

DRIVERS AND BARRIERS FOR ACHIEVING GREEN BENEFITS IN DIGITAL LOGISTICS PLATFORMS

Summary

Purpose

To provide a better understanding of digital logistics platforms' potential as a measure for achieving green benefits in the transportation sector.

Design/methodology/approach

Research uses qualitative approaches – literature review and semi structured interviews to complement state of the art research with practical insights from transportation industry. This paper provides insights into the drivers and barriers for participating in digital logistics platforms, emphasizing the role of regulations, cost reduction, and lower emissions as key drivers, and challenges related to trust, data sharing, and technical integration.

Findings

Research identified:

1. expected benefits participation in digital logistics platforms;
2. barriers and drivers faced by transportation companies to participate in digital logistics platforms.

Research limitations/implications (if applicable)

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Practical implications (if applicable)

Research results are relevant for:

1. logistics industry representatives to discuss and assess motivations for participating in digital logistics platforms and benefits to be expected for their organisation;
2. developers of digital logistics solutions, including digital logistics platforms. Developers should consider and address barriers related to data sharing, data management and security as priorities;
3. policy makers, to understand how policy measures are interpreted and implemented in business environment.

Social implications (if applicable)

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Original/value

The paper explores green investment in transport through digitisation. While transport decarbonization is widely discussed through investment in vehicles, infrastructure, alternative fuels, digital solutions providing opportunities to reduce emissions at relatively lower investment costs are barely discussed.

Keywords: Green investment, intelligent transport systems, digital logistics platforms, CO2 emissions, transport networks, collaborative logistics.

ABSTRACT

This paper highlights the emergence of digital logistics platforms as an opportunity to improve efficiency and mitigate climate impact. Digital logistics platforms are digital logistics marketplaces, matchmaking demand and supply of logistics services. Depending on the operational models of the platforms, additional services may be offered to improve operational efficiency and promote environmentally friendly options. However, to achieve these benefits, a closer collaboration and data sharing is expected between platform participants. Collaboration within the freight industry and utilising the potential of digital logistics platforms can contribute to improving operational efficiency and reduced environmental impact. Collaboration using digital logistics platforms relies on data sharing and collaboration to achieve benefits at a transport network level.

This research uses a combination of qualitative methods to provide a better understanding of digital logistics platforms' potential as a measure for achieving green benefits in the transportation sector. This research reviews existing literature for possible benefits from participating in digital logistics platforms and collaboration approaches enabling access to said benefits. To support theoretical research, a series of workshops and interviews using semi-structured questionnaires were performed to engage logistics industry representatives and provide industry perspective on participation in digital logistics platforms. This paper provides insights into the drivers and barriers for participating in digital logistics platforms, emphasizing the role of regulations, cost reduction, and lower emissions as key drivers, and challenges related to trust, data sharing, and technical integration.

The research findings suggest that green benefits are not the main driver for participation in digital logistics platforms, however they can still be achieved by addressing other drivers. Digital logistics platforms may become a valuable tool for reducing CO₂ emissions without heavy investment in vehicles and infrastructure, while also providing opportunities for cost reduction and improved operational efficiency.

Keywords: Green investment, intelligent transport systems, digital logistics platforms, CO₂ emissions, transport networks, collaborative logistics.

1. INTRODUCTION

The transport sector, including international shipping, contributes close to 26% of total greenhouse gas emissions in the European Union (EU). The transport sector, among others, has been addressed by multiple large-scale initiatives to achieve main goal of the EU becoming climate-neutral by 2050. The concept of *green investment* emerged as an effort to focus investment towards achieving climate goals by financing infrastructure, vehicles and digital solutions with lower environmental impact. While these investments can be made at a company level, collaborative approaches are discussed as an opportunity to improve the efficiency of green investment and climate impact mitigation efforts at a transport network level.

Currently companies concentrate on their primary Scope 1 emissions and the Scope 2 emissions caused by their energy use. Incoming EU regulations demand large companies to report their Scope 3 emissions produced by the supply chain. Upcoming reporting requirements will affect a wider range of companies, in particular logistics operators. This regulation will be extended gradually to cover all the companies operating inside EU by 2028. With reported emissions as reference, companies are likely to face pressure to reduce emissions. Digital solutions provide opportunities to optimise operations and improve efficiency without investing in infrastructure and vehicles. One of such digital solutions accessible to individual companies is digital logistics platforms – digital logistics marketplaces, matchmaking demand and supply of logistics services (Yang & Lin, 2023). While these platforms were created with purpose of improving matchmaking, modern digital logistics platforms may include complementary services, such as operation and fleet management and route planning. These functionalities may enable green benefits, such as improved operational efficiency and reduced emissions, that are not accessible to individual participants, however possible if platform participants collaborate as a network.

Reducing environmental impact is emerging as a shared business interest, as CO₂ emissions will be reported across the supply chain. Traditionally, logistics has been a highly competitive sector, however digital solutions, such as digital logistics platforms enable benefits for a group of companies and possibly higher benefits compared to measures available for an individual company. Collaborative investment in infrastructure, equipment and vehicles or vessels has a high-cost barrier for entry, and as an alternative, digital collaborative platforms are emerging as collaboration approaches for achieving green benefits (Shree *et al.*, 2021). Business models relying on collaboration facilitate cost reduction and enhanced customer service by leveraging shared information and assets while improving the coordination of collaborative endeavours. In such collaborative arrangements, companies are motivated to work together to unlock greater value in their partnership, ensuring its sustained success, and aligning their efforts to achieve shared business objectives (Osório *et al.*, 2013).

Although digital logistics platforms have been present in the market for years, there are significant research gaps in analyzing digital platform applications in transport. A deeper understanding of industry needs is required to provide practical insights on feasibility and efficiency of the digital logistics platforms as a measure to achieve greener logistics.

Even though research related to B2B platforms is increasing, more empirically tested research on the topic is needed (Shree *et al.*, 2021). Platform ecosystems have been studied for a long time and extensively, but the understanding of their emergence has received less attention (Pussinen *et al.*, 2023; Valkokari *et al.*, 2022). The literature focuses more on a snapshot at a given moment in time than on a longitudinal study when trying to understand the practical emergence and evolution of the ecosystem and platform (Pussinen *et al.*, 2023; Valkokari *et al.*, 2022) and the decisions that drive the ecosystem and platform emergence. As digital logistics platforms require wide adoption to create synergies and opportunities for green benefits, it is of critical importance to understand drivers and barriers for participation in such platforms.

Previous research on logistics platforms is largely focused on transactional exchange (services and products) (Daniluk *et al.*, 2016). Logistics marketplaces may also integrate features promoting green logistics, yet there has been no comprehensive systematic examination of necessary features and motivation for the companies to join to use digital logistics platforms for means to collaboration. Benefits proposed by modern platforms include simplified collaboration, information exchange and improved operations between partners (Fanti *et al.*, 2017).

Given this background, this research aims to bridge gap in existing research by providing a better understanding of how emerging digital logistics platform could address concerns and motivations of potential participants and create effective collaboration approaches for achieving green benefits. The objectives of this study are:

1. to review literature on digital logistics platforms to identify expected benefits, drivers and barriers for participants of digital logistics platforms;
2. to engage potential logistics platforms participants and gain industry insights on expected benefits, drivers and barriers for participants of digital logistics platforms;
3. to develop a model summarizing benefits, participation drivers and barriers for logistics platform participants.

2. APPROACH AND METHODOLOGY

This paper aims to combine research and industry perspectives on potential benefits and motivations for participating in digital logistics platforms. To achieve this, a combination of qualitative research methods of literature review and semi-structured interviews was used.

A literature review was performed to understand enabling technologies and respectively, benefits for participants in digital logistics platforms. Literature reviews are commonly used to understand existing perspectives, state of the art in research and knowledge gaps (Rowley & Slack, 2004; Seuring & Gold, 2012);

Semi-structured group and individual interviews were also conducted with logistics industry representatives. Semi-structured interviews allow all participants to be asked the same questions within a flexible framework (Dearnley, 2005). When used in group interviews, this approach allows discussion and reflections between participants, contributing to valuable research insights. Participants with relevant industry experience were selected. Due to their exposure to different organizations and professional experiences within their career, experts can complement the written practitioner's publications by adding another perspective (Fontana & Frey, 2000; Myers & Newman, 2007). Participants with decision making, information technology application in logistics and client management roles were targeted as profiles with knowledge relevant for research scope. Insights provided can be also used to validate findings of the literature review (Kallio *et al.*, 2016). Two to four researchers were present in the interviews with some focusing on presenting the concepts and guiding the discussions and others focusing on recording the discussion. The notes from the discussions were cross analysed by two researchers and the findings regarding the drivers and barriers collected in a two-by-two analysis frame, where Demand and Supply represent x-axis and Drivers and Barriers represent y-axis. Then the case data related to the drivers and barriers was organized under more generic themes that emerged from the case data in the table representing two-by-two analysis frame. An analysis frame was used as a basis for conceptual framework summarizing key drivers, barriers and the relationship between participants in digital logistics platforms.

Engagement of industry representatives is of critical importance to understand drivers and barriers for participation in digital logistics platforms, such as practical implications of sharing

operational data, coordinating operations and improving operational efficiency. As technologies are rapidly advancing, practical implications might drastically change in a span of just a few years (Dwivedi *et al.*, 2021).

The interviewees were first presented with the conceptual model of the digital logistics marketplace. Additionally, a simplified diagram of a freight logistics chain elements and stakeholders (land, sea, rail, hubs (land terminal, seaport)) was used to position interviewees' organizations on the chain. The semi-structured interview contained the following topics:

1. What are the benefits of joining digital logistics platforms from a participating company's perspective?
2. What are the limitations or risks of joining digital logistics platforms from a participating company's perspective?
3. How does the interviewee see the transparency of the digital logistics platforms, including such aspects as joining, visibility, pricing? Should it be open to everyone or strictly limited to approved/audited partners? If yes, what entry criteria could be used?
4. What existing information systems should the digital logistics platforms join/integrate with in a participating company?
5. Who should be the owner and operator of the digital logistics platform (joint venture, neutral operator, etc.)? What are the options for ownership and operators?

The research involved companies from Finland and Lithuania, operating in the EU market. Interviews conducted and participants are summarized in Table 1.

Table 1. Conducted group and individual interviews, participant roles

Interviewee(s) and the type of interview	Date	Participants (roles, number of persons)
Port operator, semi-structured interview	5.12.2023	Interviewees: 2 port operator management representatives, Neutral expert: 1 software development company representative Interviewers: 3 researchers
Cargo owner, semi-structured interview	18.12.2023	Interviewee: 1 cargo owner logistics procurement manager Interviewers: 3 researchers
Port operator and truck company, semi-structured group interview	19.1.2024	Interviewees: 4 port operator management representatives, 1 truck company representative Neutral expert: 1 software development company representative Interviewers: 3 researchers
Cargo owner, semi-structured interview	6.2.2024	Interviewee: 1 cargo owner logistics procurement manager Neutral expert: 1 software development company representative Interviewers: 3 researchers

Freight forwarder, semi-structured interview	22.2.2024	Interviewee: 1 freight forwarder Neutral expert: 1 software development company representative Interviewers: 2 researchers
Hub operator and logistics service provider, semi-structured group interview	6.3.2024	Interviewees: 1 operation manager, 1 community manager, 1 information technology department manager Interviewers: 2 researchers
Cargo owner, semi-structured interview	7.3.2024	Interviewee: 1 purchasing manager Interviewers: 2 researchers

3. LITERATURE REVIEW

3.1. Approaches and requirements for enabling green benefits from digital logistics platforms

A platform business is a business based on enabling value-creating interactions between external producers (supply-side) and consumers (demand-side) (Parker *et al.*, 2016). The platform itself is an infrastructure that enables participative interactions between the sides – setting also governance conditions by the platform owner on how to operate (Parker *et al.*, 2016). Digital transformation of businesses created digital platforms – an ecosystem of autonomous actors (platform and its owner, complementors – providers or producers, and consumers), which are functioning online and offline actors in open network structures with multiple layers of openness (Bieliné & Ulbinaitė, 2022; Pauli *et al.*, 2021). Digital logistics platforms are emerging from digital logistics marketplaces. Even though the service sale is the marketplaces’ primary objective, digitalisation of logistics creates opportunities for a new range of services and interaction between marketplace participants.

The sustainability of freight transport has become a major issue in the field of logistics in the past decades (Pan, 2017). Transport decarbonisation and greenhouse gas emission reduction are among global strategic priorities. This literature review focuses on green benefits enabled by participation in digital logistics platforms and conditions required to achieve these benefits.

Digital logistics platform services enabling green benefits can be characterised by whether they are provided before or after purchasing decision is made:

1. Open exchange of information before the actual product and service sales occurs. Digital logistics platforms are an opportunity to promote green logistics options by sharing sustainability related estimates, such as expected greenhouse gas or CO₂ emission (Lu *et al.*, 2007). Access to these estimates can contribute to improved Scope 3 emission management and more informed decisions. Demand side pressure creates motivation for adopting green logistics measure (Meixell & Luoma, 2015);
2. Logistics service management after purchasing decision has been made and parties are operating under contractual obligations. Digital supply chain management solutions enabled by advanced data sharing include supply chain digital twins for improving supply chain management and risk management (Ivanov & Dolgui, 2021); digital supply chain management (Kamble *et al.*, 2020), driven by data shared between participants and supply chain visibility, intended for efficient demand and supply management (Kalaiarasan *et al.*, 2022).

Green benefits may be enhanced by collaborative supply chain management activities. Digital logistics platforms may also contribute to more sustainable operations, as activities can be efficiently distributed between participating partners (Cote *et al.*, 2021) or savings achieved by optimising operation in connected transport network (Ivanov *et al.*, 2022). These include diminishing instances of empty running, lowering operating costs and others (Vargas *et al.*, 2018). Collaborative models are considered as one of the innovative solutions to effectively address the growing challenges in transport and logistics from both environmental and economic perspectives (Pomponi, 2013). Collaboration between participants of the logistics chain can enable synergistic use of resources in global supply networks, with significant gains in terms of efficiency and sustainability (Schamschula *et al.*, 2022). As collaborating parties may be remote and located across large geographical scope, collaboration relies on effective digital solutions for supply chain management and high-quality operation data. Sharing advanced operational data requires high level of trust between supply chain participants and is foundation for collaboration. Table 2 summarizes a range of desired benefits (Kalaiarasan *et al.*, 2022; Schamschula *et al.*, 2022) and enabling digital solutions required.

Table 2 Benefits enabled by digital logistics platforms and required digital solutions

#	Benefits	Enabling digital solutions required	Data shared between collaborating companies
Operational and economic benefits			
1	Greater visibility to real-time demand, rates & capacity	Fleet and/or operation management systems Intermediary transport service brokerage platforms Data sharing integrations	Service pricing Capacity information Production planning and scheduling
2	Matching demand with capacity more efficiently	Fleet and/or operation management systems	Loading/unloading schedules, estimated time of arrival sharing
Green benefits			
3	Improving operational efficiency and reducing empty miles	Intermediary transport service brokerage platforms capable of matching loading and vehicle locations Fleet and/or operation management systems, with route planning functionalities	Last known location of vehicle/vessel Journey distance estimations
4	Reducing carbon footprint	Fleet and/or operation management systems, with route planning functionalities	Vehicle location data
5	Minimizing dwelling time.	Intermediary transport service brokerage platforms capable of matching supply and demand Fleet and/or operation management systems, with route planning functionalities	Capacity information Last known location of vehicle/vessel
6	Eliminating manual and paper-based processes	Electronic document systems Enterprise resource planning systems	Freight data Compliance data Digital documents
7	Regulatory compliance	Electronic document systems	Compliance data Emission data

#	Benefits	Enabling digital solutions required	Data shared between collaborating companies
		Fleet and/or operation management systems	

As summarised in the table, for achieving green benefits, just transactional data sharing, such as orders or schedules, are not sufficient. Advanced data sharing requires mutual trust and digital integration, as majority of solutions rely on real-time or near real-time data. Further research explored drivers and barriers for supply chain members to engage in closer collaboration through digital logistics platforms to achieve green benefits.

3.2. Collaboration in digital logistics platforms

The idea for collaboration can come from the company itself or from its environment. In either case, there must be several interested companies that recognize the value of the potential interactions, assimilate it, and then use it for commercial purposes. The reasons why companies collaborate depends on individual resource endowments and industries (Schmoltzi & Wallenburg, 2011); however, when companies enter a partnership, they hope to gain benefits through knowledge transfer and information sharing. The main idea behind such cooperation models is therefore to achieve common goals and mutual benefits (e.g., resource sharing, cost savings, improved productivity and competitiveness, access to new markets, etc.) and to reduce risks. As collaboration can take various forms, it must be clearly defined to determine the shares of collaborators in outcomes, costs, and resources (Amiri and Farvaresh, 2023).

The type of collaboration most feasible for digital logistics platforms can be characterized as horizontal – collaboration between competitors and other supply chain actors, in which companies can consolidate their freight into fewer numbers of trucks, leading to cost and environmental savings (Pan *et al.*, 2019). In this sense, participation in digital logistics platform is similar in its nature to horizontal collaboration. Collaboration, as a topic, is discussed in literature, however only cases exploring collaboration in logistics were selected as relevant for scope of this paper.

Several studies have been made on collaboration drivers and barriers with different methods and frameworks. Table 3 presents main motivations and barriers for horizontal collaboration identified by Saenz *et al.* (2015) in their study of managers from 5 companies. Cost reduction and efficiency improvement seem to be more important drivers for collaboration compared to increasing sales by accessing new markets. Although horizontal collaboration faces many challenges, it appears that working with other firms that function at the same level is a suitable model for enhanced performance and joint innovation, as common threats and opportunities are shared (Saenz *et al.*, 2015).

Table 3. Drivers and barriers for horizontal collaboration (Saenz *et al.*, 2015)

Motivations	Assessment (scale 1-5)	Barriers	Assessment (scale 1-5)
Cost reduction	4.6	Organizational culture	4.2
Allowing easier response to demand fluctuations	4.4	Lack of trust	4.0
Improvement of the service level	4.2	Difficulty finding collaboration	3.6
Improvement of the vehicle fill utilization	4.2	Lack of common processes	3.6

Lower carbon emissions	3.2	Competitors acquiring information	3.2
Access new markets	3.0	Difficulty agreeing to HC terms	3.2
		Difficulty distributing the benefits in a balanced manner	2.4

Other studies have reported slightly different barriers (Table 4). Schamschula *et al.*, (2022) reported that the main issues were poorly integrated IT systems among partners and misaligned objectives (selected by 58% of interviewees who could choose two options), followed by the lack of data sharing (54%). In this study, trust, which is usually very important (Islam *et al.*, 2019), was not seen as too troublesome. The study also emphasizes, that to ensure stability and fairness of the collaboration, it is essential that a neutral body (a trustee) distributes wins and gains accordingly among the participants (Schamschula *et al.*, 2022).

Karam *et al.*, (2021) found 30 barriers in Danish transport sector and grouped them into five categories. Then they used the Analytic Hierarchy Process method and found that Behaviours and attitudes had the highest weight among the barrier categories (this category includes Lack of trust among partners, Lack of trust in the methodologies and coordinator, and failing to keep commitments), followed by the Information quality (this category includes Low information accuracy, Lack of timely information updates, Lack of real-time information, and Shared information lack important details).

Table 4. Collaboration barriers identified in other studies.

Study	Barrier Categories	Main Barriers
Schamschula <i>et al.</i> (2022)	N/A	Poorly integrated IT systems
		Misaligned objectives
		Lack of data sharing
Karam <i>et al.</i> (2021)	Behaviours and attitudes	Lack of trust among partners
		Lack of trust in the methodologies and coordinator
		Failing to keep commitments
	Information quality	Low information accuracy
		Lack of timely information updates
		Lack of real-time information
		Shared information lack important details

Literature provides insights into expected benefits from participating in digital logistics platforms, as well as drivers and barriers for businesses to collaborate to an extent needed to enable digital solutions. The studies were performed prior to the increasing requirements for Scope 3 CO₂ and corporate social responsibility directive (further referred to as CSRD) reporting. The current state of research is not sufficient to understand whether possible benefits are sufficient to overcome barriers for data sharing and collaboration. This paper aims to bridge the gap by providing insights from logistics industry representatives on participation in digital logistics platforms. In the analysis, actors from both sides were engaged together to represent the demand and supply side of the digital logistics platforms.

4. FINDINGS FROM THE INTERVIEWS AND WORKSHOPS

This research aims to increase the understanding of drivers and barriers for joining digital logistics platforms. Additionally, data sharing between participants of digital logistics platforms

is examined. In this section, findings of the individual and group interviews are described. Participants are divided into supply and demand side stakeholders. Of course, this is not always straightforward, because some stakeholders may have both roles (producer and consumer) on the digital logistics platform. Under this, research cargo owners represent demand-side and freight forwarders, truck companies and port operations represent supply-side. Then the case data related to the drivers and barriers was categorized under more generic themes that emerged from the case data.

The driver theme that contained claims common for both sides (demand and supply) were regulations. Interviewees stated that regulations such as CSRD/Scope 3 CO2 emission reporting cause emission data collection and reporting responsibility for demand side and this need flows also to the supply-side. Demand side companies may have their own emission reduction targets that flow to the supply side through logistics services purchasing decision criteria.

The barrier theme that contained claims common for both sides (demand and supply) were quality and transparency. Uncontrolled marketplace entry leads to the low-quality/capability partners. Therefore, there needs to be measures to control contributions and access to the platform. It was also stated by interviewees that it is possible that logistics companies are using so called “auction platforms” to improve their capacity utilisation. However, this may contradict the cargo owners need to control and get visibility to total logistics chain emission as this data is currently lost in this kind of trading activity. This challenge was stated by both sides – demand and supply – and there were recommendations to avoid “auction platform” type of activity on the platform.

Statements collected from the interviews are summarised and structured in Table 5.

Table 5. Drivers and barriers for participating in digital logistics platforms

	Demand side (Cargo owner)	Supply side (Freight forwarder, Truck company, Port operations)
Key drivers	<p>Regulation drivers:</p> <ul style="list-style-type: none"> • CSRD/Scope 3 cause emission data collection and reporting responsibility (as well as emission reduction needs). <p>External drivers:</p> <ul style="list-style-type: none"> • Societal/client pressure to “become greener”. • Value provision to cargo owner’s customer (e.g. required emission data from a single point). 	<p>Regulation drivers:</p> <ul style="list-style-type: none"> • CSRD/Scope 3 cause emission data collection and reporting responsibility for demand-side and also may require offering sustainable alternatives (e.g. biodiesel). <p>External drivers:</p> <ul style="list-style-type: none"> • Fulfilling demand-side requirements (buying power). <p>Business drivers:</p> <ul style="list-style-type: none"> • Return on investment and competitive advantage for green investment. • Possibility to acquire new customers through platforms and access to more profitable clients and routes. • Increasing port competitiveness with regulated transparency and intelligent optimization.
Key barriers	<p>Quality and transparency barriers:</p> <ul style="list-style-type: none"> • Uncontrolled marketplace entry may lead to the low-quality/-capability partners. • Avoiding an uncontrolled logistics “auction platform” where transparency and traceability will be lost. <p>Data sharing barriers:</p> <ul style="list-style-type: none"> • Platform API integrations cause costs (large enterprises). <p>Governance barriers:</p> <ul style="list-style-type: none"> • The owner of the platform needs to be neutral and trusted partner; • platform operator has to have business model to cover the expenses (otherwise impossible to operate the platform); • Pricing model change in long term may realise lock-in risk for company; • Overcoming chicken/egg problem in platform – both buyer and supplier sides are needed. 	<p>Quality and transparency barriers:</p> <ul style="list-style-type: none"> • Uncontrolled marketplace entry may lead to the low-quality/-capability partners. • Avoiding an uncontrolled logistics “auction platform” where transparency and traceability will be lost. • How to make emission data high quality and fair to all players, uncertainty of emissions allocation to different cargo items. • Logistics subcontractors do not necessary want to provide cargo movement transparency. <p>Data sharing barriers:</p> <ul style="list-style-type: none"> • Data sharing in competition environment. Fear that data will be revealed to competitors. <p>Governance barriers:</p> <ul style="list-style-type: none"> • Onboarding subcontractors to the platform can be complicated (e.g. needs training). • Licences and certifications needed for certain port operations (risk if not handled with care in platform). • Platforms are seen as very new model for traditional ports. <p>Investment (company, society) barriers:</p> <ul style="list-style-type: none"> • The customers are interested in emission reduction but do not truly commit ordering green logistics services. Lack of commitment hinders investments in green solutions. • Limited infrastructure for greener logistics (e.g. geographical coverage of gas filling / charging stations).

5. DISCUSSION

Drivers and barriers for collaboration in logistics are closely intertwined with external factors, such as development of technology and regulatory requirements. Analysis of drivers and barriers provided in available literature was carried out as well as findings of interviews of workshops was carried out to gain insights on change of keywords mentioned. While new research provides broader scope of drivers and barriers, previous results, although limited in quantity, as this area is not widely studied, are still relevant to understand possible shift in attitudes. Observations are structured by categories and observed patterns.

Drivers and barriers were structured into categories. Categories are based categories suggested in previous research (Karam *et al.*, 2021; Saenz *et al.*, 2015; Schamschula *et al.*, 2022).

Table 6 presents this categorization.

Table 6. Categorization of drivers and barriers for participation and data sharing between participants of digital logistics platforms

#	Driver and barrier categories	Observed evolution pattern
1. Drivers		
1.1	Motivation	<p>Cost reduction was considered to be the most relevant motivation for collaboration in 2015 and continues to be among the most frequently mentioned motivation in 2024. Possible decrease in costs is expected as key value provided to exceed effort and costs of participating in digital logistics platforms.</p> <p>Lower emissions were of relatively low importance in 2015, however change in regulation has significantly increased relevant of this driver in 2024 both due to compliance requirements and due to buyer pressure.</p>
1.2	Processes and business needs	<p>Improvement of service level achieved by collaborating was of high in relevance in 2015, however was not directly mentioned in later research. Possibly, this driver transformed to gaining competitive advantage and providing added value to customers in 2024, as quality of logistics services improved in general to comparable service across different providers.</p> <p>Improvement of operational efficiency was of high relevant in 2015 and remained relevant, although described using different keywords, such as single point of service, intelligent optimisation in 2024.</p>
1.3	Information quality	Not mentioned as a driver.
1.4	Technological	Not mentioned as a driver.
2. Barriers		
2.1	Motivation	Lack of trust between collaborating parties was considered as one of the key barriers in 2015, 2021 and 2024. Barriers continues to be of high relevance regardless of technological progress, and has become even more complex in combination with data sharing issues (as

#	Driver and barrier categories	Observed evolution pattern
		described in 2.4 of this Table). Lack of data sharing, as discussed in 2022 and again in 2024 prevents deployment of advanced technologies to achieve significant improvement in logistics operations.
2.2	Processes and business needs	<p>Organizational culture was considered as a key challenge for collaboration in 2015 and has been described as failing to keep commitments in 2021 and low-capability partners entering collaboration relationships in 2024. This barrier is also related to lack of trust between competitors.</p> <p>Different objectives and values continued to be a challenge over analysed period, as Difficulty finding collaboration was mentioned in 2015, Misaligned objectives in 2022 and avoiding transparency or excessive business data sharing in 2024.</p>
2.3	Information quality	<p>Competitors acquiring information was among key barriers in 2015 and became even more relevant in 2024, as data became more detailed and sensitive, new technologies emerged to analyse data.</p> <p>Low quality information and lack of real time data was mentioned in 2022 and continued increasing in importance, as new need for data that complies with relevant regulations emerged. While information quality and opportunities for sharing real time data are constantly improving, not all companies are digitised and variety in data quality ranges significantly even between similar companies.</p>
2.4	Technological	<p>Digital solutions for logistics progressed significantly over the past decade and variety of new solutions were proposed or custom solutions were developed by large players. Barrier referring to Lack of common processes was identified in 2015, mentioned as Technical challenges for integration between systems in 2022 and further expanded with additional complexity, such as different standards, integration costs and overall operational logic of platforms (such as applying AI to plan routes).</p>
2.5	Other	<p>Agreeing on collaboration terms has been identified as a barrier in 2015 and remained relevant in 2024, although changed slightly to agreeing on collaboration terms with digital logistics platform owners/managers.</p> <p>Role of central entity or distribution of responsibilities can be summarized in a barrier Difficulty distributing the benefits in a balanced manner in 2015, Lack of trust in methodologies and coordinator in 2022 and not only remaining relevant in 2024, but further expanding to lack of trust in compliance with regulation, quality of emission estimates provided.</p>

Research findings were summarised into conceptual model illustrating actors directly or indirectly participating in digital logistics platforms and drivers and barriers relevant to each of the actors. This model is presented in Figure 1.

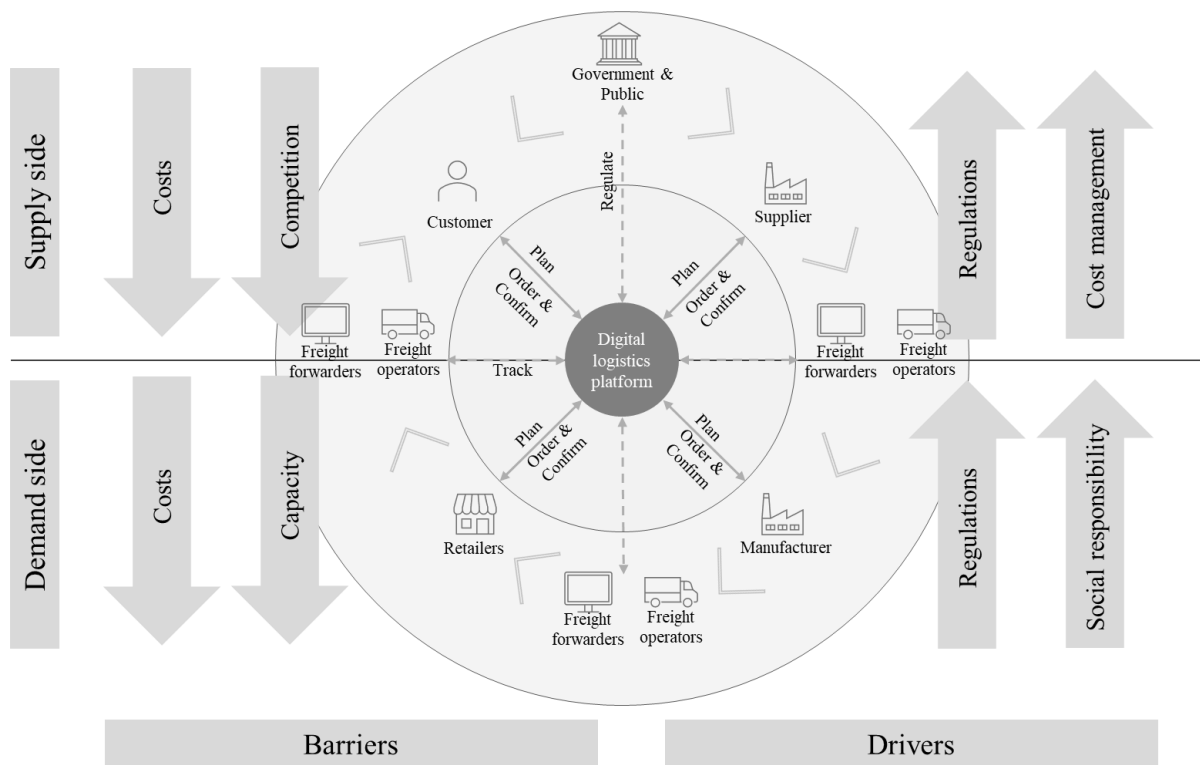


Figure 1. Conceptual framework of actors and their drivers and barriers for achieving green benefits in digital logistics platforms

Digital logistics platforms can play central role in collaboration both as a tool for information sharing between collaborating partners and as a tool for exploitation and sharing benefits enabled by the collaboration.

The Government and Public are not direct participants but have a strong influence on the logistics operational environment. Regulation is both a driver and barrier, as it sets boundaries for logistics business in terms of fair competition and mitigating climate impact, as well as other compliance aspects. The Public influences behaviour of the supply side, as increasing demand for mitigating climate impact from the public also influences the way goods are transported. Beneficiary cargo owners (such as suppliers and manufacturers) and Freight forwarders are influencing both drivers and barriers from the supply side. Costs for integration and service, capacity to integrate and provide sufficient quality information are barriers, while purchasing behaviour is among the key drivers for change.

Freight operators are facing the same drivers and barriers among themselves. Results confirm the competitive environment of logistics business, where shared data may reveal sensitive information to competitors, such as identifying key clients based on the routes. While companies recognize the benefits of sharing data, benefits, in particular cost savings, must significantly outweigh costs and risk associated with participation in digital logistics platforms. Improving operational efficiency as a measure to save costs and reduce environmental impact as well as simplifying compliance could be key value offers coming from digital logistics platforms managers.

6. CONCLUSIONS

This paper provides a comprehensive view of drivers and barriers for participation and data sharing between participants of digital logistics platforms with specific emphasis on achieving Green benefits. The research expands existing knowledge on drivers and barriers for collaboration and analyses change in business perceptions over period of 2015–2024. The research revealed that cost reduction remained the most relevant driver across analysed period, however new needs emerged in relation to change in regulation and increasing pressure for reducing environmental impact. Changes in regulation requiring reporting and managing CO₂ emissions are forcing both logistics supply and demand sides to seek collaboration solutions.

Digital logistics platforms are also expected to contribute to the improvement of operational efficiency or to provide solutions that relieve participants from compliance duties, such as CO₂ calculations. This expectation partially contradicts the key barrier mentioned – reluctance to share data and to reveal data to other participants of logistics platforms. Advanced features, including standard and regulation compliant CO₂ calculation solutions are only available if sufficient and high-quality data is accessible. Technical barriers, such as complexity of integrations between systems as well as associated costs are other key barriers, that emerged in more recent years as logistics are becoming more digitised.

Going forward, emergence of a common need for compliance and emission monitoring may encourage collaboration, as it provides shared interest and motivation for all participants of supply chain. Results of the study provide practical insights for digital logistics platform developers. Addressing concerns expressed by businesses may contribute to improved value proposition and preparing for discussions with potential collaboration partners. As requirements for tracking, reporting and managing CO₂ emissions are likely to continue to get stricter, digital logistics platforms may gain more an important role and opportunity to reduce CO₂ emissions without heavy investment in vehicles and/or infrastructure.

Research participants emphasized expectations for digital logistics platforms providing value exceeding costs and risks associated with participation in digital logistics platforms. Following research directions could contribute towards expanding knowledge:

1. while literature provides some insights on these benefits, further research into this topic would contribute to further understand of Green benefits and other benefits as well as their relevance for different stakeholder groups;
2. a theoretical digital logistics platform model combining features of several collaborative approaches, with emphasis on common goals and motivations could be proposed as a foundation for development of dedicated business solutions.

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