Logistics 4.0 and corporate sustainability: an organizational theory perspective

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RESUMO

Objetivo: O objetivo deste artigo é investigar como as teorias organizacionais podem contribuir para a compreensão das implicações da Logística 4.0 para o desenvolvimento sustentável das organizações.

Referencial teórico: A aplicação das tecnologias da Logística 4.0 pode ser uma grande aliada na implementação de ações que visem o desenvolvimento sustentável nas organizações. Há evidências na literatura de que diferentes teorias ou perspectivas organizacionais podem contribuir para a compreensão das implicações dessas tecnologias para a sustentabilidade empresarial.

Design/metodologia/abordagem: A revisão sistemática de literatura identificou 26 artigos elegíveis e aplicou extensa análise de dados qualitativos. Para análise dos resultados, foram utilizados o software Excel e a análise de conteúdo.

Resultados: As teorias e abordagens exploradas nos estudos foram a visão das capacidades dinâmicas, a teoria da difusão da inovação (modelo de Bass), a teoria do ecossistema, a teoria da cadeia de valor de Porter e a teoria da visão do processamento de informações da organização. Os resultados revelaram que a Logística 4.0 aprimora as capacidades organizacionais, otimiza recursos escassos e críticos e apoia o desenvolvimento de iniciativas sustentáveis na cadeia de suprimentos.

Implicações de pesquisa, científicas, gerenciais e sociais: Este estudo fornece implicações ao demonstrar possíveis mudanças no setor de logística de uma perspectiva ambiental, econômica e social. Além disso, os resultados podem ser uma referência para profissionais de logística ao impulsionar iniciativas competitivas na Indústria 4.0 e facilitar suas decisões estratégicas.

Originalidade/valor: A principal contribuição deste estudo consiste em abordar a aplicação de várias teorias organizacionais para entender como a Logística 4.0 pode melhorar a sustentabilidade corporativa, desenvolvendo uma agenda de pesquisa para orientar o progresso do campo de pesquisa.

Palavras-chave: Logística Inteligente; Quarta Revolução Industrial; Indústria 4.0; Cadeias de Suprimentos Sustentáveis; Desenvolvimento Sustentável; Teorias da Administração.

ABSTRACT

Purpose: The purpose of this paper is to investigate how organizational theories can contribute to understanding the implications of Logistics 4.0 for the sustainable development of corporations.

Theoretical framework: The application of Logistics 4.0 technologies can be a great ally in the implementation of measures that aim at sustainable development in organizations. There is evidence in the literature that different organizational theories or perspectives can contribute to understanding the implications of these technologies for corporate sustainability.

Design/methodology/approach: A systematic literature review identified 26 eligible articles and applied extensive qualitative data analysis. To analyze the results, Excel software and content analysis were used.

Findings: The theories and approaches explored in the studies were the dynamic capabilities view, the diffusion of innovation theory (Bass model), the ecosystem theory, Porter's value chain theory, and the organization information processing view theory. The findings revealed that Logistics 4.0 enhances organizational capabilities, optimizes scarce and critical resources, and supports the development of sustainable initiatives in the supply chain.

Research, Practical & Social implications: This study provides implications by demonstrating possible changes in the logistics industry from an environmental, economic, and social perspective. In addition, the results can be a reference for logistics professionals while driving competitive initiatives in Industry 4.0 and facilitating their strategic decisions.

Originality/value: The main contribution of this study is to address the application of several organizational theories to understand how Logistics 4.0 can improve the corporate sustainability, developing a research agenda to steer the progress of the research field.

Keywords: Intelligent Logistics; Fourth Industrial Revolution; Industry 4.0; Sustainable Supply Chains; Sustainable Development; Management Theories.

1. INTRODUCTION

In recent years, the complexity, dynamism, and requirements of the market have constantly increased. To meet the future needs of the economy and society, the evolution of technology has driven the development of new paradigms, tools and business models that directly impact the production, storage, and distribution of products (BAG; GUPTA; KUMAR, 2021; BARRETO; AMARAL; PEREIRA, 2017; STRANDHAGEN *et al*., 2017).

Logistics concerns the management of materials and information flow in companies and encompasses the activities of distribution, warehouse management, inventory management, and reverse logistics (AGUEZZOUL, 2014). The logistics aims to contribute to the creation of value for the customer, from the management of facilities, transportation, stock materials, order fulfillment, communications, third-party providers, and information within organizations (PARHI *et al*., 2022).

The increased complexity of supply chains and the outsourcing of various activities, amplify the efforts required for the management and coordination of logistics operations (CHEN; LIU, 2021). In addition, the recent digitization of processes and the expansion of cyber-physical systems (CPS) integration have caused profound changes in logistics (HOFMANN; RÜSCH, 2017; WINKELHAUS; GROSSE, 2020).

The emergence of the phenomenon of Industry 4.0 (or the fourth industrial revolution) culminated in the recent introduction of the term "Logistics 4.0" or "Smart Logistics" (BARRETO; AMARAL; PEREIRA, 2017; HOFMANN; RÜSCH, 2017). Logistics 4.0 consists of a logistics system that enables the sustainable fulfillment of individualized demands of customers and the development of industry, using digital technologies (WINKELHAUS; GROSSE, 2020). The use of intelligent systems allows the optimization of logistics processes and can enhance the capabilities of communication analysis, operation, monitoring, and adequacy of organizational processes (BARRETO; AMARAL; PEREIRA, 2017).

The expansion of awareness and the level of demand from stakeholders (customers, shareholders, regulators, non-governmental organizations, and employees) require that organizations pay attention not only to the time, cost, and efficiency of their operations, but also to seek to minimize or eliminate any negative impacts (MALTZ; PIERSON, 2022; STRANDHAGEN *et al*., 2017; TRAN *et al.,* 2019). Moreover, Logistics 4.0 can be a great ally

in the implementation of actions that aim at sustainable development, since it can improve analytical and operational capabilities and provide solutions that can enable the development of sustainable supply chains (BAG; GUPTA; KUMAR, 2021; HOFMANN; RÜSCH, 2017).

Research on the impact of Logistics 4.0 to corporate sustainability has been progressing gradually in recent years. Previous systematized reviews, such as Ejsmont, Gladysz and Kluczek (2020), Junge (2019), Strandhagen et al. (2017) and Sun *et al.* (2021), analyzed the benefits and challenges of Logistics 4.0 to enhance the organizations' sustainable performance. However, they do not explore the literature from the standpoint of organizational theories. These is relevant because the study of Logistics 4.0 is an emerging field, and researchers from different areas seek to theorize in light of various perspectives, among them, the business, management, and operations areas (WINKELHAUS; GROSSE, 2020). Furthermore, the theories are important viewpoints for understanding and analyzing contemporary issues (GLASER; STRAUSS, 2017).

In this sense, there is evidence in the literature that different organizational theories or perspectives can contribute to understanding the implications of Logistics 4.0 for the sustainable development of corporations. For example, the dynamic capabilities theory can be applied to demonstrate the tools of Logistics 4.0 as a capability that can support sustainable initiatives in organizations (TEECE, 2007), the diffusion of innovation theory can be used to understand the designations of the logistics 4.0 tools (DEV *et al.*, 2021), based on the analysis of consumer behavior patterns (BASS, 1969), among others.

Therefore, the purpose of the study is to investigate how organizational theories can contribute to understanding the implications of Logistics 4.0 for corporate sustainability. To achieve this aim, a comprehensive review of the relevant literature on the theme is proposed, exploring the application of organizational theories to underly the discussion of Logistics 4.0 for corporate sustainability, and presenting a set of recommendations for future research.

The main contributions of this investigation to can be summarized as: (a) systematizing how dynamic capabilities theory, innovation diffusion theory, organizational capabilities theory, ecological systems theory, and value chain model can support the analysis of the Logistics 4.0 advent and the implications for corporate sustainability; (b) offering a research agenda on how to connect these organizational theories to empirical research to understand the impact of Logistics 4.0 for corporate sustainability.

This article is structured in five sections: the theoretical background of this study is

discussed in Section 2 and it covers the concepts of corporate sustainability and Logistics 4.0; Section 3 presents the research method; Section 4 explores the results and discussion of findings, and, finally, Section 5 presents the final considerations and suggestions for future research.

2. THEORETICAL FOUNDATION

2.1. Logistics 4.0

Based on the trends of digitalization of organizations' processes and the use of high technology, the term Industry 4.0 was launched for the first time at the Hannover Messe Fair in 2011 (DRATH; HORCH, 2014), which is referred also as the Fourth Industrial Revolution. Industry 4.0 covers the development and integration of information and communication in real-time, for the recent advances in industrial manufacturing, especially the advances in digital technologies (BARRETO; AMARAL; PEREIRA, 2017).

Industry 4.0 is a new production model in which the establishment of smart factories occurs, which have flexible systems that integrate vertically, horizontally, and end-to-end engineering integration (LASI *et al*., 2014; KAGERMANN; WAHLSTER; HELBIG, 2013). These factories use cyber-physical systems that can make decisions and correct themselves almost independently.

Coming from the concept of Industry 4.0, the term Logistics 4.0 refers to the combination of disruptive technologies applied to logistics processes, such as transportation, inventory management, materials handling, supply chain structure, and information flow management (BARRETO; AMARAL; PEREIRA, 2017; STRANDHAGEN *et al*., 2017). The literature points out that the concept of Logistics 4.0 encompasses the use of different technologies and tools applied to logistics processes and supply chains, among them: Cyber-Physical Systems (CPS), Internet of Things (IoT), Big Data Analytics (BDA), Cloud Computing (CC), Virtual Reality (VR), Artificial Intelligence (AI), Blockchain, Mobile device-based systems, 3D Printing, Crowdsourcing, Drones, Intelligent Transportation Systems, Information Security Management, Radio Frequency Identification Systems (RFID), Automated Guided Vehicles (AGV) are used in combination with Enterprise Resource Planning (ERP) systems, Warehouse Management Systems (WMS), Transportation Management Systems (TMS), Order Management Systems (OMS), among others (CORRÊA *et al.*, 2020; IVANOV, 2022; HOFMANN; RÜSCH, 2017; STRANDHAGEN *et al.,* 2017).

The benefits of adopting Logistics 4.0 are the ability to focus employee efforts on strategic tasks, real-time tracking of material and information flows, supply chain integration, increase the quality of decision-making, increase flexibility and efficiency, and the creation of dynamic networks throughout the product life cycle (BARRETO; AMARAL; PEREIRA, 2017; IVANOV, 2022; STRANDHAGEN *et al.,* 2017).

Industry 4.0 relates to the integration of people and the environment for future industrial systems, highlighting the importance of sustainability (BAG *et al.* 2020; KAGERMANN; WAHLSTER; HELBIG, 2013). The pressure for the industry to adapt to corporate sustainability practices; the creation of new requirements related to logistics for end customers, the new guidelines and government agreements; and competitiveness, can drive the development of new technologies or business models (STRANDHAGEN *et al.*, 2017).

2.2. Corporate sustainability

Corporate sustainability encompasses normative concept that examines how society and business must act, under consideration of the environmental interactions of individuals and future generations (DYLLICK; HOCKERTS, 2002; VELEVA; ELLENBECKER, 2001). This concept is becoming a major concern in the industrial world in the last few years because of environmental degradation caused by industrial waste.

Corporate sustainability refers to the integration and incorporation of economic, environmental, and social responsibility in the organization and sustainable development as the effect of sustainable practices and sustainable strategies (PEDOL; BIFFI; MELZI, 2021; VAN MARREWIJK, 2003). There are several definitions and schools of thought regarding the perspectives of corporate sustainability, but, in general, the definitions are anchored in the triple bottom line (TBL), whose pillars correspond to the economic-financial, environmental, and social dimensions (ELKINGTON, 1998).

The social dimension includes the concern with the impacts of productive activities for the people inside and outside the organizations, aspects such as job satisfaction, health, safety, quality of life, social integration in communities, solidarity, equity, ethical behavior, justice in the distribution of goods and services, and equal opportunities in education. It aims to improve the lives of companies' employees, stakeholders, customers, and the community in which they operate (ELKINGTON, 1998; SINGH; CHAKRABORTY; ROY, 2016; BAUMGARTNER;

EBNER, 2010).

The environmental dimension refers to the rational consumption of resources and the reduction and compensation of pollution generated by effluent emissions and waste generation (ELKINGTON, 1998). Organizations can development and implement sustainable practices and policies to improve environmental performance such as the ISO14001 certification, environmental training programs for employees and managers, eco-efficiency projects, reuse, recycling, and remanufacturing of products, acquisition of environmental technologies, control and reduced atmospheric emissions, water waste and solid waste (SELES *et al*., 2019).

The economic-financial dimension is the economic prosperity attained by means of value creation, through the production of goods and supply of services (BANSAL, 2005). It is defined as how firms can stay in business over a long period of time and involves achieving a balance in all sectors of services and addressing the social issue as poverty reduction, inequality distribution, and inefficiency in the mobilization of resources (ELKINGTON, 1998).

The stakeholders like clients, logistics partners, suppliers, employees, investors, customers, associations, and government already require the commitment of companies to sustainable development and adopt environmental, social, and governance (ESG) targets (PEDOL; BIFFI; MELZI, 2021). Stock and Seliger (2016) argue that Industry 4.0 has great potential to promote sustainable industrial value creation in the TBL. Efficient logistics is a key aspect for companies promote a sustainable supply chain. For this, the recent literature indicates that the implementation of Industry 4.0 can play a crucial role in promoting green practices in the production system and logistics operations (BAG; PRETORIUS, 2020).

3. METHODOLOGICAL PROCEDURES

Considering that Industry 4.0 applications are trends with the potential in making society more sustainable and that logistics represents one of the most critical areas for Industry 4.0, due to the need to achieve a high level of integration with the supply chain (IVANOV, 2022; KAGERMANN; WAHLSTER; HELBIG, 2013), we conducted a systematic literature review (SLR) in order to analyze the scientific production on the synergy of the themes and understand how different approaches of the organizational theories can be used for understanding this relationship.

Initially used in the health area, the SLR is a methodology that aims to build a dataset of studies and analyze them in a systematic and organized way (TRANFIELD *et al*., 2003). We chose this approach because SLR is a transparent and replicable process that allows researchers to identify, appraise, and synthesize all relevant studies and provides an in-depth understanding of both quantitative and qualitative issues (CENTOBELLI *et al.*, 2020).

To develop the study, we followed the method suggested by Cerchione and Esposito (2016), which demonstrates how to organize a structured literature review. Accordingly, we organized our study into four phases: (i) material search; (ii) paper selection; (iii) descriptive analysis; (iv) content analysis. Each phase is explained below.

3.1. Material search

The first step of this SLR was to identify the relevant and eligible literature on the topic under investigation. For this, similar to the approach adopted by Ahmad and Van Looy (2020), our research design departs from the development of a SLR protocol, to minimize the occurrence of bias in the research results.

The SLR protocol (Table 1) contains the research purpose, the sources (academic databases), the search strategy, the quality criteria, and the inclusion and exclusion criteria for screening the observed studies.

As for the first step of the content search, we used two academic databases that consolidate high-level and high-impact journals for the fields of business and operations management (EJSMONT; GLADYSZ; KLUCZEK, 2020): the Web of Science (WoS) and Scopus. We searched for combinations of terms (Table 2) related to Logistics 4.0 (BARRETO; AMARAL; PEREIRA, 2017, CORRÊA *et al.,* 2020) and Corporate Sustainability (ELKINGTON, 1997, NASCIMENTO *et al.,* 2019, NANTEE; SUREEYATANAPAS, 2021). The searches were conducted in March 2022 and by "topic", i.e., searching for the terms in the titles, keywords, and abstracts of the studies.

Table 1 - SLR Research Protocol

Purpose	Investigate how organizational theories can contribute to understanding the implications of Logistics 4.0 for the sustainable development of corporations
Sources of Search	Web of Science; Scopus
Search strategy	Article title; abstract; keywords
Inclusion criteria	All relevant journal articles, reviews, and editorial that were written in English; Papers from the following areas: Business, Management and Economics, Social Sciences, Engineering, Computer Sciences, Environmental Sciences, and Decision Sciences
Exclusion criteria	Duplicates and studies that do not fit into Logistics 4.0 and corporate sustainability topics; that do not show one or more logistics processes; that do not address one or more perspectives of corporate sustainability; that do not explore emerging technologies applied to Logistics and/or do not analyze Sustainability and Logistics 4.0 on the organizational perspective.
Quality criteria	Only peer-reviewed articles

Source: The authors, 2022.

Table 2 - Search criteria

Keywords (1)	Operator	Keywords (2)	Operator	Key (3)
"Logistic* 4.0" OR "smart logistic*"	OR	("digital technolog*" OR "industry 4.0" OR "fourth industrial revolution") AND logistics	AND	"sustainab*" OR "green" OR "societal" OR "ecology" OR "environmental"

Source: The authors, 2022.

3.2. Paper selection

In relation to the step of papers selection, we identified four criteria to analyze the research papers. Using the selection criteria, the search returned a total of 486 studies. After removing non-applicable papers and duplicates, the sample was reduced to 189 studies. The subsequent screening consisted of analyzing the "title, keywords, and abstract" x "topic" in an Excel spreadsheet to verify the adherence of the studies to the research question, resulting in a sample of 65 articles.

Finally, the last stage of study screening was performed, in which the studies were read in full, and studies that did not meet one or more criteria were excluded: (i) investigated the processes of transportation, distribution, warehouse management, inventory management, and/or reverse logistics (AGUEZZOUL, 2014); (ii) explored the economic, social and/or environmental

perspective (ELKINGTON, 1997); (iii) analyzed one or more tools of Logistics 4.0 (BARRETO; AMARAL; PEREIRA, 2017; CORRÊA *et al*., 2020); and, (iv) analyzed the theme from an organizational perspective. After performing the final screening and applying the criteria, 39 articles were excluded, resulting in a final sample of 26 articles.

3.3. Descriptive and content analysis

First, the descriptive analysis was performed in Excel software and aimed to map the chronological evolution, origin, and source of the publications. In the sequence, we conducted a content analysis of the articles in the sample, in which it was possible to identify the main impacts of Logistics 4.0 and corporate sustainability, the applied theories, and the research gaps. The content analysis helped in the exploration of the material, to find divergences and convergences between the studies (BARDIN, 2011).

To extract information from the selected articles, we verified the research objective, the type of approach and data collection instrument, the group of logistics tasks analyzed, the dimension of sustainability studied, the organizational theory applied, and the research gaps pointed out in the work.

4. RESULTS AND DISCUSSION

4.1. Descriptive analysis

The first article in the sample that addresses correlated aspects of Logistics 4.0 and Corporate Sustainability was published in 2013, which shows that the study of these phenomena is in the early stages (EDMONDSON; MCMANUS, 2007). Since then, the number of publications on the subject has been growing gradually (Table 3).

Most of the papers addressing the integration between Logistics 4.0 and CS are qualitative studies. Since the phenomenon of Logistics 4.0 concerns incipient theoretical concepts, researchers do not know what questions may arise from the data, and therefore theoretical studies interviews, observations, open-ended questions, and longitudinal investigations are more suitable methods (EDMONDSON; MCMANUS, 2007).

Many of the studies were concentrated in European nations, a fact accentuated by government policy programs that stimulated the development of Industry 4.0, such as in Germany, where the government sponsored the creation of partnerships between technology

companies, universities, and research centers, to promote and produce technologies applied to the industrial area (KAGERMANN; WAHLSTER; HELBIG, 2013). A large part of the publications was conceived by developed nations such as Germany, Australia, England, France, and the United States, which concentrate about 38% of the studies.

Table 3 - The chronological distribution of the papers and their research method

Publication Year	Research method	Number of publications
2013	Conceptual	1
2017	Conceptual	2
2018	Multiple methods	1
	Survey	1
2019	Conceptual	1
2020	Case studies	2
	Quantitative modeling/ Simulation	4
	Survey	4
2021	Case studies	5
	Quantitative modeling/ Simulation	4
	Survey	1

Source: The authors, 2022.

Considering the Industry 4.0 technologies and the TBL dimensions, the results showed that the Internet of Things and Big Data and their combination with other tools are the most studied technologies in the sample. Regarding sustainability, the economic dimension is the most explored, as well as the impacts of Logistics 4.0 initiatives for this dimension.

4.2. Contributions of logistics 4.0 to corporate sustainability

This section presents the contributions of Logistics 4.0 to sustainability in organizations. Table 4 summarizes the logistics tasks explored in the studies, the logistics 4.0 technologies applied, and the impact for sustainability dimensions. The results showed that the interest in tools that can expand corporate sustainability has been gaining more space, especially, regarding the use of Industry 4.0 technologies (STRANDHAGEN *et al*., 2017). Dev, Shankar and Swami (2020) emphasize that digital innovations have an important role in the transparency and sharing of information in the supply chain, one of the essential capabilities in building sustainable supply chains. Moreover, the organizational sense can be amplified by the existence of more accurate

information, supporting decision-making and knowledge creation regarding sustainable business practices (HILPERT; KRANZ; SCHUMANN, 2013).

The literature shows that Logistics 4.0 initiatives generate economic-financial benefits, mainly due to reduced internal supply chain costs (operational and labor); increased productivity, efficiency, transparency, the accuracy of deliveries; transportation revenue, customer satisfaction, and information exchange among chain members; decreased lead time and response time (BAG *et al*. 2020; NAGY *et al,* 2018).

IoT-integrated systems can provide customers with real-time information about deliveries through improved tracking and tracing, which helps products move faster (BAG et al. 2020). The study conducted by Munsamy, Telukdarie, and Dhamija (2020) reported that digitalization, with the use of IoT and mobile devices, reduces the time required to perform tasks such as product entry and storage, consequently reducing the hours worked and the operating time of energy-consuming equipment.

Table 4 - Logistics tasks, technologies and sustainability dimension addressed in the studies

Authors	Logistics' tasks	Logistics 4.0 technologies	Sustainability Dimension
Baskutis et al. (2018)	Transportation and Transport Management	Autonomous vehicles	Environmental and Economic
Dev, Shankar, and Qaiser (2020)	General Contributions	RFID, GPS, IoT, CC and Big Data	General Contributions
Bag et al. (2020)	Transportation and Transport Management	IoT, Big Data and CC	Social and Economic
Bag and Pretorius (2020)	General Contributions	RFID, Blockchain, GPS, IoT, CC and Big Data	General Contributions
Bag, Gupta e Luo (2020)	General Contributions	RFID, IoT, CC and Big Data	General Contributions
Buntak et al. (2019)	Warehousing, Packaging and Warehouse Management	Iot, CPS, RFID, Big Data and WMS	Environmental and Economic
Cimini et al (2021)	Material Handling General	WMS, RFID, Drone, Barcodes, CC, ERP, Mobile applications, AI	Social
De Vass, Shee and Miah (2020)	General Contributions	Iot, RFID, Voice-picking, AGV, Barcodes, EDI, and ERP	General Contributions
Dev, Shankar, and Qaiser (2020)	Transportation and Transport Management	CPS, ERP, RFID, IoT, Additive remanufacturing	Environmental and Economic
Dev, Shankar, and Swami (2020)	Material Handling General	CPS, RFID, IoT, Cloud computing and ERP	Social
Dev et al. (2021)	Transportation and Transport Management	Iot, CPS, Sensors, CC and ERP	Environmental and Economic
Gupta and Singh (2021)	General Contributions	IoT, Big Data, CC, Autonomous Robots and Augmented Reality	General Contributions

Hilpert, Kranz; Schumann (2013)	Transportation and Transport Management	TMS, ERP, GPS and Mobile applications	Environmental and Social
Kazancoglu et al. (2021)	General Contributions	IoT, Big Data, CC, 3D printing and CPS	General Contributions
Kodym, Kubáč and Kavka (2020)	General Contributions	IoT, Big Data, CC, Iot, 3D printing and Blockchain	General Contributions
Kucukaltan (2020)	General Contributions	RFID, barcode, sensors, 3D printer, CC and Drones	Social and Economic
Liu et al. (2021)	General Contributions	IoT, Big Data, CC, Blockchain, AGV, VR, Robos and AI	General Contributions
Mahroof et al (2021)	Transportation and Transport Management	AI, Blockchain and RFID	Environmental and Economic
Munsamy et al. (2020)	Warehousing, Packaging and Warehouse Management	IoT, CPS, Sensors and RFID	Environmental and Economic
Nagy et al. (2018)	Information Management Transportation	CPS, Big Data, CPS, CC, Sensors, Robots, RFID, Smart Products and Smart Tools	Social and Economic
Nantee and Sureeyatanapas (2021)	Warehousing, Packaging and Warehouse Management	WMS, RFID, Automated Storage and Retrieval systems	General Contributions
Pishdar et al. (2021)	Transportation and Transport Management	IOT, ERP and Big Bata	General Contributions
Strandhagen et al. (2017)	General Contributions	Drones, 3D printing, Smart products, CC, Autonomous robots, AGV, AI and IoT	General Contributions
Trab et al. (2017)	Material Handling General	RFID, WMS, CPS, CC and IoT	Environmental and Social
Su and Fan (2019)	Transportation and Transport Management	TMS, Big Data and AI	General Contributions
Varriale et al. (2021)	Warehousing, Packaging and Warehouse Management	RFID, IoT and Blockchain	Environmental and Economic

Source : The authors, 2022.

An empirical study by Nantee and Sureeyatanapas (2021) demonstrated that productivity, resource utilization, operational accuracy, responsiveness, and financial results were positively impacted by the use of automated WMS. In addition, the authors identified that there were improvements in workers' health and safety, and in the development of their knowledge and skills.

Regarding the impacts on social sustainability, the main contributions of logistics 4.0 pointed out by the authors were: the optimization of ergonomic conditions, expansion of the safety of operations, facilitation or elimination of the execution of repetitive tasks, reduction of hours worked, and development of new skills (CIMINI *et al*., 2021; NAGY *et al*., 2018, TRAB *et al*., 2017).

The human factor is an aspect explored in some of the studies reviewed. For example, in a survey conducted with 43 companies belonging to Hungarian logistics associations, Nagy *et al.*

(2018) identified that the use of technologies such as CPS, Big Data, and IoT brought increased productivity and efficiency of the organization's employees. This has occurred because employees are now monitored in real-time, and it is possible to recognize the performance of good employees. In addition, another contribution of the study is the identification of the possibility of learning, and enrichment in the level and quality of work.

Nagy *et al*. (2018) evidenced that technologies can also impact reducing employee motivation, as many employees fear losing their jobs to process automation and robotization. Nevertheless, in a longitudinal survey conducted by Cimini *et al.* (2021), it was evidenced that technology tends to replace logistics operators in performing dangerous physical tasks and stressful and repetitive cognitive tasks. In addition, the authors point out that for some tasks in which there are many workers involved, the evolution of Logistics 4.0 tends to focus on operator assistance rather than replacement. Finally, Virtual Reality (VR) can be used for training new employees, providing the creation of multiple scenarios without interrupting logistics operations (LIU *et al.* 2018).

Several authors explore improving inventory and warehouse management tasks enabled by the use of RFID, WMS, autonomous robots, cloud computing, and IoT. For example, Trab *et al.* (2017) propose a model that uses IoT to enable controlled and safety-oriented interactions between all objects in a warehouse, from products, shelves, and forklifts, to employees.

The use of technologies such as Transportation Management Systems (TMS), Order Management Systems (OMS), CPS, IoT, and cloud computing can bring several environmental benefits, mainly in transport and distribution processes such as: reduction in the level of pollutant gas emissions, improvement in energy efficiency, diffusion of green products, minimization of waste production, amplification of the success of reverse logistics initiatives and amplification of the capacity of companies to perform the 10Rs - refuse, rethink, reduce, reuse, repair, recondition, remanufacture, reinvest, recycle and recover (NAGY *et al*., 2018; DEV; SHANKAR; SWAMI, 2020; DE VASS; SHEE; MIAH, 2020).

Environmental capability consists of the ability of organizations to capture the market, business environment, and customer data, which includes information about the demands of local and global sustainability (BAG *et al.* 2020). Logistics 4.0 tools can contribute to the development of environmental capability, as they enable better data capture, data processing, and more accurate information generation (BAG *et al.* 2020).

The study conducted by Dev, Shankar, and Swami (2020) suggests that the adoption of an RFID-enabled ERP system increases the success of reverse logistics initiatives by providing the expansion of information sharing in real-time and the diffusion of green products in the market. Furthermore, research indicates that the combination of technologies such as RFID, CPS, cloud-based ERP, virtual factory, and additive manufacturing can positively impact the environmental performance, service level performance, and economic performance of logistics operations (HILPERT; KRANZ; SCHUMANN, 2013). Data-driven optimization has also been used in the sustainable planning of multimodal transportation, enabling the construction of a sustainable supply chain, in which the performance of costs, energy consumption, GHG emissions, and customer services were improved (SU; FAN, 2019).

The use of technology has several benefits, but there are several risks associated with its implementation, as pointed out by Kodym, Kubáč and Kavka (2020). According to the framework developed by the authors, the main risks are: economic (high investment, dependence on technology, need to change the business model and competitiveness, etc.); social (loss of jobs, employees who are not able to adapt quickly enough and meet the new requirements for activities within the technologies, etc.); technical and technological (e.g. software failures, data security); legal and political risks (such as data ownership from a legal perspective); and ecological (e.g. whether transportation and energy storage for the implementation and use of logistics 4.0 technologies consume more energy than the efficiency gains that would be generated).

4.3. Logistics 4.0, corporate sustainability and organizational theories

Of the 26 studies in the sample, 9 articles presented underpinning theories. Thus, five theories or organizational perspectives were identified: dynamic capabilities theory, innovation diffusion theory, organizational capabilities theory, ecological systems theory, and value chain model. This section presents the application of such theories for the comprehension of logistics 4.0 and corporate sustainability, as well as suggestions for future research (Table 5).

4.3.1. Dynamic capabilities theory

In a dynamic context, in which changes happen quickly, the success of companies is not only linked to the improvement of processes or of the production in scale, but also to the creation

of opportunities, the reconfiguration of the tangible and intangible assets of the company, the intra, and inter-organizational technology transfer, and the modification of the business model (TEECE, 2007).

In this context, the Dynamic Capabilities Theory (dynamic capability view), which derives from the Resource-Based View (RBV) theory, considers that dynamic capabilities are those necessary for organizations to change to meet customer needs and technological opportunities, influence their operating environment, enable the development and supply of new products and services and implement new business models (TEECE, 2007).

The Dynamic Capabilities Theory has been applied to demonstrate the tools of Logistics 4.0 as a capability that can support sustainable initiatives in organizations. For example, Bag and Pretorius (2020) demonstrated that by using technological, organizational, and environmental dynamic capabilities, organizations can develop Logistics 4.0 capabilities. According to the authors, the optimization of scarce and critical resources can be supported by Logistics 4.0 capabilities, since the combination of technologies, such as IoT, BDA, and CC, provides a reduction in delivery times, improvement in the quality of processes, and assists in logistics decision-making, for the strategic, tactical, and operational levels of organizations.

The optimization of the integration capacity described by the authors is made possible, for example, by the expansion in the exchange of information with suppliers assisting in the processes of stock forecasting, timely delivery, receipt, and traceability of the companies studied, showing the strengthening of the economic dimensions in supply chains, from the reduction of costs, and improvement of quality, delivery, and flexibility (DE VASS; SHEE; MIAH, 2020).

4.3.2. Diffusion of innovation theory

The Diffusion of Innovation Theory seeks to understand the process of innovation adoption and to explain how and why new ideas and technologies spread, from the analysis of the consumers' behavior patterns (BASS, 1969). The model proposed by Bass (1969) emerges from a behavioral hypothesis and proposes that during the process of diffusion of the use of a new product/technology, two types of consumers will dictate how demand will grow. The "innovators" are the consumers who decide to adopt an innovation autonomously, that is, they adopt without the influence of the environment, and are willing to take risks. The second type corresponds to the "imitators", which are consumers who are susceptible to the influence of other

consumers who have already adopted the product/technology and susceptible to social pressure from the environment, and it is the effect of the action of the "imitators" that massify the diffusion of the innovation (speed of diffusion).

The diffusion of innovation theory has been applied to understand Logistics 4.0 tools designations and the evaluations of the diffusion of "green" products, the perceptions of innovations by stakeholders, and environmental policies (DEV; SHANKAR; QAISER, 2020; DEV; SHANKAR; SWAMI, 2020; DEV *et al.,* 2021).

Dev, Shankar, and Qaiser (2020) used Bass' (1969) classic model to analyze how the diffusion of "green" products is impacted by Logistics 4.0 tools. The social aspect of sustainability is explored by the authors, who suggest that the integration of a CC-based ERP and IoS (Internet of Services) features can influence consumer behavior toward the adoption of green products. They also point out that digital innovations have an important role in transparency and information sharing in the supply chain, one of the essential capabilities in building sustainable chains (DEV; SHANKAR; QAISER, 2020).

Table 5- Summary of organizational theories applied to the study of Logistics 4.0 and corporate sustainability, and future research directions

Theory	General conceptualization	Studies of the sample	Research and application theory	Future research directions
Dynamic capabilities view theory	An extension of resource-based view, dynamic capabilities view theory suggests that firms can modify their resources to adapt quickly to changing conditions, helping them to maintain their competitive advantage (TEECE, 2007).	Bag and Pretorius (2020) Bag, Gupta, and Luo (2020) De Vass, Shee, and Miah (2020)	a) Disruptive technologies play an essential role in building dynamic capabilities and directly support the construction of a sustainable supply chain. b) Optimization of scarce resources can be supported by Logistics 4.0 capabilities. c) Technological capabilities, organizational capabilities, and environmental capabilities can influence Logistics 4.0 capabilities. d) Human resource capability,	a) Construction of scales to measure the impact of logistics 4.0 capabilities on the organization, including sustainability aspects. b) To investigate the effect of moderating variables such as top management commitment, and organization culture on the path logistics capabilities and firm performance. c) To understand the level of interaction and collaboration requirements with CPS and smart systems since the role of human workers plays a big role in planning and control of Logistics 4.0. d) Map what skills will gain importance with the use of Logistics 4.0, how human

Theory	General conceptualization	Studies of the sample	Research and application theory	Future research directions
			management capability, and the ability of employees to perform digital transactions are important requirements for the improvement of Logistics 4.0.	learning can be supported by these systems, and how work transformation can be developed to match employees' skills. e) Analyze the shared benefits of the use of digital innovations among the different members of the supply chain, regarding massify moment of dynamic capabilities and the reflexes for sustainability
Diffusion of innovation theory (Bass model)	Diffusion of innovation theory seeks to understand the process of adoption of innovations. It explains how and why new ideas and technologies spread, based on the analysis of consumer behavior patterns, separating them in two groups: the "innovators" and the "imitators" (BASS, 1969).	Dev, Shankar, and Qaiser (2020) Dev, Shankar, and Swami (2020) Dev et al. (2021)	a) Understand how the diffusion of "green" products is impacted by Logistics 4.0 tools. b) Investigate how the alignment between technology and communication capabilities of Industry 4.0 influences the social dimension of sustainability, from the analysis of the perceptions of innovation. c) Analyze how the integration of digital innovations and of inventory and production management policies affect the diffusion of "green" products and the performance of reverse logistics systems.	a) Analyze the trade-off between implementing logistics 4.0 technologies at suppliers and investing in the return product collection processes already adopted (reverse logistics) b) Study the cascading effect of technology implementation for sustainable performance.
Ecosystem theory	The ecosystem theory applied to organizational theory assumes that a business ecosystem evolves from the interaction, interdependence, cooperation, and competition among its participating actors, passing through the following stages of maturity: birth,	Liu et al. (2021)	a) Study how the ecological chain organizational efficiency is impacted by smart logistics. b) Analise how customer needs, symbiotic relationships, and information sharing influence the ecological chain service capabilities and ecological chain technology innovation capabilities.	a) Compare innovation capability across supply chains. b) Develop an index for scaling and comparing green supply chains and intelligent logistics.

Theory	General conceptualization	Studies of the sample	Research and application theory	Future research directions
	expansion, leadership, renewal, or death (MOORE, 1993).			
Porter's value chain theory	Porter's value chain concept suggests that the competitive advantage of a company cannot be considered in general, it is also necessary to understand the internal structure of the company, how individual business elements contribute to providing products or services to competitors at a lower price or higher quality (PORTER, 1985).	Nagy et al. (2018)	a) Analysis of the impacts of Logistics 4.0 to create value for organizations, competitive advantage and improve sustainability. b) Investigating the maximization of value creation throughout the supply chain using digital innovations.	a) Investigate how Logistics 4.0 can incorporate data from all links in the chain and support decision-making at the supply chain level. b) Analyze what will be the motivating factors for companies to cooperate with their logistics partners.
Organization information processing view theory	Organization information processing view theory suggests that organizations' structure, mechanisms, and processes revolve around information flows. An increase in complexity, uncertainty, or interdependence results in an increased demand for information (GALBRAITH, 1974).	Bag et al. (2020)	a) Investigate the impacts of Logistics 4.0 on information sharing, which further enhances business logistics sustainability.	a) Investigate how information sharing enabled by Logistics 4.0 tools can improve the resilience and greenness of a sustainable supply chain.

Source: The authors, 2022.

4.3.3. Ecosystem theory

The Ecosystem Theory applied to organizational theory assumes that a business ecosystem evolves from the interaction, interdependence, cooperation, and competition among its participating actors (MOORE, 1993). According to Moore (1993), the evolution of a business ecosystem can be classified into four stages of maturity: "Birth", when the organization starts its activities; "Expansion", when the business model begins to operate and scale its offerings;

"Leadership", when organizations that have established themselves in the market begin to deal with situations of conflict within the ecosystem; and finally the last stage concerns "Renewal" or "Death", in which the ecosystem begins to become obsolete and if it does not reinvent itself and deals with the risks, it can be overtaken by other ecosystems.

This theory has been applied to study how the ecological chain organizational efficiency is impacted by smart logistics, and to analyze how customer needs, symbiotic relationships, and information sharing influence the service and technology innovation capabilities of the ecological chain (LIU *et al.,* 2021).

Liu *et al.* (2021) state that the application of ecosystem theory to the study of Logistics 4.0 is a trend. The authors' study found that two factors affect the efficiency of the smart logistics eco-chain organization: the service capabilities of the eco-chain (which determines the operational capability of the entire chain) and the technological innovation capability of the eco-chain; and these capabilities are impacted by the symbiotic relationship between the members of the eco-chain, the degree and form of information sharing, and customer needs.

In addition, the authors show that the higher the technological innovation capability of the ecological chain, the stronger the relationship between supply chain members, symbiosis, information sharing, meeting customer needs, and the service capability of the ecological chain (LIU *et al*., 2021).

4.3.4. The value chain model

Porter's (1985) value chain is a model that supports the analysis of the set of activities a company performs that result in the creation of value and competitive advantage. For Porter (1985), to understand a company's competitive advantage, it is necessary to understand the internal structure of the company, that is, how the individual business elements contribute to delivering value creation. The Value Chain Model has been applied to analyze the impacts of Logistics 4.0 to create value for organizations, competitive advantage, and improve sustainability.

The research conducted by Nagy *et al*. (2018) expresses that real-time data dissemination between companies, from Logistics 4.0 tools, can positively impact the company as a whole. The companies analyzed in this study obtained a higher level of logistics service, more efficient processes with their partners, enhanced cooperation between certain logistics functions, financial

performance, and competitiveness, resulting in greater economic sustainability.

4.3.5. Organization information processing view

Organization information processing view theory suggests that organizations' structure, mechanisms, and processes revolve around information flows. An increase in complexity, uncertainty or interdependence results in an increased demand for information (GALBRAITH, 1974). This theory was used for investigating the impacts of Logistics 4.0 on information sharing, which further enhances business logistics sustainability (BAG *et al.* 2020).

Bag *et al.* (2020) used this theory as a theoretical basis due to the importance of information processing for successful Logistics 4.0 initiatives. The research findings show how logistics 4.0 supports operations management excellence by enhancing sustainable logistics. The study demonstrates that Industry 4.0 resources applied to logistics tasks are fundamental for creating the dynamic capability to meet such information collection, processing, and sharing requirements and activate smart logistics systems for gradually transforming into a circular economy.

5. CONCLUSION

Through a systematic literature review, this study presented an overview of articles exploring Logistics 4.0 and corporate sustainability, as well as the contributions of organizational theories to the topic. The analysis showed that organizational theories cooperate in the construction and foundation of research that analyzes the impacts of digital innovations on organizations, and from the different approaches, it is possible to investigate, evaluate, and adapt processes, business models, and supply chains to seek sustainable development.

The findings revealed that Logistics 4.0 enhances organizational capabilities, optimizes scarce and critical resources, and supports the development of dynamic capabilities. Additionally, the application of Industry 4.0 technologies in logistics tasks improves the ability to collect, store, and analyze data, underpins decision-making, adds value to the business, and strengthens business intelligence and the relationship between supply chain members. As a result, it improves the level of service and increases transparency, integration, collaboration, flexibility, and information sharing in the supply chain, which is essential in the construction of

sustainable supply chains. Moreover, Logistics 4.0 supports sustainable initiatives and can facilitate and influence consumer behavior toward the adoption of green products and circular economy initiatives, improving the operational efficiency of supply chain members.

Regarding the organizational theories, their underpinning role in logistics 4.0 and corporate sustainability helps in understanding, evaluating, controlling, and modifying activities, processes, internal structures, strategies, relationships, and decision-making between the members of a supply chain taking into account aspects of the social, environmental and economic sustainability. The theories and approaches explored in the studies analyzed were the dynamic capabilities theory, diffusion of innovation theory, ecosystems theory, value chain model, and organization information processing view. The selection of organizational theories to conduct theoretical and empirical studies on the subject has profound implications for cutting-edge literature. To support the development of future studies, Table 5 provides research directions for each theory presented.

The limitations of the study include the use of articles exclusively published in English, and in the Scopus and Web of Science databases. In this sense, conference papers and research in other languages were not considered, which could contain other relevant findings. Furthermore, only studies that explored primary logistics tasks were selected.

As suggestions for future research, we propose the development of studies that explore the topic from the point of view of other organizational theories and approaches such as institutional theory, resource-based view, knowledge-based view, stakeholder theory, technology acceptance model, among others.

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