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Smart Logistics Management in the Age of Digital Transformation: A Systematic Literature Review

Yeşim CAN SAĞLAM [1]

Abstract

Recently, the Industry 4.0 paradigm has commenced to swiftly grow in the supply chain management and logistics fields. Despite this development in the logistics and supply chain management domain, the investigations of smart logistics (also known as logistics 4.0) are still in maturity. Especially, some areas such as the drivers and inhibitors of smart logistics are still an adequately unexplored area. On the other hand, smart logistics provides highly practical solutions to overcome the increasing difficulties in logistics operations by enabling worldwide cooperation. For this reason, studies in the field of smart logistics are of critical importance. This study addresses this gap by investigating the driving factors to facilitate and barriers to the adoption of smart logistics in the context of the extant literature. A systematic literature review was conducted to provide a comprehensive result to capture the dynamics and benefits of smart logistics and identify barriers deserving of further academic interest. To summarize the novel investigations in this domain, forty (40) papers were chosen and properly analyzed. As a result of the analysis, it was revealed that there are 6 main barriers preventing the adoption and implementation of smart logistics. These are risk-related barriers, data and technology-related barriers, organizational-related barriers, human resource-related barriers, economic-related barriers, and regulation-related barriers. On the other hand, as a result of the literature review, critical factors (such as investing in smart logistics, developing technological infrastructure, generating organizational culture or mission toward smart logistics, and providing top management support) that will both overcome these obstacles and facilitate the adoption of smart logistics have been determined. The accumulation of knowledge and provided insights in this research will provide advantages for both practitioners and academics interested in this emerging novel technology segment.

Keywords: Logistics, Smart Logistics, Logistics 4.0, Supply Chain Management, Smart Logistics Barriers

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2024, 13 (1), 11-31 | Araştırma Makalesi

Dijital Dönüşüm Çağında Akıllı Lojistik Yönetimi: Sistematik Literatür İncelemesi

Yeşim CAN SAĞLAM [1]

Öz

Son zamanlarda Endüstri 4.0 paradigması, tedarik zinciri yönetimi ve lojistik alanında hızlı bir şekilde yayılmaya başladı. Lojistik ve tedarik zinciri yönetimi alanındaki bu önemli gelişmeye rağmen, lojistik 4.0 olarak da bilinen akıllı lojistik üzerindeki araştırmalar yeterince gelişmedi. Özellikle, akıllı lojistiğin uygulanmasını olumlu yönde etkileyen faktörler ve uygulanmasının önündeki engeller gibi bazı önemli konular yeterince araştırılmamıştır. Hâlbuki akıllı lojistik, dünya çapında iş birliği yapılmasını mümkün kılarak, lojistik operasyonları alanındaki artan zorlukları aşmada son derece pratik çözümler sunmaktadır. Bu nedenle akıllı lojistik alanında yapılan çalışmalar kritik öneme sahiptir. Bu çalışma, mevcut literatürü göz önünde bulundurarak akıllı lojistiğin benimsenmesini kolaylaştıran itici faktörleri ve uygulanmasının önündeki engelleri araştırarak literatürdeki bu boşluğu doldurmaya çalışmaktadır. Çalışma bağlamında, akıllı lojistiği mümkün kılan faktörleri ve uygulanmasını engelleyen bariyerleri belirlemek için kapsamlı bir sistematik literatür taraması yapıldı. Bu alandaki ilgili çalışmalar tespit edilerek, kırk (40) makale seçildi ve detaylı bir şekilde analiz edildi. Analiz sonucunda, akıllı lojistiğin benimsenmesini ve uygulanmasını engelleyen 6 ana engelin olduğu ortaya konuldu. Bunlar: Risk ile ilişkili engeller, veri ve teknoloji ile ilgili engeller, organizasyon ile ilgili engeller, insan kaynakları ile ilişkili engeller, ekonomi ile ilgili engeller ve yönetmelik ile ilgili engellerdir. Buna karşılık, literatür incelemeleri sonucunda hem bu engellerin üstesinden gelmeyi sağlayacak hem de akıllı lojistiğin benimsenmesini kolaylaştıracak kritik faktörler (akıllı lojistiğe yönelik yatırımların yapılması, teknolojik alt yapının geliştirilmesi, akıllı lojistiğe yönelik organizasyonda kurumsal kültür veya misyon oluşturulması, üst yönetim desteğinin sağlanması gibi) belirlendi. Bu araştırmadan elde edilen sonuçların, hem ortaya çıkan bu yeni teknoloji segmentiyle ilgilenen uygulayıcılara hem de akademisyenlere avantajlar sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Lojistik, Akıllı Lojistik, Lojistik 4.0, Tedarik Zinciri Yönetimi, Akıllı Lojistik Engelleri

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Introduction

Supply chain management is the core component of a company's business model (Rejeb et al., 2021, p.3747). In supply chain management, logistics is progressively identified as a core component of its (McFarlane et al., 2016). In businesses, an average company's logistics costs are calculated to be between 10 and 25 percent of the total cost of its international sales. These costs comprise practices such as inventory management, warehousing, packaging, and the physical distribution of properties. Accordingly, the control of logistics practice is obligatory to sustain competitive advantage, without considering the operating sector of the firm, the geographic state, and the kind of goods manufactured, distributed, and sold (Rejeb et al., 2021, p.3747). Logistics administration keeps an audit of the entire process, from the gathering of raw materials for producing units to the final mile delivery of completed and packed outputs to the clients (Sharma et al., 2020). Logistics may be described as "the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services, and related information from their point of origin to point of consumption for the purpose of conforming to customer requirements" (Tran-Dang et al., 2022, p.93).

The age of smart logistics facilitates utilization of the capacity, thus enhancing the efficiency of the logistics service. Smart logistics is a promising remedy for encountering the growing adversity and capacity of logistics operations thanks to the worldwide collaboration and unification of channels. Technologies like information and communication, the Internet of Things, and artificial intelligence, not only create innovative functions in logistics management but also alter the narrative of logistics operations (Feng and Ye, 2021, p.352). In substance, smart logistics is a process that endeavors to eliminate the human factor and to the greatest extent feasible automate the process. The strategy of manufacturing firms is towards a forthcoming where we have an excellent conspectus of not only where a piece is correct at present, but it will also be required to understand who had it inside, when and where it was moved, why, and if it had any outcomes. This process cannot be reached without ideal information systems and will have to be provided not solely during manufacturing, but also throughout warehouse operations and material delivery. Smart logistics can bring better consequences in automation, ensuring widespread information, enhancing flexibility, and decreasing the human factor (Zoubek and Šimon, 2021, p.4263).

Smart logistics is a fundamental way to create a cross-transport network, logistics, and information-oriented organizations in industry and it is an inevitable trend for the development of modern logistics (Yan et al., 2022, p.58). Recently, many investigations focus on the new technologies associated with smart logistics like information technology (Windt and Hulsmann, 2007), big data (Govindan et al., 2018), internet of things (Montreuil, 2011; Jagtap et al., 2020), and cloud collaboration (Gregor et al., 2017), etc. In addition, various investigations discuss intelligent logistics in particular real scenarios. For instance, Okwu and Tartibu (2020) constitute a sustainable supplier assessment system by applying TOPSIS and adaptive neuro-fuzzy inference systems methods for providing a smooth warehouse service. In another study, Prajapati et al. (2020) propounded a clustering-based routing heuristic for optimizing the recent mile circulation of fresh food logistics. However, all these investigations focus on how the efficiency of smart logistics can be enhanced with technological innovation. Scarce

researches (Perotti et al., 2022; Karlı and Tanyaş, 2020) pay attention to the drivers or inhibitors of operating smart logistics. Therefore, a comprehensive study addressing and unveiling both the barriers and drivers of smart logistics in a holistic manner is missing in the literature. The aim of this study is to provide an extensive investigation of smart logistics drivers and inhibitors by embracing the Systematic Literature Review (SLR) method to present robust results in the propounded conceptual framework (Perotti et al., 2022, p.195). SLR effectuates a broad road to designate the theoretical aspects prevailing in the domain. It can also help to assess and develop the degree of maturity of literature by embracing its range and key topics (Yildiz Çankaya et al., 2022).

Smart Logistics

Although the concept of intelligent or smart comes into insight very often in the supply chain management and logistics literature, there is no proper consensus on the description of the concept of intelligent logistics (McFarlane et al., 2016, p.106). "Smart Logistics", also known as "Logistics 4.0", can be described as the technological developments that emerged in the field of logistics management with the fourth industrial revolution. Smart logistics uses intelligent technologies equipped with computer support systems based on automated processes and advanced artificial intelligence solutions (Tekin et al., 2020, p.573-574). Moreover, it is a basic approach that increases the intelligence of the system by placing advanced information and communication technologies in every component of the logistics system. The type and level of smart logistics range from basic functionality such as product monitoring and sensing environmental events to practices and methods that include problem identification, automated decision-making, and execution (McFarlane et al., 2016, p.106; Tran-Dang et al., 2022, p.95).

The benefits of smart logistics comprise providing timely delivery and supply, competency to constitute supply chains agility, flexibility, and responsiveness as well as capability to implement predictive analytics. These competencies can remarkably diminish the delivery lead times with clients. Smart logistics may enhance quality parameters tremendously and supports sustainability issue by enhancing environmental and social outcomes. It can also cut some costs considerably in the supply chain. Hence, smart logistics competencies can affect reverse decision-making at operational, strategic, and tactical levels (Bag et al., 2020). Indeed, smart services and smart products are two core ingredients of smart logistics. Specifically, the smart products can able to render additional functionality like determination, sensing, and algorithm implementation provided by accompanying technologies. On the other hand, smart services present a set of worthwhile applications and utilities applied to develop the efficiency of logistics practices. For instance, control services endeavor to delegate control duties like robbery detection, tracing and tracking, and preservation. Furthermore, risk services, leasing services, information services, and sophisticated services are extra kinds of smart services advanced and unified to fulfill logistics-associated process requirements (Tran-Dang et al., 2022, p.95). The notion of smart logistics is presented in Figure 1.

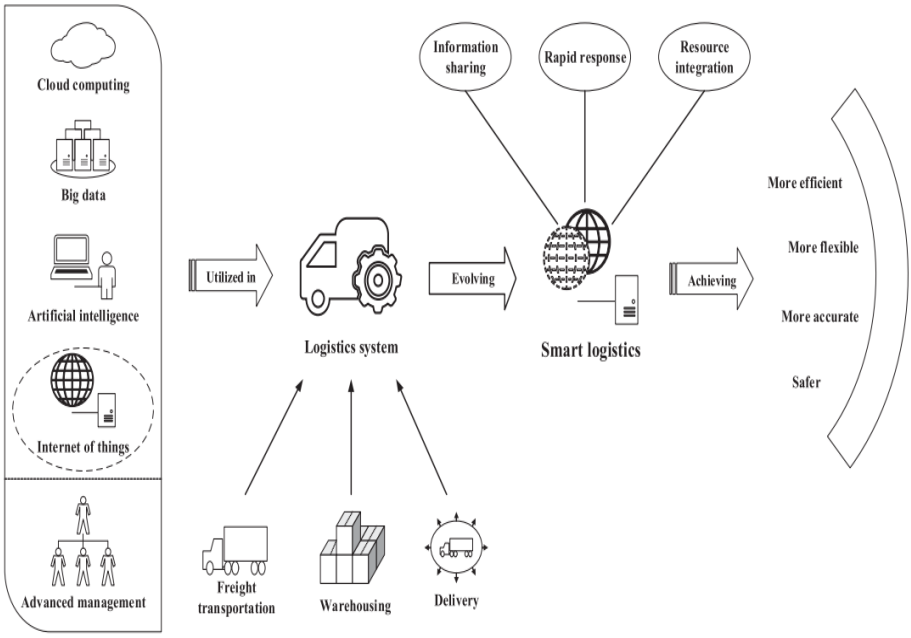

Figure 1. The notion of smart logistics (source: Ding et al., 2021:325)

To capture a broad and overall comprehension of smart logistics by synthesizing the existing clarifications of logistics, Winkelhaus and Grosse (2020) distinguish smart logistics into three sides:
(1) The implications of the altering manufacturing paradigm to mass customization on logistics.
(2) The alterations of logistics processes are endangered by the application of novel digital technologies like IoT.
(3) The significance of humans that are evaluated in their roles as employees, other stakeholders, or clients is also accompanied by environmental alterations.

Based on these sides, Winkelhaus and Grosse (2020, p.21) describe smart logistics as "a logistical system that enables the sustainable satisfaction of individualized customer demands without an increase in costs and supports this development in industry and trade using digital technologies". Technologies like the Internet of Things (IoT), big data analytics, and artificial intelligence, implemented in smart logistics differentiate from that applied in conventional logistics with four features:

- Intelligence- Intelligent technologies like automation technology, artificial intelligence, and communications technology, are implemented in the overall logistics process for advancing the automation degree of logistics operations and achieving intelligent decision-making on mutual problems related to logistics management.

- Flexibility: Thanks to its more proper demand forecasting, more effective transportation routing, and better optimization of inventory, smart logistics has an advanced degree of flexibility. The augmentation competency to cope with unforeseen topics of smart logistics meets customer expectations.
- Unification of logistics: With technologies such as IoT and information and communication technologies, information sharing among partners in the logistics process is effectuated, and connected business processes can be centrally administrated, in this way reinforcing the coordination of diverse logistics processes.
- Self-organization: intelligent decision-making and real-time monitoring facilitate the logistics system to function without considerable human intervention, which provides higher effectiveness for logistics operations (Feng and Ye 2021, p.346).

Methodology

The purpose of literature reviews is to obtain results by evaluating primary studies. The general feature of these studies is to reveal the research gaps in the literature by presenting a broad perspective and providing a more solid positioning of the information (Karlı and Tanyaş, 2020, p.616). Systematic Literature Review (SLR) is a method that creates credible scientific information for the progression of a discipline, ensures advanced quality for the review procedures, minimizes errors as well as bias, and provides more validity to the process (Yildiz Çankaya et al., 2022, p.4). An SLR is a powerful approach to determine, select, and asses existing contributions of the literature. It follows a list of particular phases that provides the relevance of research about a specific domain and the minimization of research bias and errors (Rejeb et al., 2021, p.3751). Therefore, in this study SLR has been preferred for applying a systematic procedure to achieve the research aims. The review process in this study has been designated into the subsequent three stages that have been further structured in a number of stages:

- Designing
- Execution
- Analysis and results (Evangelista et al., 2018).

Designing of the review process

In this stage, the three-step methodology suggested by Evangelista et al. (2018) and Yildiz Çankaya et al. (2022) was adopted as follows:

(1) determination of the aims of the review,
(2) identification of the associated keywords, and
(3) description of the searching criteria.

The overall designing and administration of the review process are in parallel with the three-stage suggested by Evangelista et al. (2018) and Yildiz Çankaya et al. (2022), which can be seen in Figure 2.

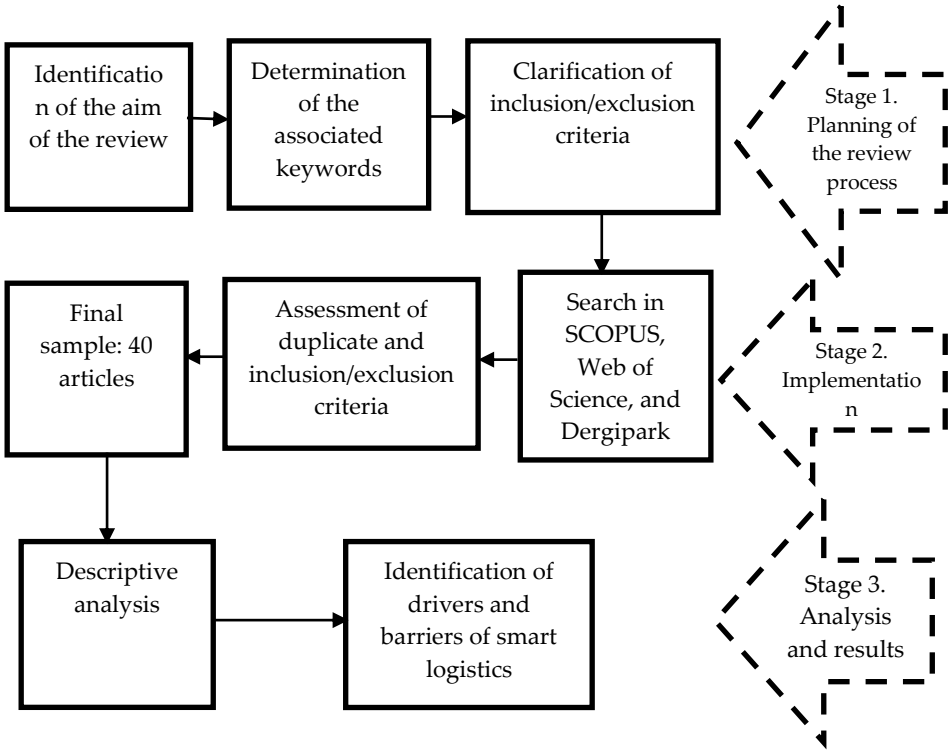

Figure 2. The process of the systematic literature review

Firstly, the aim of the research has been evidently described. As mentioned formerly, the main aim of this investigation is to examine the driving force and barriers to smart logistics adoption which can bring both academicians and practitioners a novel insight. Secondly, by investigating prior research on this domain, an initial set of qualified keywords was determined such as "barrier smart logistic", "barrier logistic 4.0", "driver smart logistic", and "driver logistic 4.0". However, it was seen that there are only a few papers appeared with these determined keywords. Then the determined keywords were separated into two categories: first "smart logistic" and "logistic 4.0" were searched. Then other keywords such as "barrier", "driver", "factor", "challenge", and "advantage" were searched in the selected papers both in the abstract and body of the articles. Thirdly, the searching criterion was determined as paper, which explains at least one driver or barrier of smart logistics. The papers which not explain at least one driver or barrier were excluded.

As Web of Science as well as Scopus databases harbor extensive coverage of management journals, many significant SLR research in the literature (e.g. Evangelista et al., 2018; Rejeb et al., 2021; Perotti et al., 2022; Yildiz Çankaya et al., 2022; D'Amico et al., 2022) have selected these two databases. Therefore, Scopus and Web of Science were selected as databases. In addition, Dergipark has provided significant Turkish studies. Therefore, besides Web of Science as well as Scopus, we selected Dergipark as a

research database. This study reviewed papers published from 2015 until the 2022. The motivation for this period choice is that the paper by Hannan et al. (2015) is the first study published parallel with this research question that serves as a beginning point for the papers' analysis. In addition, the selected article references were investigated to attain other associated researches. Only peer-reviewed English and Turkish language articles were searched and conference papers, master and doctoral theses, and book chapters were exempted from this review.

Execution of the Review Process

As a result of the search, 316 publications were identified in the Web of Science database and 162 of these publications were articles. 465 publications have been identified in the Scopus database and 214 of these publications are articles. After filtering out duplicated papers (185), the research process generated 191 articles. The previously determined keywords such as "barriers", "drivers", etc. were searched in the 191 selected articles. As parallel with our research aims, 40 articles were selected for analysis.

Analysis

Descriptive analysis

In the third stage, based on a two-step approach, the selected journal papers were analyzed. For identifying some critical characteristics of the whole last sample, a descriptive analysis was performed in the first phase. This analysis comprises the distribution of researches by time, kind of journals, and research methodology. In the second phase, the content of the chosen papers was analyzed.

The analysis procedure unveiled 40 significant studies from 2015 to 2022 and the studies were obtained from different journals like the International Journal of Logistics Research and Applications, Sustainability, Benchmarking: An International Journal, Kybernetes, Journal of Beykoz Akademy, and Cleaner Logistics and Supply Chain. Figure 3 demonstrates the dispersion of the papers through the years. Our systematic review generated the first view of the barriers or drivers of smart logistics article in 2015. In the last years, the number of studies associated with the barriers or drivers of smart logistics has increased swiftly. Totally, more than half of the selected papers (35 out of 40) were published from 2020 to 2022. This progress signifies that articles on barriers or drivers-focused studies will prosecute to expand since smart logistics becomes a significant feature of organizations' manufacturing process. Moreover, the escalating interest in the studies stresses the need for a complete analysis of the widening this domain (Yildiz Çankaya et al., 2022).

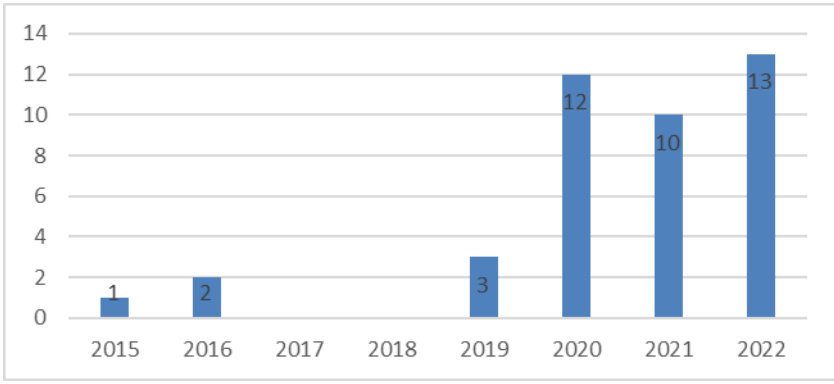

Figure 3. The dispersion of the papers through the years

In the selected articles, the analysis of the studies methods that were used is exhibited in Figure 4. Totally, 37.5 percent of the papers followed quantitative methods such as AHP, DEMATEL, and surveys, 25 percent utilized literature review, conceptual studies constituted 17.5 percent, case studies accounted for 12.5 percent, and qualitative constituted 7.5 percent. It can be concluded that the quantitative and literature review studies dominated.

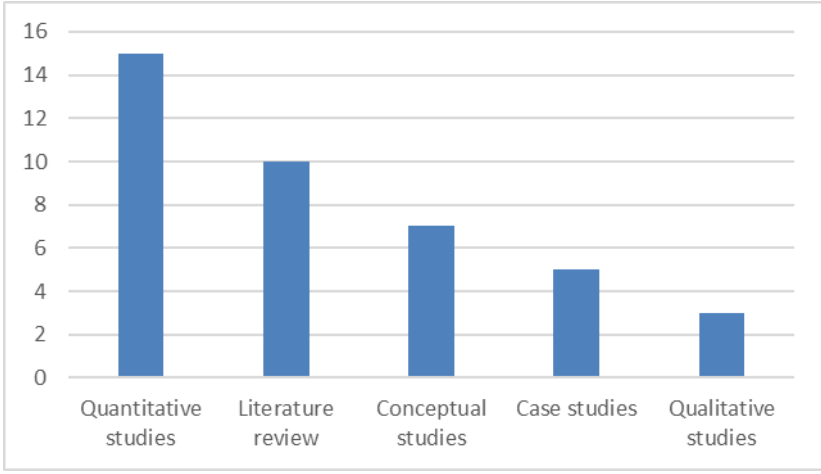

Figure 4. The methods of the selected studies

In Figure 5, It can be understood that the journals of the articles published are spread over an extensive domain. There are studies on smart logistics in 31 different journals. The other 31 journals have one article on the selected topic. The other journals presented in Figure 4 include Sustainability, IETE Technical Review, Industrial Marketing Management, Sustainable Cities and Society, Benchmarking: An International Journal, Applied Sciences, Computers in Industry, Electronics, Production Planning & Control, Journal of Science and Technology Policy Management, Production, Frontiers of Engineering Management, International Journal of Information Management, Open

Engineering, Waste Management, etc.

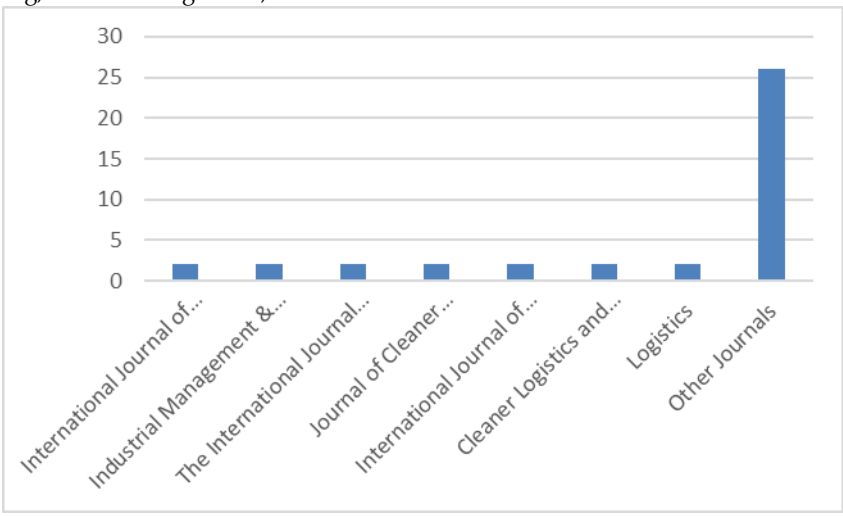

Figure 5. Journals published the selected articles

The barriers of smart logistics

As a result of the analysis of 40 selected articles from prominent journals, the barriers of smart logistics have been divided into seven main categories. As seen in Table 1, the main barriers include; risk related barriers, data and technological-related barriers, organizational-related barriers, human resources-related barriers, economy-related barriers, and regulation-related barriers. In the following subsections, we will explain each main and sub-barriers.

Table 1. The barriers of smart logistics and references

Barrier categories	References
Risk-related barriers	Liu et al. (2020); Tran-Dang et al. (2022); Perotti et al. (2022); Kodym et al. (2020); Çalışkan, (2020); Karlı and Tanyaş, (2020); Chauhan et al. (2016).
Data and technological-related barriers	Silva et al. (2021); Tran-Dang et al. (2022); Sarkar et al. (2022); Feng and Ye (2021); Zoubek and Šimon (2021); Zhang et al. (2019); Çalışkan, (2020); Karlı and Tanyaş (2020).
Organizational-related barriers	Silva et al. (2021); Sarkar et al. (2022); Perotti et al. (2022); Affia and Aamer (2021); Correa et al. (2020); Zoubek and Šimon (2021); Mahroof, (2019); Zhang et al. (2019).
Human resources-related barriers	Silva et al. (2021); Cimini et al. (2021); Affia and Aamer (2021); Correa et al. (2020); Zhang et al. (2019); Hannan et al. (2015); Çalışkan, (2020); Karlı and Tanyaş (2020); Chauhan et al. (2016);

	Sarkar et al. (2022); Sgarbossa et al. (2020); Susanty et al. (2022).
Economy-related barriers	Sharma et al. (2022); Tran-Dang et al. (2022); Yan et al. (2022); Perotti et al. (2022); Affia and Aamer (2021); Correa et al. (2020); Feng and Ye (2021); Zoubek and Šimon (2021); Zhang et al. (2019); H annan et al. (2015); Çalışkan, (2020); Karlı and Tanyaş, (2020); Čámská and Klečka, (2020); Susanty et al. (2022).
Regulation-related barriers	Tran-Dang et al. (2022); Sarkar et al. (2022); Zhang et al. (2019); Çalışkan, (2020); Susanty et al. (2022).

Risk-related barriers

Risk-related barriers describe the associated risks unveiled as a result of the implementation of smart logistics or in advance. Risk-related barriers include technology risks, risks of smart logistics partners, external environmental risks, and security risks (McFarlane et al., 2016; Liu et al., 2020; Tran-Dang et al. 2022).

***Technology risks:** Technology has a significant role in intelligent logistics. It is driven by novel technologies like the Internet of Things, big data, and cloud computing to achieve visualization and automation of logistics service operations (McFarlane et al., 2016, p.106). The technological risks of smart logistics are generally classified into two categories: the risk of technological route alteration and the risk of disruptive technology upgrades. The improvement of technology is usually not a gradual process. For instance, the development of smartphones may engender large alterations. The occurrence of this disruptive technology will tremendously influence the operation model of smart logistics, which causes to risks. Moreover, alteration of the technological route also substantially matters. The technical route usually designates the construction of smart logistics, and variation of the technical route is generally accompanied by technological advancements, which automatically cause various risks (Liu et al., 2020, p.4).

***Risks of smart logistics partners:** Smart logistics highlight the interaction among various partners. This close connection among partners escalates the effect of the risks of smart logistics partners on smart logistics. Liu et al. (2020) categorized the risks of smart logistics partners into (1) internal stakeholder risks, (2) external stakeholder risks, and (3) indirect stakeholder risks.

1) Internal stakeholders comprise the board of directors, business units, functional departments, and personnel within the firm. The risks of internal stakeholders depict the exudation of client privacy information and the infringements of the employees in the firm.

2) External stakeholders comprise suppliers, business partners, customers, distributors, competitors, contractors, and so on. One instance of the risk of

external stakeholders is supply disruptions because of suppliers' sustainable risks.

3) Indirect stakeholders chiefly comprise public institutions like the news government as well as media. With the public's rising attention to sustainability topics and the expanding impact of social media, the significance of sustainable risks brought by indirect stakeholders in smart logistics proceeds to rise.

***External environmental risks:** The external environment of smart logistics signifies external circumstances such as government administration, intermediary services, industry management, industrial policy, and a regulations system. The external environment is usually in a process of incessant alteration. Any alteration in the external environment will significantly affect the operations of smart logistics. Hence, taking corresponding prudent measures for the external environment is significant to the operation of intelligent logistics (Liu et al., 2020, p.5).

***Security risks:** Security is a significant side of the logistics industry. Because interoperation and interconnection are a prerequisite for the processes of smart logistics, digital security becomes highly significant at any grade. Combination of additional competencies to the smart objects (such as data identification, storage, and monitoring) burdensome probable risks throughout the shipping trajectories. Particularly, digital transactions attract more attention from cyber attackers and hackers (Tran-Dang et al., 2022, p.111).

Data and technological-related barriers

Data and technological-related barriers associated with data understanding, poor or missing raw data, distinctive values in different data sources for the same property, and technological infrastructure (Silva et al., 2021; Sarkar et al., 2022; Tran-Dang et al., 2022; Zhang et al., 2019; Çalışkan, 2020).

***Data understanding:** Comprehending the data that are warehoused in the transactional database is generally hard duty, which is made even hard when a firm is cosmopolitan to a substantial extent. Transactional databases are complicated systems, with feature names as well as misleading tables. The present documentation associated with data sources is generally infrequent, not give sufficient comprehension into the data. Various logistics notions are required to be known like safety stock, delivery time, safety time, and procurement to better comprehend the data and their relations.

***Poor or missing raw data:** When a firm commences a project that will utilize the raw data constituted by the routine job, it is essential to determine if the important data are being constituted as well as stored in the transactional system and their general quality. Occasionally, the project aims cannot be fulfilled because of the absence of data. In complicated Enterprise Resource Planning systems, it is probable to affirm that numerous features are not utilized by the firm. For instance, in logistics, informing where a commission is in pass to its target may be helpful to estimate whether it will be on time or not, and to make decisions about how to abstain halts in the manufacturing route.

*** Distinctive values in different data sources for the same property:** Because of the big and complicated transactional system, it is pretty widespread to encounter identical

features in various tables, associated with the same wealth, yet with diverse values. Comprehending why this occurs as well as comprehending the kind of circumstances that drive this kind of behavior may be arduous (Silva et al., 2021, p.13).

*** Technological infrastructure:** Although the aim of logistics operations is to gain efficiency, the adoption of technologies in this field can encumber a paradox. For instance, because the tangible assets of logistics are equipped with intelligent applications (like sensors) generally powered by batteries, accumulating their energy to extend their working life is significantly prioritized. These smart devices can be desired at any time to ensure convenient information that is required to improve and propose smart decision-making. Accordingly, they can be active generally to accomplish such critical requirements (Tran-Dang et al., 2022, p.110). In addition, it is particularly intractable difficult when a partner in the supply chain utilizes various technology platforms that are discordant with each other (Zhang et al., 2019, p.5).

Organizational-related barriers

Organizational-related barriers comprise access to technological infrastructure as well as to data, understanding the business processes, lack of trust and culture, and lack of top management support (Silva et al., 2021; Sarkar et al., 2022; Perotti et al., 2022; Affia and Aamer 2021; Correa et al., 2020; Zoubek and Šimon, 2021; Mahroof, 2019; Zhang et al., 2019).

*** Access to data and to a technological infrastructure:** One of the initial duties in the organization is to obtain access to data as well as to the substructure that will be utilized to course and store them. This is a duty that requires to be implemented at the early stage of the production, which can enable to interfere negative incidents. This process must not be a barrier or take a long period to cope with.

*** Comprehension of the business processes:** Generally, large firms have various complicated organization processes with different exceptions, various rules, and paths, which cannot be easily understood. In addition, the authentication of the business processes may be inadequate, which constitutes another barrier. In the logistics domain, where routine interactions with the partner of the supply chains and their systems are present, where processes are complicated for obtaining better consequences in the manufacturing process, and where significant terms like just-in-time production are being performed, the authentication has a convenient effect when novel projects begin to be improved (Silva et al., 2021, p.14).

***Lack of trust and culture:** The absence of technological culture is one of the major obstacles the logistics sector is facing as well as the firm's maturity and manner against the digital scenery impact the application of smart logistics (Perotti et al., 2022, p.201).

***Lack of top management support:** When top management support in the firm is weak for smart logistics, it is difficult to obtain these new technologies (Correa et al., 2020:8). One of the principles of Industry 4.0 stress that it is necessary to support employees by implementing a series of duties that are flavorless, too tiresome, or insecure owing to the unification of promoter as well as collaborative technologies (Sgarbossa et al., 2020, p.301).

Human resources-related barriers

Human resources-related barriers associated with a lack of knowledge of the technologies used and a lack of sufficient human resources (Silva et al., 2021; Cimini et al., 2021; Affia and Aamer, 2021; Correa et al., 2020; Zhang et al., 2019; Hannan et al., 2015; Çalışkan, 2020; Karlı and Tanyaş 2020; Chauhan et al., 2016; Sarkar et al., 2022; Sgarbossa et al., 2020; Susanty et al., 2022).

***Lack of knowledge of the technologies used:** Smart technologies have excellent potential, yet their implementation generates various technological challenges. It is particularly complex when a partner of the supply chain or organization utilizes various technology platforms which are discordant with each another (Zhang et al., 2019).

***Lack of sufficient human resources:** In spite of the powerful motivation towards automation in logistics, human resources remain convenient across various activities as well as not be replaced through technology (Cimini et al., 2021).

Economy-related barriers

Economy-related barriers comprise investment costs and focus on short-term profitability (Sharma et al., 2022; Tran-Dang et al., 2022; Yan et al., 2022; Perotti et al., 2022; Affia and Aamer, 2021; Correa et al., 2020; Feng and Ye, 2021; Zoubek and Šimon, 2021; Zhang et al., 2019; Hannan et al., 2015; Çalışkan, 2020; Karlı and Tanyaş, 2020; Čámská and Klečka, 2020; Susanty et al., 2022).

***Investment costs:** The high cost of information technology investments makes it difficult to implement smart logistics (Karlı and Tanyaş, 2020, p.624). Many firms have a challenge in consolidating financial resources for developing smart logistics. Furthermore, the establishment of novel technologies and the incorporated ecosystem may cause extra costs for organizations utilized for practices like training, controlling, proximity to get utilized operating, and administrating the technology operations (Tran-Dang et al., 2022, p.111).

***Focus on short-term profitability:** It is difficult to estimate and designate business purposes in the long term. Performing smart technologies necessitates affluent investment, yet the fruit of it may have taken after years. The adoption of smart logistics is not probably when firms solely follow their short-run economic benefits (Zhang et al., 2019, p.6).

Regulation related barriers

In a global logistics network, stakeholders, and all partners are necessitated to share knowledge, protocols, and resources for achieving maximized efficiency and transparency. The Internet of Things serves a critical role to facilitate interconnectivity as well as data barter among any sides of logistics ubiquitously as well as universally. Nevertheless, owing to the diverse regulations of countries, the success of the appointed regulations for regular management of international activities is arduous to be materialized (Tran-Dang et al., 2022, p.111). A lack of convenient standards leads to a hardship in the utilization of smart technologies to automate the appropriate practices (Karlı and Tanyaş, 2020, p.624; Zhang et al., 2019, p.6).

The enablers of smart logistics

After identifying the barriers to smart logistics, the enablers of smart logistics have been determined from the related studies. Table 2 demonstrates the enablers of smart

logistics and references.

Table 2. The enablers of smart logistics

Enablers	References
*Develop technological infrastructure	Khan et al. (2022b); Parhi et al. (2022); Winkelhaus and Grosse (2020); Liu et al. (2020); D'Amico et al. (2022); Khan et al. (2022a); Chen et al. (2022); Büyüközkan and Ilıcak, (2021)
*Enhance trust and collaboration	Bag et al. (2020); Khan et al. (2022b); Parhi et al. (2022); Liu et al. (2020b)
*Facilitate knowledge transfer	Jagtap et al. (2020); Liu et al. (2020b); Khan et al. (2022); Kucukaltan et al. (2022); Winkelhaus and Grosse (2020)
*Development of analytical capabilities	Kucukaltan et al. (2022); Khan et al. (2022)
*Create a smart work environment	Khan et al. (2022b); D'Amico et al. (2022)
*Top management commitment and support	Khan et al. (2022a); Parhi et al. (2022); Khan et al. (2022b)
*Invest in logistics 4.0	Khan et al. (2022b)
*Training and Education employees	Khan et al. (2022b); Parhi et al. (2022); Winkelhaus and Grosse (2020); Sarkar et al. (2022); Khan et al. (2022); Chen et al. (2022)
*Governmental norms & support	Parhi et al. (2022); D'Amico et al. (2022); Khan et al. (2022a)
*Create cybersecurity and threat resilience	Parhi et al. (2022); Chen et al. (2022)
*Generate organizational culture & mission toward smart logistics	Parhi et al. (2022); Perotti et al. (2022)
*Constitute cost-sharing methodologies	Parhi et al. (2022); Cimini et al. (2021); Khan et al. (2022); Chen et al. (2022)

The purpose of Industry 4.0 is to generate smart organizations as well as supply chains applying novel technologies comprising cyber-physical systems, big data, and the Internet of Things. These new technologies are utilized to advance the various component of the supply chain like manufacturing, logistics, and warehousing to the following grade. Among these ingredients, smart logistics can be evaluated as a significant part of Industry 4.0 as well as *developing technological infrastructure* can be advantageous for the digitalization of the supply chain (Khan et al., 2022, p.1). Besides, *enhancing trust and collaboration* among supply chain partner facilitates logistics organization to convert into smart systems and provides to meet the increasingly complicated client demands (Liu et al., 2021b, p.367). Enhancement of trust and collaboration among partners can *facilitate knowledge transfer*, which enhances the success of smart logistics (Kucukaltan et al., 2022, p.2013).

Smart logistics ability progress necessitates improving dynamic competencies like environmental and technological capabilities to facilitate digital technologies as well as realize plans (Bag et al., 2020, p.608). Hence, *developing analytical capabilities and creating a smart work environmen*t have a road that facilitates to implementation of smart logistics.

Just like in any practice in the firm, smart logistics requires *top management commitment and support* to administrate all processes successfully. *Investing in innovative attempts such as smart logistics*, is an important factor in their adoption (Khan et al., 2022b, p.7). Smart logistics purposes to exterminate imprecision and develop speed operations based on information. Human involvement is necessary to interconnect with devices as well as control the processes (Bag et al., 2020, p.608). Therefore, *training and educating employees* have critical importance in this process.

The government and policymakers should formulate obligatory policies, plan administration initiatives, governance various training programs, and help adopt smart logistics systems (Parhi et al., 2022, p.10). In addition, managers should advance a various technology application method to overcome the risks as well as security issues associated with smart logistics (Chen et al., 2022, p.3930). In this line, they should *create cybersecurity and threat resilience.* According to Perotti et al. (2022, p.201), the absence of culture and mission is one of the biggest barriers the logistics industry is facing, because the firm's manner toward the digital prospect influences the application of smart logistics. Therefore, managers should *generate organizational culture and mission toward smart logistics.* Lastly, *constituting cost sharing methodologies* among partners can solve economy-related barriers because the strategies of cost-sharing diminish the high initial investment costs of smart technologies (Parhi et al., 2022, p.6).

Conclusion

Smart logistics is receiving increasing significance because of the recognition of industry 4.0 recently, reinforcing the necessity to pay attentive attention to significant factors for providing its victories application. This study aims to carry out an in-depth systematic literature review to determine and identify the barriers to the application of intelligent logistics and relevant factors for successful implementation. A systematic literature review process on articles published from 2015 to 2022 was performed in the Scopus, Web of Science, and Dergipark databases. Among these articles, the study by Hannan et al. (2015) is the first article published in this domain. Accordingly, that presented as a commencing point for the article's analysis. Totally, 40 articles have been chosen and reviewed in detail.

When the results of the study are evaluated, it is seen that three main elements stand out. First of all, it has been observed that the studies on the barriers and enabling factors of smart logistics applications have increased significantly in the last three years (2020, 2021, and 2022). This finding indicates that the focus of research has shifted towards barriers and enabling factors of smart logistics. The second finding obtained from the descriptive analysis was that the articles, examined in this research, have preferred quantitative approaches in terms of methodologies, followed by literature reviews and conceptual studies. It is thought that the main reason for this situation is that the concept of smart logistics has just begun and that there are not enough applications to offer practical solutions in this field (Karlı and Tanyas, 2020, p.626).

Thirdly, as a result of the analysis, it was revealed that there are six main barriers that prevent the adoption and implementation of smart logistics. These are; risk-related barriers, data and technological-related barriers, organizational-related barriers, human resources-related barriers, economy-related barriers, and regulation-related barriers. Last but not least, as the enablers of the implementation of smart logistics, these factors

have been recommended in examined studies: develop technological infrastructure, enhance trust and collaboration, facilitate knowledge transfer, development of analytical capabilities, create a smart work environment, top management commitment and support, invest in logistics 4.0, training and educating employees, governmental norms & support, create cybersecurity and threat resilience, generate organizational culture & mission toward smart logistics, and constitute cost sharing methodologies. Managers and policy makers can benefit the outcomes of this research. In this way, they can overcome the barriers of smart logistics as well as facilitate the implementation of its.

In conclusion, this study makes three important contributions to the logistics literature. First, it provides descriptive statistics for the current state of the developing smart logistics literature. Secondly, it highlights the obstacles to the implementation of smart logistics and sheds light on why smart logistics is not spreading further in business. Finally, it presents the factors facilitating the implementation of smart logistics and offers managers suggestions to overcome the barriers mentioned.

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