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A Systematic Literature Review on Physical Internet Transforming current logistics to Sustainable Logistics

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Abstract

This study presents the first systematic literature review on the Physical Internet (PI) using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. A significant gap exists in the current literature regarding how PI can transform traditional logistics systems into sustainable models, which serves as the core motivation for this research. The review addresses two primary research questions: (a) identifying current trends in PI-related research, and (b) uncovering the key barriers hindering PI adoption. A total of 275 articles were initially retrieved from Web of Science and ScienceDirect, covering the period from 2019 to 2025. After applying inclusion criteria, 50 studies were selected for analysis. Findings reveal a growing academic interest in PI. Major barriers to its adoption include lack of standardization, insufficient government policy support, high initial investment costs, and concerns over data security. This review offers a foundational synthesis to guide future academic inquiry and practical strategies for overcoming challenges in PI implementation. The scope of this study is limited to the defined time

horizon.

Keywords
Physical Internet, PI, Sustainable Logistics, Systematic Literature Review, PRISMA, Adoption Barriers, Research Gaps.

1. Introduction
Current logistics systems have significant contributions not only to global economic growth but also to global temperature rise. The sustainability concern arises from the usage of fossil fuels in many transportation systems. These fuels pollute the air and harm the environment (Abbasi and Nilsson, 2016). In addition to sustainability issues, there is also the concern of transportation efficiency, which results in wasted fuel, delays, and congested transportation networks (Barysienė et al., 2015). Moreover, poor planning can lead to the transportation of empty or underutilized containers. This wasteful practice generates unnecessary emissions and environmental harm (M. Abbasi and F. Nilsson, 2016). Furthermore, some logistics companies still rely heavily on manual paperwork, which makes the process less responsive and inefficient (Hayek et al., 2023). As the volume of data increases, the adoption of real-time data-sharing and visibility tools becomes essential. Limited adoption of such tools reduces the ability to optimize routes, thus affecting both the sustainability and resilience of supply chain logistics (Shaikh et al., 2023).

To address these logistical challenges, the concept of the Physical Internet (PI) has been introduced. It is based on the principles of the digital Internet, including the standardized transmission of information packets through interconnected networks. Similarly, the PI aims to deliver physical products using standardized containers via collaborative logistics networks with shared, well-connected hubs. This system reduces emissions from transportation by minimizing unnecessary freight movements. It also enables waste reduction and promotes collaboration among business partners (Montreuil et al., 2013). Such collaboration allows businesses to share vehicles and hubs, ultimately saving space, time, and fuel (Crainic and Montreuil, 2016).

The adoption of PI is crucial to managing the increasing pressure on global supply chains to become more efficient, sustainable, and resilient. As PI encourages the sharing of resources among businesses, it offers substantial reductions in waste, delays, and emissions (Pan et al., 2017). This makes it essential in the fight against climate change. According to the Paris 2015 Agreement, global temperatures should not increase by more than 2°C. Given that supply chain logistics contributes about 7% of global emissions, the adoption of PI could play a pivotal role in meeting this target (Stojanović et al., 2021). Therefore, PI offers a promising solution to current logistics challenges.

In terms of sustainability's triple bottom line, the PI has a substantial impact. Environmentally, it enables reduced carbon emissions and energy consumption through optimized routing and resource sharing. It also minimizes waste and empty transportation runs (Bag et al., 2020; Kong et al., 2020). Economically, PI allows cost efficiency by maximizing vehicle space utilization and reducing operational costs (Fahim et al., 2021; Pan et al., 2017). Socially, it fosters collaboration among businesses and supports the development of new job markets. As a result, PI contributes significantly to the environmental, economic, and social dimensions of sustainability.

To the best of our knowledge, this study represents the first systematic literature review on the Physical Internet. The lack of such reviews in existing literature motivates this research. This study aims to address the following research questions:

RQ1: What are the current research growth trends in Physical Internet?
RQ2: What are the barriers hindering the adoption of Physical Internet?

This study aims to explore existing literature on the PI to provide both foundational knowledge and future research directions. Section 2 describes the review methodology. Section 3 presents and discusses the results. Finally, Section 4 concludes the study.

2. Review Methodology
In the domain of supply chain, there are various methodologies available to conduct a systematic literature review. Since this is the first known systematic review focusing specifically on the Physical Internet, we began by reviewing existing SLR studies within the broader field of supply chain management and logistics. From this overview, we

identified the PRISMA framework as the most suitable and least biased methodology for our study. Table 1 summarizes several prior studies, their review approaches, and the databases they utilized for literature retrieval. Based on this comparative analysis, this study adopts the PRISMA framework as its review methodology.

Table 1. Overview of Systematic Literature Review in the domain of SCM

Title	Review Methodology			Used Databases				Citation
	PRISMA	SLR	Others	Scopus	Web of Science	Science Direct	Others	
A systematic literature review of Technological developments and Challenges for inland waterways Freight transport in intermodal Supply chain management			▪	▪			▪	**(S. Gbako, D. Paraskevadakis, J. Ren, J. Wang, and Z. Radmilovic 2025)**
Sustainable supply chain visibility management on the ground of blockchain awareness: A systematic literature review	▪				▪	▪	▪	**(M. H. Miraz, A. Ya'u, H. H. Jin, O. Aigbogun, J. B. Sarkar, M. T. Hasan, and A. Kalam 2025)**
Intelligent supply chain management: a systematic literature Review on artificial intelligence contributions	▪			▪		▪		**(A. R. Teixeira, J. V. Ferreira, and A. L. Ramos 2025)**
A systematic literature review on supply chain risk Management in 3pl operations: risk identification and Assessment	▪			▪				(Siqueira et al. 2025)

Logistics/scm 4.0 maturity model review: opportunities for Industry 4.0 technologies application		▪		▪	▪			**(N. T. Machado and C. M. T. Rodriguez 2025)**
Systematic Literature Review of Supply Chain Relationship Approaches amongst Business-to-Business Partners	▪				▪			**(F. Jamaluddin and N. Saibani 2021)**

The PRISMA framework (Page et al., 2021) offers a structured and transparent approach for conducting systematic reviews. It is widely recognized and accepted within the supply chain logistics research for its clarity and reproducibility. PRISMA enables the application of eligibility criteria including inclusion and exclusion parameters which helps reduce bias and subjectivity during article selection. Accordingly, we apply the three-step PRISMA framework, consisting of: identification, screening, and inclusion. These steps are discussed in detail in the following subsections.

2.1 Identification

The identification process involved defining keywords, formulating search strings, applying filters, and selecting appropriate databases for literature extraction. As referenced in Table 1, commonly used databases for systematic reviews in supply chain literature include Scopus, Web of Science, ScienceDirect, and EBSCO. Among these, Web of Science and ScienceDirect were selected for this study

Although Scopus is widely used, a comparative analysis by Mongeon and Paul-Hus (2016) indicates that 84% of journal titles indexed in Web of Science are also included in Scopus. Therefore, to avoid duplication and ensure efficiency, Scopus was excluded from this review.

The study began with the formulation of search strings aligned with the research questions. The primary search terms used were: “Physical Internet,” “Logistics,” and “Barriers.” Various combinations of these terms were tested to optimize the retrieval of relevant articles. Additionally, a publication year filter was applied, limiting the search to articles published between 2019 and 2025.

Using the optimal search string in Web of Science, 48 articles were retrieved. From ScienceDirect, 227 records were extracted. After merging and removing 4 duplicate entries, the total number of unique records identified for the screening stage was 271.

2.2 Screening

In this phase of the study, the title and abstract of all 271 records were manually screened. A total of 219 articles were excluded as they did not align with the scope and objective of this review. As a result, 52 records were retained for full-text retrieval. Among these, 2 articles could not be retrieved due to limited access to those journals. Thus, 50 full-text articles proceeded to the final inclusion phase.

2.3 Inclusion

After completing the screening phase, a total of 50 papers were included in this study. These selected papers form the basis for the systematic literature review and subsequent analysis. The PRISMA Flow Diagram illustrating the

selection process shown in Figure 1. The diagram was prepared using a standardized tool developed by Haddaway et al. (2022).

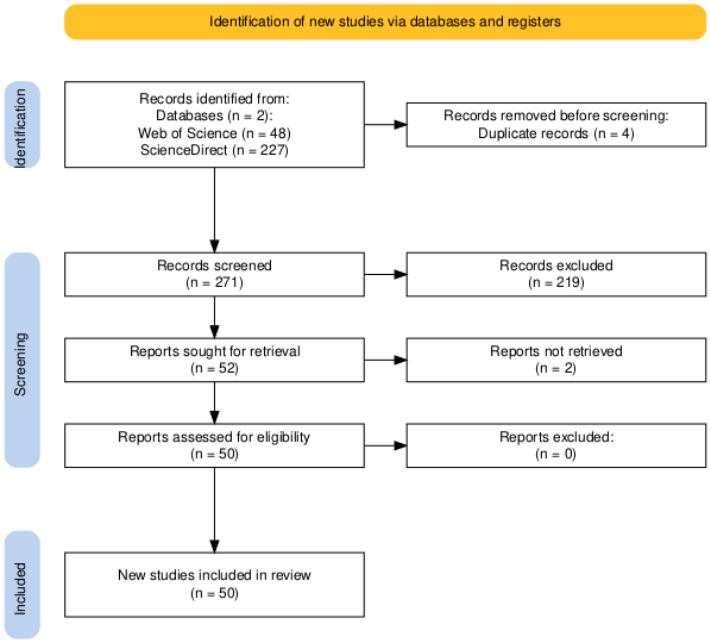

Figure 1. PRISMA Flow Diagram illustrating the identification, screening, and inclusion process used in this systematic literature review.

3. Results and Discussion

3.1 Numerical Results

This study highlights the prominent journals publishing research articles on the Physical Internet. Table 2 presents the journal names along with the number of related papers published between 2019 and 2025. Among all the journals, Computers & Industrial Engineering stands out as the leading publication outlet for PI-related research. It is followed by the International Journal of Production Economics, which holds the second position with seven articles published during the study period. Moreover, the continued prominence of Computers & Industrial Engineering reflects its central role in disseminating research in this emerging field.

Table 2. Journals Publishing PI Research

Journal Name	Number of Articles
Computers & Industrial Engineering	9
International Journal of Production Economics	7
Transportation Research Part E: Logistics and Transportation Review	5
Transportation Research Procedia	3
IFAC-PapersOnline	3
Journal Of Cleaner Production	3
Advanced Engineering Informatics	2
Computers In Industry	2
Sustainable Cities and Society	1
IEEE Access	1

Transportation Research Part D: Transport and Environment	1
Sustainable Materials and Technologies	1
Journal Of Open Innovation: Technology, Market, And Complexity	1
Transportation Research Part C: Emerging Technologies	1
Research In Transportation Business & Management	1
Transportation Engineering	1
Transport Policy	1
Futures	1
Digital Business	1
Energy Research & Social Science	1
Resources Policy	1
IEEE Internet Of Things Journal	1

This study will assist new researchers in identifying relevant journals for publishing or reviewing work on the Physical Internet. Among these, the journal Computers & Industrial Engineering has an impact factor of 6.5, reflecting its standing in the field. The International Journal of Production Economics follows with an even higher impact factor of 10.0, indicating strong scholarly quality. Additionally, Transportation Research Part E: Logistics and Transportation Review holds an impact factor of 8.8, underscoring its influence in logistics and sustainability research. These impact factors demonstrate that PI research is increasingly recognized within high-quality academic venues. This growing visibility indicates that significant and credible work is being conducted in the area, reinforcing the relevance and importance of PI in the broader logistics and supply chain discipline.

3.2 Graphical Results

This section highlights the trends, patterns, and insights derived from the extracted data. Research interest in the PI has increased significantly, indicating a steady rise in academic attention over the study period. According to the data, only a small number of studies were published in 2019. However, interest in the topic grew rapidly, with the number of publications doubling by 2021, reaching a total of 12 articles that year. This growth suggests that the PI is an emerging and expanding area of research. Figure 2 illustrates the upward trend in the number of publications per year, reflecting both the field's growing relevance and the academic community's increasing engagement. This trajectory

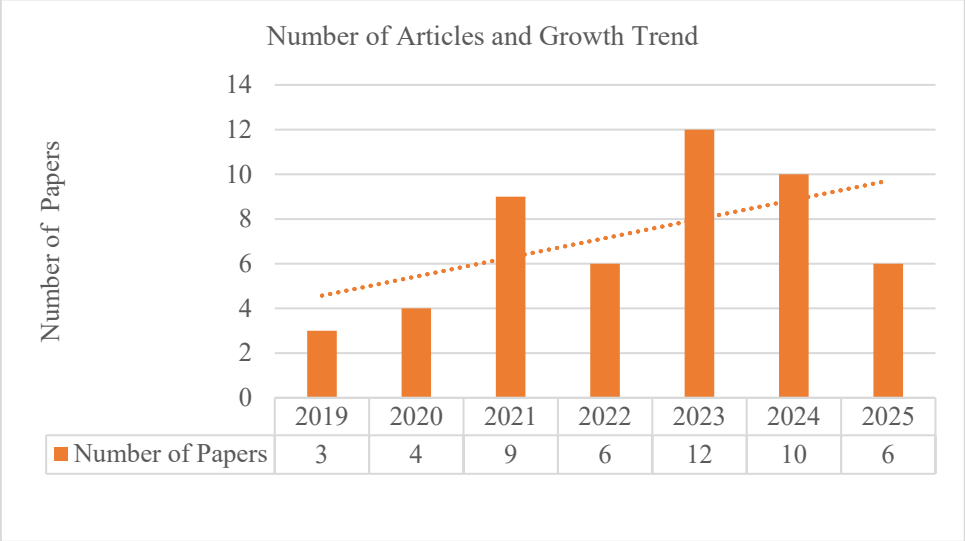

Figure 2. Number of Articles and Growth Trend

also aligns with the broader global emphasis on sustainability, as articulated in the Paris 2015 Agreement.

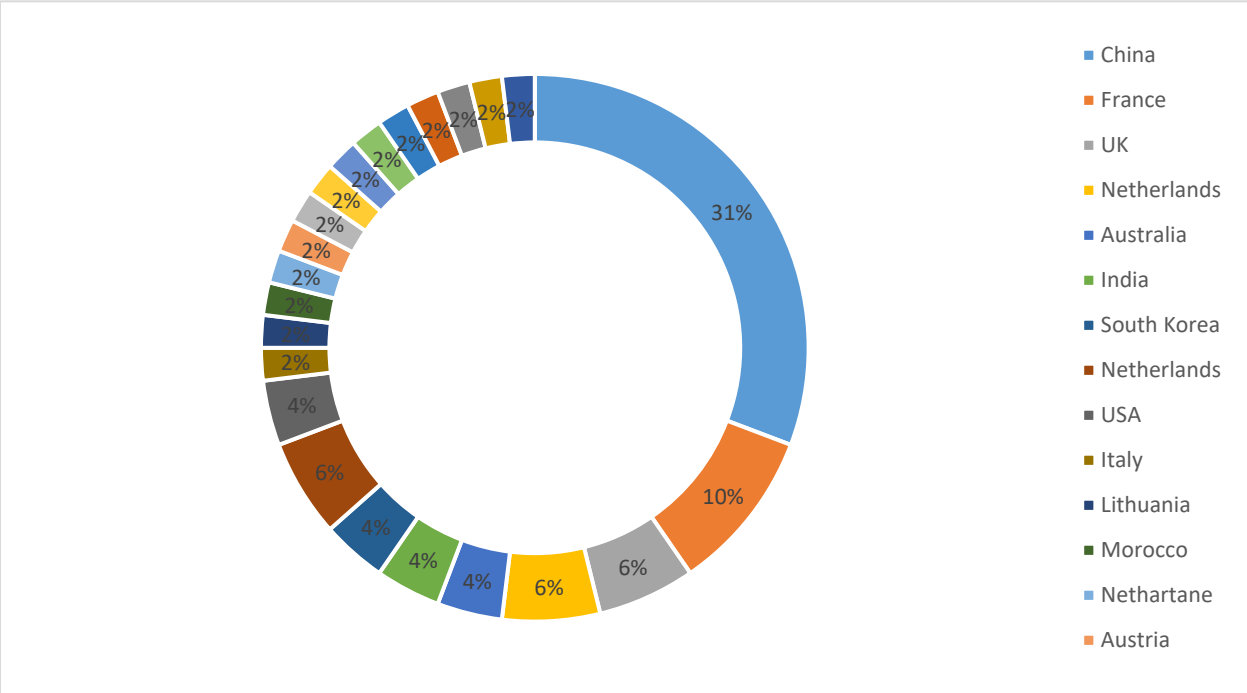

Figure 3. Geographical Representation of Reviewed Papers

The donut chart (Figure 3) illustrates the country-wise contributions to literature on the Physical Internet. The largest share of contributions comes from China, accounting for 30% of the total publications. This reflects China's strong interest in transforming current logistics systems into sustainable models through the implementation of the PI concept. Following China, France is the second-largest contributor, with 10% of the publications significantly less than China's share. Researchers from the United Kingdom and the Netherlands hold the next positions, each contributing 6% to the overall literature. Table 3 below provides an overview of these leading countries along with selected citations from their respective contributions.

Table 3. Country With a few corresponding citations

Country	Authors
China	(Kong et al. 2021; Liu et al. 2022; Ng et al. 2024; Qu et al. 2024; Xu et al. 2025)
France	(Essghaier et al. 2023; Pan et al. 2017; Pan et al. 2021; Perez et al. 2024; Wu et al. 2025)
UK	(Churchman and Longhurst 2022; Hayek et al. 2023)

Figure 4 depicts the relationship between the application areas discussed in the literature and the functions that the research focuses on. The identified functions include decision support, forecasting, inventory control, network design, optimization, planning, procurement, routing, scheduling, and simulation. Meanwhile, the application areas observed in the reviewed papers include inventory, logistics, manufacturing, production, retail, supply chain, transportation, and warehousing, among others. In the chart, each individual cell represents the number of papers that address a particular combination of function and application area. The darker the shade, the greater the frequency of occurrence. The heatmap highlights the frequent application of optimization techniques within the contexts of logistics and transportation. These descriptive statistics provide valuable insight into the dominant research directions and methodological emphases in the field. Such insights help identify prominent themes and guide future research in targeted and underexplored areas.

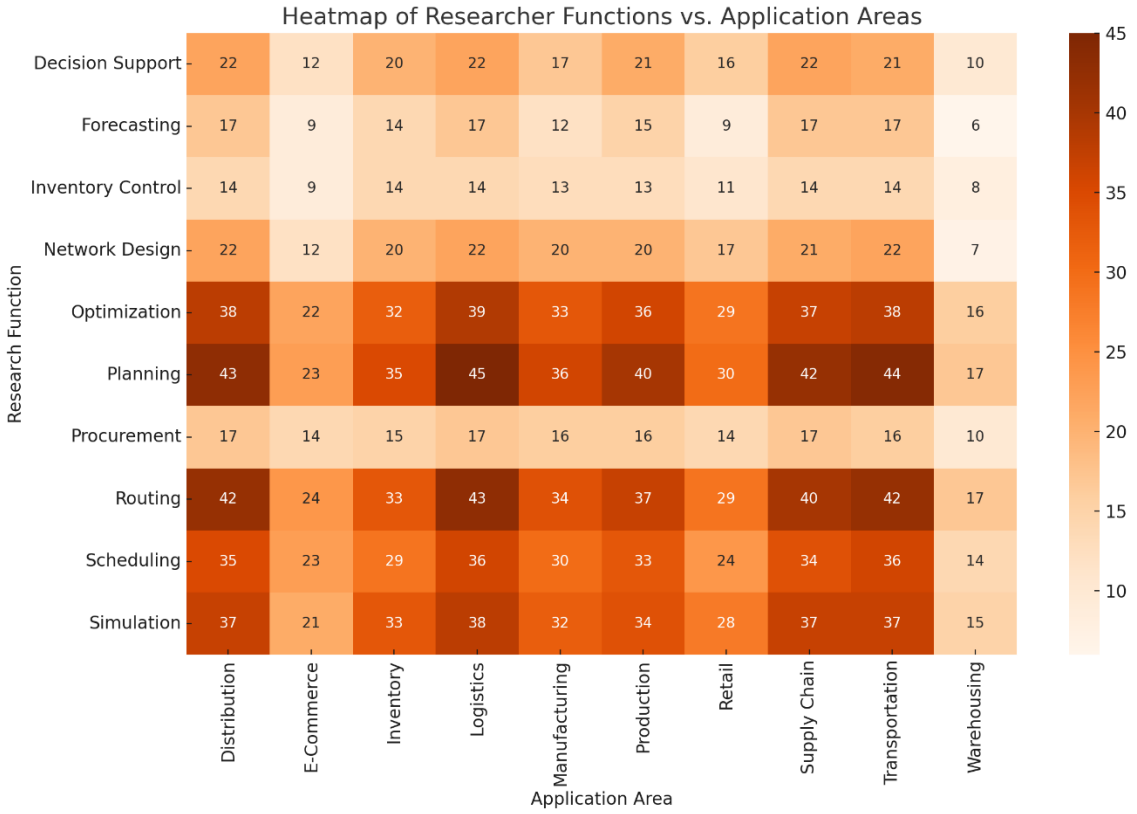

Figure 4. Highlights of the relationship between Research Function and Application areas mentioned in the retrieved papers

3.3 Barriers Hindering the adoption of Physical Internet

Every emerging system faces obstacles in its early development phase. Similarly, the PI, being a relatively new concept, is also subject to several challenges that hinder its broader adoption. Although PI offers promising benefits, certain key barriers continue to limit its implementation. These include the lack of standardization, absence of supportive government policies, high initial investment costs, and data security concerns.

The PI relies on resource sharing and network interoperability. To enable seamless resource sharing, it requires standardized logistical processes. However, current logistics systems often lack uniformity, making standardization one of the primary barriers to PI adoption (Pan et al., 2017). For example, without standardized containers and handling protocols across organizations, it becomes difficult to ensure efficient transportation and stacking across the supply chain. Developing and implementing these standards demands significant investmentleading to the second major barrier.

A high initial investment is another substantial obstacle. Implementing a hyperconnected logistics infrastructure, which is fundamental to PI, necessitates extensive capital to develop hubs, digitized routing systems, and interoperability platforms. Many organizations may hesitate to commit such resources, especially when the roles and participation levels of other stakeholders remain unclear (Fahim et al., 2021). This uncertainty also highlights the need for shared accountability across collaborating businesses.

To address this, strong governmental support and clear regulatory policies are crucial. Without firm policy direction and incentives, the pace of PI adoption may slow significantly (Hayek et al., 2023). Governments can play a pivotal

role in establishing the frameworks necessary for cross-industry collaboration and long-term infrastructure development.

Another critical concern is data security. Since PI encourages information sharing across multiple entities, businesses may be reluctant to participate due to fears about data privacy and cybersecurity risks (Shaikh et al., 2023). This hesitancy is understandable, especially in sectors where proprietary logistics data can influence competitive advantage.

In summary, these barriers lack standardization, high initial investment, weak policy support, and data security risks are central to the current challenges facing PI implementation. Given the limited number of studies in this area, it is likely that more barriers remain unidentified. Continued research is essential to explore these issues further and to develop actionable strategies for overcoming them. As the field remains underexplored, it offers rich opportunities for future investigation and innovation.

3.5 Gaps in PI Literature

The concept of the PI and its integration into existing logistics systems is still in its early stages compared to other well-established supply chain innovations. As such, the field presents numerous research gaps. Since this study is, to the best of our knowledge, the first systematic literature review in this domain, it aims to consolidate available knowledge and highlight the key areas where further investigation is needed.

One major gap identified in the literature is the limited real-world implementation of the PI (Tran-Dang et al., 2020). While several studies propose conceptual frameworks, very few address their practical application. This disconnect creates uncertainty about how these models can be effectively translated into real-world logistics operations. Thus, empirical case studies and pilot implementations are necessary to test the validity and performance of existing frameworks in complex, real-life supply chain environments. Small-scale pilot projects could be especially valuable in identifying potential barriers in collaborative logistics systems and guiding future scalability.

Another gap involves the integration of Industry 4.0 technologies into the PI framework (Bag et al., 2020). Technologies such as the Internet of Things (IoT), Blockchain, and Artificial Intelligence (AI) are already transforming various areas of logistics and supply chain management. However, their application within the PI context remains underexplored. Future research should focus on integrating these technologies into conceptual and operational PI models to enhance resilience, interoperability, and automation.

A third research direction concerns the organizational acceptance of PI. Transforming existing logistics systems to adopt PI principles may encounter behavioral and structural resistance (Shaikh et al., 2023). Since PI relies on cross-organizational collaboration, understanding human factors, cultural readiness, and organizational change management is crucial. Future research should explore strategies to overcome resistance and promote a culture of shared responsibility and trust.

Additionally, governmental involvement and policy development represent another important gap. Because the PI model often involves cross-border logistics and infrastructure, supportive regulatory frameworks are essential. Research is needed to assess how legal and policy mechanisms can be designed to facilitate smooth, international implementation of PI systems.

Finally, standardization remains a significant unresolved challenge. The effectiveness of PI depends on the interoperability of logistics components such as containers, vehicles, and hubs. Future research should focus on the development of global standards to ensure seamless integration across different logistics networks.

In summary, the PI presents a promising but underdeveloped area of study. Addressing these research gaps will be essential for advancing both the theory and practice of sustainable, hyperconnected logistics.

3.6 Validation

This study is carried out by following standardized and well recognized PRISMA 2020 guidelines which made this study bias free. This study can be replicated by following the steps and guidelines. Therefore, these results highlight the actual scenario of the current literature.

4. Conclusion

This study presents the first systematic literature review on the PI. It offers a structured synthesis of existing research by addressing two primary research questions: (1) identifying current growth trends in PI research, and (2) exploring key barriers to PI adoption. Following PRISMA guidelines, a total of 275 articles were initially retrieved from two major databases: Web of Science (48) and ScienceDirect (227). After removing four duplicate entries, 271 records were screened based on their titles and abstracts. Of these, 219 were excluded due to lack of relevance or scope alignment. A total of 52 articles were selected for full-text review, out of which 50 were included in the final analysis.

The findings reveal a growing trend in PI research over recent years, particularly from 2021 onward, indicating increasing academic attention. Computers & Industrial Engineering emerged as the most prominent journal publishing in this domain. Additionally, the review identifies four primary barriers to PI adoption: lack of standardization, absence of strong government policies, high initial investment requirements, and data privacy concerns. This study successfully addresses its core research questions. The growing number of publications suggests that PI is an emerging and promising research area with expanding relevance. Journals such as Computers & Industrial Engineering and the International Journal of Production Economics are actively shaping the scholarly conversation around PI. Like any research, this study has limitations. It is restricted by a defined time horizon (2019–2025), which may have excluded earlier foundational work on PI. Future reviews could benefit from a broader temporal scope, potentially starting from the first documented mention of the PI concept. Additionally, a more comprehensive inclusion of grey literature and industry reports could enhance future studies.

Despite its limitations, this study lays a foundation for future research by highlighting underexplored areas and critical barriers. The findings serve as a valuable resource for both academic researchers and industry practitioners aiming to implement or advance PI systems in pursuit of sustainable logistics.

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Biographies

Abu Saleh Md Nakib Uddin is a student of MASc in Industrial Systems Engineering at the University of Regina. He has been awarded fully funded MASc Position by the Faculty of Engineering and Applied Science due to his research excellence in undergraduate studies. During the first semester (Winter 2025) of his master's studies, he was awarded "SGI Graduate Student Traffic Safety Research Scholarship" by the Faculty of Graduate Studies and Research as a part of the Winter 2025 Main Scholarship Competition at the University of Regina. Before stating his master's studies in Canada, he received his bachelor's degree in industrial and production engineering from the Military Institute of Science and Technology, Bangladesh. During his junior year of his bachelor's degree, he delved into developing an Ecofriendly Gutter Cleaner where he got exposure of research. From that point on, he has been passionate about research, and he aims to start his career in academia. Before he defended his undergraduate thesis, he was able to write some journal papers because of his passion. He published his co-author papers in reputed journals. And he attended International Conferences virtually and physically. He is a student member of CORS and was an IEOM Student Member.

Sharfuddin Ahmed Khan is currently an Associate Professor and Associate Program Chair of Industrial Systems Engineering at the University of Regina, Saskatchewan, Canada. Prior to this role, he served as a Lecturer (September 2009 – August 2019) and later as an Assistant Professor (September 2019 – December 2021) at the University of Sharjah, United Arab Emirates. He then joined the University of Regina as an Assistant Professor (January 2022 – June 2025) before being promoted to his current position. Dr. Khan has contributed extensively to top-tier academic journals and Scopus-indexed conferences in areas such as supply chain management, sustainability, and engineering

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Dr. Shireen Al Hourani, Ph.D., PMP, is an Associate Professor at University Canada West, Vancouver, with over 20 years of combined experience in academia and industry. She previously served as Assistant Professor at King Abdulaziz University and German Jordanian University, where she taught courses in industrial and mechatronics engineering, including project management, production planning, and engineering design. Her academic leadership included overseeing senior capstone projects, accreditation processes, and contributing to student development through training and evaluation initiatives. Before entering academia, Dr. Al Hourani held several leadership roles in the pharmaceutical industry at Hikma Pharmaceuticals, including Engineering Director and Senior Supply Planning Manager for the MENA region. Her work focused on excellence in engineering, lean manufacturing, preventive maintenance systems, and SAP PM implementation. She has authored multiple research papers in pharmaceutical engineering, automation, and supply chain optimization. Dr. Al Hourani's interdisciplinary expertise spans mechanical and mechatronics engineering, operations excellence, and business leadership. She holds a Ph.D. in Mechanical Engineering from the University of Jordan and professional certifications in project management and leadership.