that the list of digital technologies has increased over the years to include the most recent developments (e.g. blockchain), and the researchers' interest has shifted to more advanced technologies (e.g. from RFID to big data analytics).

Since there is no single technology linked to the 4.0 paradigm and technology evolves continuously, focusing on how the different technologies can be integrated into logistics processes may not capture the overall potential of the fourth industrial revolution. The transition towards Logistics 4.0 may, therefore, be described better through design principles, which are not bound to a specific technology, but give an overview of the development directions in Logistics 4.0 processes (Hofmann and Rüsch 2017; Ghobakhloo 2018). Design principles were developed in Industry 4.0 literature (Hermann, Pentek and Otto 2016; Ghobakhloo 2018; Oztemel and Gursev 2020; Srai and Lorentz 2019; Ghadimi et al. 2019), where the term was coined for the elements that define how to create value by inserting the CPS concept into the manufacturing process (Hermann, Pentek and Otto 2016). To the best of the authors' knowledge, none of the papers analysed has explicitly defined an analogous term for Logistics 4.0. Nevertheless, the literature on Logistics 4.0 sets out common elements that can be associated with Industry 4.0 design principles.

In the literature on Industry 4.0, the fundamental design principles that enable improvements in processes refer both to autonomous objects equipped with embedded sensors that collect, store and transfer data in an autonomous way (e.g. intelligent robotics, industrial automation and smart objects) (Oztemel and Gursev 2020), and to the virtualization of the physical world, achieved by acquiring real-time data automatically (Hermann, Pentek, and Otto 2016). This double perspective is confirmed in Logistics 4.0 literature. Logistics processes should be designed so that physical tasks and operations are performed by autonomous systems, e.g. automated guided vehicles (AGV) (Hofmann et al. 2019) and real-time data is acquired autonomously from physical systems (Culot et al. 2020; Seyedghorban et al. 2020).

Industry 4.0 is based on the principle of the Internet of Everything, which enables all the objects, systems and players in the value chain to connect globally (Hermann, Pentek and Otto 2016; Srai and Lorentz 2019; Ghadimi et al. 2019). Cooperation and coordination among the various elements is established through these connections and data and information can be combined and shared (Ghobakhloo 2018). Coherently, great attention is given in the literature on Logistics 4.0 to the fact that processes can integrate and exchange data and information along both the vertical and the horizontal level of the supply chain (Calatayud, Mangan, and Christopher 2019; Ghadge et al. 2020), laying the basis for communication among objects, systems and supply chain actors (Hofmann et al. 2019).

According to Hermann, Pentek and Otto (2016), CPS decisions are based on an analysis of real data collected from the physical world and imparted to the decision maker(s) in a decentralized fashion. The analysed data can provide value in the form of improvements as to how internal decisions are taken or as a new stream of revenue from selling information as a service to external customers (Ghobakhloo 2018; Srai and Lorentz 2019; Ghadimi et al. 2019). Similarly, several authors claim that Logistics 4.0 processes should depend on data analytics and intelligence to support and improve decision making, so as to maximize value from the extracted data for internal decisions and external customers (Hofmann and Rüsch 2017; Ghadge et al. 2020).

While there is high interest in the topic, little is known about how the design principles can be applied to logistics processes and, more precisely, how these principles can affect the settings of the new Logistics 4.0 processes. Moreover, current knowledge about the application of design principles to logistics processes is derived from unstructured observations, mainly dependent on the expertise of scholars and practitioners and their suggestions. For example, Hofmann and Rüsch (2017) studied how utilizing Logistics 4.0 for specific logistics concepts (kanban and just in time/just in sequence) changes the associated processes, testing their theory through experts with knowledge in the field.

2.2. Maturity models for adopting the 4.0 paradigm

Maturity is evaluated to capture the evolutionary nature of a phenomenon or a concept (Frederico et al. 2019). In the context of Industry 4.0, different authors have used maturity models to measure organizational readiness (Schumacher, Erol and Sihn 2016; De Carolis et al. 2017), develop action plans for implementing Industry 4.0 (Pessl, Sorko and Mayer 2020) and related technologies (Bibby and Dehe 2018) within organisations, and study technology implementation patterns in various manufacturing companies (Frank, Dalenogare and Ayala 2019). Few studies have addressed the development of maturity models and frameworks in the context of Supply Chain 4.0 and Logistics 4.0, and existing models stress the role played by organizational elements in enabling the shift towards 4.0.

Frederico et al. (2019) developed a maturity framework for Supply Chain 4.0 consisting of four maturity levels, each underpinned by four dimensions connected to organizational skills, leadership capabilities, technology and strategic goals, which enable and support the introduction of the 4.0 paradigm in the supply chain. Oleśków-Szłapka and Stachowiak (2019) have also stressed the importance of management, in terms of it having the necessary investment and innovation capabilities to lead the 4.0 transition. Their maturity model addresses the evolution of material and information logistics flows, assessing the managers' knowledge of existing technical solutions, yet neglecting the process features that are impacted by the Logistics 4.0 paradigm.

Facchini et al. (2019) and Asdecker and Felch (2018) focused more sharply on the evolution of logistics processes. The first study addresses different logistics processes, i.e. purchase logistics, production logistics, distribution logistics and after sales logistics. In contrast, the author of the second study only concentrated on the delivery process. In both studies, the maturity assessment covers the digitalization of the processes from an information flow perspective. In these two models, maturity is explained as a system's ability to retrieve and integrate data in an automated way and ultimately exchange them with the supply chain players involved in the process.

Some attempts have been made to use maturity models to capture the evolution of the Logistics 4.0 transformation process within organizations and supply chains. Existing maturity models nevertheless often take an organizational perspective and do not explain how the logistics process can evolve towards the 4.0 paradigm, when both the physical and the digital information flows are taken into consideration according to the perspective introduced by the CPS concept.

3. Methodology: a systematic literature review approach

A systematic literature review (SLR) was conducted to address the RQs. According to the process suggested by Tranfield, Denyer and Smart (2003), the SLR was structured into three phases, planning, conducting and reporting. The phases are summarized in Figure 1 and detailed as follows.

3.1. Planning

The planning phase consisted of defining the keywords, database and period for the search. The keywords selected belong to the domain of Logistics 4.0 and transportation, and were assembled as per the following search string: (“logistics 4.0” OR “supply chain 4.0” OR “smart logistics” OR “smart supply chain” OR ((logistics OR “supply chain”) AND “industry 4.0”)) AND (transport* OR distribution OR deliver* OR ship* OR “freight forward*”). The databases selected for the search were Scopus, Web of Science and Science Direct, and included all the works published up to March 2021.

3.2.Conducting

In the conducting phase, the search was carried out using the criteria set in the previous step. Duplicate entries were removed and the search results were screened by selecting only articles in English and published in international peer-reviewed journals or international conferences (1,362 papers). As their second selection step, the authors read the abstract of each paper and then the complete article. The scope of the articles was restricted to papers dealing with operations management or supply chain management with a focus on transportation management in the context of Industry 4.0. Consequently, 1,305 articles were excluded for the following four criteria. Firstly, the research areas were out of scope, i.e. learning and human resource management (395 papers), smart cities and urban logistics (328 papers), non-industrial fields (77 papers), technology development (41 papers), organizational culture (9 papers), energy and smart grids (9 papers) and others (11 papers). Secondly, the supply chain management operations were out of scope, i.e. production management (163 papers), procurement and supplier management (76 papers), intralogistics (62 papers), warehouse management (8 papers) and inventory management (3 papers). Thirdly, the papers with limited discussion on transportation management (88 papers). Lastly, the papers with limited discussion on Logistics 4.0 (e.g. Logistics 4.0 being mentioned among further research developments) (35 papers). The screening process produced a selection of 57 articles. Two types of information were collected for each paper, primary data about the papers, and information on their content and the data used to answer the RQs.

3.3. Reporting

The papers analysed were presented in a two-step process (Tranfield, Denyer and Smart 2003). The first step consisted of carrying out a descriptive analysis of basic primary data (author, journal, date of publication, etc.). We also carried out a co-occurrence analysis of the author keywords to gain an overview of the topics, using VOSviewer. The data were analysed and the papers classified through thematic analysis, following the steps suggested by Vaismoradi, Turunen and Bondas (2013). Firstly, we read the papers thoroughly, jotting down our initial ideas. For each paper, we focused on discussions about transportation processes, looking for elements relating to the Logistics 4.0 principles presented in Section 2.1. These elements were then collected and analysed, searching for commonalities among the different papers. We highlighted the patterns that can help to explain how Logistics 4.0 principles have contributed to change the transportation process, using a top-down approach. Starting from these patterns, we identified the three constituent dimensions whereby Logistics 4.0 design principles can be integrated into the transportation process. We lastly gave a clear definition and name to each pattern and constituent dimension. The maturity levels were then highlighted in an approach similar to that described previously. When developing the constituent dimensions and the maturity model, the authors discussed the discrepancies and their different opinions concerning the interpretation of the papers, until reaching the point of agreement.

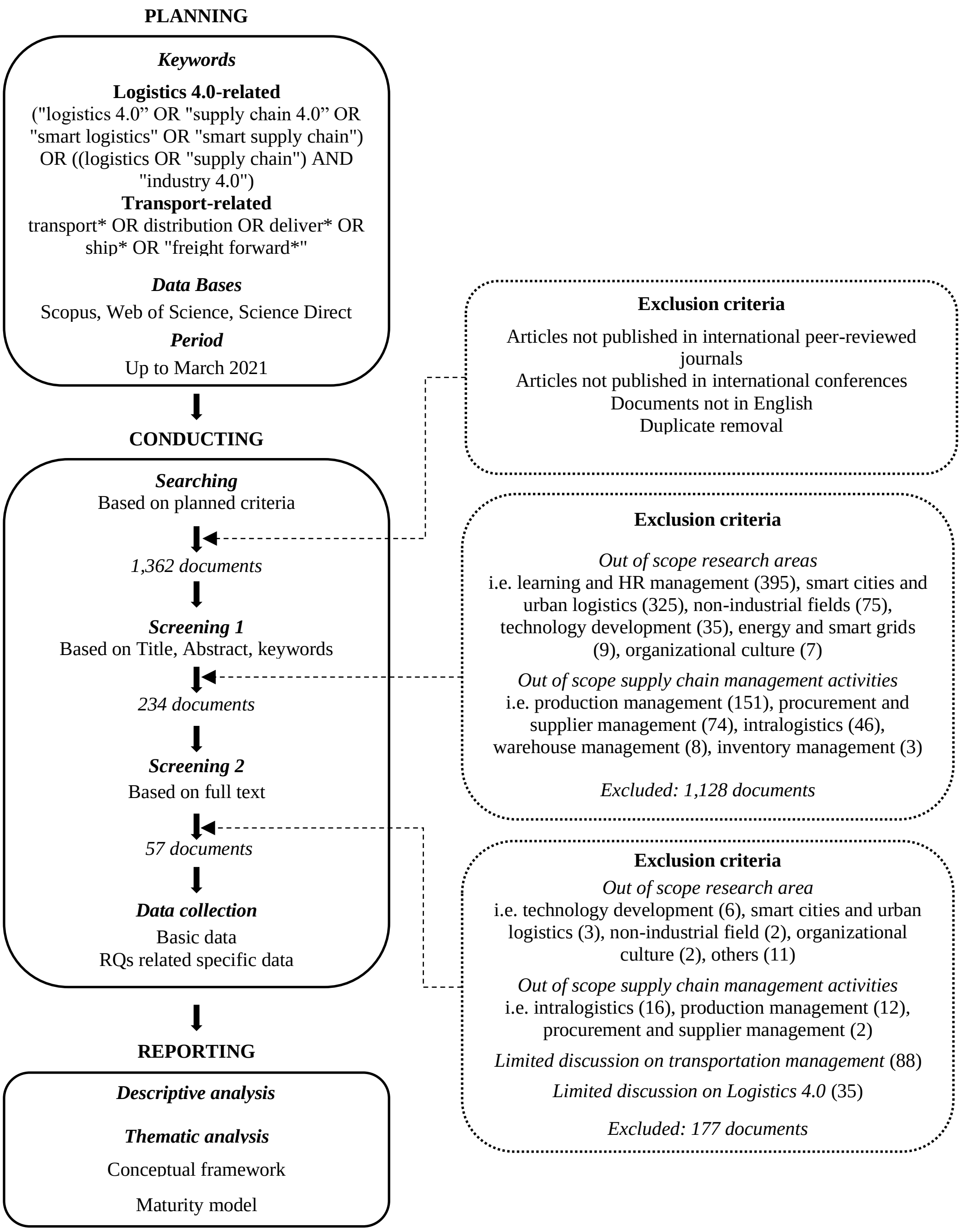

Figure 1 - SRL methodology

4. Evidence from the literature analysis

This section presents the results of the review of the papers identified through the systematic literature search process. A descriptive analysis of the year of publication and keywords is first given. The content of the papers is described coherently with the patterns identified during the reporting phase of the literature analysis (Table 1) according to the concept-based structure proposed by Webster and Watson (2002). The table highlights the top-down approach used to identify the patterns. For example, starting from the Logistics 4.0 design principle Automation (see later), we found that Physical Thing is one of the recurring elements in the transportation process that is impacted, as per the papers analysed. We also found that the level of autonomy of the Physical Thing was the main property affected by the Automation principle.

Table 1 - Patterns extracted from the literature review

	Automation			**Integration**	**Intelligence**		
	Physical Thing	**Data Acquisition**		**Connectivity**	**Analytics**		**Digital Service**
Articles	**Level of Autonomy**	**Frequency of Acquisition**	**Level of Automation**	**Network Span**	**Decision Level**	**Decision Scope**	**Application**
Agárdi, Kovács and Bányai 2019	x					x	
Altuntaş Vural et al. 2020				x			x
Arif et al. 2020		x	x	x		x	x
Asdecker and Felch 2018				x			x
Bányai 2018						x	
Bányai, Illés and Bányai 2018						x	
Ben-Daya, Hassini and Bahroun 2019		x	x			x	x
Bosona et al. 2018		x	x	x		x	x
Bosona, Gebresenbet and Olsson 2018				x		x	x
Bucovetchi, Simioana and Stanciu 2017	x	x	x	x			
Daudi and Thoben 2020				x	x	x	
de Vass, Shee and Miah 2020						x	
Dev, Shankar and Qaiser 2020				x			x
Di Puglia Pugliese, Guerriero and Macrina 2020	x						
Ding et al. 2020		x	x				
Elavarasi, Murugaboopathi		x	x	x	x	x	x

and Kathirvel 2019							
Ellefsen et al. 2019					x	x	
Fahim et al. 2021			x	x			
La Scalia et al. 2017		x	x		x		x
Gath, Herzog and Edelkamp 2013				x		x	
Gath, Herzog and Edelkamp 2014				x		x	
He, Li and Kumar 2021				x			
Hilpert, Kranz and Schumann 2013		x					
Hoffmann and Prause 2018	x						
Hofmann and Rüsch 2017	x	x	x	x	x	x	x
Iacob et al. 2019		x	x	x	x	x	x
Ilin, Simic and Saulic 2019	x	x	x	x			
Issaoui et al. 2019	x		x	x			x
Ivankova, Mochalina and Goncharova 2020				x			x
Ivaschenko, Syusin and Sitnikov 2017				x		x	
Kayikci et al. 2020							x
Kucukaltan et al. 2020	x		x				x
La Scalia et al. 2016					x		x
Lee, Kang and Prabhu 2016					x		x
Liu et al. 2019			x	x	x	x	x
Lumsden and Stefansson 2007		x	x	x			
Luo and Fu 2017		x	x	x	x	x	
M’hand et al. 2019		x	x			x	x
Müller, Jaeger and Hanewinkel 2019	x		x			x	
Paprocki 2017	x						
Pournader et al. 2020				x			x
Proto et al. 2020	x	x	x	x			x
Rahman et al. 2020	x	x	x				x
Rani, Kumar and Kumar 2018						x	

Ranieri et al. 2018	x	x				x	x
Sciortino et al. 2016					x		
Sharma, Chauhan and Chand 2016		x					
Sivamani, Kwak and Cho 2014		x			x		
Song et al. 2021						x	
Su and Fan 2020		x	x	x	x	x	x
Tang and Veelenturf 2019	x			x			
Tatham, Fisher and Gapp 2013	x						
Teucke et al. 2018		x	x	x	x	x	x
van Lopik et al. 2020		x	x	x		x	
Vieira et al. 2019				x	x	x	
Yavas and Ozkan-Ozen 2020				x			
Zhang 2018b		x	x	x		x	

All the aspects are well covered, especially those relating to integration and intelligence, included in more than half the selected papers. Only in one paper, by Hofmann and Rüsch 2017, are all the aspects analysed considered, offering a logistics-oriented Industry 4.0 application model, which, however, concentrates only on two logistics contexts (kanban and Just in time/Just in sequence).

Figure 2 shows that, although some Logistics 4.0 concepts were initially discussed in 2007 under the term “Smart Logistics”, most papers on Logistics 4.0 in the transportation process are very recent, as almost three-quarters of the articles were published since 2018 (42 papers). Conference papers make up one quarter of all analysed papers. They lead the research in this area, and include seminal papers first presented at international conferences and then accepted for journal publication (e.g. Hofmann and Rüsch 2017). These findings support the newness and innovativeness of this topic.

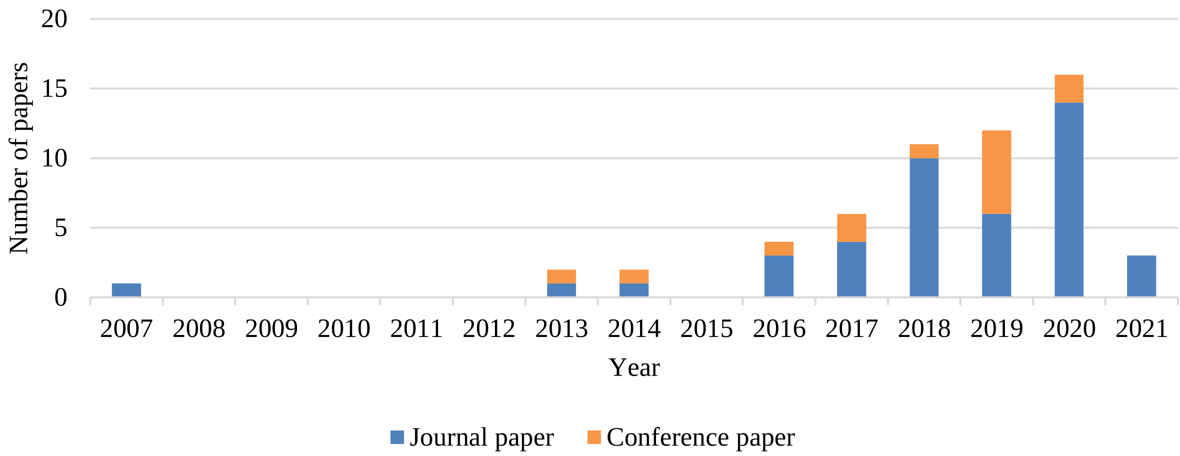

Figure 2 - Distribution of papers over time

The analysis of author keywords (Figure 3) confirms and reinforces several concepts highlighted in Logistics 4.0 literature.

Firstly, Logistics 4.0 is closely linked to Industry 4.0, since “Industry 4.0” is the most frequently occurring keyword (19 times), and is in co-occurrence with most of the other keywords, meaning that it is related and referred to by most Logistics 4.0 keywords.

Secondly, a number of digital technologies belong to Logistics 4.0 in transportation (keywords “drone”, “internet of things”, “artificial intelligence”, “blockchain”, “big data”), confirming the technology plurality defining Logistics 4.0.

Thirdly, we found several groups of keywords reflecting the concepts of the design principles. Group (i) relates to transportation process autonomy, in terms of physical automation (i.e. keyword “drone”) and data gathering (i.e. keywords “internet of things”). Group (ii) relates to the relevance of neighbourhood processes, such as production (i.e. keyword “just in time”) and actors (i.e. keyword “supply chain management” and “information sharing”) in transportation management. The last group (iii) relates to transportation process “smartness” (i.e. keywords “smart logistics, “artificial intelligence”, “big data”).

Lastly, from the analysis of the keywords, it was possible to get a feeling of the more frequent transport management problems (i.e. keyword “vehicle routing problem”), and the methods used to investigate Logistics 4.0 in transportation (i.e. keywords “simulation”, “multi-agent systems”).

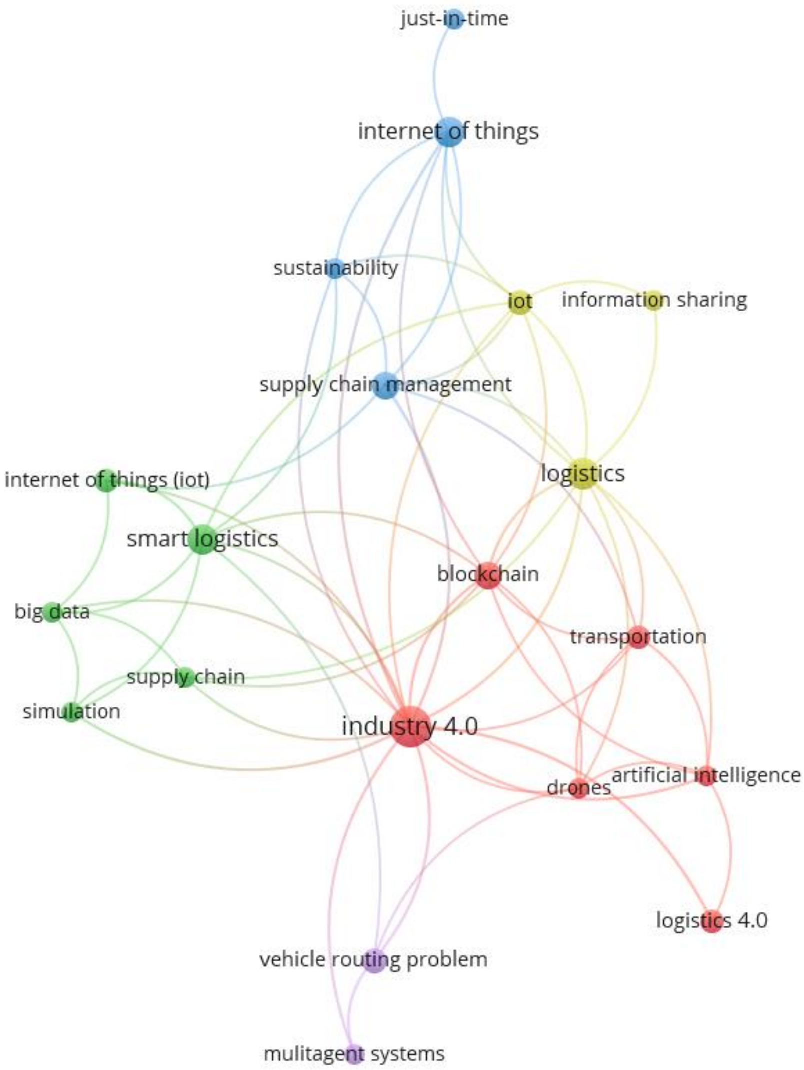

Figure 3 - Co-occurrence analysis of author keywords in the selected papers

4.1. A conceptual framework for Logistics 4.0 in the transportation process

The patterns extracted from the literature were aggregated into three sets of elements describing Logistics 4.0 in the transportation process. The first set includes Logistics 4.0 principles, which define the design principles relating to Logistics 4.0 in the transportation process and describe how to design a transportation process in a 4.0

context. The second set includes the process layers, which are the elements of the process which are affected by their corresponding Logistics 4.0 principle. The final third set includes the process dimensions, which are the properties whereby a Logistics 4.0 and a traditional transportation process can be distinguished apart. These three constituent dimensions have been organized into a conceptual framework, as shown in Figure 4.

Three Logistics 4.0 principles, Automation, Integration and Intelligence, were identified. The framework indicates the process layers corresponding to each Logistics 4.0 principle, with one or more process dimensions being then assigned to each process layer. The framework also shows the connection between the physical and the digital worlds in the transportation process. Since, in CPS, the physical world represents the basis for the overall system, the Logistics 4.0 principle Automation, which acts on the physical world, represents the basis of the framework. The Logistics 4.0 principle Integration is the principle by which the data collected from the physical world can be accessed by the different supply chain players. The principle Intelligence, lastly, builds on the previous principles, enabling all the players involved in the transportation process to take decentralized and data-driven decisions.

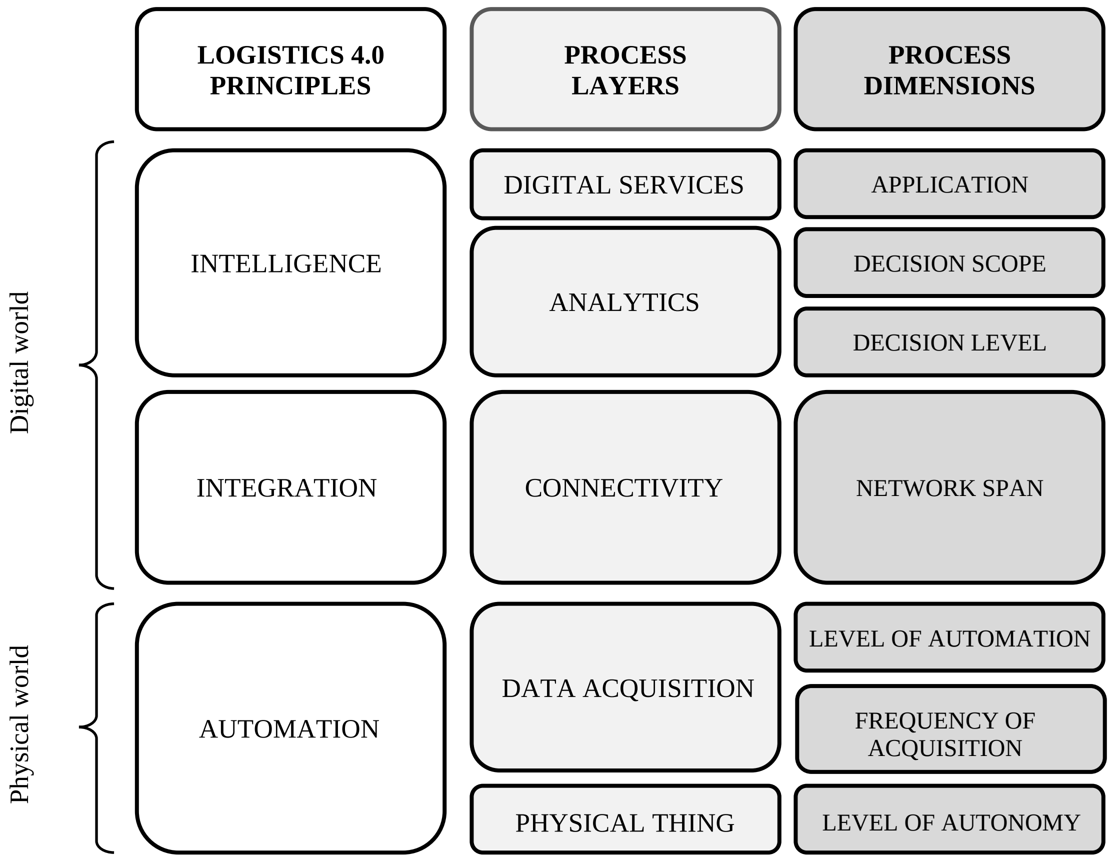

Figure 4 - Conceptual framework for Logistics 4.0 in transportation

4.1.1. Automation

Logistics 4.0 literature contains an extensive discussion on how autonomous vehicles and technologies such as drones (Bucovetchi, Simioana and Stanciu 2017; Issaoui et al. 2019) and freight sensors (La Scalia et al. 2017) will create value in transportation processes over the next years. Automated technologies contribute to reducing the consumption of resources and increasing personalized delivery methods (Kucukaltan et al. 2020). Accordingly, many authors started to include elements connected to these new technologies in their studies on the transportation process. Agárdi, Kovács and Bányai (2019), for example, developed a vehicle routing algorithm for last mile delivery using both vans and drones to serve customers. Attention is also being paid to placing sensors on freight, which can collect, store and transfer data autonomously, providing information about the freight status (Sciortino et al. 2016; La Scalia et al. 2017; Proto et al. 2020). The automation of data collection is also stressed by many authors, which deemed the acquisition of real-time information necessary for the virtualization of the physical world required by the CPS implementation and to achieve the full benefits derived from real-time, end to end visibility (Arif et al. 2020; Fahim et al. 2021). The Logistics 4.0 principle Automation was derived from and is embedded in two process layers, Physical Thing and Data Acquisition. Following the principle of Automation, the transportation process should be designed so that autonomous systems, Physical Things, carry out physical tasks (e.g. Hoffmann and Prause 2018) and real-time Data Acquisition from physical systems is provided autonomously.

Physical Thing is the physical elements involved in the transportation process (e.g. means of transport, cargoes). It includes autonomous vehicles that can be operated without human intervention and are considered one of the most promising upcoming technologies (Ranieri et al. 2018; Ilin, Simic and Saulic 2019). The technologies vary according to type of delivery. Robots and drones can be used mainly in last mile logistics (Agárdi, Kovács, and Bányai 2019; Di Puglia Pugliese, Guerriero and Macrina 2020) and humanitarian logistics (Tatham, Fisher and Gapp 2013; Tang and Veelenturf 2019). Autonomous trucks, vans and lorries are better suited to long distance, full truck load freight transport needs (Hofmann and Rüsch 2017). Physical Thing includes freight with sensors that can collect, store and transfer data during the transportation process and, therefore, can communicate with their environment in a relatively autonomous way. Level of Autonomy is the process dimension that describes this process layer.

The Data Acquisition layer refers to the collection of data from physical objects. On field-data can be gathered with a different level of automation and with a different frequency. Data can be automatically retrieved in real time from sensors and GPS systems, increasing the transportation process’s responsiveness and the value that

Logistics 4.0 can deliver to the transportation process (Hilpert, Kranz and Schumann 2013; Bucovetchi, Simioana and Stanciu 2017; Luo and Fu 2017; Bosona et al. 2018; Teucke et al. 2018; Liu et al. 2019). RFID tags can be used to collect data periodically, based upon the tag's reading frequency (Sharma, Chauhan and Chand 2016; Ben-Daya, Hassini and Bahroun 2019). Consequently, two process dimensions describe this layer, Level of Automation in acquiring data and Frequency of Acquisition of data. The Data Acquisition layer enables the virtualization of the physical world and its consequent integration with the digital world, thereby introducing the next Logistics 4.0 principle, Integration.

4.1.2. Integration

With the virtualization of the physical world, enabled by the Data Acquisition layer, data collected from physical objects can be shared among the different actors involved in the transportation process. The fact that the transportation process is able to integrate and exchange data and information is a topic of particular interest in the literature on Logistics 4.0, as it lays the basis for communication among objects, systems and supply chain actors (e.g. Hofmann and Rüsch 2017). Accordingly, in designing a transportation process, the Logistics 4.0 principle Integration encourages the sharing of information inside and outside the boundaries of a company, at both vertical and horizontal levels of the supply chain, giving the supply network access to the data (e.g. Arif et al. 2020).

In Logistics 4.0, Integration takes place at the process level by connecting different transportation tasks, and at the supply chain level by connecting the different players involved in the transportation process and giving access to information. The Integration principle is translated into the Connectivity process layer, which refers to the capability to make the collected data accessible to different actors. The related process dimension is the Network Span, which refers to the number of supply chain players able to access the information. Differing Network Spans call for differing integration capabilities. Process integration can be carried out at the transportation level, for example, by integrating first mile and last mile operations (pickup and delivery, respectively) (Bányai, Illés and Bányai 2018), or transport and other supply chain such as production, in a Just in Sequence fashion (He, Li and Kumar 2021). Integration among different players is usually achieved by using platforms that enable information to be shared (Bosona, Gebresenbet, and Olsson 2018; Müller, Jaeger and Hanewinkel 2019). Platform-based information sharing is facilitated through interoperability (Ben-Daya, Hassini and Bahroun 2019), standard compatibility (Bosona, Gebresenbet and Olsson 2018) and user privacy, potentially backed by blockchain (Pournader et al. 2020). New service providers, such as system integrators, can also emerge (Ivaschenko, Syusin and Sitnikov 2017; Ivankova, Mochalina and Goncharova 2020; Altuntaş Vural et al. 2020).

4.1.3. *Intelligence*

Researchers claim that, in Logistics 4.0 transportation processes, decision making should be supported by data analytics and process "smartness", maximising the value from the extracted data for both internal decisions and external customers (e.g. Hofmann and Rüsch 2017). These concepts have been embedded in the Logistics 4.0 principle Intelligence. This third and last Logistics 4.0 principle has a threefold meaning. Firstly, it gives the opportunity to perform decentralized decisions. Secondly, it gives the ability to read, aggregate and interpret local and global data collected from the physical world to provide relevant information to the decision maker(s). Thirdly, it provides the opportunity to use data to offer a service which is useful for the internal or external players involved in the transportation process. Intelligence is embedded in the two process layers, Analytics and Digital Services.

Analytics emphasizes the impact that the principle of Intelligence has on transportation process decisions. It includes the Decision Level process dimension, which reflects the level of centralization in the decision-making process, with decentralized distributed decisions being possible because of the Connectivity layer (Gath, Herzog and Edelkamp 2013, 2014). The second process dimension is the Decision Scope, which defines the type of decisions supported by the data collected. These data can refer to static information (e.g. hub location, infrastructure, package dimension and demand (Sivamani, Kwak and Cho 2014; Bányai, Illés and Bányai 2018)) or to dynamic information about the product (e.g. temperature and humidity (La Scalia et al. 2017; La Scalia et al. 2016; Elavarasi, Murugaboopathi and Kathirvel 2019)), the customer (e.g. real-time delivery location, variable orders (Sivamani, Kwak and Cho 2014)) and shipment (e.g. real-time vehicle location, traffic data (Liu et al. 2019) and context-related data (e.g. supplier disruptions (Vieira et al. 2019)). Transport decisions supported by data analysis can include vehicle routing and scheduling, thus the execution and planning of transport tasks (e.g. Su and Fan 2020). Decision-making of this kind is backed by both static data, including hub and delivery point location and infrastructure, and variable data about the customer's real-time delivery location and shipment data (Lee, Kang and Prabhu 2016; Rani, Kumar and Kumar 2018; van Lopik et al. 2020).

The fifth and last process level, Digital Services, refers to the value that the data analysis generates for the internal or external players involved in the transportation process, and is translated into the Application process dimension, which is associated to different types of value creation. For example, the ability to record and know the status of the process, visibility, is the performance cited most often in transportation (Lumsden and Stefansson 2007; Bosona, Gebresenbet and Olsson 2018; Arif et al. 2020). Visibility helps to monitor product and shipment conditions and to take responsive decisions about re-routing products and shipment scheduling (La Scalia et al. 2017; La Scalia et al. 2016).

4.2. Maturity model

The literature findings showed different available configuration options for the process dimensions identified in the Logistics 4.0 transportation process. These have been combined in a maturity model capturing the evolution of the transportation process towards Logistics 4.0 implementation (Figure 5).

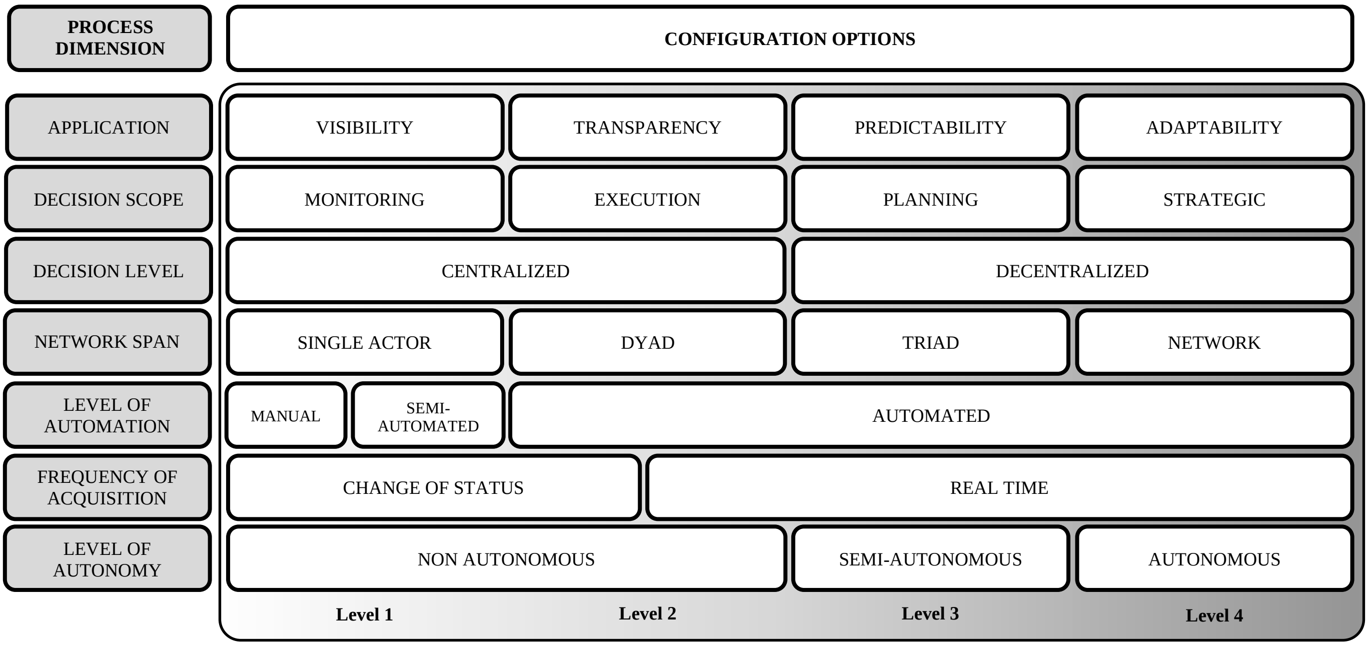

Figure 5 - Maturity model for the Logistics 4.0 transportation process

Four maturity levels were developed, going from a low Logistics 4.0 implementation level, Level 1, up to Level 4, where the 4.0 model is completely integrated into the transportation processes, making it possible to achieve the highest value. These four levels can describe maturity according to a “horizontal” perspective along the single process dimensions, and a “vertical” perspective across all the process dimensions.

From the horizontal perspective, the Level of Autonomy process dimension includes three different configuration options, non-autonomous, semi-autonomous and autonomous. Most physical elements involved in the transportation process (e.g. means of transport, cargoes) covered in the literature analysed are not autonomous. Notably, many Logistics 4.0 solutions are built on traditional transportation systems, and work on the virtualization of physical objects through the medium of data collection technologies (Teucke et al. 2018; Ben-Daya, Hassini and Bahroun 2019; Liu et al. 2019). These technologies usually collect a small amount of information about the objects, e.g. the location of lorries or vans (Sharma, Chauhan and Chand 2016). Moving towards physical autonomy, next up are semi-autonomous vehicles and semi-autonomous freight, where human intervention is needed in specific tasks, in the first case (Paprocki 2017; Hoffmann and Prause 2018), and which can exchange information about their status autonomously and in real time, in the second (La Scalia et al. 2017; Müller, Jaeger and Hanewinkel 2019; Proto et al. 2020). In its full implementation, Logistics 4.0 requires the Level of Autonomy to be autonomous for the physical objects involved in the transportation process. The term autonomous objects generally refers to autonomous vehicles, such as drones, that can be operated without human intervention (Ranieri et al. 2018; Hofmann and Rüsch 2017). Two different Frequency of Data Acquisition options were then identified, change of status, meaning that data are collected when a predetermined condition is satisfied (e.g. the truck reaches the warehouse), and real-time, meaning that data are continuously collected and transmitted to the transport actors (Ding et al. 2020). Manual and semi-automated data acquisition from the physical world can be implemented via traceability sheets and barcode systems, respectively (Arif et al. 2020). The final configuration option for the Level of Automation process dimension, automated data acquisition, is enacted through sensors and IoT devices (Ben-Daya, Hassini and Bahroun 2019). Several authors (Bosona et al. 2018; Luo and Fu 2017; Arif et al. 2020) have highlighted the fact that adopting Logistics 4.0 in transportation requires real-time automated data acquisition processes in most of its applications (Teucke et al. 2018; Ben-Daya, Hassini and Bahroun 2019; Dev, Shankar and Qaiser 2020).

Collected data can be shared with actors at different levels of the supply chain network. The Network Span of data integration moves from the single actor to the entire network. A single actor span is mainly associated with specific 4.0 software applications, such as last-mile vehicle routing navigation software (Bibby and Dehe 2018; van Lopik et al. 2020; Su and Fan 2020) or applications used to monitor product quality during delivery (Teucke et al. 2018; La Scalia et al. 2016; Elavarasi, Murugaboopathi and Kathirvel 2019). Actor integration extends across three further groups. The first is the supply chain dyad, which includes situations where for example, supplier and producer combine their transport and ordering processes to improve transportation process performance (Gath, Herzog and Edelkamp 2013) or supply chain resilience (Vieira et al. 2019). The second is the supply chain triad, where information collected during the transportation process can be accessed by the shipper, the logistics service provider (LSP) and the customer in the same supply chain (Lumsden and Stefansson 2007; Asdecker and Felch 2018; Bosona et al. 2018; Dev, Shankar and Qaiser 2020). The third group is the supply chain network. Network integration is usually enabled by platforms connecting various actors (Iacob et al. 2019; Arif et al. 2020; Yavas and Ozkan-Ozen 2020). Since Logistics 4.0 implementation is associated with global access to data acquired from the physical world, the network configuration option represents full maturity for the Network Span process dimension.

The Decision Level process dimension includes two configuration options. The first, centralized decision level, means that decisions take place at one central node, usually hosted by the company owning the solution (Luo and Fu 2017; Elavarasi, Murugaboopathi and Kathirvel 2019; Su and Fan 2020). We found fewer articles covering the second option, decentralized decision level, which can include decisions taken by different supply chain actors in a distributed way (e.g. different customers make autonomous decisions based on alerts provided by the LSP (Iacob et al. 2019)) and decisions taken autonomously by objects such as intelligent containers or vehicles, and customer order systems that select the best path according to predefined rules and real-time information (Gath, Herzog and Edelkamp 2013, 2014; Iacob et al. 2019; Liu et al. 2019). Four different configuration options were identified for the Decision Scope process dimension - monitoring, execution, planning and strategic - which represent the type of transportation decisions impacted by the analysis of collected data. Monitoring is the base for decision making because it provides the means to understand the transportation process status. Monitoring can include the vehicles' position (M'hand et al. 2019; Su and Fan 2020), product quality during delivery (Luo and Fu 2017; Teucke et al. 2018; Bosona et al. 2018; Bosona, Gebresenbet and Olsson 2018; Ben-Daya, Hassini and Bahroun 2019; Elavarasi, Murugaboopathi and Kathirvel 2019) and driver monitoring, including the driver's health and driving behaviour (de Vass, Shee and Miah 2020; Song et al. 2021). Execution decisions about the transportation process are observed mostly in vehicle routing problems. Vehicle routing is used to optimize the distribution path economically (Müller, Jaeger and Hanewinkel 2019; van Lopik et al. 2020; Agárdi, Kovács and Bányai 2019) and environmentally (Ranieri et al. 2018; Su and Fan 2020), or to re-route products whose quality was impaired during delivery (Sciortino et al. 2016; Ben-Daya, Hassini and Bahroun 2019). Among the planning decisions impacted by the adoption of Logistics 4.0, order rescheduling decisions are cited most frequently (Bányai 2018; Bányai, Illés and Bányai 2018), together with asset repositioning (Daudi and Thoben 2020). Strategic decisions are investigated the least frequently, and refer mainly to transport network reconfiguration (Vieira et al. 2019; Dev, Shankar and Qaiser 2020), assessments about the profitability of serving customers that are used in making decisions about allocation (Ellefsen et al. 2019) and the selection of transport mode (Hofmann and Rüsch 2017). We assumed that higher maturity is associated with long-term decisions implicating a high commitment of resources. The Application process dimension covers a range of values, starting from basic visibility on the status of the transportation process, mainly in terms of logistics tracking (Bosona, Gebresenbet and Olsson 2018; M'hand et al. 2019; Su and Fan 2020) and product tracing (La Scalia et al. 2016; G. La Scalia et al. 2017; Arif et al. 2020). The end point is the transportation process's adaptability to external and internal changes (Gath, Herzog and Edelkamp 2014; Zhang 2018b), which deals with autonomous and self-adapting decision making. This situation refers to a fully mature Logistics 4.0 implementation and increases the transportation process's responsiveness to dynamic events (Altuntaş Vural et al. 2020). Among the examples of adaptive systems are re-routing in real time based on traffic conditions (Hofmann and Rüsch 2017; Ranieri et al. 2018; Liu et al. 2019) and the periodic adjustment of optimal logistics path decisions on the basis of customer location and expected delivery lead time (Zhang 2018; Lee, Kang and Prabhu 2016). Both visibility and adaptability are expected to increase flexibility, improving cost efficiency and increasing service levels, thereby creating value for the supply chain actors (e.g. Ben-Daya, Hassini and Bahroun 2019). Moreover, visibility can help to increase environmental sustainability in transport by providing real data on noxious emissions that can help set targets in emission reduction initiatives (Hilpert, Kranz and Schumann 2013). Moving on from visibility, the configuration option of transparency enables transportation process actors to detect and understand the causes underlying the observed transportation process phenomena. Transparency in the form of studying the environmental conditions of the transportation process can indicate the product's status during delivery. The outcome is that the product's quality is improved, late deliveries are reduced and value is created with the improvement to service level (La Scalia et al. 2017; Teucke et al. 2018). Transparency can be achieved by adopting technologies such as blockchain, which can keep track of events during the transportation process in a univocal way (Issaoui et al. 2019). Predictability is the third configuration option identified. It represents the ability to forecast different based on real-time data analysis, with the help of big data analytics (Rahman et al. 2020), and is backed up by an understanding of the causes influencing the variables of interest. The predicted scenarios can be used to feed simulation models (Sciortino et al. 2016; Asdecker and Felch 2018), which can help to define corrective measures and alternative plans for the transport systems (Vieira et al. 2019). Predictability could potentially help in optimizing transport costs (e.g. Sciortino et al. 2016).

The full implementation of Logistics 4.0 requires constructing autonomous and self-controlled logistics systems that can interact with each other and with different supply chain actors. These systems must provide real-time data to the analytics supporting decentralized optimized decisions and value-added business services and processes. Keeping in mind the evolutionary trajectory of Logistics 4.0 and adopting a vertical perspective, Logistics 4.0 maturity for the proposed model can be defined as follows. At Level 1, the physical objects involved in the value creation process are not autonomous. Manual and semi-automated data acquisition cannot retrieve the data generated at the physical level with the high frequency required by real-time applications. Data are, therefore, extracted with a change of status frequency, diminishing the accuracy, timeliness and reliability of the information collected. Data are shared and used by the single company adopting the solution, with centralized decision-making processes and monitoring. Visibility is the main value provided through data analysis. While the Physical Thing layer still consists of non-autonomous objects at Level 2, data are collected in real time and in an automated way, thus increasing the performance of the transportation process. Data are shared between two different supply chain actors (i.e. dyad) involved in the transportation process, and their use is operationally-oriented, being used primarily for improving execution, even though decisions are still centralized. At this level, along with data visibility, data can be interrogated in order for transparency in the mapped processes. Semi-autonomous physical objects are introduced at Level 3, and they provide real-time data automatically to the users. The Network Span has expanded, as data have become available to three supply chain actors (i.e. triad) involved in the transportation process. Decisions are decentralized, and data are used in the planning phase, meaning that it is possible to predict future situations. At the last level, Level 4, Logistics 4.0 is fully implemented within transportation processes. Objects are autonomous, and automatically retrieved real-time data is available to the network of actors involved in the transportation processes. Decisions are decentralized, and information is also used at the strategic level. Because of its adaptability, the transportation process adapts automatically, even with no human intervention.

5. Conclusions

In reviewing the existing literature, the aim of this study was to clarify how Logistics 4.0 can be applied to transportation processes, as well as providing an overview on how the transportation process is evolving towards the 4.0 paradigm.

To answer RQ1, “What are the process dimensions that need to be considered in order to integrate Logistics 4.0 design principles within the transportation process?”, the authors set out a conceptual framework of Logistics 4.0 for the transportation process. The framework includes the Logistics 4.0 principles, process layers and corresponding process dimensions that are to be taken into account when designing a Logistics 4.0 transportation process. The integration between the physical world and the digital world in a Logistics 4.0 transportation process is also highlighted and discussed.

To answer RQ2, “How can the transportation process be configured towards the implementation of Logistics 4.0 and so create value?”, the authors then provided a maturity model to describe how a Logistics 4.0 transportation process can evolve and increasingly create value. The proposed maturity model includes two maturity perspectives, a “horizontal” type of maturity, along the process dimensions defined, and a “vertical” type of maturity, developed across the different process dimensions. These findings reinforce the perception that maturity for Logistics 4.0 in the transportation process is a complex concept. Logistics 4.0 could move along the single process dimension and among the different process dimensions, in a more systemic view.

5.1. Theoretical contributions and practical implications

This study presents both academic and practical implications. From a theoretical perspective, this research is one of the first studies focusing on how Industry 4.0 design principles can be defined and applied in the context of Logistics 4.0 and specifically to the transportation process. Building on the existing definitions of Logistics 4.0 and 4.0 paradigm-related theory, this study has investigated how the concept of CPS and design principles are deployed in transportation, highlighting the different transportation process elements affected by the concepts of the fourth industrial revolution. As a result, researchers can now appreciate the specific implications of the 4.0 paradigm in the transportation process. Moreover, our investigation extends the current theory on maturity models for adopting the 4.0 paradigm from a process perspective currently missing in the literature, by defining the available configuration options for the Logistics 4.0 transportation process and offering an overview of their implementation maturity. Our study highlights the complexity underlying the evolution towards the adoption of Logistics 4.0 in the transportation process. While the maturity models presented in the context of the fourth industrial revolution show a linear development towards the 4.0 transition, the process of implementation becomes more complex if a process perspective is adopted. Two possible maturity directions were suggested by the analysis of the different configuration options, one “horizontal” and one “vertical”. The two options can be combined in transition roadmaps, which can be company- or process-specific. From our research, it emerges that both perspectives must be adopted, since it is necessary to work on both the single process dimensions and their combination in order to complete the transition to the fourth industrial revolution.

From a practical viewpoint, the Logistics 4.0 principles identified set the working areas for the 4.0 transition. For companies, they highlight the importance of physical automation and autonomously acquired information, a connected supply network and data analysis for making decisions to develop their transportation process. This study also helps companies understand how to set their transportation process according to the identified layers and dimensions to create value.

In transiting towards Logistics 4.0, companies should think holistically about their transportation process, taking in both the physical and the information flow perspectives and looking at potential synergies with other processes and actors in the supply chain. The maturity model displays how the transportation process elements can be configured towards fully implementing the fourth industrial paradigm, and, therefore, helps companies to understand how to create value through Logistics 4.0. Moreover, logistics companies can use the maturity model to determine how their transportation process is currently positioned and to customize their transition strategies. By showing the different Logistics 4.0 principles (i.e. Automation, Integration and Intelligence) and highlighting how these principles can be translated into development paths towards Logistics 4.0, the maturity model can help companies see how to start approaching this systemic transition. It also can help them set out their vision of how their transportation process could evolve along the “horizontal” and “vertical” dimensions of maturity. Based on their skills, expertise and strategic objectives, companies could opt for a 4.0 implementation following a “horizontal” maturity path (e.g. moving from conventional trucks to autonomous vehicles and pursuing maturity at the Level of Autonomy dimension). They could, instead, decide to advance their transportation process maturity following the “vertical” maturity path and bring all the different principles into play (e.g. introducing IoT devices to collect real-time data autonomously, integrating these data with the data and the processes of their supply chain partners and taking data-driven decisions).

5.2. Limitations and future directions of research

This work contains some limitations, the main one being related to its conceptual nature. To provide empirical evidence, one suggested line of research is to map the current status of Logistics 4.0 in companies and explore the maturity levels identified in this study. Advancing our work with empirical research can support the findings from literature, and help to define how the configuration options are currently being implemented, according to industrial field evidence. The outcome of the present study also opens a future research opportunity, that of measuring the impact that each

Logistics 4.0 principle has on overall transportation process performance. This impact could be measured, for example, by quantifying the reduction in costs that autonomous vehicles can bring to the last mile delivery process (Agárdi, Kovács and Bányai 2019) or by quantifying the decrease in collaboration costs ensuing from bringing together the different actors involved in the transportation process. It could also be possible to measure the impact that the combination of the different process layers has on a specific transportation process performance. Considering, as an example, first mile transport, studies could be carried out to quantify the reduction in sales losses achieved when re-routing products on the basis of predicted quality deduced from product information collected during the delivery (Sciortino et al. 2016). Lastly, future studies can investigate the role played by different players in driving the Logistics 4.0 transition process, by identifying who can lead the change and which organizational levers can drive the change management process. In particular, the role of third party logistics as an innovator leader is an interesting topic to be explored (Marchet et al. 2017), because of the central role it plays to link and integrate different supply chain elements.

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