Progress towards Federated Logistics through the Integration of TEN-T into A Global Trade Network

D4.2 Policy guide, Briefing sheets and case study on freight transport for policymakers in emerging economies

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
AI	Artificial Intelligence
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
ASI	Avoid-Shift-Improve
BC	Block Chain
BD	Big Data
BDA	Big Data Analysis
CCI	Corridor Connectivity Index
CMR	Convention relative au contrat de transport international de Marchandises par Route or a Road Transport Document
COVID	Coronavirus Disease
DSS	Decision support systems
DUT	Unified transport document
EC	European Commission
EGTN	European Global T&L Network
ETA	Expected time of arrival
ETC	Expected commute time or Transit time
ETP	European Technology Platform
EU	European Union
GHG	Greenhouse Gas Emissions
GPS	Global Positioning System
HGV	Heavy goods vehicle
ICT	Information and Communications Technology
IEA	International Energy Agency
IoT	Internet of Things
ISO	International Standards Organisation
ITF	International Transport Forum
KPI	Key Performance Indicators
LDV	Light duty vehicle
LL1	Living Lab 1
LL2	Living Lab 2
LNG	Liquefied Natural Gas
LSP	Logistics Service Provider
ML	Machine Learning
NGO	Non-Governmental Organisation

OECD	Organisation for Economic Co-operation and Development
OLI	Open Logistics Interconnection
OR	Operations Research
PCA	Principal Component Analysis
PI	Physical Internet
PLANET	Progress towards Federated Logistics through the Integration of TEN-T into A Global Trade Network
RFID	Radio frequency identification
SCM	Supply Chain Management
SME	Small and Medium enterprises
SUMP	Sustainable Urban Mobility Plan
TCO	Total cost of ownership
TEN	Trans-European Network
UNECE	United Nations Economic Commission for Europe
UTD	Unified transport document
VRP	Vehicle routing problem
WSN	Wireless sensor networks

Executive Summary

The present report aims to provide information and tools for logistics and policymakers stakeholders policymakers. More specifically, the policy guide aims to promote technology and policy transfer from the experiences of the PLANET project in the EU to emerging economies by increasing decision-makers' awareness. The policy guide provides an overview of the freight innovations seen in the PLANET project. It suggests a methodological approach for decision-makers at a national and local level in emerging economies. The guide also provides policy recommendations to facilitate the adoption of concepts such as physical Internet, synchromodality and blockchain technologies. A 4-step process is recommended in the policy guide for decision-makers to include the relevant stakeholders for developing freight sector measures.

Three case studies have been developed on Physical Internet, logistics and operations Management and smart contracting in synchromodal transport. the case studies are developed using the case study method, a proven method to increase awareness using real-life examples. The case studies are developed in a conversational tone depicting a hypothetical situation that the policymakers can relate to. Each case study has questions posed for the reader to evoke their response.

In summary, this deliverable combines[2] different aspects and cases covering the relevant aspects of innovative developments observed in the PLANET project that are relevant for decision-makers in emerging economies. The individual elements, viz. briefing sheets, case studies and the policy guide, can be consulted separately depending on the extent of interest in the topic. For example, a policymaker interested in the physical internet will refer to the respective briefing sheet to get an initial idea of the topic. The policymaker would refer to a case study on the physical internet to get a practical implementation. For an overall picture of interrelations, the policy guide serves the purpose and suggests a process that can be easily implemented in practice. In terms of dissemination, the individual briefing sheets, the case studies and the policy guide will be available in the open library being developed under task 4.3 and in the learning courses developed under task 4.4 of WP4.

[2] Also as indicated in the description of work (DoW)

1 Introduction

This version of the deliverable D4.2 (Briefing reports for public authorities and Guide on the inclusion of disadvantaged regions into the international trading system) addresses the objective of the task T4.2 and its respective subtasks. The objective of the task is to develop briefing sheets (ST4.2.1), case studies (ST4.2.2) and a policy guide (ST4.2.3) targeted at increasing the awareness of government authorities (both local and national) in emerging economies through examples from the PLANET project and the EU.

Purpose of this section is to map PLANET's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 1: Adherence to PLANET's GA Deliverable & Tasks Descriptions

PLANET GA Component Title	PLANET GA Component Outline	Respective Document Chapter(s)	Justification
Deliverable			
D4.2 : Briefing reports for public authorities and guide on the inclusion of disadvantaged regions into the international trading system	Briefing sheets and case studies on the importance of freight transport to increase the awareness of local authorities in emerging economies, through examples from EU; policy options for low carbon freight transport through technological improvements.	All Chapters	The deliverable presents briefing sheets, case studies and policy guide, based on PLANET project key technological concepts and relevant to PLANET T&L and policy makers stakeholders.
TASKS			
ST4.2.1 Develop briefing sheets on the importance of freight transport to increase the awareness of local authorities in emerging economies, through examples from the EU:	Develop briefing sheets on the importance of freight transport to increase the awareness of local authorities in emerging economies, through examples from the EU: In this subtask the results from the Living Labs, especially those that involve introducing measures and policies to increase the efficiency of freight movement and promote low carbon freight, will be documented as briefing sheets for use by the decision makers. The briefing sheets will focus on the TENT network and its global trading partners from the emerging economies.	Chapter 2	This chapter presents 7 briefing sheets on the subjects of Physical Internet and Blockchain, Enablers of PI, Technologies in Logistics, Reducing emissions from Logistics, Implementing IoT and Blockchain, Synchromodality and Hyperconnected logistics.
ST4.2.2 Develop case studies on freight practices leading towards an integrated low-emission EU-Global Trade Logistics Network:	Develop case studies on freight practices leading towards an integrated low-emission EU Global Trade Logistics Network: In this subtask, based on the experiences at the local level from Living Labs, detailed case studies will be developed, documenting the process of transformation of the local freight practice and developing low-emission freight options. The case studies will	Chapter 3	This chapter introduce three case studies using real-life examples and more specific this are on Physical Internet, logistics and operations Management and smart contracting in synchromodal transport.

	not only focus on the technological measures but also on the governance and policy making processes. The case studies, along with the briefing sheets shall be shared.		
ST4.2.3 Develop a policy briefing on the benefits of improved technology in freight operations and its impact on low carbon freight transport, targeted at decision makers and public authorities	Develop a policy briefing on the benefits of improved technology in freight operations and its impact on low carbon freight transport, targeted at decision makers and public authorities: In this subtask, a guide targeting policy makers will be developed which will feature a step by step process on identifying, measuring, and monitoring policy challenges and opportunities in implementing low carbon freight transport. The guide will feature the experiences at a local level and from non-public sectors involved in the low carbon freight sector.	Chapter 2 and 4	Chapter 2 includes policy suggestions relevant to the topics of the briefing sheets. Chapter 4 recommendations for adopting innovative technologies in the logistics sector.

For achieving each subtask goals, we have closely followed the development of the PLANET project in WP1 through 3, extracted the key concepts, and developed 7 briefing sheets on Physical Internet and Blockchain, Enablers of PI, Technologies in Logistics, reducing emissions from Logistics, Implementing IoT and Blockchain, Synchromodality and Hyperconnected logistics. Each briefing sheet introduces the topic and cites examples. The briefing sheets provide information on the specific topic with policy suggestions relevant to the topic. The briefing sheets aim to introduce the policymakers in emerging economies to the innovative aspects of logistics developments in the EU in the areas of Physical Internet and Blockchain and facilitating knowledge transfer. Finally, subsequent section of the report all the above are presented and analysed in detail.

2 Briefing sheets for policymakers in emerging economies

2.1 Physical Internet and Blockchain

2.1.1 What is the Physical Internet?

Physical Internet (PI) is an emerging transport and logistic (T&L) paradigm advocating an open global logistics system based on physical, digital, and operational interconnectivity through encapsulation, interfaces, and protocols (Pan et al., 2017). Interconnectivity can be the seamless integration of physical entities, such as hubs or containers, and human or organisational actors to form one collaborative logistics network (Montreuil, 2011; Saoud & Bellabdaoui, 2017).

The introduction of PI promises to revolutionise T&L practices and to improve crucial variables such as cost, utilisation rate, and emissions through improved multi-modal integration and open accessibility to static and mobile infrastructures. PI is a hyper-connected T&L system whose operation follows the principles of open and standardised interfaces, monitoring and data sharing, intelligent decision-making, and modularised encapsulation (see PLANET deliverable D2.13). The section below briefly describes the principles of PI.

With the adoption of PI in Logistics, there is a possibility to achieve higher efficiency and utilisation of cargo transport, including intermodal shipments that utilise greener transport modes. With Physical Internet, potential technological, standardisation and infrastructural elements enabled, a 300% increase in transport demand could be achieved with only a 50% increase in assets (see PLANET deliverable D 1.2). A study (Sarraj et al. 2013) demonstrates that PI could reduce the total cost by 30% and greenhouse gas emissions by 60% while maintaining a high level of service delivery to the customers. Section 2.6 elaborates on the measures available for policymakers to reduce emissions Other advantages include time efficiency due to uninterrupted delivery services and improved driver working conditions (Hasan et al., 2021). However, the study by (Hasan et al., 2021) highlights that despite the advantages the PI may offer, it cannot continue relying on centralised networks or the existence of a leading authority. This way, the PI can increase if it is a distributed and community-driven concept and approach.

Although the progress in many technological and infrastructural elements of the T&L system is ongoing, some of the technologies, such as the Internet of Things (IoT) and smart contracts, available in the PI are described in sections 2.2 and 2.3, the PI is still in development and is expected to become functional over the following few decades (see PLANET deliverable D2.13).

2.1.2 What is blockchain?

Blockchain has brought modern T&L networks into a new era. The cryptocurrency markets have popularised blockchain technology, yet the theory of blockchains can be implemented in other sectors to increase transparency, security, and decentralising data. In simple terms, a blockchain is a series of connected blocks, hence the term chain. Each block in the chain has data stored and information on the preceding block and the following block. The only exception is the first block in the blockchain, the genesis block. The nature of the blockchain predefines the data stored in the block. The process of writing data in a block is called a transaction. These transactions are secured by complex algorithms enforcing data security. All the data in the blockchain is called a ledger or a database (Chbaik et al., 2022). The critical difference between a conventional database and a blockchain ledger is that blockchains allow for distributed ledgers. This means that the copy of the ledger is shared with all the critical nodes in the ecosystem (Tapscott & Tapscott, 2018). In a logistics sense, this could be the suppliers, carriers, and consumers. Any new addition to the chain is first crosschecked with other copies of the ledger to avoid duplication and discrepancies. Once the transaction is accepted, it is copied to all the copies of the ledger. Having a distributed ledge increases the security of the blockchain and increases transparency. For example, blockchain technology has been used in logistics to detect fake and counterfeit products (Kersten et al., 2017).

It has the potential to redesign informational and financial flows, supplementing physical flows in the supply chain (Treiblmaier, 2019). It is also a promising technology in Logistics Management and Optimization with its intrinsic characteristics, such as data integrity and decentralised operations. The blockchain is a disruptive innovation due to its capability to ensure data immutability and public accessibility of data streams. Moreover, it is decentralised, and distributed infrastructure prevents the problems of the current centralised approaches, including trust issues, such as fraud, corruption, tampering and falsifying information, and their limited resiliency (Perboli et al., 2018). In short, blockchain allows multiple parties to share and update data, building trust in the actions without a need for participant verification; removal of intermediaries reducing cost and complexity, time-sensitive interactions; and the exchange of transactions (PwC, 2020).

Some of the key characteristics of blockchain are (Nayak & Dutta, 2017):

- Decentralisation. Instead of one central node, control over a transaction is distributed among peers via a distributed ledger.
- Digital Signature. Transactions take place using unique digital signatures that rely on public and private keys, offering authentic proof of ownership.
- Chain of Blocks. Transactions are stored in blocks using cryptographic methods.
- Data integrity. Data cannot be tampered with, as complex algorithms and consensus ensure immutability and safety.

Benefits of BC in freight

With the characteristic of blockchain mentioned in the section above, it provides the following benefits in the freight transport (PwC, 2020):

- Enhance supply chain transparency and traceability – providing end-to-transparency by integrating data from all the participants in the supply chain;
- Monitoring of performance history of carriers and suppliers; providing proof-of-origin of supply chain along with an assurance of compliance and safety standards; and increasing real-time information on events and the status of various transport modes.
- Ensure security, immutability, and authenticity – authenticate data and documents, detect fraud, and prevent theft
- Reduce process complexity – eliminate intermediaries, improve quality assurance, and increase the level of automation
- Improve operational efficiencies – improve compliance, reduce transaction cost, and reduce human error
- Reduce process complexity – eliminate intermediaries, improve quality assurance, and increase the level of automation

2.1.3 Interrelation of PI and Blockchain

Application use case and features

Physical Internet aims for a paradigm shift towards economically, environmentally, and socially sustainable logistics. However, the implementation requires infrastructure, technology, and business model transformations, which cannot be met by centralised solutions, as proposed by various literature. The study (Meyer et al., 2019) highlights that a Blockchain-based conceptual framework offers a solution for fundamental barriers to the Physical Internet concerning the exchange of value and physical assets in logistic networks and decentralised leadership structures.

Concerning PI requirements, the study (Meyer et al., 2019) based on various literature analyses and stakeholder interviews (with Shippers, Logistics Service Providers (LSP), and Researchers and consultants) shows some PI requirements in two categories - Infrastructure and Operation and information (see

Table 2).

Table 2: Stakeholder requirements for Physical Internet

Requirements	Stakeholders		
	Shipper	LSP	Researchers
Infrastructure			
Distributed benefits through defined responsibilities and roles	X	X	X
The network structure of equal power and no central leadership	X	X	X
A structure characterised by high integrity, robustness, and resilience	X	X	X
Rules (or certificate) for entry, participation, and network usage		X	
Fast, cheap, and reliable interconnection of nodes, transport assets and containers	X	X	X
Operation and Information			
Assurance of trustful collaboration and data sharing	X	X	X
Secure and fair rewarding rules for service		X	
Assurance of fair shipment routing and container consolidation		X	X
Integration of on-demand or on-per-use contracts for services	X	X	
Integration of algorithms for efficient shipment routing and container consolidation		X	X
Transparency about containers along the shipment process (track and trace)	X	X	X

Those PI requirements can be met by at least one BC functionality or a combination of many mutually dependent features. Figure 1 (below) shows that BC technology can solve PI barriers and allows a trustful and secure exchange of value in an untrustworthy environment (Meyer et al., 2019)

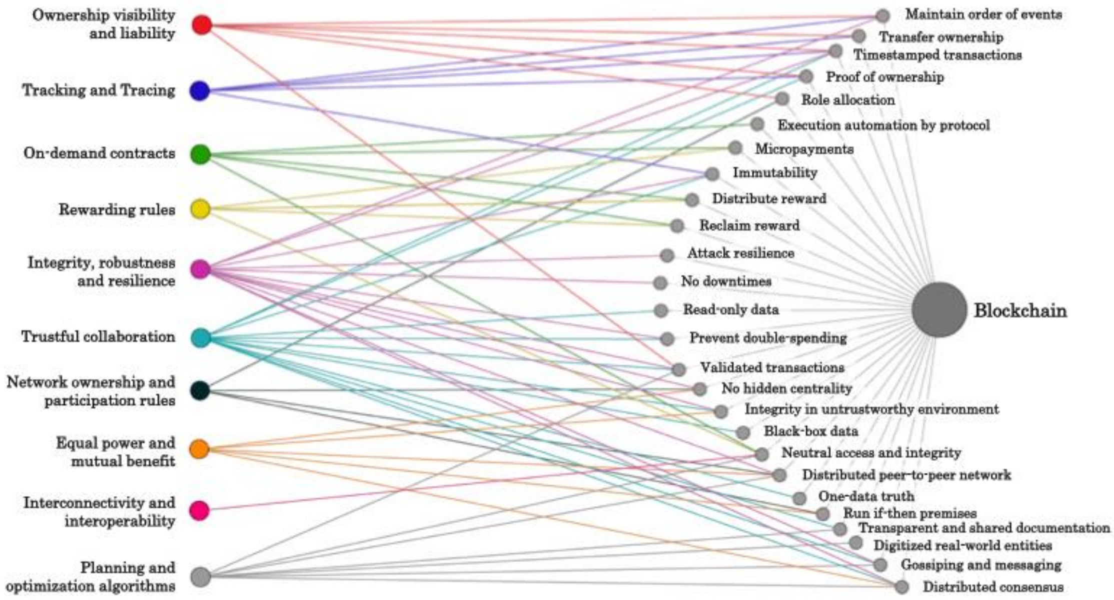


Figure 1: Physical Internet and Blockchain Interrelationship diagram (Meyer et al., 2019)

- Ownership liability and product traceability – able to transfer value securely and transparently between peers and prove ownership of transferred object with the timestamped transactions.
- On-demand contracts and rewarding – Protocol-based smart contracts confirm the fulfilment of a contract and execute the reward for the fulfilled services and the possibility to transfer even small amounts of money between actors.
- Integrity, collaboration, and leadership – assured by the immutability of BC data and equal power distribution to each peer.
- Shipment allocation and PI algorithms – provide a trustful database and can derive all kinds of information, such as performance indicators (e.g., delivery reliability) or routing and handling data.

Besides that, blockchain has several use cases that support logistic companies to increase speed, traceability, and cost reduction. Some of them are highlighted below (PwC, 2020 :

- Provenance refers to a timeline of changes in an object's ownership, custody, or location. It ensures every shipped good has a digital "passport" that proves its authenticity.
- Payments and invoicing – Blockchain can store and share digitised records while creating smart contracts that automatically handle invoices and payments to shorten processing times and ensure accuracy.
- Digital documentation: the combination of blockchain with the Internet of Things (IoT) enables intelligent logistics contracts. This is possible when digitised documents (e.g., bills of lading, certificates, invoices, pre-advice) and real-time shipment data are embedded into blockchain-based systems.
- Identity management: Blockchain Identity Management uses a distributed trust model to ensure privacy where identity documents are secured, verified, and validated by authorised participants.

- Logistics marketplace: enables smooth and integrated communication across complex supply chains. It can also create platforms where logistics service providers offer free capacity in trucks and ships – in real-time.

Status quo PI and BC in freight in EU and disadvantaged region

Logistics services are evolving rapidly (worldwide), mainly due to the introduction of new management frameworks, such as the Physical Internet and Industry 4.0, and new technologies, primarily ICT-based, such as the Internet of Things (IoT), Business Analytics, Artificial Intelligence, and Blockchain companies (Perboli et al., 2018). However, as the logistics supply chain involves multiple parties directly or indirectly, it can create challenges related to communication and end-to-end visibility – making logistics processes inefficient. At the same time, expectations of all participants in the supply chain related to information transparency, reliability (track and trace) and service (payment) are increasing. As mentioned in the sections above, BC is emerging as a possible solution for these challenges.

Nevertheless, there are still hurdles to its proper implementation. They are (PwC, 2020):

- Knowledge and awareness - Lack of understanding and awareness of BC and its potential, limited skilled workforce and lack of trust among companies
- Interoperability – integration issue due to different solutions applied by each involved party, and no standard 'one blockchain' solution
- Performance – only specific use cases of existing blockchain solutions (e-g- online payments)
- Regulation and governance – lack of definite legal frameworks to govern blockchain transactions in different domains
- Risk of disintermediation – affecting intermediates

Based on the study by ALICE-ETP (Ballot et al., 2020), the current status of PI in various aspects:

- Non-standardised transhipment Nodes
- Rise of booking platform for logistic services
- Separated subnetworks – no interconnected global networks, and the goods cannot seamlessly flow across them
- Availability of network integration and embracing digitalisation strengthen interconnectivity, but the coordination function within supply chains is fragmented and differs among different chains
- The governance of Logistics Nodes, logistics networks and Systems of Logistics Networks is characterised by a scattered and unbalanced set of terms, rules, standards, and regulations; and no harmonised reference agreed on governance framework yet.

Living Labs in PLANET project

Referring to the PLANET project (deliverable 2.15), BC technologies are used by LL2 partners and specifically by the Port of Rotterdam for the digitisation of logistics documents and target the exchange of information between shipping lines, logistics operators and the Port of Rotterdam. Interoperability between the Blockchain networks of the two ports – Port of Valencia (PoV) in LL1 and Port of Rotterdam (PoR) in LL2 - is achieved through the Blockchain network of the logistics operators, namely DHL, as can be seen in Figure 5.

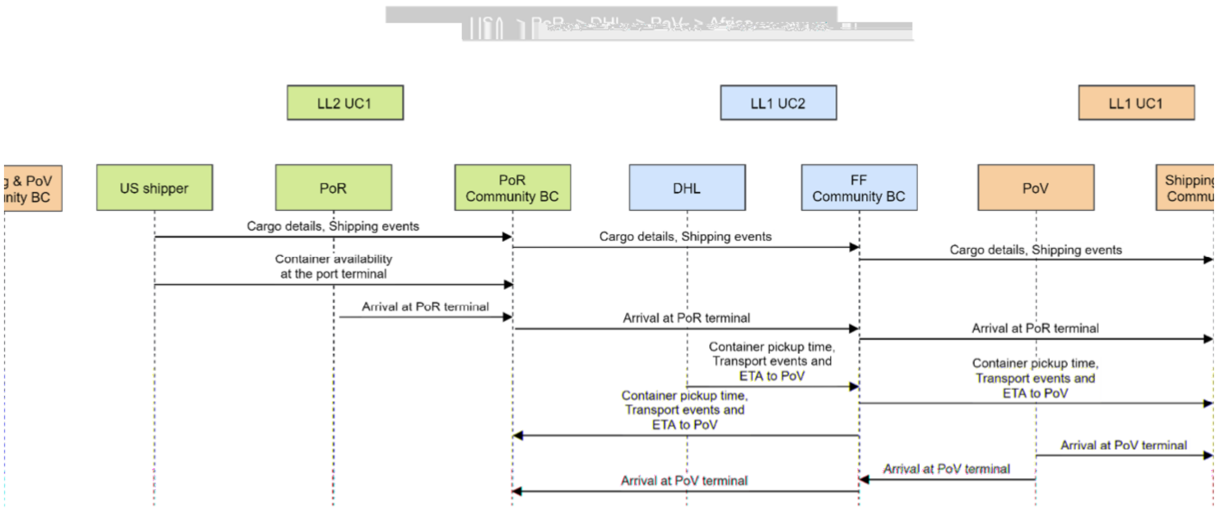


Figure 2: Exchange of Road Transport Document scenario (PLANET project (D 2.15)

PoV and PoR use different road transport documents; PoV uses the Unified Transport Document (UTD, or DUT, as the Spanish acronym), while the PoR uses the electronic Road Transport Document (eCMR). Information and events related to road freight transport can be shared, through eCMR, across both platforms enabling road transport optimisation between the PoR and PoV. An example of a possible optimisation scenario: The road segment of an international shipment involves the following steps. A truck picks up the freight at the PoR, and the driver issues an e-CMR. Information about the dispatch, destination, ETA, freight volume and weight are immediately shared across the integrated Blockchain platforms of LL1 and LL2. Connected warehouses and logistics service providers at the PoV are now empowered to anticipate the incoming cargo and reserve storage or transport space for the next shipment segment while the freight is in transit. The EGTN Blockchain Service acts as a proxy between the two ports, which exchange hashes of the documents along with metadata through their Blockchain systems, with the actual documents being shared through the EGTN Platform and retrieved only by trusted actors. PoV uses the Blockchain in Transport Alliance (BiTA)14, while the Port of Rotterdam uses GS1 standards15. The EGTN Blockchain Service adopts a mix of the above standards to define a common data model and accommodate the different structures.

Other examples - Literature Review

Blockchain-based solution for Fresh food use case

An example of a fresh food use case is taken from the study (Perboli et al., 2018) in which GUEST (GO, UNIFORM, EVALUATE, SOLVE, and TEST) methodology was applied to design the use case related to an e-commerce food retailer located in Europe. The Solution canvas (Figure below(5)) depicts the topic from a technological viewpoint.

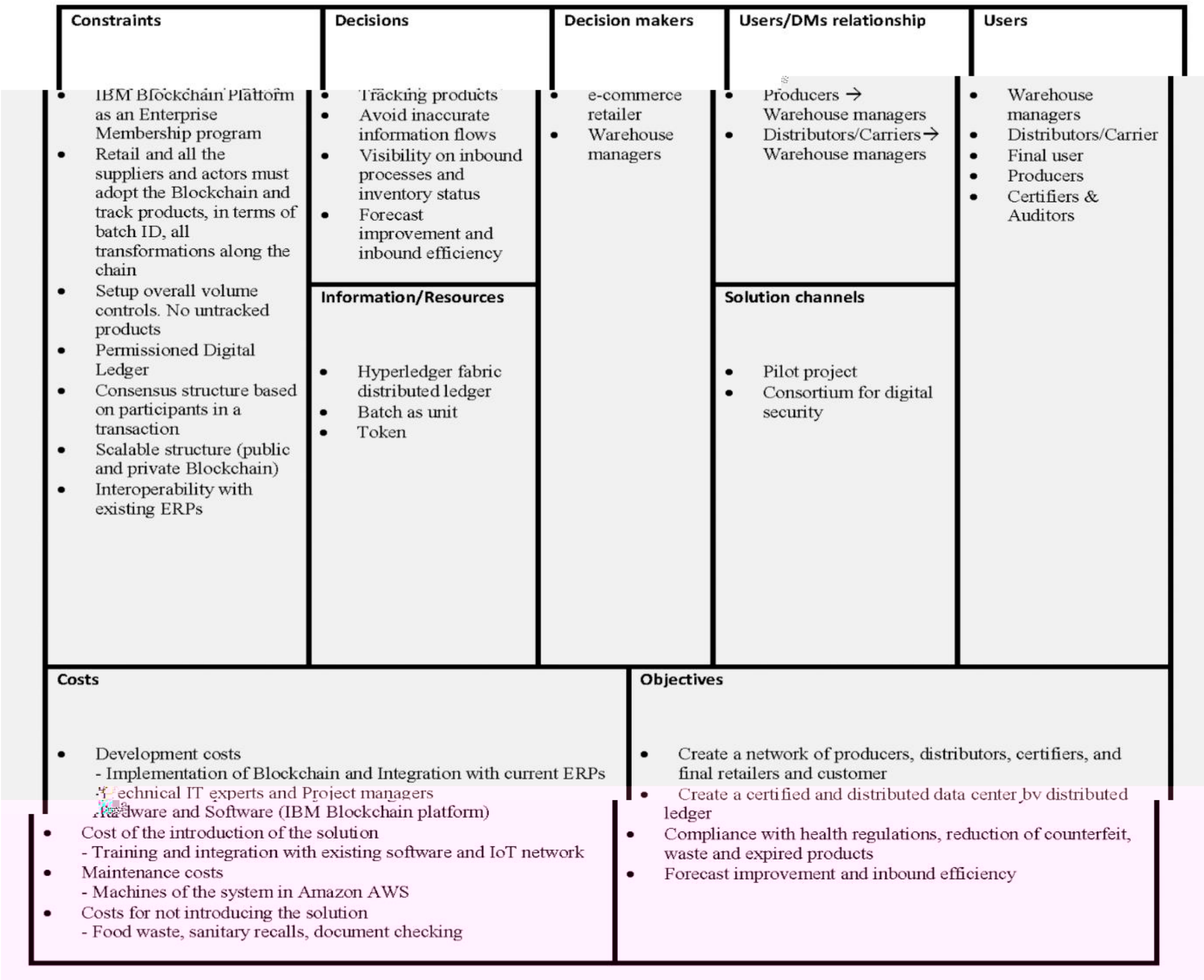


Figure 3: Solution Canvas

This use-case shows that the cost of implementing blockchain is highly sustainable compared to the resulting benefits. With the adoption of the IBM Blockchain Platform, immediate savings are generated by reducing the waste of goods due to better management of use-by-date information and identifying possible unsafe storage conditions.

2.1.4 Logistic revolution due to Physical Internet (PI)

The Physical Internet (PI) creates a more efficient, effective and sustainable supply chain and aims to revolutionise freight and logistics transport (Neila et al., 2022). PI supports reaching zero-emission targets by reducing the environmental impacts of freight transport with effective logistics networks (Plasch et al., 2021). Like Digital Internet, which moves data packages, the PI strives to connect, synchronise, and ship regular modular containers from the origin to the destination, thereby creating robust and collaborative logistics networks (Neila et al., 2022). This means PI creates open access platform for those companies which previously operated independently without sharing warehouses and modes of transport. With this, those companies collaborate if they transport goods along the same route, effectively utilising resources. Sharing resources, such as vehicles and data, and designing transit centres also enable seamless interoperability, optimising the transportation of goods concerning cost, speed, efficiency, and sustainability. A case study in French companies (a simulation-based experiment with a real-life experiment) showed that collaboration in a PI network allows for a 30% reduction of total induced costs and a 60% reduction of GHG reduction while offering the same (standard) operation service (Sarraj et al., 2014). See figure 1, depicting the foundation of the PI.

Figure 1: PI foundation framework (Moshood & Sorooshian, 2021)

Principles of PI in transport and logistics

To incorporate current Transport & Logistics practices into the PI concept, an Open Logistics Interconnection (OLI) has four layers. They are Encapsulation (to standardise the packaging process of cargo and goods); Shipping (to specify transportation goods and the process); Networking (to define the infrastructure interconnection from transporting facilities to customers); and Routing (to create detailed transport plans from origin to destination) (see PLANET deliverable D2.13). In addition, these layers could include four fundamental PI principles in the T&L infrastructure (see PLANET deliverable D2.13):

- The ability to effectively handling of modular packaging with standardised containers;
- The increasing digitisation of T&L infrastructure (with IoT sensors and Track and Trace capabilities);
- The integration of the firm decision support tools (DSS) that enable efficient cargo and fleet routing and distribution; and
- the open access to transport, terminal, and warehousing services.

In a nutshell, companies associated with logistic services are motivated to enter PI networks considering: a reduction in logistics, storage and handling costs; access to enhanced logistics resources and competencies; acceleration of the transition to greener and cleaner transportation activities, increase efficiency in hub-utilisation, last-mile deliveries and general cargo transport; enter into system integration and collaborative business strategy to improve transparency along the supply chain network; and co-develop innovative business models (Plasch et al., 2021).

To achieve logistics optimisation, the PI sets common and universally agreed-upon standards and protocols to enable horizontal and vertical cooperation betw[illegible] g4(r)-3(ag-2(a)13(nsis-5(atio)78(n s4( )4 TJ[illegible]

2.1.5 Enablers and success factors to enhance freight transport with PI and blockchain

Logistics challenges

The current global logistics services are not efficient as they could be and are unsustainable in the long run from an economic, environmental, and societal perspective. Though some progress was achieved, logistic service inefficiencies still exist in vehicles not loaded to the total capacity – on average less than 50% full (Belien et al., 2017) and trucks driving back empty after the deliveries. The multimodal option is also relatively less utilised. Twenty per cent of heavy-duty vehicles in the United States and 30-40 per cent in the EU travel empty after deliveries, causing inefficiency in the road transport (Matusiewicz, 2020). One in five journeys (in Europe) was performed by empty vehicles (Eurostat, 2019).

Moreover, freight transportation (in developed countries) is responsible for nearly 15% of greenhouse gas emissions (see PLANET deliverable D2.13). The other issues of unsustainable logistic practices include products sitting idle, mediocre coordination and communication within the distribution network, and low network security and robustness (Montreuil, 2011). The logistics supply chain involves multiple parties directly or indirectly, creating communication and end-to-end visibility challenges – making logistics processes inefficient. At the same time, expectations of all participants in the supply chain related to information transparency, reliability (track and trace) and service (payment) are increasing (PwC, 2020). Therefore, improved logistic services are a need to address the challenges. An introduction of the Physical Internet (PI) with ICT-based technologies can be a part of the solution.

2.1.6 Policy recommendations

A clear legal framework to govern blockchain transactions in various domains is still an issue for blockchain implementation. Limited accepted business practices are also a reference for operating and managing blockchain solutions (PwC, 2020). This section highlights how policymakers can include BC and PI.

PI requires a higher level of interconnectivity and interoperability in terms of physical, informational, and operational aspects. Interconnectivity ensures complete collaboration among all supply chain actors, compatibility with all applied technical-technological tools and solutions, and optimum execution of all operations (Moshood & Sorooshian, 2021). Emerging digital technologies in PI enable an interconnected network of intermodal hubs, collaborative protocols, and standardised, modular, and smart containers. In particular, emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Big Data Analytics (BDA), Cloud Computing (CC), and Blockchain (BC) create innovations in information sharing, advanced data processing and analytics, and decision making for PI realisation and logistic optimisation. IoT-relevant technologies provide a way to collect and share data ubiquitously and universally. Likewise, intelligent data processing tools such as AI, ML, and BDA extract insight from these data for predictive applications and support improved decision-making.

Moreover, BC offers a secure and trusting mechanism to facilitate Internet-based transactions and exchanges for the PI-enabled open logistic networks. CC can offer affordable and accessible services and resources for Internet-connected users. CC provides unlimited services (i.e., PaaS, or platform as a service; IaaS, or infrastructure as a service; SaaS, or service as a service) to store and process the massive volume of data generated by IoT devices in the IoT-enabled systems (Tran-Dang & Kim, 2021).

Data availability (and management) – define and build laws around data use, sharing and protection. It is vital to engage with regulators to help shape how the environment evolves. It is also necessary to consider privacy implications (e.g., GDPR requires personally identifiable information to be erasable. This has to be reconciled with the fact that data immutability is an essential characteristic of blockchain) (PwC, 2020).

The modular and standardised container allows shared sustainable, robust, lightweight, and scalable PI containers. Furthermore, PI containers can collect and store logistics and supply chain information using smart tags, including RFID and GPS technologies. Using smart tags ensures container identification, integrity, routing, conditioning, traceability, and security in the interconnected logistic network (Treiblmaier et al., 2020) and saves the packaging process time.

Using shared, fully loaded, and energy-efficient PI vehicles reduce transportation costs and carbon footprint. The programming model, such as mixed-integer linear programming, helps meet the demand of shipment orders belonging to different areas, minimising total costs, exploiting truck capacity and reducing empty trips. Likewise, well-planned PI transit centres encourage efficient and effective cargo handling. Using coordination algorithms for matching demand and supply, PI transit centres transfer PI trailers from one truck to another efficiently and sustainably (Treiblmaier et al., 2020).

Government support is crucial for global logistic sustainability. Providing finance from the central government pushes the PI logistic economy, while government cybersecurity regulation removes risks and vulnerabilities (Moshood & Sorooshian, 2021). When national regulations are not synchronised with legal environments associated with different countries, it affects legal security and seamless international transport. Therefore, the legal framework is beneficial for synchronising the legal environment in countries with relatively disparate legal systems (Treiblmaier et al., 2020). To manage the routing of cargo through the network and service assignments transparently based on commonly agreed on rules to ensure fair allocation of costs, risks, and responsibilities among the involved providers (Ballot et al. 2020)

The cooperation model redefines the existing revenue-sharing practices among stakeholders in the new PI-enabled business models, such as PI hub holders and PI movers (Treiblmaier et al., 2020). Stakeholder involvement in shaping the trusted tech discussion: engage with regulators and industry groups to help share emerging policies and best practices. Use existing regulations as a guide (PwC, 2020). For example, two significant initiatives for blockchain standards include those by the International Standards Organization (ISO) and the IEEE Society (Koh et al., 2020). Support understanding where blockchain fits in a business environment, focusing on long-term value – an external shared resource that makes new scale economies possible (PwC, 2020).

2.2 PI Technologies in Logistics Operations

2.2.1 Introduction

As technology develops and improves, it has a profound effect on the way people and goods move. Innovations in information technology have a significant impact on consumer behaviour. On the other hand, technological improvements have benefitted the supply chain through automation, efficiency gains, increasing competitiveness and new strategies to attract customers.

Technological improvements have streamlined many processes in logistics supply chain management. The introduction of technologies such as electronic data interchange, global positioning systems (GPS), and Smart Contracts (through blockchains) lead to various advantages for the carriers.

The COVID pandemic has shown that flexible, integrated, and transparent supply chains, with predictive analysis and insights, have been the most resilient. Incorporating advanced technologies will become inevitable for many carriers to stay in business due to stiff competition. Choosing the right technology that echoes the organisational strategy can lead to economic and environmental efficiencies. The supply chains of tomorrow will be predictive, self-adjusting and intelligent.

2.2.2 Technology landscape

In the present day and age, a consumer is not just interested in simply ordering a product. However, they are also curious to know when it will be delivered (as accurate as possible) and where their product is after ordering and want to adjust the delivery time window and location. This was not possible a few years back; this "improved" customer service is partly due to the technological innovations that shippers and freight carriers (such as DHL, TNT, and UPS) adopted.

On a broad level, digitisation is a significant factor for the improvements. As the adoption of information and communication technology improves among shippers and carriers, more features can be offered to their customers. Further, digitisation increases efficiencies and generates enormous amounts of data, which can help companies gain insights.

Analytical insights

As digitisation takes centre stage, the entire supply chain becomes more transparent, i.e., all the actors involved in the supply chain (supplier – shipper – customer) can know the location of their shipments. The innovations in data management and data processing, esp. big data analysis, open a wide range of opportunities. One such is the possibility for predictive and prescriptive insights. For example, shippers can identify any existing blocks in the route or can predict in a short time if a block is going to occur and prescribe a new route that would still allow the delivery with minimum delay. This will ensure the customer receives the shipment on time and reduce costs incurred for the carrier.

The real-time visibility of the entire global value chain provides companies with critical demand and supply data, with which the suppliers can adjust their demand while the goods are still in transit.

Through AI and ML[3], analytics can also provide the essential data to predict demand over time and help suppliers manage their manufacturing to meet the demand. In addition, ML algorithms can analyse scenarios and allow efficient pricing options for suppliers and shippers.

Innovation in-vehicle technologies

The advent of electric vehicles enables carriers to move towards cleaner and quieter vehicles for deliveries. Carriers such as DHL are already moving to electric vehicles for urban deliveries. This shift to electric vehicles not only improves the corporate image of the carrier, thus boosting the competitive

[3] AI = Artificial Intelligence | ML = machine learning

edge, but also benefits the local environment from reduced air pollution. There are also other economic benefits from reduced fossil fuel purchases.

Another delivery vehicle technology is the use of drones for parcel deliveries. Drones can be used in large warehouses and cities (as last-mile delivery). Drones can have built-in barcode scanners that would feed the data directly into the inventory database, and the routes of the drones can be pre-programmed. Using drones can reduce delays in warehouse operations and reduce labour costs.

IoT and Smart contracts

The Internet of Things (IoT) and Blockchain are two increasingly popular technologies making strides in logistics. IoT aims to deliver an interconnected system by using intelligent sensors. The European Commission Information Society defines IoT as "things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts" (Ben-Daya et al., 2019). IoT devices can collect information using the internet, RFID, and other sensors. This information can relate to the state of the products being transmitted. For example, IoT can be beneficial when shipping perishable products and products that need to be in cold storage while in transit. Through the sensors, the shipper is aware of any changes in the shipping environment for the products, and necessary action can be taken (Paksoy et al., 2021).

Blockchain technology is increasingly becoming prevalent in logistics (see section 2.1.2 for an elaborated explanation). With the introduction of blockchains, smart contracts have become popular in blockchain applications. While the term "smart contract" was coined in 1997 (Szabo, 1997), it was a theoretical concept until the introduction of blockchain.

In simple terms, a smart contract is a computer code (like the "if-then" condition) that records the promises of each contracting party (Golinska-Dawson et al., 2020). Smart contracts are integrated into the blockchain and are automatically executed when certain pre-described and agreed conditions are met. Smart contracts need specific types of blockchains to operate. A blockchain needs to be able to execute the code necessary for executing smart contracts (Bocek et al., 2017). With the inclusion of smart contracts, transactions between companies can be automated across the entire supply chain (DHL & Accenture, 2018) (Paksoy et al., 2021)

2.2.3 Challenges

Clearly, the collaboration between governments and the private sector can deliver mutual benefits. However, while embracing innovative technology options is the way forward, there are certain challenges on both ends. Some of the broad challenges are identified here.

Technical capacity and awareness

A key ingredient for any step towards adopting innovative technologies is knowledge and awareness of the available options. Once such awareness is developed, it is easier for governments to move towards technological solutions as they can understand the benefits of such technologies.

A planned technical capacity development program is essential for involved government staff to increase awareness of the various technology options and the results they can produce. Of course, governments need not implement all these options, but knowing the available options can increase and allow them to identify key stakeholders and partners on their journey towards smart governance and smart logistics.

Logistics companies also need to embark on training activities that can improve employees' skills and work performance. When partnering with governments, joint skill development programs could improve overall employment opportunities (OECD, 2002).

There could also be partnerships between developed and emerging economies in skills building. For example, developed countries can send their logistics experts to develop and run logistics training courses in their emerging economy counterparts. The experts will improve human capital and promote the harmonisation of intermodal operations.

Resource allocation

Resource availability is a crucial factor for governments to introduce innovative approaches. Many governments have introduced the concept of e-governance, leading to the digitalisation of various government services. The next step in evolution is moving from e-governance to smart governance. Moving to smart governance will mean a need for investments in 5G technology and big data centres to collect and store the immense data that will be generated and analysed, implementing IoT sensors. Through partnerships and innovative business models, governments can generate resources for new technology.

Agreements between governments and the private sector should include aspects such as pricing (for direct and indirect costs), construction and operational provisions, and use of transport technologies and provide safeguards against the monopoly (OECD, 2002).

Security and privacy

As new technologies rely on large amounts of data processing and collection, a robust system and a proper framework are essential for collecting and storing data. Governments need to establish necessary policies and regulations for collecting and sharing data. With proper regulations in place, the data management frameworks can be decentralised such that no single entity has all the data, encouraging collaboration among various entities. By embracing open data standards, governments can ensure that data is available for other actors, avoid duplication in data collection, and improve resource efficiency.

2.2.4 Policy recommendations

Though logistics might be a sector dominated by private entities, there is still a role for governments at various levels to play an important role and benefit from their participation. First, as we have seen, the supply chain is a complex ecosystem involving various stakeholders and geographical contexts, especially when the deliveries involve multiple countries. Secondly, deliveries within a country will mean that the logistics vehicles are part of the vehicular traffic, and benefits from optimising logistics can also result in efficiency gains in an urban context.

Logistics providers are also subjected to various government policies and regulations to conduct operations. These policies and regulations can allow logistics companies to embrace innovation, benefitting governments in achieving climate-related goals.

Promoting technologies in the logistics sector is also to the benefit of the governments. Many governments have digitised the agenda and implemented smart cities and smart governance projects and policies. Smart cities and smart governance projects are important in supply chain management locally and globally. Smart cities can help companies improve logistics and operations by reducing traffic congestion and improving energy efficiency. In addition, smart city technologies can facilitate communication between suppliers and customers, which can help reduce inventory costs and improve product quality.

Hence, for a start, governments need to work with logistics providers. The partnership will provide the governments with a clear understanding of the logistics operators' needs and synergies. For example, the logistics operators generate immense amounts of data, and in many cases, private operators hold this data. With a proper partnership with the governments, the data can be shared such that the data can support local planning and transport routing in cities. The participation from the governments will be to make cities more efficient. At the same time, companies work with governments to improve their operating efficiency. The partnership can also support governments in implementing ICT infrastructure that governments will be able to provide due to a lack of resources.

Through the partnership, governments and logistics operators can understand the final goals of each of the entities and choose the innovation options. For example, governments can use smart sensors to identify parking needs for delivery vehicles and allocate the required parking facilities. By sharing data, logistics operators have an overview of the real-time traffic data, and the delivery routing can be optimised. Optimising deliveries can also help companies reduce commuting time and thus translate to economic benefits.

2.3 Implementing the Internet of Things and Big data in PI

2.3.1 Introduction

Emerging digital technologies in the Physical Internet enable an interconnected network of intermodal hubs, collaborative protocols, and standardised, modular, and smart containers. In particular, emerging technologies such as the Internet of Things (IoT) and Big Data Analytics (BDA), together with Artificial Intelligence (AI), Machine Learning (ML), Cloud Computing (CC), and Blockchain (BC), create innovations in information sharing, advanced data processing and analytics, and decision making for PI realisation and logistic optimisation systems (Tran-Dang & Kim, 2021). This paper focuses on IoT and Big data, their impact on the supply chain, challenges and supporting policies and planning.

2.3.2 Internet of Things

The Internet of Things (IoT) connects physical objects via wireless sensors and communication devices, resulting in an interconnected network of uniquely addressable objects. The sensing device is uniquely addressable and inherits standardised communication protocols, which allow the devices to collect autonomously, process, and share data in a global infrastructure of connected physical objects (Koot et al., 2021). The things in the IoT paradigm include physical and virtual entities, networks, and technologies. Integrated ICT, such as Radio Frequency Identification (RFID), Wireless Sensor Networks (WSN), and Global Positioning System (GPS), connect the different elements of IoT. Table 6 shows the critical IoT technologies for logistics applications (Tran-Dang et al., 2020a).

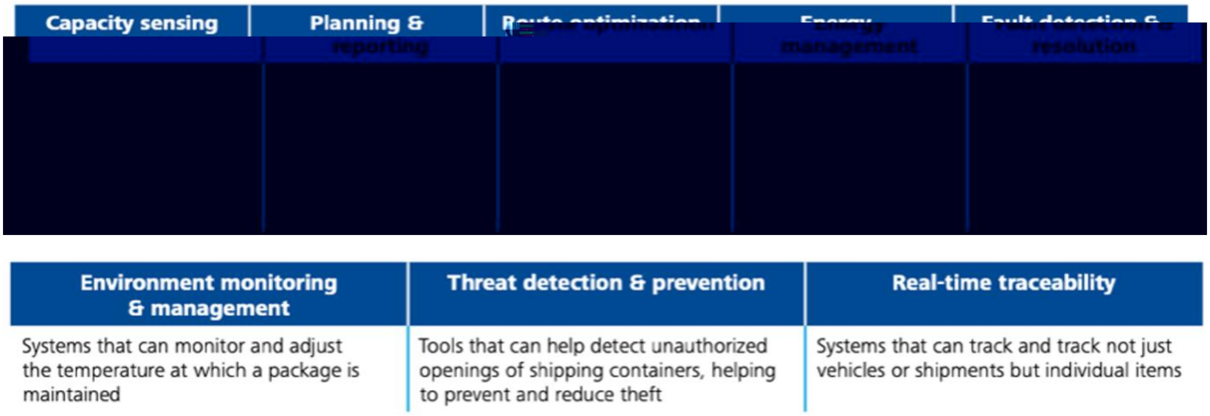
Table 3: Critical IoT technologies (Source: Tran-Dang et al., 2020)

	Functional Block	Enabling Technologies	
		Classification	Examples of key technologies
Enabling Technologies for Data-Driven IoT	**Data-Acquisition** *Generate and acquire relevant IoT data*	Identification	RFID, 2D-QR, Bar-Code, NFC
		Sensing	Sensors (i.e., bio-sensors, humidity, temperature sensors)
		Tracking	GPS, GPRS (General Packet Radio Service)
	Connectivity *Transmit IoT data to IoT devices and Cloud*	Global coverage	Cellular (2G, 3G, 4G, 5G), satellite
		Long range coverage	LPWA (Low Power Wide Area) (Sigfox, LoRa, NB-IoT, LTE-M)
		Short range coverage	Wi-Fi, Zigbee, Bluetooth, BLE (Bluetooth Low Energy)
	Data Processing *Filter, classify, sort, analyze IoT data to get insights into it*	Cloud Computing: The whole big IoT data is processed at the remote and powerful Cloud	
		Edge/Fog Computing: Sets of IoT data are processed at edge IoT devices or Fog nodes near to the data sources (i.e. gateways, routers) to improve performances (e.g. reduced latency, balanced traffic-load)	
		Big Data Analytics, Machine Learning, Artificial Intelligence: Relevant algorithms are used to analyze the IoT data and then predict the trends to improve decision makings	
		Middleware: Regardless the IoT characteristics (i.e., heterogeneity, complex structure), middleware relies only the IoT data to create intelligence applications, and services.	

Some of the critical applications of IoT in logistics domains include real-time monitoring of product conditions (e.g. the status of shipments inside the containers), smart warehousing (e.g. real-time localisation of inventory in the warehouse), freight transportation (e.g. real-time freight tracking for efficient management of shipments), and last-mile delivery (Tran-Dang et al., 2020a). In addition, the real-time monitoring of physical assets via IoT technologies improves logistics operations' transparency, traceability, and reliability by mapping the real world into the virtual world (Koot et al., 2021).

Considering the application of IoT for logistics supply (e.g., warehouse, trucks, and planes etc.), it supports capacity sensing, planning, and reporting, route optimisation, energy management, and fault detection and resolution (see Figure 4). In contrast, for logistic demand (e.g. customers, packages, containers, etc.), it supports environment monitoring and management, threat detection and prevention, and real-time traceability (see Figure 4)(Lacey et al., 2015).

Figure 4: Applications of IoT for logistics supply and demand (warehouse, trucks, planes, etc.)



2.3.3 Big Data

The 'Big Data' in logistics refers to the enormous datasets generated at various levels (e.g., routes, carriers, deliveries, transportation modes etc.), which are growing at an accelerated pace. The extraction of useful information from these vast datasets is called 'Big Data Analytics (BDA)', which could be valuable for organisations (Koot et al., 2021) in terms of forecasting demand in businesses, understanding customers' purchasing patterns, and estimating warehouse capacity.

The study (Yan et al., 2019) highlights that big data has a transformative significance for the current state of logistics and its future development. The core of achieving highly efficient operation in the various stages of logistics lies in processing the value of Big Data and combining it with different equipment and operation strategies. The extensive application of the IoT, mobile internet and other advanced technologies support collecting relevant logistic data from several components (such as logistics elements, facilities, tools, and operation processes). Big data can generate tremendous value, and with the maturity of technologies such as cloud computing, the computation and storage of vast amounts of data would be more accessible. The value of big data grows with the connection among data, the expansion, re-usage, and reorganisation of big data. Moreover, the accessibility of big data plays a vital role in enhancing the level of development of all societies. Big data can be re-used as digital assets by various organisations (e.g. government, industry and other societal organisations), which, when transferred to the community, create more societal value (Yan et al., 2019).

2.3.4 Impact of IoT and BD

Impact of IoT

IoT has many positive impacts on each stage of the global logistics supply chain, from manufacturing to retail. It can overcome shortcomings in some areas of logistics, e.g., monitoring; production management; logistics operations, information, exchange, and communication efficiency; modelling supply chains, intelligent information collection and security. It improves the visibility of the supply chain, tracks deliveries in real-time, and improves data accuracy (Tadejko, 2015).

The ability to collect information in real-time allow businesses to respond to incidents and requests almost instantaneously and understand the detail of the occurrence. In addition, the collected data helps logistic managers to correct operational inefficiencies that might have existed earlier, deliver outstanding service, and reduce safety and security risks (Sunol, 2016).

Impact of Big Data (BD)

The impact of the implementation of BD in logistics results in enhanced operational efficiency by using maximum resources, improving transparency, and making process quality and performance better; improved customer experience by maintaining customer loyalty and retaining them; and increased revenue by making effective data-driven business model (Wang et al., 2017) (Yan et al., 2019). With big data analytics technology, through RFID tags, GPS devices, bar codes, and many more, logistics companies can track their vehicles in real-time, capturing real-time traffic, on-road network, and fleet data. This data makes logistics managers easier to optimise routes and plan and schedule deliveries. In addition, big data provides a detailed insight into the process of loading, carrying, unloading, and delivering to warehouse managers, which helps them to plan the routes and schedule the deliveries in a better way to increase safety and decrease fuel expenses. Moreover, Big data analytics helps supply chain managers understand their companies' market scenario and competitive requirements, which gives them a chance to improve customer responsiveness, control inventory, save money, and enhance agility. With Big data, the retailers and supply chain managers also get the required information about customer behaviour, product performance, store performance, supplier relations, replenishment planning, etc. (Lahoti, 2020).

Therefore, implementing big data technology effectively reduces procurement, warehousing, and internal logistics distribution share and finally expects to achieve zero stock, zero distance, and zero freight (Wang et al., 2017).

Impact of combining IoT and BD to accelerate supply chain management

Implementing IoT and Big data can bring tremendous benefits to businesses and participants of a supply chain. IoT in Logistics brings the interconnectivity of devices, sensors, and systems that increases the volume, velocity, and variety of data. In contrast, big data provides the ability to make sense of historical information and predict potential scenarios and outcomes. Businesses capable of combining these two technologies can transform from solely service organisations to information-driven businesses. Any business decisions can be based on timely, reliable, and statistically significant data and on accurately understanding the relationship between weather conditions, carrier, transportation mode, workforce productivity, delivery time, and profitability. IoT and BD can avoid under or over-allocation of resources by tracking warehouse, workforce, and transportation utilisation in real-time (and over time) to meet (customer) demand (Sunol, 2016) as well as saving cost, mitigating risks, and increasing efficiency.

2.3.5 Challenges and supporting policies and planning

Though IoT and Big Data pose several benefits, some key challenges exist in the implementation – in terms of technical, economic, environmental, social as well as regulation. Supporting policies help tackle those challenges.

Technical

A good communication or connectivity network enables adequate multi-modal, global freight transportation. However, the logistics system faces crucial challenges in designing and deploying a reliable and pervasive connectivity network in the IoT to collect data. Logistic companies must carefully select the appropriate radio with considerable receiver sensitivity. Choosing suitable materials for smart objects, especially packaging boxes and containers, reduces unreliable communication (Tran-Dang et al., 2020a) (Dutta & Bose, 2015).

Economy

A high-computing system with a high investment cost is required to manage, process, and analyse data collected by many smart objects through a dynamic flow of logistics operations. Moreover, for these new technologies, businesses need to consider additional costs, such as training, and getting familiar with operating, controlling, and managing the technology operations. Small and medium enterprises (SMEs) will likely have more financial, human resources and technical limitations and a higher uncertainty in deploying IoT-based solutions. Therefore, the realisation of IoT requires a considerable investment in infrastructure transformations and integration with advanced ICT technologies that are adequate and suitable for business situations (Tran-Dang et al., 2020a) (Tran-Dang et al., 2020b).

Environment

The physical infrastructure and facilities required for IoT and Big Data must be equipped with smart objects (such as RFID and sensors) and high-performance computing systems (such as fog nodes, data centres, and servers). Moreover, they continuously consume a considerable amount of energy for performing multiple tasks such as sensing, identification, data exchanging, and data processing. Therefore, there is a need to establish and examine an efficient green computing platform capable of supporting the provisions of IoT applications for the overall sustainability of the system (Tran-Dang et al., 2020a).

Social

Regarding social sustainability, technologies supporting IoT and Big Data (such as batteries, physical connections, and energy fields) pose significant issues. For example, the batteries for smart objects (such as packaging containers) can potentially cause critical risks, such as explosions of hazardous materials during handling, storage, and transportation processes (Tran-Dang et al., 2020a). Therefore, safety measures and standards must be followed to avoid such consequences. Moreover, digital security has been an essential issue in protecting privacy, data confidentiality, and security (Tran-Dang et al., 2020a) (Tadejko, 2015). Furthermore, integration of other systems to the smart objects (., data storage, identification, location monitoring, etc.) imposes potential risks along the shipping trajectories, such as hacking and cyber-attack during a digital transaction. Therefore, a suitable environment to implement Blockchain technology should be considered to address the security issues in the IoT environment (Tran-Dang et al., 2020a).

2.3.6 Policy recommendations

The policies issued by various actors and countries pose challenges to achieving optimal sharing through the proposed IoT model. For example, some countries have their development and management policies which can have adverse impacts on both the application of IoT in the PI and the implementation of methodologies, such as restrictive regulation on national safety and security denying transnational transportation of containers (Tran-Dang et al., 2020a).

Therefore, policymakers must create an enabling environment for the IoT by leading and encouraging standards that will make interoperability and widespread adoption possible (Tadejko, 2015). Countries must also develop a long-term plan on a macro level and construct a data-sharing information platform. Besides that, logistic companies must also pay attention to information system standardisation and sharing to build cross-platform, collect multi-level information resources, and create a seamless information chain (Wang et al., 2017).

2.4 Hyper-connected logistics infrastructure

Physical Internet (PI) was initially defined by (Montreuil, 2011) as “an open global logistics system founded on physical, digital and operational interconnectivity through encapsulation, interfaces and protocols”. Further research and development suggest advancing the PI concept from interconnected to hyperconnected (Crainic & Montreuil, 2016).

Hyperconnectivity, in general, is defined as “super-fast connectivity, always-on, on the move, roaming seamlessly from network to network, where we go – anywhere, anytime, with any device”. A hyperconnected system is where the components and actors are deeply connected on various layers and are available anytime and anywhere. The hyperconnectivity in the network enables the PI stakeholders and constituents to avail and share all the information when making decisions regarding their abilities and capabilities (Oger et al., 2018).

A hyperconnected logistics system aims to improve the efficiency of goods delivery in terms of routing, speed, and inventory management (Betti et al., 2019). This is possible due to the deep integration and sharing of information at various layers. Therefore, to improve logistics capability, efficiency, and sustainability, a hyperconnected logistics system depends on the connectivity among the PI layers, such as digital, physical, operational, transactional, legal, and personal layers.

A hyperconnected system requires strong collaboration among the various logistics actors. Research has shown that horizontal and vertical collaboration and cooperation allow operators to gain more insight into their capabilities and abilities. This identification will enable organisations to use the capacity and ability of other counterparts in the PI network when such a capability is absent internally. Hyperconnected logistics can encourage cooperation over competition, thus providing benefits to all actors involved. In addition, a hyperconnected logistics system can provide environmental and economic benefits.

2.4.1 Hyperconnectivity in PI

The advent of the physical internet (PI or π) concept has mimicked the transfer of packages in the real world to that of the Digital Internet. In the PI world, the goods are transported, stored, and processed in a network, i.e., the PI network. The goods are encapsulated (or packaged) in standardised and reusable special π-containers. The standardisation allows for better space and material efficiency. The π-containers are modular and smart, i.e., equipped with sensors capable of transmitting and receiving information. The vehicles and processing centres can handle the π-containers and are part of the π-network, sharing information across the network.

The entire world can be split into unit zones at a minor level to develop a network. Unit zones form a local cell, cells combine to create an area, and combined areas form regions. Hubs link these building blocks; the hubs can be access-hubs linking unit zones, local hubs link local cells, and gateway hubs link areas. Hubs can also be multi-functional, i.e., a local hub can function as an area hub (Betti et al., 2019). In an urban context, low-carbon delivery vehicles do the last-mile deliveries at a unit level. The intermediary transport between hubs at different levels happens with vehicles faster than those used for last-mile deliveries.

A crucial element in the above construct is the ability to share information between the various network elements. In a hyperconnected system, this sharing of information increases economic and environmental efficiencies. Using a hyperconnected system in a hypothetical example, (Crainic & Montreuil, 2016) show that travel times and fuel consumption can be reduced by 42% and 44%, respectively. An experiment in the consumer goods industry by a France-Canada-Switzerland team simulated the benefits of hyperconnected logistics and found that the total induced costs can reduce by 30%. In addition, GHG emissions can be reduced by 60%[4], mainly by using multimodal transport while maintaining the same service level to the customers and providing a single day shift for the drivers (Sarraj et al., 2014). Hyperconnected logistics system also addresses a serious problem currently faced by the trucking industry, i.e., the high driver turnover rate (Shaikh et al., 2021).

An example of a hyperconnected logistics system can be seen in the figure below (Crainic & Montreuil, 2016). It can be seen in the figure that long-distance freight transport is facilitated by multimodal transportation, and the hubs are located at strategic locations, i.e., close to airports, railway stations, seaports, and dry ports. The last-mile connectivity is met through sustainable urban transport vehicles. The open distribution centres (marked by ▼) allow the transport of goods between hubs.

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[4] The electricity generated to run rail transport is from cleaner sources.

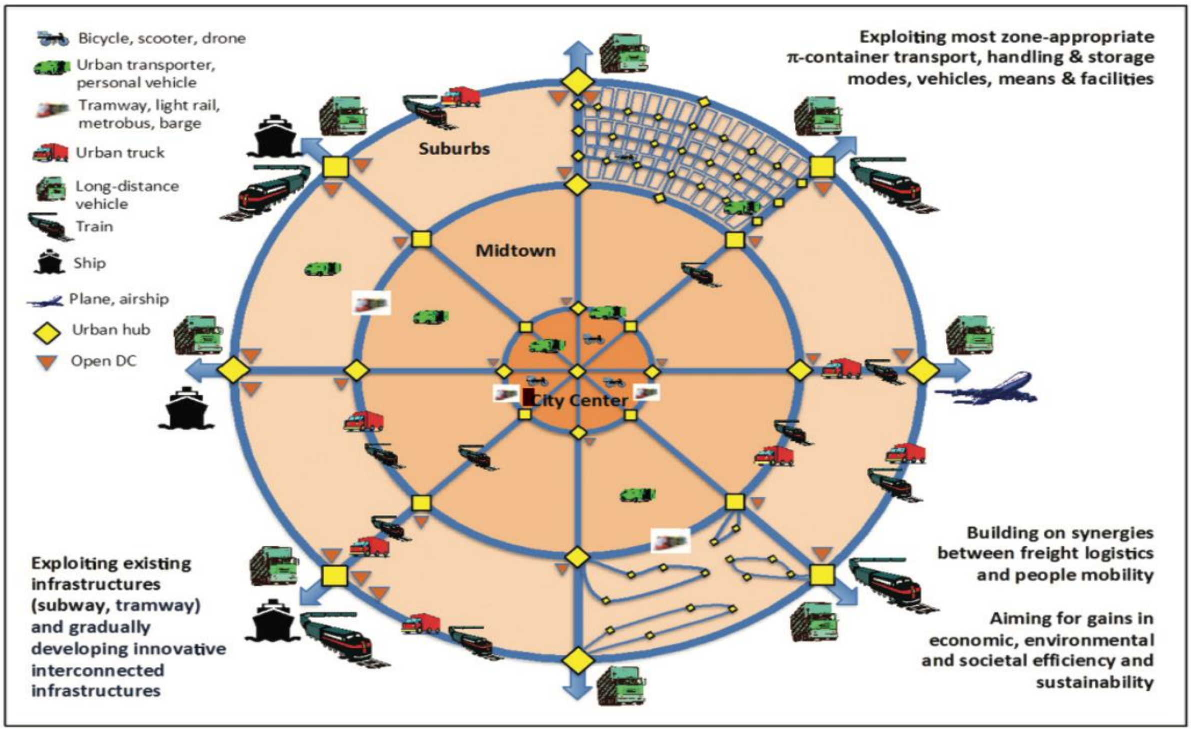

Figure 5:Example of a hyperconnected logistics system

2.4.2 Challenges

Implementing hyperconnected π-network has various challenges that can be addressed through proper enabling frameworks and measures.

- : From a government perspective, hyperconnectivity requires the involvement of public authorities at various levels with logistics stakeholders. The involvement allows the logistics operators to convey the hurdles in current legislation, policy, and regulation, that deter the implementation of hyperconnectivity. Through collaboration with logistics operators, governments can also standardise the π-containers and implement necessary legislation. When working with local governments, the urban planning context can be integrated into the planning of the hubs and consolidation centres. Synergies such as using existing facilities as hubs and working with existing operators can also be identified.

- : using various transport modes to reach the destination is an integral part of increasing the economic and environmental efficiencies in the supply chain. Similarly, providing the consumer with information on the possibility of transporting goods through multimodal modes is also essential. The needs of the consumers dictate logistics operators, and consumers can choose other modes only if they are aware of such possibilities. Being multimodal can bring economic savings for the operators that can be shared with consumers. On the contrary, unimodal can also increase costs, and the consumer needs to be aware of the savings when multimodal options are chosen.

- : hyperconnected networks encourage cooperation among logistics operators. Collaboration among operators may initially look at stifling competition, but on the contrary, it can minimise costs throughout the supply chain. The partnership can also result in identifying the capabilities that need to be developed internally versus capabilities that other operators can use.

- : The absence of standards can become an oppressive factor in supporting cooperation in developing hyperconnectivity. The standards apply to either the containers used for packaging, in sharing information or the standard used in vehicles. Having proper standards can create a level playing field for operators and focus on other areas of competitiveness.
- : The future of logistics will not remain the same. The pandemic years have shown that logistics will be more digital, and failure to shift and adapt to the innovation might force some operators to extinction. But on the other hand, innovation in a logistics company's future growth strategy can allow companies to remain in business.
- : Data protection and mutual trust must be maintained when sharing data between the actors in the network. This transparency allows a high quality of service, ease in mitigating disputes, and easy and secure financial transfers. More importantly, a high trust level enhances cooperation among the actors.

2.4.3 Policy Recommendations

To implement a hyperconnected logistics system, governments can play an essential role, yet a complementary role is also necessary from the private sector.

Governments can create enabling frameworks that allow the use of innovative technologies. For example, implementing a 5G network policy or providing incentives for cleaner and smart vehicles can encourage operators to adopt such technologies. In addition, governments at the local level can increase their awareness of PI and industry 4.0 and incorporate such concepts in the urban planning processes.

Allowing the participation of private operators to work with the public sector, especially in last-mile deliveries, using the rail network etc., will not only encourage the private sector to use existing infrastructure but also provide additional revenue sources for the government.

Implementing blockchain technologies with smart contract capabilities to increase trust and transparency can ensure that transactions are transparent and automated. For implementing a PI, it is essential to have a neutral entity that acts as an orchestrator. The orchestrator can be a physical entity, for example, the government or a computer algorithm. Introducing blockchain technology will essentially make the supply chain paperless, and it can be used to build trustworthiness in processes by detecting forgery.

Implementing a π-network will need introducing π-containers; this will pose an additional cost. Implementing a phased approach to introduce the π-containers will allow an easy transition. The start could be from small containers and addressing the city logistics sector.

2.5 Synchromodality: what and why

2.5.1 Introduction

If shippers can change the way the goods are shipped based on the traffic situation or if shippers can switch between rail, road, water, or air transport in real-time based on the demands of the customers, the efficiency of logistics operations is significantly influenced. The key idea behind synchromodality is to enable unseen synergies in logistics.

Synchromodality or synchronised intermodality is a concept where shippers can use multiple modes to deliver shipments. Synchromodality can encourage mode-shift to environmentally friendly modes of transport and provide economic benefits to the shippers.

Introducing synchromodality in the freight sector can also create innovative business models and encourage cooperation among freight operators. However, for governments to encourage synchromodality, there is a need for some policy alignment, and this will lead to more significant social, environmental, and economic benefits.

2.5.2 Synchromodality: what

When freight is transported, the focus of the shippers is to keep the costs low and deliver the consignment in a realistic time frame. Therefore, shippers usually choose a transport mode to achieve this. So, consignments are shifted from road to rail, and this introduces the concept of intermodal transport – transport of goods with at least two different modes, where the shipments remain in the same mode throughout the trip (Delbart, Molenbruch, Braekers, & Caris, 2021). From an environmental perspective, intermodal transport can also lead to lower emissions and for shippers, it can provide economic benefits (Pan, Ballot, & Fontane, 2013). However, most of the consignments are shipped via road transport. In 2020, the total share of inland freight transport by road was 77.4%, an increase of 8% from 2010 (EUROSTAT, 2022). A possible reason for the continued dependence on road transport is that the shippers face fewer uncertainties with road transport compared to the other modes. These uncertainties include strikes, natural calamities, and infrastructure problems (Svensson, 2000). Also, when consumers expect speedy deliveries in the digital age, intermodal transport tends to be slower than unimodal transport. This is because of the loading and unloading time involved when shifting modes.

With synchromodality, the shippers can decide which modality is used depending on the nature of the shipment, the delivery time desired and the costs incurred in a "single transport service" (Tavasszy, Behdani, & Konings, 2015) or a "coherent transport product" (Behdani, Fan, Wiegmans, & Zuidwijk, 2014). In addition, synchromodality can be made possible when different transport infrastructures are available between the freight terminals.

For example, a container is shipped via sea and planned to use road transport to the destination. However, after shipping, the shipper realises that the destination warehouse is congested. In a synchromodal system, the shipper can shift the container to a slower water-based or a rail-based system while the container is en route.

2.5.3 Synchromodality: why

One significant benefit of synchromodality is the environmental benefit that it can bring when compared to unimodal transport, which is heavily based on road transport. The International Transport Forum (ITF) predicts that the freight transport demand will double over the next three decades. Under the current situation, global freight emissions will not lower by 2050 but will increase by 22% compared to the 2015 levels (ITF, 2021). As a result, freight transport also contributes significantly to global greenhouse gas (GHG) emissions. While implementing bolder moves to improve vehicle technologies in the road transport sector can reduce GHG emissions, a more tangible impact can be seen by shifting the freight from road to rail and water transport. The CO emissions from rail and water-based transport systems are 3.5 and 5 times lower than road transport (McKinnon, 2016).

In addition to providing environmental benefits, synchromodality can also provide economic benefits to the shippers. The ability to adjust the transport mode in real-time and avoid and overcome uncertainties gives the shippers an edge to predict the deliveries more accurately and reduce operating costs.

Since synchromodality requires sharing of data between modes, the shippers can also benefit from cooperating with other shippers to reduce empty container flows (Behdani et al., 2014). Furthermore, synchromodality can also be scalable locally for urban deliveries. Urban logistics providers can also use different vehicle types (such as cargo bikes and delivery vans) depending on the shipment sizes and adjust to consumer needs.

2.5.4 Policy Recommendations

To implement synchromodality (and intermodality), both private and public actors need to cooperate. Cooperation becomes the key to realise the benefits of the concept in a shorter timeframe.

Technology

As synchromodality requires multiple modes and for the shippers to make the decision to move modes, there is a need for real-time information. There is a need to embrace the new technology options in logistics. For example, using the Internet of Things (IoT), shippers can know the state of the shipments and the location. When synchromodality is embedded into the Physical Internet (PI)[5] structure, synergies are observed, as PI advocates for encapsulation, i.e., modular packages with standardised sizes that can be easily categorised. When IoT and encapsulation come together, it is easier to move the shipment between modes reducing the transfer time.

This would also mean a need for proper data collection, management, and retrieval systems. As the role of technology in logistics increases, vast amounts of data are generated, and the need for data storage and retrieval becomes prominent.

The introduction of blockchain technology in the logistics sector can support easier, more transparent, and more secure data retrieval. Blockchain technology, coupled with smart contract capabilities, can automate the synchromodality process with conditions defined by the shipper (Acero, Saenz, & Luzzini, 2021). For example, a shipper carrying perishable food stocks can prioritise the consignment if there are delays in the transport. Pre-defined conditions can also automate the costing process based on the consumers' needs and urgency for the delivery. An automated process will automatically compute the costs and time involved in the consignment reaching the consumer, in general, and very simple terms similar to a GPS showing all possible routes to a destination and identifying the eco-friendly and fast routes, accounting for the real-time traffic situation.

[5] Montreuil originally defined Physical Internet (PI) (Montreuil, 2011) as "
"

Infrastructure

While data management requires a certain level of infrastructure provisioning for synchromodality, the scope of infrastructure is broad. We are essentially talking about the entire transport system. This includes the rolling stock (i.e., trains, trucks, barges) and terminals (dry and water ports, railroads, roads, and water channels).

Governments play an important role in the provision of the necessary basic infrastructure. Therefore, while planning new or expanding the existing infrastructure networks, it is essential to have a holistic approach and incorporate the synchromodality objectives, i.e., physically integrating modes. In addition to integrating the modes, it is also essential to picture from a network perspective such that shifting between modes along the network is possible.

The data gathered from the various data points merge at data centres, managed by an orchestrator (Tavasszy et al., 2015). The main role of the orchestrator would be to match the actual supply and demand at the operating level. The role of the orchestrator can be held by an actor in the supply chain or automated through an ICT platform. The orchestrator may also be responsible for data exchange between the various entities involved in the supply chain, the shippers, the carriers, and the consumers. By sharing information within the supply chain actors, it is easy to mitigate unexpected events such as delays on the network and cancellation of orders.

When proper infrastructure is provided, shippers can have seamless transactions with customers. As the number of transport modalities increases for the shippers, they are flexible on how the shipment is delivered to the customer. In this event, when an order is placed, the shipper would not fix the mode of transport but decide on the delivery characteristics, e.g., when they need the delivery. Based on the preference, the costs for shipping can be optimised. This is similar, in a general sense, to e-commerce deliveries. When customers place an order, they will not choose how the product is shipped but rather the delivery date. Faster deliveries will attract a higher shipping cost.

Institutional arrangements

Governments play an important role in implementing synchromodality and the physical internet. Through incentives and policies, governments can encourage the disclosure and sharing of data collected by the shippers. Using blockchain technology here could increase the security and transparency of the data-sharing process.

Similarly, governments can encourage options that allow small and medium enterprises (SMEs) to work together or incentivise SMEs to use innovative technology that allows them to benefit from PI and synchromodality. With PI and synchromodality, new business models are bound to arise, and these models could allow SMEs to collaborate in shipping their consignments. A potential possibility in an urban context would be shippers collecting orders from various SMEs and delivering them to the customers. This is facilitated through micro hubs and consolidation centres that could act as urban ports for further deliveries within the city. The deliveries can then be decided through different transport modes depending on the consumers and shipment needs.

On a broader scale, governments can also support seamless clearance procedures for shipments from foreign countries. Governments can also automate tax calculation and payment procedures such that the necessary formalities are electronically completed. Again, using smart contracting can streamline this process.

Partnerships with governments and private entities can enable data sharing about the consignments. Consignments will spend less time at the border clearance when integrated with electric clearance facilities, and travel time and costs can be saved.

Awareness

For governments and the private sector to openly embrace synchromodality, there is a dire need to increase awareness of the concept and the potential benefits that synchromodality (and the physical internet) can bring to each of the involved entities. Once there is an increase in awareness, shippers will not insist on the kind of transport used for shipping their consignments but rather focus on the quality of the service being provided. This will also allow the consignment carriers to choose the mode that is essential for the consignment to be delivered. Therefore, the carriers will only need to satisfy the shippers' demands in terms of service quality, thus optimising the costs incurred as long as the service quality objective is met.

A mental shift from thinking of modes as competing entities to complementary modes is essential. This can only be achieved through proper infrastructure integration, which is possible through increased awareness of the synergies. It has to be considered that implementing synchromodality is a time taking process as it requires coordination among various actors and government institutions.

2.6 Reducing emissions from logistics

2.6.1 Introduction

Logistics activities include various stakeholders and require many resources, significantly impacting its sustainability performance. A major share of the impact of the logistics activity comes from moving the goods, i.e., transportation. In the EU, transport is one of the largest energy-consuming sectors, leading to a high share of GHG emissions (European Commission, 2011). Yet, there is a direct link between economic growth and transportation (European Environmental Agency, 2022). The recent technological trends in the logistics sector have increased consumers' expectations. For example, same-day deliveries and free returns of purchased goods have fuelled the logistics demand to a great extent. In the EU, inland freight transport activity increased more than passenger transport by 22% between 2000 and 2019. (European Environmental Agency, 2022). In 2020, the total share of inland freight transport by road was 77.4% and an increase of 8% from 2010 (EUROSTAT, 2022).

The environmental impact of the freight sector will continue to grow in the next decades (McKinnon et al., 2015). Therefore, addressing the growing freight issue is critical as addressing it will not only reduce the environmental burden but can also pave the way for innovation and reduce other externalities such as congestion, accidents, and noise pollution.

The Avoid-Shift-Improve framework can support addressing the emissions issue from logistics. The framework advocates the need to reduce the need for unnecessary logistics by avoiding such trips, shifting a major share of logistics from mono-modal transport to multimodal transport, and improving the efficiencies of vehicles and processes.

2.6.2 Avoid-Shift-Improve Framework

In the early 1990s, Germany introduced the Avoid-Shift-Improve or the ASI framework. It was officially mentioned in 1994 in the German Parliament's Enquete commission report[6] as a strategy to reduce emissions (Deutsche Bundestag, 1994) from road transport in particular At the base of the framework are the three pillars viz. Avoid, Shift, and Improve (Bongardt et al., 2019).

- **Avoid:** Is the collection of measures that aim at reducing the need for the number of trips (in passenger transport) and the number of shipments (for freight)
- **Shift:** This is the collection of measures that promote a shift from high energy-consuming modes to energy-efficient and low carbon transport modes, i.e., for example, from road transport to railways and waterways. Shift measures also promote multimodality. Hence shift measures promote a shift from unimodal transport to multimodal transport options.
- **Improve:** This is a collection of measures that improve the energy efficiency of logistics modes; done through introducing low-carbon fuels, innovative vehicle technologies and improving the fuel efficiency of vehicles.

The ASI approach has gained a lot of approval from European and international entities. International development agencies advocate this framework when implementing low-carbon transport. Organisations such as the OECD International Transport Forum (ITF) (ITF, 2019) and the International Energy Agency (IEA) actively promote the ASI approach as means for reducing emissions from the transport sector.

2.6.3 Implementing the ASI framework in logistics

While the three pillars of the ASI framework seem very straightforward to implement, logistics is a sector that involves various actions and, thus, increased complexity in implementation. Furthermore, with the advent of new concepts in logistics, implementing the right measures can be confusing, especially for logistics operators and policymakers.

Avoid Measures

The fundamental idea of strategies under the Avoid pillar is to reduce unwanted and unnecessary trips and shipments. In Europe, empty vehicles constitute about a fifth of road freight journeys (EUROSTAT, 2021). Therefore, addressing the empty vehicles needs to be the primary consideration, as reducing these empty trips can result in emission savings. While consumer behaviour change is one end of the solution, the other is in partnerships between the public and private sectors and logistics operators.

The partnerships and aligning goals among the various entities involved in the logistics chain can significantly reduce the growing freight volumes and address the empty vehicle journeys (Punte et al., 2019).

From a technology point of view, innovations in the logistics sector can also contribute towards reducing freight volumes. Some potential options introduced by the technological innovation are 3D printing (where products are locally printed and significantly reducing or avoiding shipping trips), decentralising production and storage (this will reduce and consolidate trips) and using alternative materials product design (this will reduce the trips made to transport material that cannot be locally resourced).

[6] Introduced as vermeiden, verbessern, verlagern

Innovations such as the Physical Internet (PI or π) mimic how the digital internet transmits information. The digital internet encapsulates information in one packet, such as the source, delivery, and route. PI exploits this feature of the digital internet and suggests modularisation and standardisation of the π-containers. Furthermore, these containers are equipped with smart sensors, incorporating the Internet-of-Things (IoT)[7], enabling interconnectivity between the containers and the network.

For example, in a conventional system, a single driver travelling from Quebec to Los Angeles will travel over 10,000 km round-trip and need about 240 hours to transport one container. In a π-enable logistics network, the same task would require 60 hours to reach the destination, requiring 17 drivers, each driving for about 3 hours between the transit points in the π-network. This also would mean that the drivers can complete the task in a single shift (McKinnon et al., 2015). The result will yield considerable economic and environmental savings.

From a policy perspective, some measures can include financial instruments that incentivise low-carbon efforts.

Shift measures

The crux of the Shift measures is to promote multimodality and shift freight from carbon-intensive road transport to more efficient modes such as rail and waterways. Road transport and air transport are far more energy intensive and thereby more emitting sources than rail or water-based freight transport modes. In comparison, the type of vehicle and the fuel influence the emissions from road transport. For example, light-duty vehicles (LDVs) cause more emissions per ton-kilometre than heavy goods vehicles (HGV) (Pfoser, 2022).

Multimodal freight transport means using two or more modes of transport to transport the freight. The generic definition of multimodal transport has given rise to various concepts such as intermodal transport, combined transport, and co-modal transport. Intermodal transport means two or more modes transport the same loading unit without loading or unloading in the transport chain (UNECE et al., 2001). Combined transport is intermodal transport with environmentally friendly modes (Pfoser, 2022). When the trucks are carried by railroads, the process is called a rolling motorway and is a typical implementation of the combined transport concept. During the transport on a rolling motorway, the drivers may be seated either in the truck or a coach during the rail travel. A similar process can also be observed on water transport where trucks are ferried on waterways, ro-ro vessels, and ro-ro standing for roll-on/roll-off vehicles. Transporters can save costs when the vehicles are unaccompanied, i.e., transported without the drivers either on the rolling motorways or ro-ro vehicles. Co-modality is defined as the "efficient use of different modes on their own and in combination" to obtain "an optimal and sustainable utilisation of resources" (EC, 2006). The European Commission introduced the definition in 2006 in their mid-term review of the 2001 transport white paper. The definition suggests that the promotion of higher efficiency can be achieved through unimodal transport. Hence, the definition was criticised as not conducive to implementing multimodal transport. Co-modality did not receive much traction in implementation (Pfoser, 2022).

Several efforts are in place by the European Commission to encourage multimodal transport, yet the share of sustainable transport modes is minimal compared to road transport (EUROSTAT, 2022). This is

[7] ENISA defines IoT as "a cyber-physical ecosystem of interconnected sensors and actuators, which enable intelligent decision making." (https://www.enisa.europa.eu/topics/iot-and-smart-infrastructures/iot)

partially due to the various actors involved in freight transport reforms and a need for collaborative action, as discussed in the earlier section.

Improve measures

Improve measures aim to improve freight transport vehicles' fuel and vehicle efficiencies. A significant share of the improvement measures is targeted at road transport vehicles. Innovations in engineering and technology have constantly improved vehicle efficiencies. For example, innovations in tire technologies have led to low rolling resistance tires, and aluminium wheels have reduced the weight of wheels (Punte et al., 2019). Lighter vehicles consume less fuel and allow more freight transport, thus reducing freight trips.

Advances in fuels have allowed the trucking sector to shift from conventional fuels to alternative fuels such as biofuels, liquified natural gas (LNG), electricity and hydrogen. In terms of lowering particulate emissions, the LNG seems to be a promising alternative; still, LNG does not support reducing CO emissions (Teixeira et al., 2021). Electricity and hydrogen infrastructure can initially pose a high upfront investment cost (Zhao et al., 2018). In the longer term, as more vehicles are converted to electric and hydrogen, the costs may be justified. The environmental benefits are also higher when the multimodality is coupled with the improvement measures. Though hydrogen vehicles can significantly impact the GHG emissions from freight, the cost of producing clean hydrogen is still prohibitive. Some European researchers have also shown that electricity has a much higher economic and environmental efficiency when the total cost of ownership is compared (Strack et al., 2022). Yet, the central claim remains that moving away from conventional fuels in trucking and promoting multimodality is the way forward.

2.6.4 Challenges

Reducing emissions from the freight sector, unlike the passenger transport sector, needs collaboration and buy-in from the logistics service providers (LSPs) and the customers. To adopt low-emission freight transport, the LSPs will need to make certain sacrifices, but if the cost of these sacrifices is less than the benefits the LSPs receive, their buy-in process can be more straightforward.

Some challenges in getting the LSPs on the government’s side to implement low-carbon freight transport are as follows:

a. Economic benefits: The primary factor that encourages LSPs to change their practices is the financial benefit, i.e., the profit they receive from operations. If the current processes are expensive, LSPs attempt to reduce the costs and increase profits. To overcome these challenges, if the LSPs are convinced that the total cost of ownership (TCO) of new vehicle technologies is less than the current situation, then it is a factor LSPs may consider. Similarly, if multimodal transport is reliable and less expensive, LSPs may also start using multimodal transport. The reliability of multimodal transport is one of the reasons for the current deterrence. Participating in the PI for LSPs is more of a strategic decision. If participating in the PI network can prove profitable and efficient, LSPs would be willing to share data, resources, and customer orders with competing organisations (Pan et al., 2019).
b. Consumer preference: The LSPs are also influenced by the perception and demands of the consumers. Increasing consumer awareness can also affect the implementation of low-carbon freight transport. Customers who do not explicitly ask for sustainable transport modes or reject these practices do not provide an incentive for the LSPs to follow sustainable transport practices. Customers requesting green logistics options can pressure the LSPs (Chu et al., 2019). Research

conducted by interview LSPs clearly shows that the LSPs are willing to provide multimodal transport if the customers explicitly as for multimodal transport or have a specific delivery date that allows the use of multimodal transport (Pfoser, 2022).

c. Infrastructure: To move to sustainable freight transport, LSPs also need the required infrastructure. Multimodality needs multimodal terminals, and they facilitate a vital shift to other modes. A multimodal terminal is also essential for promoting the implementation of digital infrastructure. A PI network will need a digital platform acting as a neutral orchestrator, whose responsibility will be to maximise the total synergy gains of the network while being impartial (Ciprés & de la Cruz, 2019).
d. Organisational frameworks: The complexity of organisational procedures can influence the uptake of low-carbon freight practices by the LSPs. With high organisational complexity, LSPs will be deterred from moving towards multimodal transportation. Easing formal procedures such as customs, inspection, and other administrative procedures can speed up the total time spent by transport. Using blockchain technology with smart contracting can support overcoming this challenge. Governments will need to work internally to streamline the processes and procedures and develop enabling frameworks, supporting horizontal collaboration in a PI network.

2.6.5 Policy recommendations

Governments have a crucial responsibility and role in unlocking the emission reduction potential from the freight sector. Governments have the potential to incentivise low-carbon approaches and penalise carbon and energy-intensive projects and practices.

In recent decades government, freight transport policies have significantly transformed, especially in identifying the importance of sustainable freight practices. Yet, there are differences among countries, and emerging economies can leapfrog learning from the practices of their developed counterparts. Moreover, as the importance of climate mitigation increases, the role of governments in addressing climate concerns and decarbonising the logistics sector will also increase in the forthcoming years.

Some policy instruments that the governments can avail are (adapted from (McKinnon et al., 2015)):

- : Government can impose taxes mainly on fuels and vehicles that are carbon intensive and provide incentives for the purchase and use of low-carbon vehicles. The incentives can be in the form of installing infrastructure for electric vehicles and developing/subsidising the construction of urban consolidation centres.
- : governments can provide necessary legislation for vehicle design for freight transport, incorporate regulations that incentivise sustainable transport modes to compete with the trucking industry, allow the collaboration of the private sector in state-run freight modes
- : Through proper regulations and frameworks, governments can pave the way for data sharing and control how much data is collected. For example, a centralised data-sharing platform for freight operators will encourage data sharing.
- : Through standards set by the governments, freight operators can be compelled to follow standards in terms of package sizes and loading requirements. Standardisation can be a crucial element in implementing Physical Internet, while data sharing can be a key for implementing IoT in the freight sector.

- : governments can encourage collaboration among freight operators and pave the way for synchromodality[8], enabling freight operators to avail the services of each other and collaborate rather than compete. The future of competition in the freight sector will be primarily from the customer service perspective.

[8] Synchromodality is the ability for freight operators to dynamically switch modes and routes while the freight is in transit. Synchromodality can be enables mainly through inter freight operator collaboration and efficient data sharing.

3 Case studies for decision-makers to increase the awareness of PI

The case studies described in this section depict a real-life situation of the technologies and concepts discussed in the briefing sheets chapter above. For policymakers, the case studies attempt to relate to situations that they face and enable them to consider options that are relevant to the problem.

On another level, these case studies can also be utilised as teaching cases for courses developed in task 4.4 in WP4 of the PLANET project.

3.1 Physical Internet: Case Study – last mile delivery in Madrid

3.1.1 Introduction

Despite the power of computers ever increasing and multiple established analytic models available, there is still a vast potential for optimisation in supply chain operations. This limitation is often associated with the lack of benefit evidence, the unwillingness of operations managers to go through the hassle of changing processes that work, despite not utilising smart decision-making, and the sheer lack of monitoring infrastructure and equipment to enable smart decision-making. The use of analytics tends to be limited to basic routing decision making, and typically not in an automated manner either, but rather as an intermediate step for informing a freight forwarder who oversees a shipment. To expand analytics and smart decision-making utilisation in the Physical Internet (PI) and T&L contexts, the adaptation of analytics models in context-specific applications to address real-world needs and add value to existing processes is essential.

Description of technology innovation

Montreuil (2013) and Colin (2016) proposed a classification based on the Open Logistics Interconnection (OLI) to integrate current Transport & Logistics practices into the PI concept. This proposal contains four core layers being:

- **Encapsulation**: Standardises the packaging process of cargo and goods consolidated/deconsolidated into π-containers for transportation via the PI. It is also responsible for the consolidation/ deconsolidation of π-containers into π-movers.
- **Shipping**: Specifies what must be transported and the transportation process conditions and constraints. It is responsible for making appropriate adjustments to the shipping instructions to ensure compliance.
- **Networking**: Networking defines the interconnected infrastructure of available processing, storage and transporting facilities (transport services, terminals, distribution centres, warehouses) through which the goods will be transported from their origins (manufacturing, distribution, and other locations) towards their customer(s) locations.
- **Routing**: Routing is a process that creates a plan that describes the stage-by-stage detailed visiting and usage of network nodes and links from origin to destination.

The above PI layers attempt to integrate the following four principles in the Transport and Logistics (T&L) infrastructure operation, deviating from current practices. These are:

- The ability to effectively handle **modular packaging** such as π-containers. Standardised containers have revolutionised the logistics industry. However, their size range offering is limited yielding operational inefficiencies. Operations Research (OR) based decision support tools can provide tools for compartmentalised routing. Thus, increasing the modularity of the containers and the number of transhipments.

- The increasing **digitisation** of T&L infrastructure creates an information offering that remains unutilised mainly. IoT sensors and Track and Trace capabilities are integrated into the PI workflow, enabling new functionality for cargo prioritisation, re-routing, identification, and handling damaged goods.
- The integration of robust **decision support tools** (DSS) enables efficient cargo and fleet routing and distribution under uncertain and adjustable terminal, warehouse, and network conditions. Building on existing protocols (Sarraj, 2014), a toolbox comprising established and novel Operations Research and Machine Learning (ML) models is developed, adapted for the PI context, and applied in a modular and robust way.
- The **open access** to transport, terminal, and warehousing services through the "as-a-Service" paradigm improves operational efficiency. In addition, by incorporating open access in the PI layers, standardised collaboration protocols to identify and form mutually beneficial agreements are possible.

Problem owner

City Login is a parcel delivery company in Madrid and has been facing an interesting challenge for the past two to three years. Because many people have started ordering more things online due to the global pandemic, more and more parcels are being ordered and shipped worldwide. In 2022, these parcels must be delivered to the customer as quickly as possible. However, the city is not a distribution centre, and deliverers and companies must deal with other road users, traffic, diversions and the weather. This sometimes makes it difficult to meet most parcels' track and trace requirements today. Customers want timely delivery in minutes rather than hours, and non-conformance to these requirements can make customers initially angry with the deliverers but can also make them dissatisfied with the delivery company, which does not help their reputation. Furthermore, in big cities, the deliverers often get stuck in traffic jams, which makes it impossible to guarantee delivery. A company like City Login can lose customers because of this.

3.1.2 Background – facts and figures

The performance of freight transportation is one of the crucial elements for the sustainability of supply chains and logistics. Despite the progress achieved, inefficiencies are evident in the high frequency of empty truck trips and relatively low utilisation of multimodal resources. According to Eurostat (2019), one in five road freight journeys in Europe was performed by empty vehicles. Inland freight transport modal split across Europe indicates that 76.3% of freight movements (based on tonne-kilometres) were undertaken by road in 2019, while more emission-efficient modes such as rail and inland waterways only carried 17.6% and 6.1%, respectively. Despite ambitious emission reduction targets, the inland road freight ratio increased (up from 75.6% in 2018). Moreover, freight transportation (in developed countries) is responsible for nearly 15% of greenhouse gas emissions. Improved transportation efficiency is, therefore, an essential objective for environmental and financial purposes.

3.1.3 Actors and stakeholders

- Parcel delivery companies aim to optimise their transport network.
- Public authorities seek to reduce the congestion caused by home delivery companies.

3.1.4 Solution

When considering collaboration for last-mile delivery logistics, the high uncertainty of the urban environment that arises from road traffic, limited parking availability, and handover uncertainty, are found to cause significant delays and inefficiencies to last-mile operators and cities. To address this challenge, delivery status updates are circulated and stored in the cloud by one or more operators. These are then analysed to identify collaboration options between vans or operators. To expedite a late delivery round completion time, operators sent assistance vehicles that share the delivery load. This involves undertaking the following actions:

- Identify which vans can be sent for assistance without inflicting severe delays in their delivery obligations
- Identify how many and which parcels require to be transferred from the late vehicle to the helping vehicle
- Identify a common meeting point
- Dynamically redesign the delivery round for both vehicles featuring the common meeting point.

A critical factor for effectively addressing delivery delays is the availability of helping vans, which is typically limited as operators aim to utilise all their resources in the planning phase. Offering fair and balanced criteria for determining helping rounds promotes collaboration between otherwise competing operators. However, operators seek solutions internally rather than handing over their deliveries to other operators. A collaborative DSS is therefore required to offer fair and balanced alternatives for collaboration to last-mile operators.

As illustrated in Figure 1, the first step of the process involves identifying all the delivery rounds operating in proximity. Following the openness principles of the Physical Internet, the proposed algorithm can consider the delivery rounds of one or more operators as candidates for helping the delivery round run late. The process firstly filters the rounds in terms of ETC to identify the ones with higher availability and then undertakes the more computationally intensive process of determining the centroid for each round. The round centroid calculation considers all pending delivery locations for each round separately.

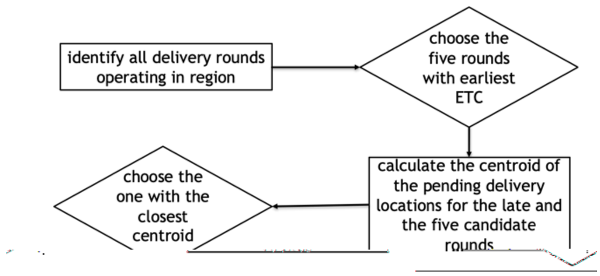

Figure 6: Nearby and available help round identification algorithm

Figure 2 illustrates all the delivery locations used for the round centroid calculation for the late running round (leftmost light blue) and the five candidate help rounds. The figure quantitatively confirms that the round depicted in pink operates in proximity to the late running round (light blue) and is therefore considered the ideal assistance option.

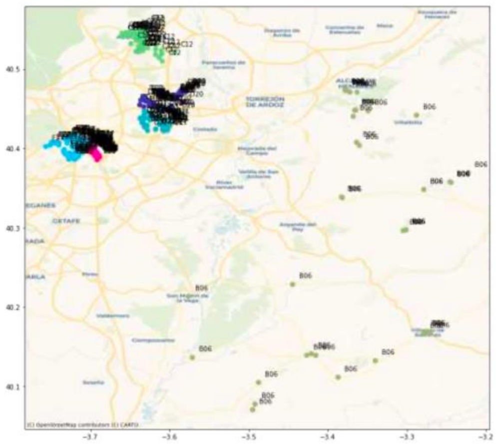

Figure 7: Pending delivery locations for the later rounds and the five candidate help rounds

Once the optimal help round has been identified, confirmed that it is operating in proximity to the late running round, and has sufficient spare time for handling additional parcel deliveries, the task of **reshuffling the pending parcels** is initiated. This task aims to identify which of the pending parcels of the two rounds should be delivered by which vehicle to alleviate overall delivery delays. The late running round requires sharing some of its load with the helping round. However, it is not clear which ones should be transferred up to this point. **Figure 3** illustrates how the border for the delivery locations of the late running and helping delivery rounds changes before (dashed line) and after (continuous line) the parcel reshuffling. The delivery locations border for the help round, which is operating at the bottom right of Figure 3, moves further north claiming the shaded area after the parcel reshuffling is served by the help round.

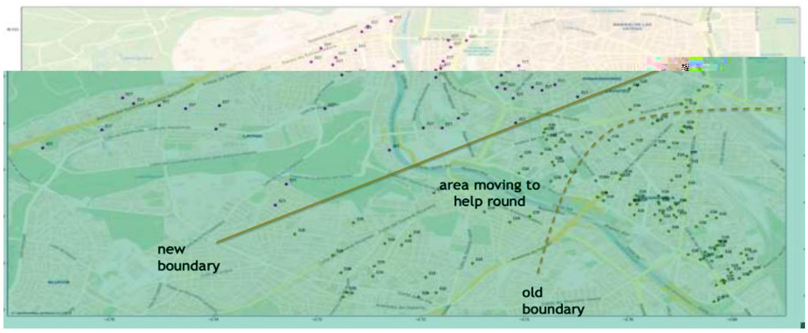

Figure 8: Area extension served by the help round after parcel reshuffling

After reshuffling the parcel delivery locations and establishing the area moving to the help round, it is required to convert that information to instructions for the two vans and drivers. This includes the new routes for both vehicles that incorporate a meeting point and the information on which parcels require to be transferred from one van to the other.

The **meeting point** represents a location suitable for the two vans to visit. However, there is no guarantee up to this point that the two vans will arrive there simultaneously. To address this, a common time window is set on both vans for reaching the meeting point. The time window is set to start 30 minutes from the current time and last for 30 minutes. The time window start and duration can be appropriately adjusted depending on the position of the vehicles compared to the meeting point and the time available until the 9 pm cut-off. If no solution can be found, the meeting point time window is relaxed by either delaying its start time, expanding it or both.

A Travelling Salesman Problem with time windows is then solved, including a common time window for reaching the meeting point. At the same time, no time window constraints are considered for all other locations. As illustrated in Figure 4, the two rounds meet simultaneously (at 12:18, the start of the time window) to exchange the parcels, and then the help round (shown in blue) delivers the additional parcels.

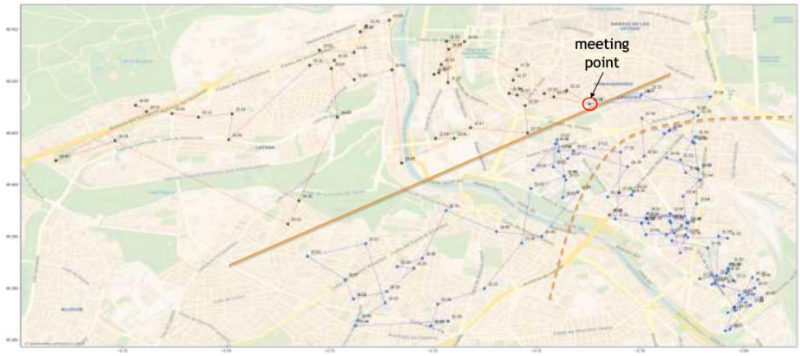

Figure 9: Vehicle rounds redesigned with meeting point using VRP with time windows

The help round ETC changes from 21:03 to 16:56, reducing its duration by a significant four hours. This allows plenty of time to deliver the parcels, even with adverse traffic conditions that are not yet accounted for. The help delivery round ETC is also updated to 18:19, costing an additional two hours to the termination time of the round.

3.1.5 Way forward

Higher first-attempt delivery success is key for all the stakeholders involved. Each package returned to the warehouse due to a failed, or out-of-time delivery generates economic, social, and ecological costs. It is, therefore, key for Last Mile delivery companies to save the costs associated with a second try. Currently, second delivery attempts represent around 20% extra daily cost for operations due to the additional kilometres needed to either come back and try delivery on the same day or to return to base and plan the delivery for the next or a later date. It is also key for the cities to avoid additional running by delivery vehicles, as they contribute to road occupation and pollution emissions. Finally, from a business perspective, customer satisfaction is key, and it is therefore important for consumers to receive deliveries successfully without additional contact or disturbance.

Solutions may consider convenience delivery points but also utilise better monitoring and daily management based on AI applications. Such applications allow operators to predict the impact of real-life non-planned events and anticipate corrective actions to resolve them using optimisation methods, which yield savings in personnel cost, fuel consumption and road and vehicle wear and tear. The solution presented here enables a field of tools to work on minimising these problems that affect the entire last-mile industry. Moreover, with the support of the public sector and such new disruptive technologies, private sector collaborative operations can be promoted and prioritised.

3.1.6 Conclusions

The dynamic algorithm developed offers a solution to the last-mile delivery rounds delays in the urban context. The tool is useful for last-mile operators addressing delivery delays. Still, it also offers an opportunity for collaborative last-mile logistics, as it creates fair criteria for assessing the helping rounds available in a region. The algorithm is end-to-end in determining and identifying optimal help rounds and dealing with parcel reshuffling and delivery round redesign through a meeting point. As multiple last-mile operators run delivery rounds in proximity, integrating this methodology in an EGTN-type platform enables collaborative logistics to be applied fairly, substantially increasing the collaboration opportunities and benefits between operators.

3.1.7 Further questions for research/questions for students

Physical internet

What is the Physical Internet? What makes PI different from how logistics is organised today?
How would PI enable decision-makers in the supply chains to make better decisions?
Think of policymakers; how would they be looking at it? Not just the EU but also policymakers in emerging economies.

Shared logistics

What makes shared logistics different from how logistics is organised today?
If the principle of shared logistics is based on shared resources, how do you do the planning?
What are alternative scenarios for shared logistics?
How can you help each other out and make a transfer from one delivery company to the other?
What kind of arrangement – capacity sharing contract – could be set up?

3.1.8 Contact details

Name Kostas Zavitsas

E-mail k.zavitsas@vltn.be

3.1.9 References

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Eurostat, 2019. Energy, transport, and environment statistics. 2019 edition. Publications Office of the European Union, Luxembourg.

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Sarraj, R., Ballot, E., Pan, S., Hakimi, D., Montreuil, B., 2014. Interconnected logistics networks and protocols: simulation-based efficiency assessment. International Journal of Production Research, 52 (11): 3185-3208.

3.1.10 Reading materials

Colin, J-Y., Mathiew, H., Nackechbandi, M., 2016. A proposal for an open logistics interconnection reference model for a Physical Internet. 3rd International Conference on Logistics Operations Management (GOL), Fez, Morocco.

3.1.11 Key concepts

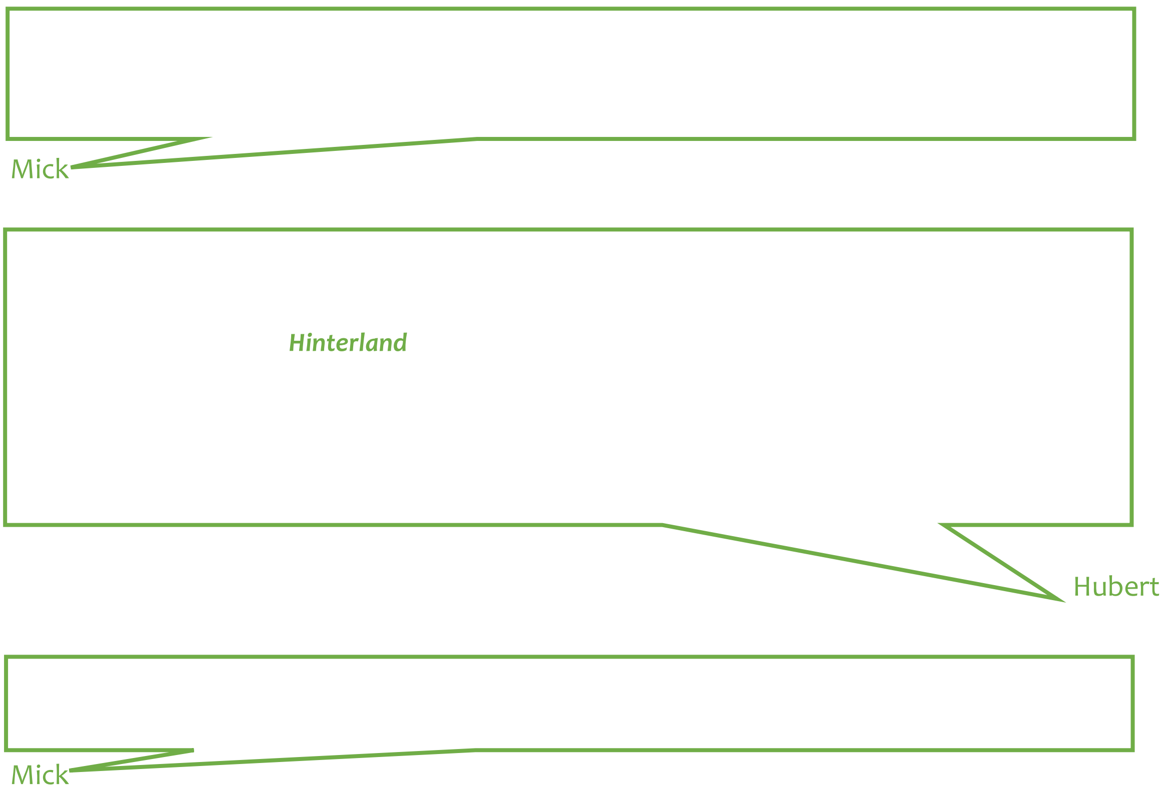
Existing concepts in the domain of Supply Chain Management indicate where this use case ties into existing curricula at business schools. This use case also explains how new concepts come into play when optimising this part of the supply chain.

Existing concepts in the SCM curriculum	**A new concept in the SCM curriculum**
Last mile Dynamic routing Travelling Salesman Problem	Compartmentalised routing Modular packaging

3.2 Logistics and Operations Management & Data Analytics: Case Study – Assessment of Connectivity

3.2.1 Introduction

When **Hubert Steiner** (50 years old) looks out over the grounds of the container terminal in Mannheim from his executive office, he thinks about a few things. After all, he has been in the business for a long time, almost 30 years, and has also been managing director of this wonderful terminal in Germany for quite some time (10 years). However, times change, and the industry changes with it. Nowadays, there is a big movement towards more **sustainable forms of transport and business**. Hubert expects that within the next ten years, more and more barges will be berthed on fuels other than conventional ones, such as LNG and hydrogen. He also thinks that fewer and fewer containers will be transported by truck. Besides the green transition, Hubert also notices that a **digital transition** has been set in motion. He has already built an online platform where shippers can upload relevant documents for transport, register their cargo and check the water levels at the terminal. Hubert is even considering having an app built because **all transitions seem to accelerate** these days. Despite the transition from digitalisation to sustainability, Hubert believes it is important not to lose sight of the basics of his container terminal. After all, how many containers he tranships each year does not depend solely on green and digital solutions. His son, **Mick Steiner**, is 20 years old and studying transport economics and maritime logistics. Hubert has a conversation with Mick, about the changing times and the importance of always coming back to and reasoning from the foundation of his terminal.



Hubert

Mick

3.2.2 Background – facts and figures

Megaregions and supercities

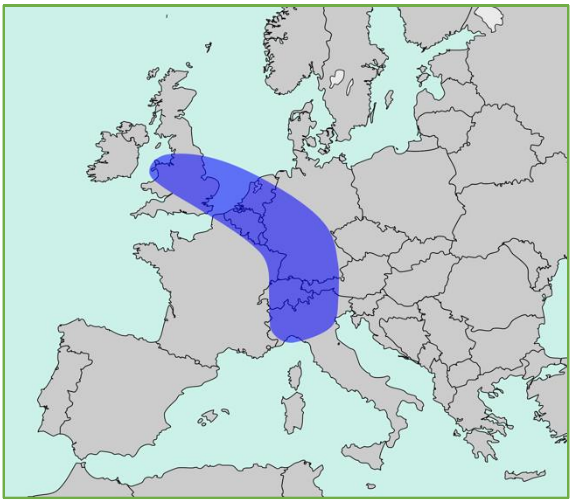


Figure 10: Blue Banana (Platon, 2012a).

A **megalopolis** or supercity, also called a megaregion, is a group of metropolitan areas perceived as a continuous urban area through common transport systems, economy, resources, and ecology (Hagler, 2009). Europe is best known for the Blue Banana; see **Figure 1**. It sketches a multinational European megalopolis, encompassing several metropolises from different (Western) European states. Roughly speaking, the Blue Banana starts with the agglomerations of Milan and Turin and ends with the agglomerations in the West Midlands of Great Britain, with in between the agglomerations of, amongst others, the Randstad, the Flemish Diamond and the Ruhr.

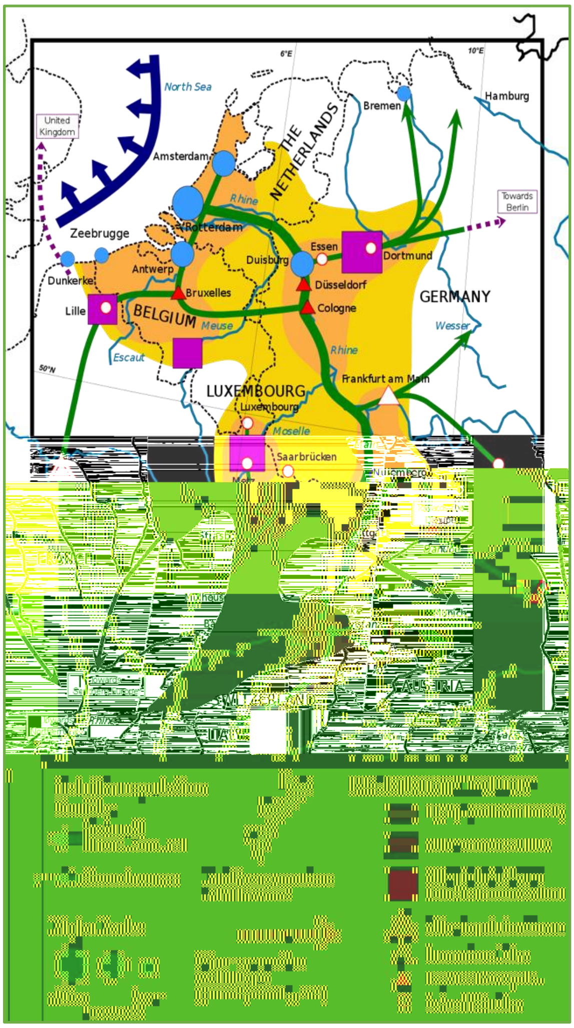


Figure 11: Rhine area analysis (Platon, 2012b).

Figure 2 offers a more specific overview of the Blue Banana, zooming in on the Netherlands, Belgium, Germany and Switzerland. In the Netherlands and Belgium, the major seaports of Rotterdam, Amsterdam and Antwerp-Bruges are located, providing maritime connections to the rest of the world. Major axes connect these ports to a network of river, road and rail links that run through the entire megaregion. This way, there is a connection to industrial regions like Dortmund and Lille. There are also connections to other large cities, such as Frankfurt, Zurich and Brussels. This area is not only connected to what is displayed on the map: the connections run to other parts of Europe. To the East, the various roads are further connected to the Danube. In the South, it extends to Italy and the Iberian Peninsula and the North to Berlin and the Scandinavian countries. The cluster around Dortmund, for example, is characterised by many industrial cities such as Essen, Dusseldorf, Cologne and Dortmund itself. For the various terminals on these main transport corridors, connecting perfectly to these networks is essential. After all, the better a terminal is connected to the network, the more cargo it will be able to generate for handling.

European clusters and the Ten-T policy

As seen in Figure 3, the Blue Banana is not the only form of industrial cluster in Europe. Around the Mediterranean Sea in Spain, France and Italy, a chain of industrial activity can also be seen in cities such as Valencia, Barcelona, Marseille, and Genoa are located in this area. A Green Banana also runs through Poland, Austria, Hungary, the Czech Republic, and Slovenia. The Baltic states have the Gulf of Finland, and an agglomeration can also be recognised in Germany, Denmark, and Sweden.

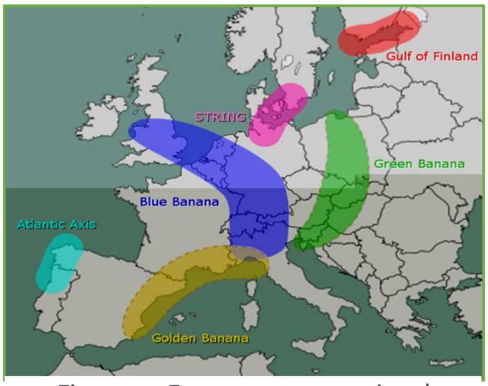


Figure 12: European transnational megalopolises (Public Welfare, 2022).

The TEN-T policy of the European Commission focuses on the implementation and development of a European network of roads, railways, inland waterways, sea routes, ports, and airports (European Commission, 2020a). The case study assesses the connectivity of inland terminals in the TEN-T network (Figure 4). The TEN-T policy addresses a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes and railroad terminals. The ultimate policy objective is to close gaps and remove the bottleneck and technical barriers in the EU. You will help to assess where improvements can be made. In Appendix 1, you can find an overview of the TEN-T network.

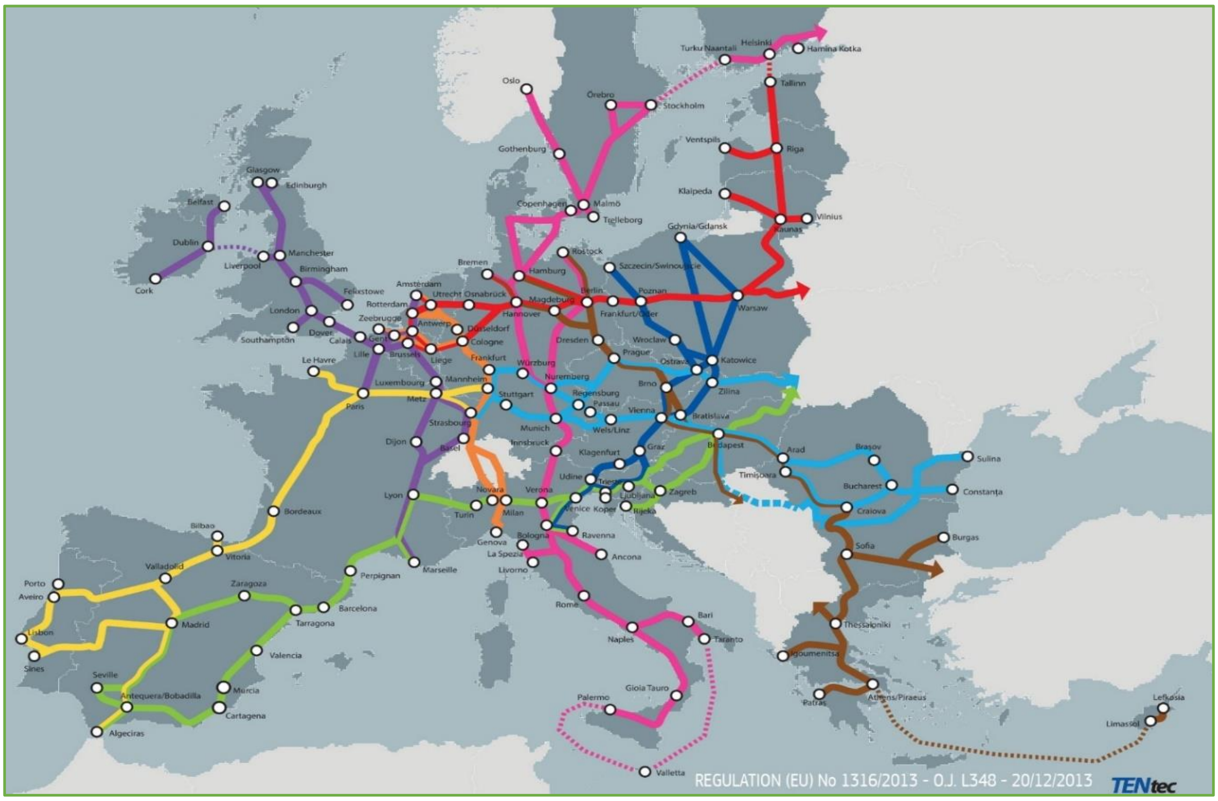


Figure 13: Ten-T Network (European Commission, 2022b).

3.2.3 Actors and stakeholders

Hubert Steiner, our container **terminal director** from the introduction, is the main actor in the web of actors and stakeholders. After all, an inland terminal is what inland terminal connectivity is all about. The director of such a terminal wants to know how well his terminal is doing and how it performs compared to other terminals in the network. Only then can the terminal improve itself. Other actors are, therefore, **other terminals on the corridor** of an inland network. However, these terminals should not only be seen from a competition perspective but also a cooperation perspective. After all, of course, the terminals compete for more cargo, but at the same time, terminals will also have to work together to improve the joint connectivity of the entire corridor. This can be done by jointly investing in new railway tracks, building alternative fuel facilities, and creating an online network with track and trace and booking facilities.

Considering investments, it is evident to name **shareholders** and **investors** of the terminals themselves as actors. In this respect, **authorities** such as municipalities, provinces and the national government are also important, as they can invest in projects to improve terminal connectivity. **Policymakers** and lobbyists are also not unimportant players within the web of actors. **Legislators** and **regulators** also determine how much an inland terminal can improve its connectivity. After all, if a terminal wants to expand its capacity in terms of land area, a regulation from the municipality is needed to obtain permission for this expansion. Finally, the companies and people who run the inland terminals, the **inland terminal users**, are essential for the survival and competitiveness of inland terminals. Inland terminals try to develop and improve themselves as much as possible to handle more cargo and attract more users.

3.2.4 Solution

The **PLANET Corridor Connectivity Index** (CCI) aims to capture a transport node's level of integration in the TEN-T network and the global maritime transport network since accessibility and connectivity are indicators for the effectiveness of the transport network as an enabler for trade. This methodology envisages a connectivity index which indicates the best nodes in the transport network, reflected by seven components. The hypothesis is that the strongest nodes – with the highest corridor connectivity index score- are a predictor for the most favourable routes as reflected by actually shipped volumes. Ideally, a map with the corridor connectivity index of multiple seaports and inland ports will highlight the best route through the network by using the scores of each node in the network.

The CCI is constructed from seven components, using Principal Component Analysis (PCA). PCA is a statistical method to reduce the dimensionality of a dataset. This is done to simplify the understanding of the data which results from data collection on (currently) 26 sub-components for n amount of transport nodes. To ensure the dataset does not become unmanageable, we aim to express the corridor connectivity of a node in a single indicator – the CCI – which is the weighted average of the score of the components. Read Jansen and Mosmans (2022) to understand the different components of the CCI. This will help you to answer the case study questions.

Below you will find an overview which should help you better understand the relationship between corridors, inland nodes, and terminals. In this case, you will assess various inland nodes (N) in a corridor; however, an inland node can consist of one or multiple terminals (T).

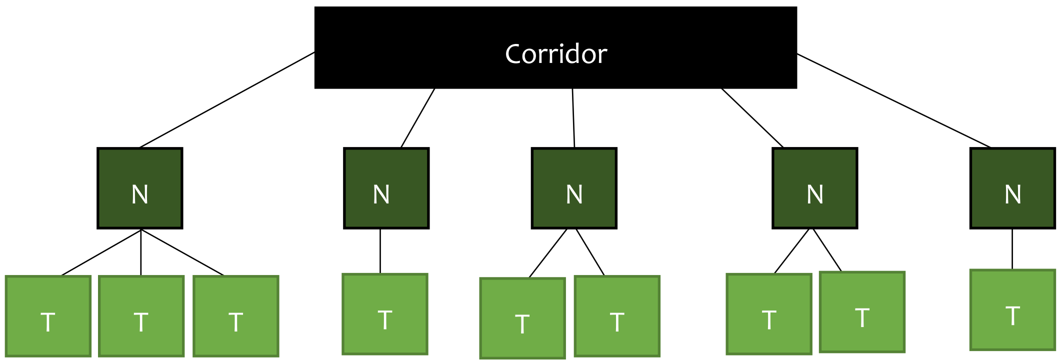


Figure 14: Corridor Connectivity overview sketch

3.2.5 Way forward

The CCI was developed for the Rhine-Alpine corridor of TEN-T, which runs from Rotterdam and Antwerp across the Rhine and the Alps to the Italian port of Genoa. The CCI and its results for all inland terminals in this corridor are, therefore, already known. The CCI is currently being developed for two other corridors, the Rhine-Danube corridor and the Baltic-Adriatic corridor. The more corridors developed with the CCI, the more robust its results will become. At the same time, more and more can be learned about the weights that should be attached to the components in terms of the PCA.

3.2.6 Conclusions

We are currently on the verge of a large number of developments in the area of digitalisation and sustainability. Inland terminals will also have to develop and change in this respect. In addition, there are always unpredictable disruptions to consider, as the war in Ukraine and the COVID-19 pandemic have shown. When inland terminals have their corridor connectivity in order, they will be better able to react to these disruptions. The CCI can facilitate inland terminals, shareholders, policymakers and other parties involved with making decisions regarding disruptions, developments and innovations.

3.2.7 Further questions for research/questions for students

Question 1

a) How would you describe hinterland connectivity as a concept?
b) What components are mentioned in the literature that indicate an inland port's connectivity? Name the components and for each component, explain in one or two sentences what it measures.
c) Which of the indicators best indicates connectivity? Explain your answer.

Question 2

What is the best-performing inland node on port capacity? And why?

To answer this question, you will have to take the following steps

- Determine the terminal area (m2), barge capacity (total length of quayside in meters) and the rail capacity (total length of tracks in meters) per terminal for each inland node in your corridor
- Calculate index values for each of the terminals, and the base value should be the maximum value of each of the three components
- Calculate the index values for each of the nodes; each terminal within one node has equal weights.

After you have obtained your result, you must crucially look for why this might be the case; it can be due to the data or a terminal; use the data to state why.

Question 3

What is the best-performing inland node on service frequency? And why?

To answer this question, you will have to take the following steps

- Determine the service frequency for each inland terminal to each seaport terminal for your assigned mode
- Calculate index values for each of the terminals; the base value should be the maximum value of an index value
- Calculate the index values for each of the nodes. Each terminal within one node has equal weight.

Then you must critically look for why this might be the case; it can be due to the data or a terminal; use the data to state why.

Question 4

Select two other components of the list of Jansen and Mosmans (2022):

- Quality of infrastructure
- Efficiency and ease of processing
- Service quality (centre of gravity in the distance per rail)
- Digital connectivity
- Green facilities

To answer this question, follow for both components the same methodology as Jansen and Mosmans (2022). First, specify why you chose these two specific indicators for further investigation. Then you must critically examine why certain inland terminals score better for these two indicators than other inland terminals. Use the data to state the reason why.

Question 5

Overall, what is the best-performing inland node and the worst-performing node? How can the worst-performing node improve itself?

To answer this question, you will have to take the following steps:

- First, you create an overall index value based on the outcomes of Question 1, Question 2 and Question 3. Each indicator has the same weight.

Question 6

M tf fl fl ttf n fl n fl S n n n n n ffltffl tf n n n n fl n fl ttf tf n fl m fl

- fl Y ttfn fl ttf n fl fl n fl tf
- n tf fl n fl fl fl fl ffih fl n fl n n ffltf n fl n
- Y n n fl n n n fl ffih tf n fl n nffltf fl n tf fl fl n n fl Y ffY flfl tf fl ttf ttf fl fl n fl n ttf

Format of your presentation

- Prepare a slide deck of 6 slides: each question to be answered on one slide;
- 10-15 minutes per group.
- Illustrate your slides with graphs, tables, and diagrams in which you bring forward the results.

3.2.8 Contact details

Maurice Jansen m.jansen@ese.eur.nl

Hannah Mosmans mosmans@ese.eur.nl

3.2.9 References

European Commission. (2020a). Trans-European Transport Network (TEN-T). Retrieved from https://ec.europa.eu/transport/themes/infrastructure/ten-t_en on the 2nd of May 2022.

European Commission. (2020b). . Retrieved from https://ec.europa.eu/transport/infrastructure/tentec/tentec/portal/site/maps_upload/SchematicA0_EUcorridor_map.pdf on the 2nd of May 2022.

Hagler, Y. (2009). . Retrieved from https://rpa.org/work/reports/defining-u-s-megaregions on the 2nd of May 2022.

Platon, A. (2012a). . https://commons.wikimedia.org/wiki/File:Blue_Banana.svg on the 2nd of May 2022.

Platon, A. (2012b). . Retrieved from https://commons.wikimedia.org/wiki/File:Rhine_area_analisys.svg on the 2nd of May 2022.

Public Welfare. (2022). . Retrieved from https://en.public-welfare.com/3980920-the-blue-banana-european-economic-ridge on the 2nd of May 2022.

3.2.10 Reading materials

Langen, P. de & Sharypova, K. Intermodal connectivity as a port performance indicator. (2013), pp. 97–102.

3.2.11 Data sources / key concepts

You can use all open-access sources you can find on the internet. However, we have stated some useful sources in the table below to get you going. In addition, we have created an excel template which you can use as a base. However, you are free to create your a(n 0 G15[(ex)6( )-53as)-54eate c ake(s)-44(e)13(--4( )-5( )-4n

#	Corridor	Mode	Seaports	Inland nodes
				Utrecht, Liège, Lugano, Milano, Mainz, Mannheim, Nijmegen/Arnhem,
7	Rhine-Alpine	Barge	Antwerp, Rotterdam, Gent, Genova, Vlissingen, Zeebrugge	Amsterdam, Basel, Bruxelles, Duisburg, Düsseldorf, Köln, Karlsruhe, Koblenz, Utrecht, Liège, Lugano, Milano, Mainz, Mannheim, Nijmegen/Arnhem,
8	Atlantic	Rail	Bilbao, Bordeaux, Le Havre, Leixoes/Porto, Sines/Lisbon, Algeciras	Bobadilla, Aveiro, Bergara, Madrid, Mannheim, Metz, Paris, Strasbourg, Valladolid, Vitoria
9	North Sea - Mediterranean	Rail	Cork, Dublin, Dunkerque, Edinburgh, Felixstowe, Glasgow, Liverpool, London, Manchester, Gent, Antwerp, Southampton, Marseille	Amsterdam, Basel, Birmingham, Brussels, Lyon, Metz, Dijon, Strasburg, Lille, Luxembourg
10	Rhine-Danube	Rail	Constanta, Sulina	Arad, Budapest, Brasov, Bratislava, Craiova, Munich, Nürnberg, Košice, Ostrava, Wien, Passau, Praha, Regensburg, Stuttgart, Vukovar, Wels/Linz, Zilina

Appendix 2 How to calculate an index

An **index** measure changes against a base value using a consistent dataset with a range of values. An index is thus a composite statistic – a measure of changes in a representative group of individual data points, or in other words, a compound measure that aggregates multiple components. A famous example in logistics is the port liner connectivity index.

The equation is as follows:

In this equation, the case value is the value of a specific inland terminal for a specific component, and the base value is the value for the inland terminal that scored highest (which will thus be used as the basis).

3.3 Smart Contract enabled Synchromodal Transport

PLANET Teaching Case

3.3.1 Introduction

Brian observed the simmering rain outside while sitting at his desk. He had been working late, ensuring that his planners had booked all containers for the day. It would be himself to blame for his late hours. He had inspired his planners to walk the extra mile to book containers via waterways and rail instead of trucks whenever possible. He also made the solemn promise to help them by doing so. And then, he discovered that checking the various multimodal routes and ensuring that containers would arrive on time despite multiple modes of transport being used was more challenging than he anticipated. His planners were doing their best; they also saw the benefits, but Brian felt he had started to ask too much of them. One of the planners remarked that moving freight from truck to barge and rail, i.e., establishing a "modal shift", was not so much a hot topic anymore.

3.3.2 Synchromodality

He then stared at his computer screen, watching a slide presentation sent to him. It presented "Synchromodality in Practice", made by a university professor. It came down to a mechanism where bookings do not specify the transport service, which implies that modes of transport, routes, and departure times are decided later. Instead, the bookings only specify customer demand, such as origin and destination, sufficient time windows for pickup and delivery, or admissible transport times. Replanning transport services was not unknown to him, but bookings that merely focused on the demand side without specification of the supply side were novel to him.

In a way, he liked the presentation. It addressed some of the issues he and his planners had been facing. For instance, planners were hesitant to book a container on a barge when the arrival time of the container at the port of discharge was uncertain, even if the planned transportation time from the port to the final destination rendered barge transport feasible. On the other hand, synchromodal transport allows the allocation of containers to specific modes of transport at the moment of arrival, avoiding the risk of doing the planning that needs to be adjusted afterwards.

He was trying to understand the position of the transport operator in all of this. It sounded too good to be true. How would a Synchromodal operator plan capacity when no shipper commits to a specific transport service in advance? In particular, if she promises that 95% of the containers will arrive on time, how does she plan for that? From the presentation, he read that redundant capacity is reserved to hedge against uncertainty. The higher the required service levels and uncertainties at hand, the more capacity needs to be reserved along alternative routes, which comes at a cost. This all made sense to Brian. It would imply that tighter customer demands trigger a higher price. He also realised that the Synchromodal operator absorbs the risks associated with uncertain travel times on the network, for instance.

[9] This case was written by Rob Zuidwijk at the Rotterdam School of Management (RSM), Erasmus University. The case is based on MSc thesis Lynn Niemeijer and PLANET project work with help from Maurice Janssen (UPT Erasmus) and Aljosja Beije (Blocklab). This case is based on field and desk research. It is written to provide material for class discussion rather than to illustrate either effective or ineffective handling of a management situation.

He wondered

Question 3

When capacity is planned on a network based on a certain target reliability, how would that inform the pricing of the transportation service? Discuss a price strategy incorporating target service levels and costs of reserving capacity on the network.

Question 4

Consider the workflow of Synchromodal planning in Exhibit 3 and the possible use of Smart Contracts there. Discuss at least two pros and two cons of using smart contracts to automate decisions in this workflow.

Exhibit 1:

The main concepts of Synchromodal Transport are explained in the case text. Here some aspects are explained in more detail[10]. Comparing Synchromodal transport with other concepts that coordinate the use of multiple modes of transport helps to better appreciate the concept; see Figure 1.

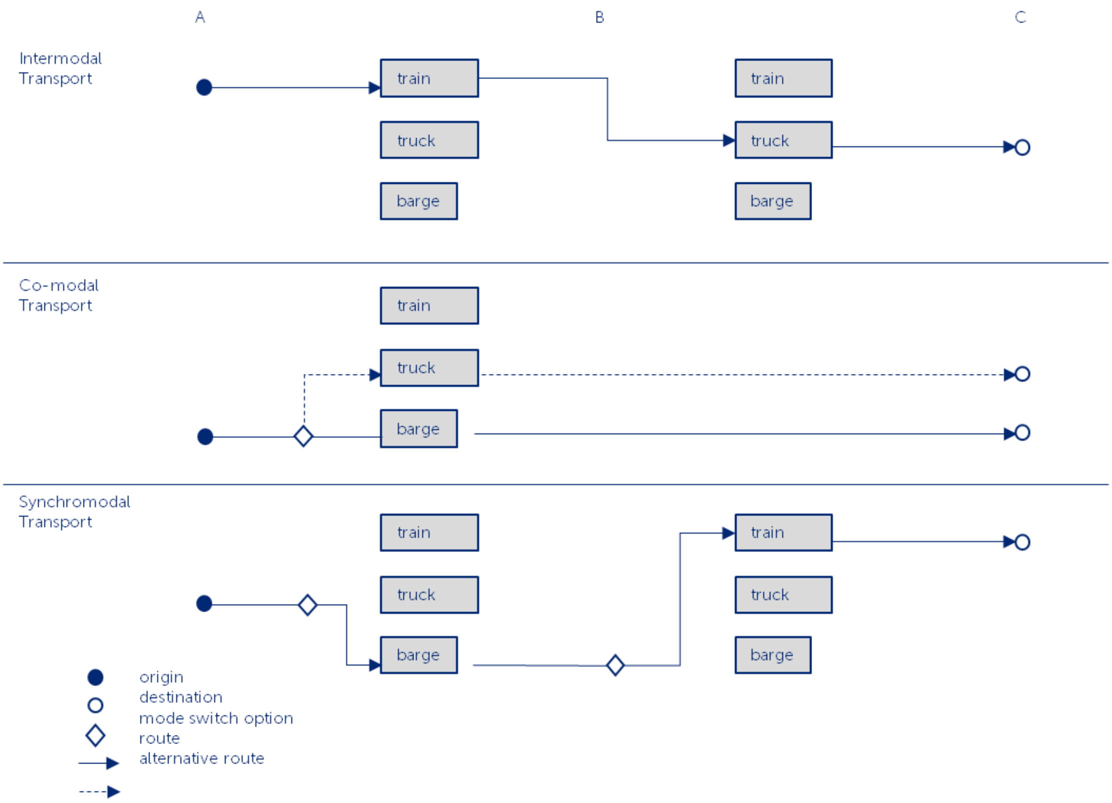


Figure 15: Intermodal, Co-modal, and Synchromodal transport. Adapted from: The future of freight transport: ECT's vision on sustainable and reliable European transport. Europe Combined Terminals, October 2011.

In the Figure, Intermodal transport depicts the planned sequential use of modes of transport. For example, to move from A to C, a container is transported by train from A to B, transhipped on a truck to move from B to C. Here the vertical synchronisation of sequential transporting and handling processes aims at avoiding waiting times. If a container is planned to be transported by barge from A to C but fails

[10] For even more background, we refer to: Behzad Behdani, Yun Fan, Bart Wiegmans, Rob Zuidwijk (2016). Multimodal schedule design for synchromodal freight transport systems. European Journal of Transport and Infrastructure Research 16(3): 424-444.

to be on time for departure, then a backup option would be to truck it. Here transport modes are organised as alternatives to hedge for uncertainties, which may involve horizontal collaboration between transport operators. However, in this case, the barge transport must be re-booked to a truck service. Synchromodal transportation combines the best of both worlds by using modes of transport both in sequence and as alternatives. Moreover, as explained, the mode choices are not made in advance but upon the container's arrival. This results in the dynamic routing of the container through the network, which will be discussed in more detail in Exhibit 2.

Exhibit 2: Dynamic Routing

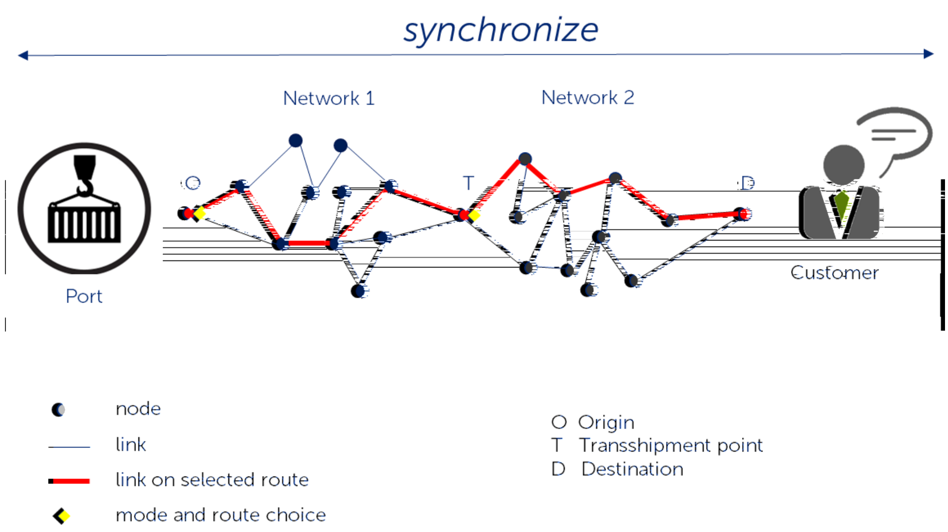


Figure 16: .

Dynamic routing implies that containers, upon arrival, find a route through a network (In Figure 16, Network 1 could be an inland waterway network) and at some point continue the route, possibly through another network (In Figure 16, Network 2 could be a road network). Interestingly enough, while dynamically choosing a route, dynamic customer preferences can also be considered. For instance, if it turns out that the required arrival time and date of the container change while the container is en route, the route can be adjusted accordingly. Furthermore, in dynamic routing, we need to be able to adapt routes according to events such as delays on the network.

So, the adaptive plan allows one to choose the most appropriate route under changing circumstances. Relevant circumstances are those that impact the availability and transit times of the various modes of transport along the links in the network. For example, if a certain route faces congestion, another route can be chosen that allows expedited transport. In order to demonstrate the benefit of adaptive routing, we consider both the total transport cost (vertical) and reliability (horizontal) of adaptive (blue) vs non-adaptive transport plans in the example network in Figure 17. Here reliability refers to the relative number of timely arrivals.

As usual, one always needs to make a trade-off between total transport cost and reliability. Making many reservations of transport capacity in the network will result in higher costs. The best possible

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[11] See: Rob Zuidwijk (2015). Are we Connected? Inaugural address, Erasmus University. Available via: http://repub.eur.nl/pub/79091

performance is low cost and high reliability, the lower-right corner in Figure 16. We can compare the two planning approaches (non-adaptive versus adaptive) based on the achieved trade-off between costs and reliability. The result is that adaptive solutions can achieve a better reliability-cost trade-off. Indeed, the adaptive solutions in (A) are better than the non-adaptive (B) both in terms of reliability and transport cost, although when accepting lower reliability levels, costs can be reduced by not making additional reservations (C). As such, we have illustrated that a particular innovation at the micro level, in this case, adaptive routing, creates better performance at the network level.

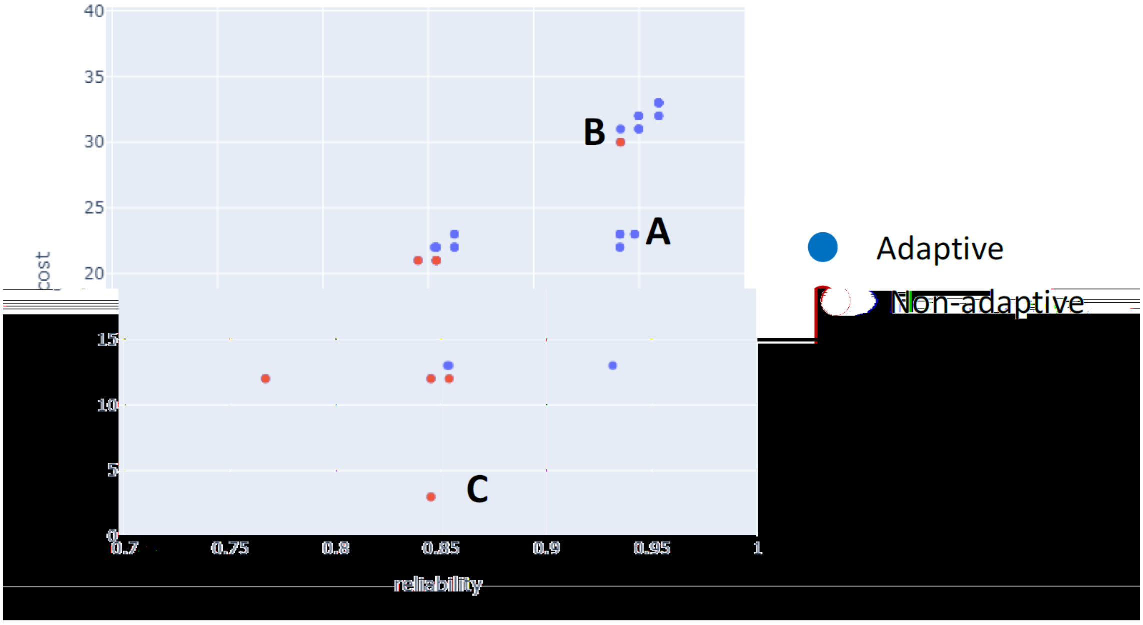

Figure 17: Reliability and cost of adaptive versus non-adaptive plans.

Exhibit 3: Smart Contracts in Synchromodal Booking

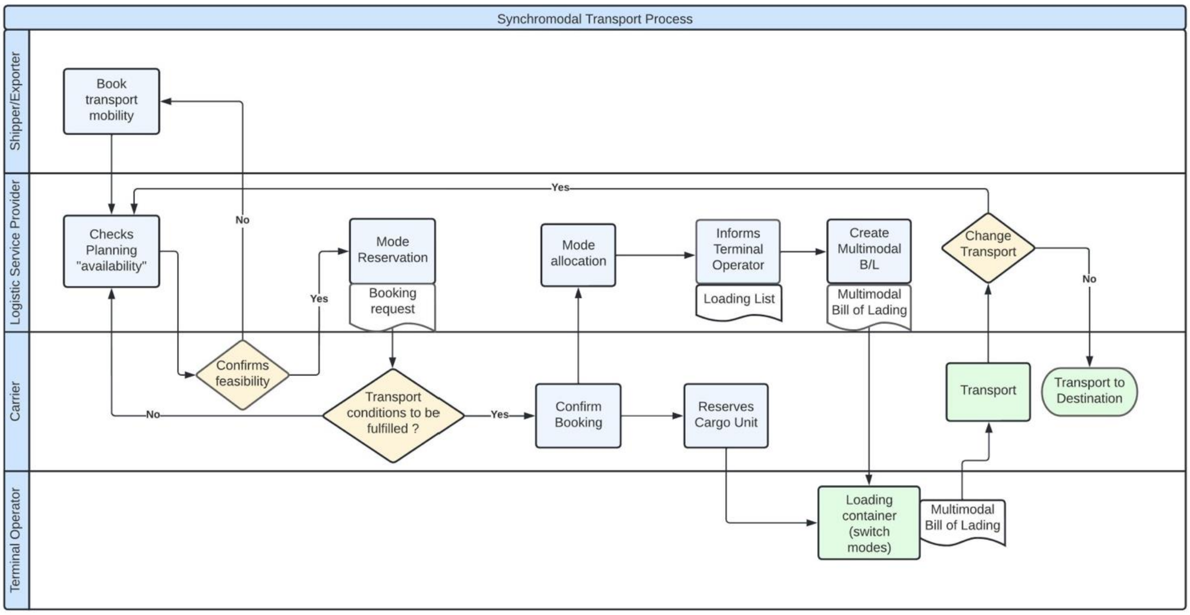

Figure 18: Synchromodal booking process

Figure 18 displays a workflow of a Synchromodal booking process. Here we discuss the benefits of using smart contracts in this process based on the Monte Carlo simulation. Figure 4 illustrates how the process flows in Synchromodal booking are modelled; each process step will take time, which is modelled by a stochastic variable.

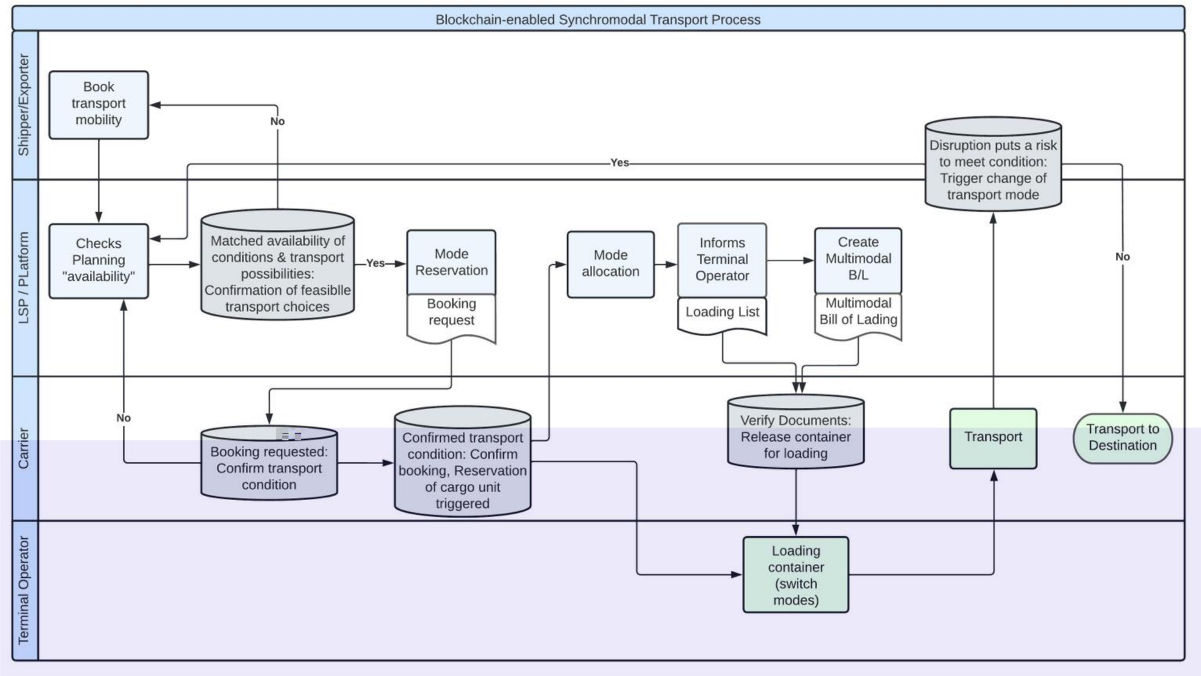

Figure 19: Synchromodal booking process enhanced by smart contracts

In Figure 19, several of these process steps are replaced by Smart Contracts. The smart contract functionality in these specific process steps results in shorter processing times. Given those time savings in particular process steps, using a Monte Carlo simulation, we can analyse the overall reduction of the completion time of the import process, as indicated in Figure 20.

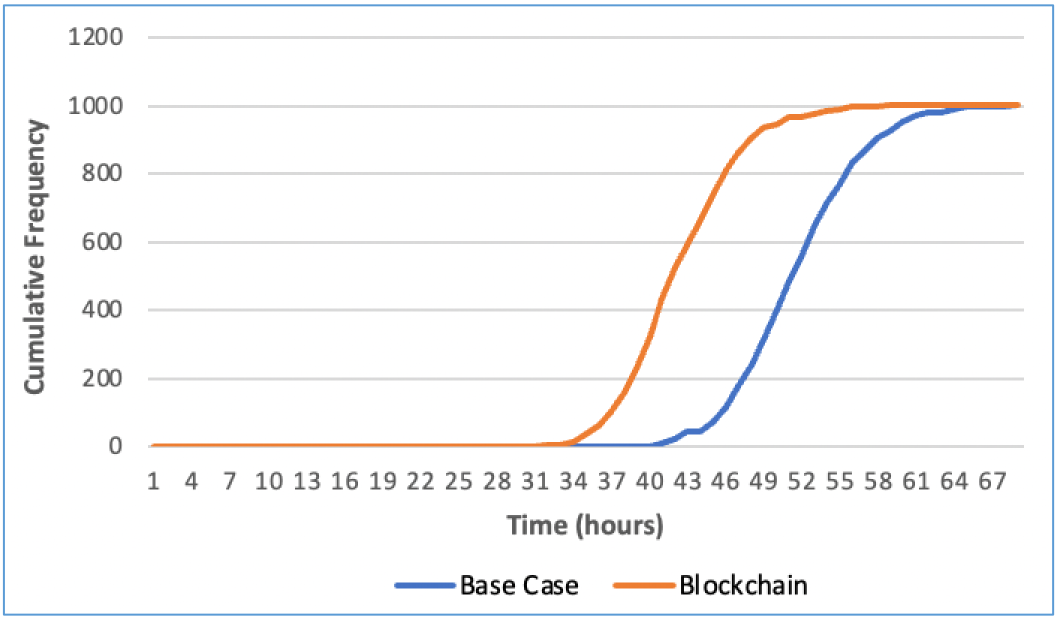

Figure 20: Monte Carlo simulation of overall time savings

The case in which Smart Contracts (Figure 19) are used – based on Blockchain technology – features a smaller throughput time (horizontal axis) as compared to the base case (Figure 18). The vertical axis shows the cumulative frequencies of the corresponding What is important here is the shift to the left from base case to smart contract case, i.e., toward lower throughput times

4 Guide for policymakers in emerging economies

4.1 Executive Summary

4.1.1 What have we done

This guide provides policymakers in emerging economies with an overview of innovative technologies such as the physical internet, blockchain, Internet of Things (IoT) and synchromodality in the logistics sector to implement multimodal freight transportation systems. The guide provides policy recommendations to foster and implement these technologies in the freight sector. The guide also provides a brief on the importance of urban logistics. Finally, it gives policy recommendations to facilitate the adoption of innovative freight technologies inspired by the learning in the PLANET Project and the EU. The recommendations also include a 4-step approach to implementing innovative freight sector policies.

4.1.2 The findings

In our task in the PLANET project, we found that logistics providers are subjected to various government policies and regulations to conduct operations. These policies and regulations can allow logistics companies to embrace innovation, benefitting governments in achieving climate-related goals by shifting to multimodal freight transport.

The PLANET project found that policymakers, specifically in emerging economies, often have a rough overview of freight sector policies, esp. in the urban logistics sector. More insight is essential into innovative technologies, such as the Physical Internet or Blockchain, that might fundamentally change the urban logistics system. We also found that several emerging economies have a problem involving stakeholders due to the diverse nature of the freight sector in the respective countries and cities. The lack of stakeholder involvement also makes the introduction of necessary frameworks for technologies complex.

Facilitating the adoption of innovative technologies through sufficient frameworks and regulations can accelerate the transformation in the freight sector. However, the future of the freight sector depends on how companies compete to serve their customers and provide various options to the customers. This area is not a level playing field, benefiting large companies. Through proper policy framework, this can be equalised.

There is a lot of potential for public and private sector collaboration, esp. in data gathering, developing new business models, and implementing new technologies. This option is less explored in the emerging economy context. Through proper collaboration, synergies can be unlocked, benefitting the country's social, economic and environmental aspects.

Promoting aspects such as synchromodality and hyperconnected logistics systems can enable countries to advance technologically towards multimodal freight transportation systems. As a result, multimodal freight systems can potentially reduce the CO_2 emissions from the sector and thus allow countries to meet their climate goals.

Finally, stakeholder involvement and data availability are at the apex of addressing the issues in the logistics sector, and technological innovations with good collaboration can allow countries and cities to overcome these challenges.

4.1.3 Our recommendations

Involve stakeholders and adopt a multi-stakeholder participatory approach

One critical insight from the Planet cases was that Governments and public administrations need to work closely with logistics and technology providers. The partnership will provide the decision-makers with a clear understanding of the logistics operators' needs and synergies. For example, logistics operators generate immense amounts of data, and private operators hold this data in many cases. With a good partnership with the governments, the data can be shared to support local planning and transport routing in cities. The participation from the governments will be to make cities more efficient. At the same time, companies work with governments to improve their operating efficiency. The partnership can also support governments in implementing ICT infrastructure that governments will be able to provide due to a lack of resources.

Invest in and improve the technical awareness and capacity of staff

A planned technical capacity development program is essential for involved government staff (and stakeholders) to increase awareness of the various technology options and the operation of the freight sector in general. Of course, governments need not implement all the available freight options. Still, knowing the options can accelerate their journey towards smart governance and logistics. Logistics companies must also embark on training activities to improve employees' skills and work performance.

Allocate sufficient resources and capacity

Resource availability is a crucial factor for governments to introduce innovative approaches. However, not all resources need to come from the government; through proper collaboration with the private sector, mutually beneficial aspects can be explored. Governments can also tap into fiscal instruments such as taxation and cross-subsidies to incentivise beneficial practices, such as introducing electric vehicles or improving the energy intensity of freight vehicles.

Many governments have introduced the concept of e-governance, leading to the digitalisation of various government services. The next step in evolution is moving from e-governance to smart governance. Moving to smart governance will mean investing in 5G technology and big data centres to collect and store the big data generated and analysed, implementing IoT sensors. Through partnerships and innovative business models, governments can create resources for new technology.

Setting standards to ensure security and privacy

Governments can pave the way for data sharing and control how much data is collected through proper regulations and frameworks. For example, a centralised data-sharing platform for freight operators will encourage data sharing.

Through standards set by the governments, freight operators can be compelled to follow standards in terms of package sizes and loading requirements. Therefore, standardisation can be a crucial element in implementing Physical Internet and Internet-of-Things

Reduce complexity in procedures through innovation

Easing formal procedures such as customs, inspection, and other administrative procedures can speed up the total time spent by transport. Using blockchain technology with smart contracting can support overcoming this challenge. Governments will need to work internally to streamline the processes and procedures and develop enabling frameworks, supporting horizontal collaboration in a PI network.

4.2 Introduction to the policy guide

The current global logistics services are not efficient as they could be and are unsustainable in the long run from an economic, environmental, and societal perspective. Despite progress, logistic service inefficiencies still exist in vehicles not loaded to the total capacity – on average less than 50% full (Belien et al., 2017) and trucks driving back empty after the deliveries. The multimodal option is also relatively less utilised. Twenty per cent of heavy-duty vehicles in the United States and 30-40 per cent in the EU travel empty after deliveries, causing inefficiency in road transport (Matusiewicz, 2020). Empty vehicles perform one in five journeys (in Europe) (Eurostat, 2019). Moreover, freight transportation (in developed countries) is responsible for nearly 15% of greenhouse gas emissions (see PLANET deliverable D2.13).

The environmental impact of the freight sector will continue to grow in the following decades (A. McKinnon et al., 2015). Therefore, addressing the growing freight issue is critical. It will reduce the environmental burden, pave the way for innovation, and reduce other externalities such as congestion, accidents, and noise pollution.

The other issues of unsustainable logistic practices include products sitting idle, mediocre coordination and communication within the distribution network, and low network security and robustness (Montreuil, 2011). The logistics supply chain involves multiple parties directly or indirectly, creating communication and end-to-end visibility challenges – making logistics processes inefficient. At the same time, expectations of all participants in the supply chain related to information transparency, reliability (track and trace) and service (payment) are increasing (PwC, 2020). Logistics activities include various stakeholders and require many resources, significantly impacting its sustainability performance. A significant share of the impact of the logistics activity comes from moving the goods, i.e., transportation. In the EU, transport is one of the largest energy-consuming sectors, leading to a high share of GHG emissions (European Commission, 2011). Yet, there is a direct link between economic growth and transportation (European Environment Agency., 2022).

Furthermore, the technological trends in the logistics sector have increased consumers' expectations. For example, same-day deliveries and free returns of purchased goods have fuelled the logistics demand to a great extent. In the EU, inland freight transport activity increased more than passenger transport by 22% between 2000 and 2019. (European Environment Agency., 2022). In 2020, the total share of inland freight transport by road was 77.4% and an increase of 8% from 2010 (EUROSTAT, 2022). Therefore, improved logistic services are a need to address these challenges.

In the present day and age, a consumer is not just interested in simply ordering a product. However, they are also curious to know when it will be delivered (as accurately as possible) and where their product is after ordering. Therefore, they want to adjust the delivery time window and location, which was not possible a few years back. The "improved" customer service is partly due to the technological innovations that shippers and freight carriers (such as DHL, TNT, and UPS) adopted.

As technology develops and improves, it has a profound effect on the way people and goods move. Innovations in information technology have a significant impact on consumer behaviour. On the other hand, technological improvements have benefitted the supply chain through automation, efficiency gains, increasing competitiveness and new strategies to attract customers.

Technological improvements have streamlined many processes in logistics supply chain management. The introduction of technologies such as electronic data interchange, global positioning systems (GPS), and Smart Contracts (through blockchains) lead to various advantages for the carriers.

The COVID pandemic has shown that flexible, integrated, and transparent supply chains, with predictive analysis and insights, have been the most resilient. Incorporating advanced technologies will become inevitable for many carriers to stay in business due to stiff competition. Choosing the right technology that echoes the organisational strategy can lead to economic and environmental efficiencies. The supply chains of tomorrow will be predictive, self-adjusting and intelligent.

This policy guide aims to support decision-makers in emerging economies to increase their awareness of the technologies that are available in the freight sector. The reader is informed on how these technologies can enable the shift to multimodal freight transportation systems, their climate benefits, the means of implementing such measures, and the critical actors involved in the implementation.

4.3 Technology in the logistics industry

As digitisation takes centre stage, the entire supply chain becomes more transparent, i.e., all the actors involved in the supply chain (supplier – shipper – customer) can know the location of their shipments. Furthermore, innovations in data management and processing, esp. big data analysis, open a wide range of opportunities. One such is the possibility for predictive and prescriptive insights. For example, shippers can identify any existing blocks in the route or can predict in a short time if a block is going to occur and prescribe a new route that would still allow the delivery with minimum delay. This ensures that the customer receives the shipment on time and reduces costs incurred for the carrier.

The real-time visibility of the entire global value chain provides companies with critical demand and supply data, with which the suppliers can adjust their demand while the goods are still in transit.

The freight sector is crucial in transporting goods and products through supply chains. The freight sector is also experiencing innovations due to the advent of digital solutions. Using digital solutions has proven to streamline the supply chain operations and its management.

Innovative technologies such as artificial intelligence (AI), machine learning (ML), Internet-of-Things (IoT), distributed ledger technology or blockchains are developing at an unprecedented rate and are shining light on new opportunities in the freight sector (Wang & Sarkis, 2021).

Digitalisation enhances transport sustainability in physical, environmental, economic, and social dimensions (Sarkis et al., 2020). Technological innovations also increase the possibility of multimodal transport and encourage an integrated freight transportation system (Harris et al., 2015).

Through AI and ML[12], analytics can also provide the essential data to predict demand over time and help suppliers manage their manufacturing to meet the demand. In addition, ML algorithms can analyse scenarios and allow efficient pricing options for suppliers and shippers.

4.3.1 Vehicles

The advent of electric vehicles enables carriers to move towards cleaner and quieter vehicles for deliveries. Carriers such as DHL are already moving to electric vehicles for urban deliveries. This shift to electric vehicles not only improves the corporate image of the carrier, thus boosting the competitive edge, but also benefits the local environment from reduced air pollution. There are also other economic benefits from reduced fossil fuel purchases.

[12] AI = Artificial Intelligence | ML = machine learning

Another delivery vehicle technology is the use of drones for parcel deliveries. Drones can be used in large warehouses and cities (as last-mile delivery). Drones can have built-in barcode scanners that would feed the data directly into the inventory database, and the routes of the drones can be pre-programmed. Using drones can reduce delays in warehouse operations and reduce labour costs.

4.3.2 IoT, Big data and Smart contracts

Internet of Things (IoT)

The Internet of Things (IoT) and smart contracts are two increasingly popular technologies making strides in logistics. IoT aims to deliver an interconnected system by using intelligent sensors. The European Commission Information Society defines IoT as "having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts" (Ben-Daya et al., 2019). IoT devices can collect information using the Internet, RFID, and other sensors. This information can relate to the state of the products being transmitted. For example, IoT can be beneficial when shipping perishable products and products that need to be in cold storage while in transit. Through the sensors, the shipper is aware of any changes in the shipping environment for the products, and necessary action can be taken (Paksoy et al., 2021).

The Internet of Things (IoT) connects physical objects via wireless sensors and communication devices, resulting in an interconnected network of uniquely addressable objects. The sensing device is uniquely addressable and inherits standardised communication protocols, which allow the devices to collect, autonomously process, and share data in a global infrastructure of connected physical objects (Koot et al., 2021). The IoT paradigm includes physical and virtual entities, networks, and technologies. Integrated ICT, such as Radio Frequency Identification (RFID), Wireless Sensor Networks (WSN), and Global Positioning System (GPS), connect the different elements of IoT. Table 1 shows the critical IoT technologies for logistics applications (Tran-Dang et al., 2020a).

Table 4: Key enabling IoT technologies for logistics applications (Source: Tran-Dang et al., 2020)

	Functional Block	Enabling Technologies	
		Classification	**Examples of key technologies**
Enabling Technologies for Data-Driven IoT	**Data-Acquisition** *Generate and acquire relevant IoT data*	Identification	RFID, 2D-QR, Bar-Code, NFC
		Sensing	Sensors (i.e., bio-sensors, humidity, temperature sensors)
		Tracking	GPS, GPRS (General Packet Radio Service)
	Connectivity *Transmit IoT data to IoT devices and Cloud*	Global coverage	Cellular (2G, 3G, 4G, 5G), satellite
		Long range coverage	LPWA (Low Power Wide Area) (Sigfox, LoRa, NB-IoT, LTE-M)
		Short range coverage	Wi-Fi, Zigbee, Bluetooth, BLE (Bluetooth Low Energy)
	Data Processing *Filter, classify, sort, analyze IoT data to get insights into it*	Cloud Computing: The whole big IoT data is processed at the remote and powerful Cloud	
		Edge/Fog Computing: Sets of IoT data are processed at edge IoT devices or Fog nodes near to the data sources (IoT gateways, routers) to improve performances (e.g., reduced latency, balanced traffic-load)	
		Big Data Analytics, Machine Learning, Artificial Intelligence: Relevant algorithms are used to analyze the IoT data and then predict the trends to improve decision makings	
		Middleware: Regardless the IoT characteristics (i.e., heterogeneity, complex structure), middleware relies only the IoT data to create intelligence applications, and services.	

Some of the critical applications of IoT in logistics domains include real-time monitoring of product conditions (e.g. the status of shipments inside the containers), smart warehousing (e.g. real-time localisation of inventory in the warehouse), freight transportation (e.g. real-time freight tracking for efficient management of shipments), and last-mile delivery (Tran-Dang et al., 2020a). In addition, the real-time monitoring of physical assets via IoT technologies improves logistics operations' transparency, traceability, and reliability by mapping the real world into the virtual world (Koot et al., 2021).

Considering the application of IoT for logistics supply (e.g., warehouses, trucks, planes etc.), it supports capacity sensing, planning, reporting, route optimisation, energy management, and fault detection and resolution (see Table 5 (Lacey et al., 2015)). In contrast, for logistic demand (e.g. customers, packages, containers, etc.), it supports environment monitoring and management, threat detection and prevention, and real-time traceability (see Table 6 (Lacey et al., 2015)).

Table 5: Applications of IoT for logistics supply (warehouse, trucks, planes, etc.)

Capacity sensing	Planning & reporting	Route optimization	Energy management	Fault detection & resolution
Systems that can detect and communicate open spaces in a warehouse,	Systems that can detect and analyze events such as traffic accidents	Tools that can map the shortest or most fuel-efficient	Tools that monitor and enable decision making	Systems that can monitor fleets of

Table 6: Applications of IoT for demand (customer, packages, containers, etc.)

Environment monitoring & management	Threat detection & prevention	Real-time traceability
Systems that can monitor and adjust the temperature at which a package is maintained	Tools that can help detect unauthorized openings of shipping containers, helping to prevent and reduce theft	Systems that can track and track not just vehicles or shipments but individual items

Big Data

The "Big Data" in logistics refers to the enormous datasets generated at various levels (e.g., routes, carriers, deliveries, transportation modes etc.), which are growing at an accelerated pace. The extraction of useful information from these vast datasets is called "Big Data Analytics (BDA)", which could be valuable for organisations (Koot et al., 2021) in terms of forecasting demand in businesses, understanding customers' changing patterns, and estimating warehouse capacity.

The study (Yan et al., 2019) highlights that big data has a transformative significance for logistics and its future development. The core of achieving highly efficient operation in the various stages of logistics lies in processing the value of Big Data and combining it with different equipment and operation strategies. The extensive application of the IoT, mobile internet and other advanced technologies support collecting relevant logistic data from several components (such as logistics elements, facilities, tools, and operation processes). Big data can generate tremendous value. With the maturity of technologies such as cloud computing, the computation and storage of vast data would be more accessible. The value of big data grows with the connection among data, the expansion, re-usage, and reorganisation of big data. Moreover, the accessibility of big data plays a vital role in enhancing the level of development of all societies. Big data can be re-used as digital assets by various organisations (e.g. government, industry and other societal organisations), which, when transferred to the community, create more societal value (Yan et al., 2019).

Smart Contracts through Blockchain

Blockchain (BC) is increasingly becoming prevalent in logistics. In addition, the cryptocurrency markets have popularised blockchain technology. Yet, the theory of blockchains is implemented in other sectors to increase transparency and security and decentralise data. In simple terms, a blockchain is a series of connected blocks, hence the term chain. Each block in the chain has data stored and information on the preceding block and the following block. The only exception is the first block in the blockchain, the genesis block.

The nature of the blockchain predefines the data stored in the block. The process of writing data in a block is called a transaction. These transactions are secured by complex algorithms enforcing data security. All the data in the blockchain is called a ledger or a database (Chbaik et al., 2022). The critical difference between a conventional database and a blockchain ledger is that blockchains allow for distributed ledgers. A copy of the ledger is shared with all the critical nodes in the ecosystem (Tapscott & Tapscott, 2018). In a logistics sense, this could be the suppliers, carriers, and consumers. Any new addition to the chain is first crosschecked with other copies of the ledger to avoid duplication and discrepancies. Once the transaction is accepted, it is copied to all the copies of the ledger. Having a distributed ledge increases the security of the blockchain and increases transparency. For example, blockchain technology has been used in logistics to detect fake and counterfeit products (Kersten et al., 2017).

With the introduction of blockchains, smart contracts have become popular in blockchain applications. While the term smart contract came into existence in 1997 (Szabo, 1997), it was a theoretical concept until the introduction of blockchain.

In simple terms, a smart contract is a computer code that records the promises of each contracting party (Golinska-Dawson et al., 2020). Smart contracts are integrated into the blockchain and are automatically executed when certain pre-described and agreed conditions are met. Smart contracts need specific types of blockchains to operate. In addition, a blockchain needs to be able to execute the code necessary for executing smart contracts (Bocek et al., 2017). With smart contracts, transactions between companies can be automated across the entire supply chain (DHL & Accenture, 2018; Paksoy et al., 2021).

In short, blockchain allows multiple parties to share and update data, building trust in the actions without a need for participant verification; removal of intermediaries reducing cost and complexity, time-sensitive interactions; and the exchange of transactions (PwC, 2020).

Some of the key characteristics of blockchain are (Nayak & Dutta, 2017):

- Decentralisation. Instead of one central node, control over a transaction is distributed among peers via a distributed ledger.
- Digital Signature. Transactions take place using unique digital signatures that rely on public and private keys, offering authentic proof of ownership.
- Chain of Blocks. Transactions are stored in blocks using cryptographic methods.
- Data integrity. Data cannot be tampered with, as complex algorithms and consensus ensure immutability and safety.

4.3.3 Physical Internet

Physical Internet (PI) is an emerging transport and logistic (T&L) paradigm advocating an open global logistics system based on physical, digital, and operational interconnectivity through Encapsulation, interfaces, and protocols (Pan et al., 2017). Interconnectivity can be the seamless integration of physical entities, such as hubs or containers, and human or organisational actors to form one collaborative logistics network (Montreuil, 2011; Saoud & Bellabdaoui, 2017).

The introduction of PI promises to revolutionise T&L practices and to improve crucial variables such as cost, utilisation rate, and emissions through improved multimodal integration and open accessibility to static and mobile infrastructures. PI is a hyper-connected T&L system whose operation follows the principles of open and standardised interfaces, monitoring and data sharing, intelligent decision-making, and modularised Encapsulation (see PLANET deliverable D2.13). The section below briefly describes the principles of PI.

With the adoption of PI in Logistics, there is a possibility to achieve higher efficiency and utilisation of cargo transport, including intermodal shipments that utilise greener transport modes. With Physical Internet, potential technological, standardisation and infrastructural elements enabled, a 300% increase in transport demand could be achieved with only a 50% increase in assets (see PLANET deliverable D 1.2). A study (Sarraj et al. 2013) demonstrates that PI could reduce the total cost by 30% and greenhouse gas emissions by 60% while maintaining a high level of service delivery to the customers. Other advantages include time efficiency due to uninterrupted delivery services and improved driver working conditions (Hasan et al., 2021). However, the study by (Hasan et al., 2021) highlights that despite the advantages the PI may offer, it cannot continue relying on centralised networks or the existence of a leading authority. This way, the PI can increase if it is a distributed and community-driven concept and approach. Although the progress in many technological and infrastructural elements of the T&L system is ongoing, the PI is still in development and is expected to become functional over the following few decades (see PLANET deliverable D2.13).

4.3.4 Status quo PI and BC in freight in EU and disadvantaged regions

Logistics services are evolving rapidly (worldwide), mainly due to the introduction of new management frameworks, such as the Physical Internet and Industry 4.0, and new technologies, primarily ICT-based, such as the Internet of Things (IoT), Business Analytics, Artificial Intelligence, and Blockchain companies (Perboli et al., 2018). However, as the logistics supply chain involves multiple parties directly or indirectly, it can create challenges related to communication and end-to-end visibility – making logistics processes inefficient. At the same time, expectations of all participants in the supply chain related to information transparency, reliability (track and trace) and service (payment) are increasing. As mentioned in the sections above, BC is emerging as a possible solution for these challenges.

Nevertheless, there are still hurdles to its proper implementation. They are (PwC, 2020):

- Knowledge and awareness - Lack of understanding and awareness of BC and its potential, limited skilled workforce and lack of trust among companies
- Interoperability – integration issue due to different solutions applied by each involved party, and no standard 'one blockchain' solution
- Performance – only specific use cases of existing blockchain solutions (e-g- online payments)
- Regulation and governance – lack of definite legal frameworks to govern blockchain transactions in different domains
- Risk of disintermediation – affecting intermediates

Based on the study by ALICE-ETP (Ballot et al., 2020), the current status of PI in various aspects:

- Non-standardised transhipment Nodes
- Rise of booking platform for logistic services
- Separated subnetworks – no interconnected global networks, and the goods cannot seamlessly flow across them
- Availability of network integration and embracing digitalisation strengthen interconnectivity, but the coordination function within supply chains is fragmented and differs among different chains

- The governance of Logistics Nodes, logistics networks and Systems of Logistics Networks is characterised by a scattered and unbalanced set of terms, rules, standards, and regulations, and no harmonised reference agreed on governance framework yet.

4.3.5 Application use case and features

Physical internet aims for a paradigm shift towards economically, environmentally, and socially sustainable logistics. However, the implementation requires infrastructure, technology, and business model transformations, which cannot be met by centralised solutions, as proposed by various literature. The study (Meyer et al., 2019) highlights that a Blockchain-based conceptual framework offers a solution for fundamental barriers to the Physical Internet concerning the exchange of value and physical assets in logistic networks and decentralised leadership structures.

Concerning PI requirements, a study (Meyer et al., 2019) based on various literature analyses and stakeholder interviews (with shippers, logistics service providers (LSP), researchers, and consultants) shows some PI requirements in two categories - Infrastructure and Operation and information (see Table 7).

Table 7: Physical Internet requirements (Meyer et al., 2019)

Requirements	Stakeholders		
	Shipper	LSP	Researchers
Infrastructure			
Distributed benefits through defined responsibilities and roles	X	X	X
The network structure of equal power and no central leadership	X	X	X
A structure characterised by high integrity, robustness, and resilience	X	X	X
Rules (or certificate) for entry, participation, and network usage		X	
Fast, cheap, and reliable interconnection of nodes, transport assets and containers	X	X	X
Operation and Information			
Assurance of trustful collaboration and data sharing	X	X	X
Secure and fair rewarding rules for service		X	
Assurance of fair shipment routing and container consolidation		X	X
Integration of on-demand or on-per-use contracts for services	X	X	
Integration of algorithms for efficient shipment routing and container consolidation		X	X
Transparency about containers along the shipment process (track and trace)	X	X	X

Those PI requirements can be met by at least one BC functionality or a combination of many mutually dependent features. Figure 21 shows that BC technology can solve PI barriers and allows a trustful and secure exchange of value in an untrustworthy environment (Meyer et al., 2019)

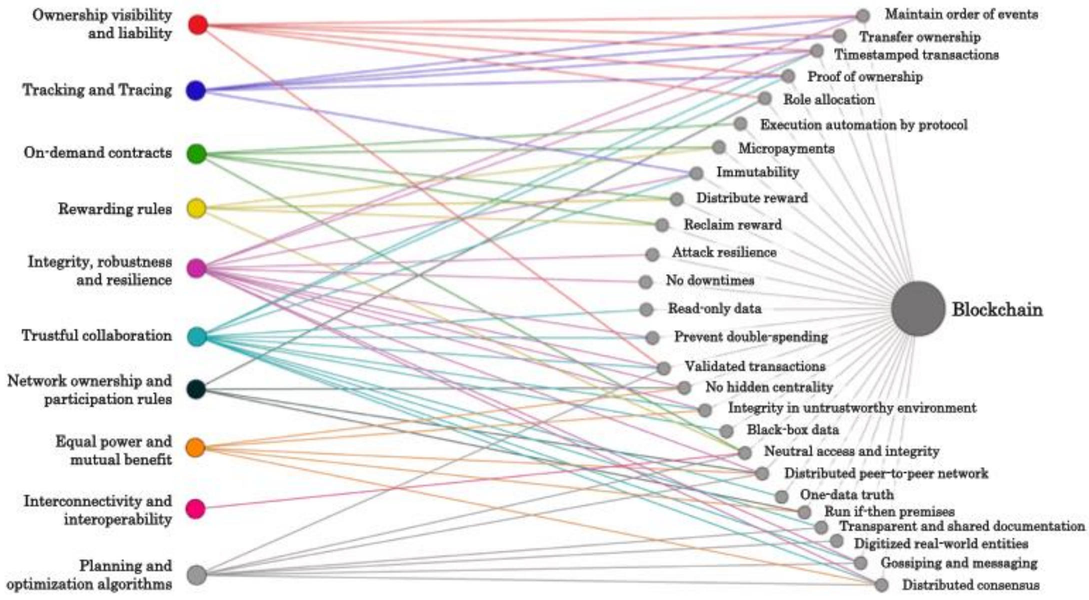

Figure 21: Physical Internet and Blockchain Interrelationship diagram (Meyer et al., 2019)

Ownership liability and product traceability – able to transfer value securely and transparently between peers and prove ownership of transferred object with the timestamped transactions

- On-demand contracts and rewarding – Protocol-based smart contracts confirm the fulfilment of a contract and execute the reward for the fulfilled services, and the possibility to transfer even small amounts of money between actors
- Integrity, collaboration, and leadership – assured by the immutability of BC data, and equal distribution of power to each peer
- Shipment allocation and PI algorithms – provide a trustful database and can derive all kinds of information, such as performance indicators (e.g., delivery reliability) or routing and handling data

Besides that, blockchain has several use cases that support logistic companies to increase speed, traceability, and cost reduction. Some of them are highlighted below (PwC, 2020):

- Provenance refers to a timeline of changes in an object's ownership, custody, or location. It ensures every shipped good has a digital "passport" that proves its authenticity.
- Payments and invoicing – Blockchain can store and share digitised records while creating smart contracts that automatically handle invoices and payments to shorten processing times and ensure accuracy.
- Digital documentation: the combination of blockchain with the Internet of Things (IoT) enables intelligent logistics contracts. This is possible when digitised documents (e.g., bills of lading, certificates, invoices, pre-advice) and real-time shipment data are embedded into blockchain-based systems.
- Identity management: Blockchain Identity Management uses a distributed trust model to ensure privacy, where identity documents are secured, verified, and validated by authorised participants.
- Logistics marketplace: enables smooth and integrated communication across complex supply chains. It can also create platforms where logistics service providers offer real-time free capacity in trucks and ships.

4.3.6 Living Labs in PLANET project

Referring to the PLANET project (deliverable 2.15), BC technologies are used by LL2 partners and specifically by the Port of Rotterdam for the digitisation of logistics documents and target the exchange of information between shipping lines, logistics operators and the Port of Rotterdam. Interoperability between the Blockchain networks of the two ports – Port of Valencia (PoV) in LL1 and Port of Rotterdam (PoR) in LL2 - is achieved through the Blockchain network of the logistics operators, namely DHL, as can be seen in Figure 5.

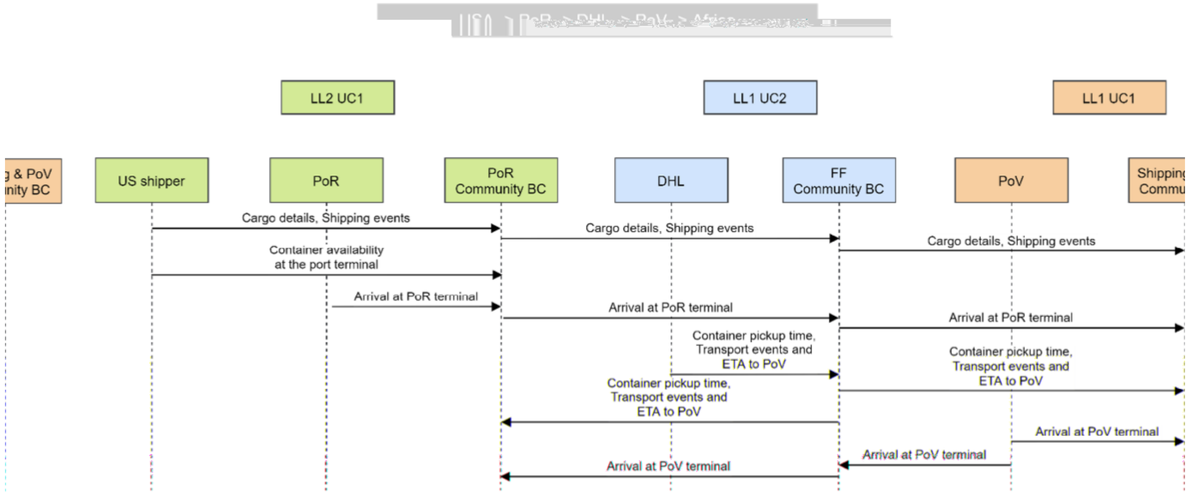

Figure 22: Exchange of Road Transport Document scenario (PLANET project (D 2.15)

PoV and PoR use different road transport documents; PoV uses the Unified Transport Document (UTD, or DUT, as the Spanish acronym), while the PoR uses the electronic Road Transport Document (eCMR). Information and events related to road freight transport can be shared, through eCMR, across both platforms enabling road transport optimisation between the PoR and PoV. An example of a possible optimisation scenario: The road segment of an international shipment involves the following steps. A truck picks up the freight at the PoR, and the driver issues an e-CMR. Information about the dispatch, destination, ETA, freight volume and weight are immediately shared across the integrated Blockchain platforms of LL1 and LL2. Connected warehouses and logistics service providers at the PoV are now empowered to anticipate the incoming cargo and reserve storage or transport space for the next shipment segment while the freight is in transit. The EGTN Blockchain Service acts as a proxy between the two ports, which exchange hashes of the documents along with metadata through their Blockchain systems, with the actual documents being shared through the EGTN Platform and retrieved only by trusted actors. PoV uses the Blockchain in Transport Alliance (BiTA)14, while the Port of Rotterdam uses GS1 standards15. The EGTN Blockchain Service adopts a mix of the above standards to define a common data model and accommodate the different structures.

4.3.7 Logistics challenges

The current global logistics services are not efficient as they could be and are unsustainable in the long run from an economic, environmental, and societal perspective. Though some progress was achieved, logistic service inefficiencies still exist in vehicles not loaded to the total capacity – on average less than 50% full (Belien et al., 2017) and trucks driving back empty after the deliveries. The multimodal option is also relatively less utilised. Twenty per cent of heavy-duty vehicles in the United States and 30-40 per cent in the EU travel empty after deliveries, causing inefficiency in road transport (Matusiewicz, 2020). One in five journeys (in Europe) was performed by empty vehicles (Eurostat, 2019).

Moreover, freight transportation (in developed countries) is responsible for nearly 15% of greenhouse gas emissions (see PLANET deliverable D2.13). The other issues of unsustainable logistic practices include products sitting idle, mediocre coordination and communication within the distribution network, and low network security and robustness (Montreuil, 2011). In addition, the logistics supply chain involves multiple parties directly or indirectly, creating communication and end-to-end visibility challenges – making logistics processes inefficient. At the same time, expectations of all participants in the supply chain related to information transparency, reliability (track and trace) and service (payment) are increasing (PwC, 2020). Therefore, improved logistic services are a need to address the challenges. Introducing the Physical Internet (PI) with ICT-based technologies can be a part of the solution.

4.3.8 Principles of PI in transport and logistics

To incorporate current Transport & Logistics practices into the PI concept, an Open Logistics Interconnection (OLI) has four layers. They are Encapsulation (to standardise the packaging process of cargo and goods); Shipping (to specify transportation goods and the process); Networking (to define the infrastructure interconnection from transporting facilities to customers); and Routing (to create detailed transport plans from origin to destination) (see PLANET deliverable D2.13). In addition, these layers could include four fundamental PI principles in the T&L infrastructure (see PLANET deliverable D2.13):

- The ability to effectively handling of modular packaging with standardised containers;
- The increasing digitisation of T&L infrastructure (with IoT sensors and Track and Trace capabilities);
- The integration of the firm decision support tools (DSS) that enable efficient cargo and fleet routing and distribution; and
- the open access to transport, terminal, and warehousing services.

In a nutshell, companies associated with logistic services are motivated to enter PI networks considering: a reduction in logistics, storage and handling costs; access to enhanced logistics resources and competencies; acceleration of the transition to greener and cleaner transportation activities, increase efficiency in hub-utilisation, last-mile deliveries and general cargo transport; enter into system integration and collaborative business strategy to improve transparency along the supply chain network; and co-develop innovative business models (Plasch et al., 2021).

To achieve logistics optimisation, the PI sets common and universally agreed-upon standards and protocols to enable horizontal and vertical cooperation between organisations (Treiblmaier et al., 2020).

4.4 Synchromodality and Hyperconnected Logistics

The International Transport Forum (ITF) predicts that the freight transport demand will double over the next three decades. Under the current situation, global freight emissions will not lower by 2050 but will increase by 22% compared to the 2015 levels (ITF, 2021). As a result, freight transport also contributes significantly to global greenhouse gas (GHG) emissions. While implementing bolder moves to improve vehicle technologies in the road transport sector can reduce GHG emissions, a more tangible impact can be seen by shifting the freight from road to rail and water transport. It is because the CO emissions from rail and water-based transport systems are 3.5 and 5 times lower than road transport (A. C. McKinnon, 2016).

In addition to providing environmental benefits, synchromodality and hyperconnected logistics systems can also provide economic benefits to the shippers. The ability to adjust the transport mode in real-time and avoid and overcome uncertainties gives the shippers an edge to predict the deliveries more accurately and reduce operating costs.

Suppose shippers can switch modes based on the traffic situation or on the customers' demands. In that case, the efficiency of logistics operations is significantly influenced. The key idea behind synchromodality is to enable unseen synergies in logistics.

Synchromodality or synchronised intermodality is a concept where shippers can use multiple modes to deliver shipments. Synchromodality can encourage mode-shift to environmentally friendly modes of transport and provide economic benefits to the shippers.

Introducing synchromodality in the freight sector can also create innovative business models and encourage cooperation among freight operators. However, for governments to promote synchromodality, there is a need for some policy alignment, and this will lead to more significant social, environmental, and economic benefits.

Hyperconnectivity, in general, is defined as “super-fast connectivity, always-on, on the move, roaming seamlessly from network to network, where we go – anywhere, anytime, with any device”. A hyperconnected system is where the components and actors are deeply connected on various layers and are available anytime and anywhere. The hyperconnectivity in the network enables the PI stakeholders and constituents to avail and share all the information when making decisions regarding their abilities and capabilities (Oger et al., 2018).

A hyperconnected logistics system aims to improve the efficiency of goods delivery in terms of routing, speed, and inventory management (Betti et al., 2019). This is possible due to the deep integration and sharing of information at various layers. Therefore, to improve logistics capability, efficiency, and sustainability, a hyperconnected logistics system depends on the connectivity among the PI layers, such as digital, physical, operational, transactional, legal, and personal layers.

A hyperconnected system requires strong collaboration among the various logistics actors. Research has shown that horizontal and vertical collaboration and cooperation allow operators to gain more insight into their capabilities and abilities. This identification will enable organisations to use the capacity and ability of other counterparts in the PI network when such a capability is absent internally. Hyperconnected logistics can encourage cooperation over competition, thus providing benefits to all actors involved. In addition, a hyperconnected logistics system can provide environmental and economic benefits.

4.4.1 Enablers and barriers to synchromodality

To implement synchromodality (and intermodality), private and public actors must cooperate. Cooperation becomes the key to realise the benefits of the concept in a shorter timeframe.

Technology

As synchromodality requires multiple modes and for the shippers to make the decision, there is a need for real-time information. Therefore, there is a need to embrace new technology options in logistics. For example, using the Internet of Things (IoT), shippers can know the state of the shipments and the location. When synchromodality is embedded into the Physical Internet (PI)[13] structure, synergies are observed, as PI advocates for Encapsulation, i.e., modular packages with standardised sizes that can be easily categorised. When IoT and Encapsulation come together, it is easier to move the shipment between modes reducing the transfer time.

This would also mean a need for proper data collection, management, and retrieval systems. As the role of technology in logistics increases, vast amounts of data are generated, and the need for data storage and retrieval becomes prominent.

Blockchain technology in logistics can support more accessible, transparent, and secure data retrieval. Blockchain technology, coupled with smart contract capabilities, can automate the synchromodality process with conditions defined by the shipper (Acero et al., 2021). For example, a shipper carrying perishable food stocks can prioritise the consignment if there are delays in the transport. Predefined conditions can also automate the costing process based on the customers' urgency for the delivery. An automated process will automatically compute the costs and time involved in the consignment reaching the consumer. In general, and in straightforward terms similar to a GPS showing all possible routes to a destination and identifying the eco-friendly and fast routes, accounting for the real-time traffic situation.

Infrastructure

While data management requires a certain level of infrastructure provisioning for synchromodality, the scope of infrastructure is broad. We are essentially talking about the entire transport system. This includes the rolling stock (i.e., trains, trucks, barges) and terminals (dry and water ports, railroads, roads, and water channels).

Governments play an essential role in the provision of the necessary basic infrastructure. Therefore, while planning new or expanding the existing infrastructure networks, it is vital to have a holistic approach and incorporate the synchromodality objectives, i.e., physically integrating modes. In addition to integrating the modes, it is also necessary to picture from a network perspective such that shifting between modes along the network is possible.

The data gathered from the various data points merge at data centres, managed by an orchestrator (Tavasszy et al., 2015). The primary role of the orchestrator would be to match the actual supply and demand at the operational level. The part of the orchestrator can be held by an actor in the supply chain or automated through an ICT platform. The orchestrator may also be responsible for data exchange between the various entities involved in the supply chain, the shippers, the carriers, and the consumers.

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[13] Montreuil (2011) originally defined Physical Internet (PI) as “

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By sharing information within the supply chain actors, it is easy to mitigate unexpected events such as delays on the network and cancellation of orders.

When proper infrastructure is provided, shippers can have seamless transactions with customers. As the number of transport modalities increases for the shippers, they are flexible on how the shipment is delivered to the customer. In this event, when an order is placed, the shipper would not fix the mode of transport but decide on the delivery characteristics, e.g., when they need the delivery. Based on the preference, the costs for shipping can be optimised. This is similar, in a general sense, to e-commerce deliveries. When customers place an order, they will not choose how the product is shipped but the delivery date. Faster deliveries will attract a higher shipping cost.

Institutional arrangements

Governments play an essential role in implementing synchromodality and the physical internet. Through incentives and policies, governments can encourage the disclosure and sharing of data collected by the shippers. Blockchain technology could increase the data-sharing process's security and transparency.

Similarly, governments can encourage options that allow small and medium enterprises (SMEs) to work together or incentivise SMEs to use innovative technology that enables them to benefit from PI and synchromodality. With PI and synchromodality, new business models are bound to arise, and these models could allow SMEs to collaborate in shipping their consignments. For example, a potential possibility in an urban context would be shippers collecting orders from various SMEs and delivering them to the customers. This is facilitated through micro hubs and consolidation centres that could act as urban ports for further deliveries within the city. The deliveries can then be decided through different transport modes depending on the consumers and shipment needs.

On a broader scale, governments can also support seamless clearance procedures for shipments from foreign countries. Governments can also automate tax calculation and payment procedures to complete the necessary formalities electronically. Again, using smart contracting can streamline this process.

Partnerships with governments and private entities can enable data sharing about the consignments. As a result, consignments will spend less time at the border clearance when integrated with electric clearance facilities, saving travel time and costs.

Awareness

For governments and the private sector to openly embrace synchromodality, there is a dire need to increase awareness of the concept and the potential benefits that synchromodality (and the physical internet) can bring to each involved entity. Once there is an increase in awareness, shippers will not insist on the kind of transport used for shipping their consignments but rather focus on the quality of the service. This will also allow the consignment carriers to choose the mode essential for delivering the shipment. Therefore, the carriers will only need to satisfy the shippers' demands in terms of service quality, thus optimising the costs incurred as long as the service quality objective is met.

A mental shift from thinking of modes as competing entities to complementary modes is essential. This can only be achieved through proper infrastructure integration, which is possible through increased awareness of the synergies. It has to be considered that implementing synchromodality is a time taking process as it requires coordination among various actors and government institutions.

4.4.2 Challenges to Hyperconnected logistics system

Implementing hyperconnected π-network has various challenges that can be addressed through proper enabling frameworks and measures.

- : From a government perspective, hyperconnectivity requires the involvement of public authorities at various levels with logistics stakeholders. The involvement allows the logistics operators to convey the hurdles in current legislation, policy, and regulation, that deter the implementation of hyperconnectivity. Through collaboration with logistics operators, governments can also standardise the π-containers and implement necessary legislation. When working with local governments, the urban planning context can be integrated into the planning of the hubs and consolidation centres. Synergies such as using existing facilities as hubs and working with existing operators can also be identified.
- : using various transport modes to reach the destination is an integral part of increasing the economic and environmental efficiencies in the supply chain. Similarly, providing the consumer with information on the possibility of transporting goods through multimodal modes is also essential. The needs of the consumers dictate logistics operators, and consumers can choose other modes only if they are aware of such possibilities. Being multimodal can bring economic savings for the operators that can be shared with consumers. On the contrary, unimodal can also increase costs. Therefore, consumers need to be aware of the savings when choosing multimodal options.
- : hyperconnected networks encourage cooperation among logistics operators. Collaboration among operators may initially look at stifling competition. Still, on the contrary, it can minimise costs throughout the supply chain. The partnership can also result in identifying the capabilities that need to be developed internally versus capabilities that other operators can use.
- : The absence of standards can become an oppressive factor in supporting cooperation in developing hyperconnectivity. The standards apply to either the containers used for packaging, in sharing information or the standard used in vehicles. Having proper standards can create a level playing field for operators and focus on other areas of competitiveness.
- : The future of logistics will not remain the same. The pandemic years have shown that logistics will be more digital, and failure to shift and adapt to the innovation might force some operators to extinction. But on the other hand, innovation in a logistics company's future growth strategy can allow companies to remain in business.
- : Data protection and mutual trust must be maintained when sharing data between the actors in the network. This transparency allows a high quality of service, ease in mitigating disputes, and easy and secure financial transfers. More importantly, a high trust level enhances cooperation among the actors.

4.5 Reducing emissions from Logistics

Logistics activities include various stakeholders and require many resources, significantly impacting its sustainability performance. A significant share of the impact of the logistics activity comes from moving the goods, i.e., transportation. In the EU, transport is one of the largest energy-consuming sectors, leading to a high share of GHG emissions (European Commission, 2011). Yet, there is a direct link between economic growth and transportation (European Environmental Agency, 2022). The recent technological trends in the logistics sector have increased consumers' expectations. For example, same-day deliveries and free returns of purchased goods have fuelled the logistics demand to a great extent. In the EU, inland freight transport activity increased more than passenger transport by 22% between 2000 and 2019. (European Environmental Agency, 2022). In 2020, the total share of inland freight transport by road was 77.4% and an increase of 8% from 2010 (EUROSTAT, 2022).

The environmental impact of the freight sector will continue to grow in the following decades (A. McKinnon et al., 2015). Therefore, addressing the growing freight issue is critical as managing it will reduce the environmental burden, pave the way for innovation, and reduce other externalities such as congestion, accidents, and noise pollution.

4.5.1 ASI Framework

The Avoid-Shift-Improve (ASI) framework can support addressing the emissions issue from logistics. The framework advocates the need to reduce unnecessary logistics by avoiding such trips, shifting a significant share of logistics from mono-modal transport to multimodal transport, and improving the efficiencies of vehicles and processes.

At the base of the ASI framework are the three pillars, viz. Avoid, Shift, and Improve (Bongardt et al., 2019).

- **Avoid:** Is the collection of measures that aim at reducing the need for the number of trips (in passenger transport) and the number of shipments (for freight)
- **Shift:** This is the collection of measures that promote a shift from high energy-consuming modes to energy-efficient and low carbon transport modes, i.e., for example, from road transport to railways and waterways. Shift measures also promote multimodality. Hence shift measures promote a shift from unimodal transport to multimodal transport options.
- **Improve:** This is a collection of measures that improve the energy efficiency of logistics modes; done through introducing low-carbon fuels, innovative vehicle technologies and improving the fuel efficiency of vehicles.

The ASI approach has gained a lot of approval from European and international entities. International development agencies advocate this framework when implementing low-carbon transport. Organisations such as the OECD International Transport Forum (ITF) (ITF, 2019) and the International Energy Agency (IEA) actively promote the ASI approach as means for reducing emissions from the transport sector.

Avoid Measures

The fundamental idea of strategies under the Avoid pillar is to reduce unwanted and unnecessary trips and shipments. In Europe, empty vehicles constitute about a fifth of road freight journeys (EUROSTAT, 2021). Therefore, addressing the empty vehicles needs to be the primary consideration, as reducing these empty trips can result in emission savings. While consumer behaviour change is one end of the solution, the other is in partnerships between the public and private sectors and logistics operators.

The partnerships and aligning goals among the various entities involved in the logistics chain can significantly reduce the growing freight volumes and address the empty vehicle journeys (Punte et al., 2019).

From a technology point of view, innovations in the logistics sector can also contribute towards reducing freight volumes. Some potential options introduced by the technological innovation are 3D printing (where products are locally printed and significantly reducing or avoiding shipping trips), decentralising production and storage (this will reduce and consolidate trips) and using alternative materials product design (this will reduce the trips made to transport material that cannot be locally resourced).

Innovations such as the Physical Internet (PI or π) mimic how the digital internet transmits information. The digital internet encapsulates information in one packet, such as the source, delivery, and route. PI exploits this feature of the digital internet and suggests modularisation and standardisation of the π-containers. Furthermore, these containers are equipped with smart sensors, incorporating the Internet-of-Things (IoT)[14], enabling interconnectivity between the containers and the network.

For example, in a conventional system, a single driver travelling from Quebec to Los Angeles will travel over 10,000 km round-trip and need about 240 hours to transport one container. In a π-enable logistics network, the same task would require 60 hours to reach the destination, requiring 17 drivers, each driving for about 3 hours between the transit points in the π-network. This also would mean that the drivers can complete the task in a single shift (A. McKinnon et al., 2015). The result will yield considerable economic and environmental savings.

From a policy perspective, some measures can include financial instruments that incentivise low-carbon efforts.

Shift measures

The crux of the Shift measures is to promote multimodality and shift freight from carbon-intensive road transport to more efficient modes such as rail and waterways. Road transport and air transport are far more energy intensive and thereby more emitting sources than rail or water-based freight transport modes. In comparison, the type of vehicle and the fuel influence the emissions from road transport. For example, light-duty vehicles (LDVs) cause more emissions per ton-kilometre than heavy goods vehicles (HGV) (Pfoser, 2022).

Multimodal freight transport means using two or more modes of transport to transport the freight. The generic definition of multimodal transport has given rise to concepts such as intermodal transport, combined transport, and co-modal transport. Intermodal transport means two or more modes transport the same loading unit without loading or unloading in the transport chain (UNECE et al., 2001). Combined transport is intermodal transport with environmentally friendly modes (Pfoser, 2022). The process is called a rolling motorway when the trucks are carried by railroads. It is a typical implementation of the combined transport concept. While on a rolling motorway, the drivers may be seated either in the truck or a coach during the rail travel. A similar process can also be observed on water transport where trucks are ferried on waterways, ro-ro vessels, and ro-ro standing for roll-on/roll-off vehicles. Transporters can save costs when the vehicles are unaccompanied, i.e., transported without the drivers on the rolling motorways or ro-ro vehicles. Co-modality is defined as the "efficient use of different modes on their own and in combination" to obtain "an optimal and sustainable utilisation of resources" (EC, 2006). The European Commission introduced the definition in 2006 in their mid-term review of the 2001 transport white paper. The description suggests that higher efficiency can be promoted through unimodal

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[14] ENISA defines IoT as "a cyber-physical ecosystem of interconnected sensors and actuators, which enable intelligent decision making." (https://www.enisa.europa.eu/topics/iot-and-smart-infrastructures/iot)

transport. Hence, the definition was criticised as not conducive to implementing multimodal transport. Co-modality did not receive much traction in implementation (Pfoser, 2022).

Several efforts are in place by the European Commission to encourage multimodal transport. Yet, the share of sustainable transport modes is minimal compared to road transport (EUROSTAT, 2022). This is partially due to the various actors involved in freight transport reforms and a need for collaborative action, as discussed earlier.

Improve measures

Improve measures aim to improve freight transport vehicles' fuel and vehicle efficiencies. A significant share of the improvement measures is targeted at road transport vehicles. Innovations in engineering and technology have constantly improved vehicle efficiencies. For example, innovations in tire technologies have led to low rolling resistance tires, and aluminium wheels have reduced the weight of wheels (Punte et al., 2019). Lighter vehicles consume less fuel and allow more freight transport, thus reducing freight trips.

Advances in fuels have allowed the trucking sector to shift from conventional fuels to alternative fuels such as biofuels, liquified natural gas (LNG), electricity and hydrogen. In terms of lowering particulate emissions, the LNG seems to be a promising alternative; still, LNG does not support reducing CO emissions (Teixeira et al., 2021). Electricity and hydrogen infrastructure can initially pose a high upfront investment cost (Zhao et al., 2018). The costs may be justified in the long term as more vehicles are converted to electric and hydrogen. The environmental benefits are also higher when the multimodality is coupled with the improvement measures. Though hydrogen vehicles can significantly impact the GHG emissions from freight, the cost of producing clean hydrogen is still prohibitive. Some European researchers have also shown that electricity has a much higher economic and environmental efficiency when the total cost of ownership is compared (Strack et al., 2022). Yet, the central claim remains that moving away from conventional fuels in trucking and promoting multimodality is the way forward.

4.5.2 Challenges in reducing emissions

Reducing emissions from the freight sector, unlike the passenger transport sector, needs collaboration and buy-in from the logistics service providers (LSPs) and the customers. To adopt low-emission freight transport, the LSPs must make certain sacrifices. Still, if the cost of these sacrifices is less than the benefits the LSPs receive, their buy-in process can be more straightforward.

The primary factor that encourages LSPs to change their practices is the financial benefit, i.e., the profit they receive from operations. If the current processes are expensive, LSPs attempt to reduce the costs and increase profits. To overcome these challenges, if the LSPs are convinced that the total cost of ownership (TCO) of new vehicle technologies is less than the current situation, then it is a factor LSPs may consider. Similarly, if multimodal transport is reliable and less expensive, LSPs may also start using multimodal transport. The reliability of multimodal transport is one of the reasons for the current deterrence. Participating in the PI for LSPs is more of a strategic decision. If participating in the PI network can prove profitable and efficient, LSPs would be willing to share data, resources, and customer orders with competing organisations (Pan et al., 2017).

The LSPs are also influenced by the perception and demands of the consumers. Increasing consumer awareness can also affect the implementation of low-carbon freight transport. Customers who do not explicitly ask for sustainable transport modes or reject these practices do not incentivise the LSPs to follow sustainable transport practices. Customers requesting green logistics options can pressure the

LSPs (Chu et al., 2019). Research conducted by interviewing LSPs shows that the LSPs are willing to provide multimodal transport if the customers explicitly as for multimodal transport or have a specific delivery date that allows the use of multimodal transport (Pfoser, 2022).

4.6 Sustainable Urban Freight

The International Transport Forum (ITF) predicts that global freight demand will triple between 2015 and 2050 (ITF, 2019). The World Bank (2022) data show that, in 2021, about 57% of the global population live in urban areas. This figure is expected to increase in the coming years. Growing populations and economies are expected to increase the demand and supply of goods and services in urban areas. Hence the need for freight in urban areas will increase. A significant share of the freight activity happens on roads, and road freight is prominent among inland freight transport modes in the EU (EUROSTAT, 2022). A similar situation can be found in many emerging economies (ITF, 2018). The goal of policies in urban freight is to minimise the negative externalities while streamlining the operations (Holguín- Veras, 2014). The negative socio-economic impacts can be seen in Figure 23. About 15-20% of the vehicle kilometres (four wheels or more) travelled in urban areas are due to commercial vehicles. They take up about 20% to 40% of the carriageway and cause about 20% to 40% of the emissions (Herzog, 2010). As the freight fleet in many emerging economies is dominated by old vehicles, their share in air pollution is also high (Mejia, 2021).

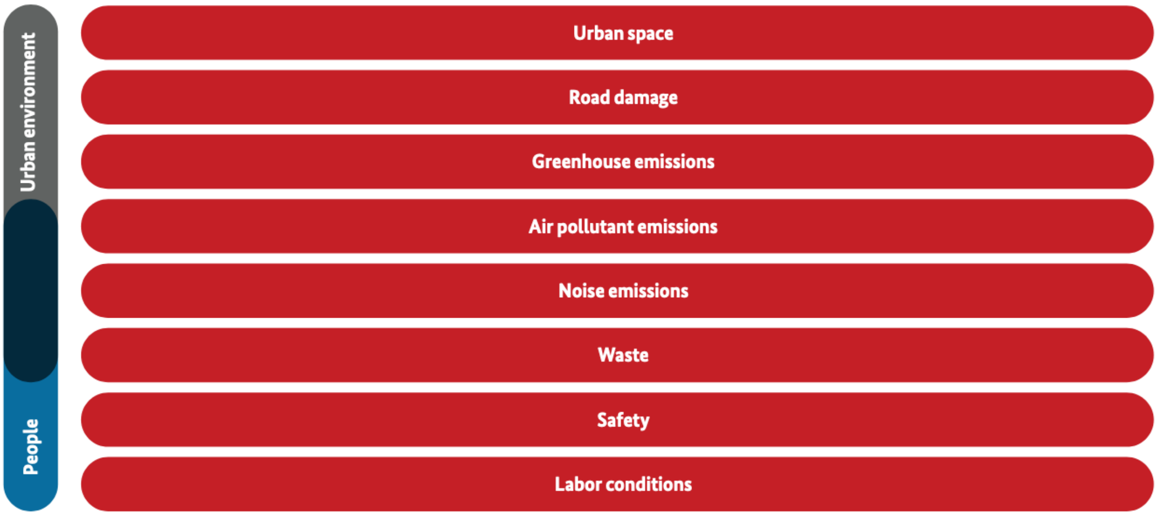

Figure 23: Negative impacts of urban freight (Mejia, 2021)

Urban logistics has been a topic not considered necessary by many local governments and only recently gained attention (Akgün, 2021). The local government overlooked urban freight due to the number and kind of stakeholders involved in urban freight operations. Governments in emerging economies have not been at the discussion table concerning urban logistics. The supply chain logistics were under the purview of higher government levels and mainly focused on rail-based transport. Even from an academic point of view, emerging economies did not gain enough attention in logistics research (Mareï & Savy, 2021). Added to this, how logistics operate in emerging economies is starkly different from global north cities. Mareï and Savy (2021) found in their research that

Technological developments, changing policy focus triggered by the climate crisis, and increased public participation bring innovations in the urban freight sector. However, local decision-makers must embrace these new technologies and work with other stakeholders to gain the most from the urban freight sector. This would require strengthening internal capacities from technological and governance aspects. This is crucial to effectively embed urban freight in local transport governance and utilise the available technologies.

Using digital technologies such as IoT, 5G and automation, local governments can work with the private sector to develop state-of-art urban freight platforms that are connected and hence support options such as synchromodality and hyperconnectivity (see sections 2.4 and 2.5). When such solutions are adopted, cities can adapt vehicle flows based on the information they obtain from the freight operators and vice versa.

By introducing urban consolidation centres and using light electric vehicles (e.g., cargo e-bikes), urban freight planning and implementation can be embedded into the current plans for electrifying and digitising the transport sector. Moreover, adopting such innovations can give rise to new business models, such as micro-hubs and delivery lockers. Including the needs of the urban freight sector in transport, plans will allow for streamlining the flow of urban freight traffic and also provide dedicated space for urban freight vehicles for loading and unloading.

The City of Bologna, Italy, implemented an innovative approach to developing its sustainable mobility plans. The city's Sustainable Urban Mobility Plan (SUMP) has been developed for the entire metropolitan area. It closely aligns with sectoral goals for urban logistics as well as biking. The City Mobility Planning Office intended to bring these elements together. Bologna's experience highlights that stakeholder engagement is crucial to any decision-making process in a metropolitan area. The main challenge was finding feasible and effective ways for policymakers to steer urban logistics, a market dominated by private businesses with often little municipal planning experience (Rupprecht Consult, 2019).

Though there may be no single solution to address urban freight planning and management, an approach that is based on proper stakeholder involvement (including both the formal and informal freight operators), data-based decision-making, and making use of the available technologies can give the emerging economies a chance to leap-frog towards making urban freight sector manageable and sustainable.

Local governments, when planning urban freight in concert with conventional transport and urban planning, can unlock synergies that will create better linkages, affect the overall transport patterns in the city, and provide economic benefits to the city.

4.7 Policy recommendations

Though logistics might be a sector dominated by private entities, there is still a role for governments at various levels to play an important role and benefit from their participation. First, as we have seen, the supply chain is a complex ecosystem involving different stakeholders and geographical contexts, especially when the deliveries involve multiple countries. Secondly, deliveries within a country will mean that the logistics vehicles are part of the vehicular traffic, and benefits from optimising logistics can also result in efficiency gains in an urban context.

Logistics providers are also subjected to various government policies and regulations to conduct operations. These policies and regulations can allow logistics companies to embrace innovation, benefitting governments in achieving climate-related goals.

Promoting technologies in the logistics sector is also to the benefit of the governments. Many governments have digitised the agenda and implemented smart cities and smart governance projects and policies. Smart cities and smart governance projects are essential in supply chain management locally and globally. Smart cities can help companies improve logistics and operations by reducing traffic congestion and improving energy efficiency. In addition, smart city technologies can facilitate communication between suppliers and customers, which can help reduce inventory costs and enhance product quality.

While various measures can be and are needed for managing the logistics sector, a policymaker would need to tailor-make the measures based on their need and the goal at the respective level of governance. The freight market situation, infrastructure availability, and political support also dictate the policymaker's making their measures toolkit. It is important to note that measures always have an offset effect, and this has to be considered before deciding on a particular measure (A. McKinnon et al., 2015). For example, a cost-cutting measure can result in increased freight activity.

In the following sections, we describe the requisites for developing measures to adopt innovative technologies in the logistics sector. We also describe a broad 4-step process that could aid policymakers in identifying the measures accepted by all stakeholders.

4.7.1 Involving the stakeholders

Governments need to work with logistics providers. The partnership will provide the governments with a clear understanding of the logistics operators' needs and synergies. For example, logistics operators generate immense amounts of data, and private operators hold this data in many cases. With a good partnership with the governments, the data can be shared to support local planning and transport routing in cities. The participation from the governments will be to make cities more efficient. At the same time, companies work with governments to improve their operating efficiency. The partnership can also support governments in implementing ICT infrastructure that governments will be able to provide due to a lack of resources.

Through the partnership, governments and logistics operators can understand the final goals of each of the entities and choose the innovation options. For example, governments can use smart sensors to identify parking needs for delivery vehicles and allocate the required parking facilities. By sharing data, logistics operators have an overview of the real-time traffic data, and the delivery routing can be optimised. Optimising deliveries can also help companies reduce commuting time and thus translate to economic benefits.

4.7.2 Increase technical capacity and awareness

A key ingredient for any step towards adopting innovative technologies is knowledge and awareness of the available options. Once such awareness is developed, it is easier for governments to move towards technological solutions as they can understand the benefits of such technologies.

A planned technical capacity development program is essential for involved government staff to increase awareness of the various technology options and the results they can produce. Of course, governments need not implement all these options, but knowing the available options can increase and allow them to identify key stakeholders and partners on their journey towards smart governance and smart logistics.

Logistics companies must also embark on training activities to improve employees' skills and work performance. When partnering with governments, joint skill development programs could improve overall employment opportunities (OECD, 2002).

There could also be partnerships between developed and emerging economies in skills building. For example, developed countries can send their logistics experts to develop and run logistics training courses in their emerging economy counterparts. The experts will improve human capital and promote the harmonisation of intermodal operations.

4.7.3 Resource allocation

Resource availability is a crucial factor for governments to introduce innovative approaches. Many governments introduced e-governance, leading to the digitalisation of various government services. The next step in evolution is moving from e-governance to smart governance. Moving to smart governance will mean investing in 5G technology and big data centres to collect and store the big data generated and analysed, implementing IoT sensors. Through partnerships and innovative business models, governments can create resources for new technology.

Agreements between governments and the private sector should include aspects such as pricing (for direct and indirect costs), construction and operational provisions, and use of transport technologies and provide safeguards against the monopoly (OECD, 2002).

Government can impose taxes mainly on carbon-intensive fuels and vehicles and provide incentives for purchasing and using low-carbon vehicles. The incentives can be in the form of installing infrastructure for electric vehicles and developing/subsidising the construction of urban consolidation centres (A. McKinnon et al., 2015).

4.7.4 Infrastructure and frameworks

Logistic Service Providers (LSPs) also need the infrastructure for sustainable freight transport. Multimodality needs multimodal terminals, and they facilitate a vital shift to other modes. A multimodal terminal is also essential for promoting the implementation of digital infrastructure. A PI network will need a digital platform acting as a neutral orchestrator, whose responsibility will be to maximise the total synergy gains of the network while being impartial (Ciprés & de la Cruz, 2019).

Similarly, for synchromodality and hyperconnected logistics networks, having local hubs is crucial at an urban level. Governments can play an essential role in planning for these hubs together with the private stakeholders. Synergies can be unlocked when planning multimodal transport and logistics hubs. This can reduce the load on freight transport networks and enable efficient transport flows in cities.

The complexity of organisational procedures can influence the uptake of low-carbon freight practices by the LSPs. With high organisational complexity, LSPs will be deterred from moving towards multimodal transportation. Easing formal procedures such as customs, inspection, and other administrative procedures can speed up the total time spent by transport. Using blockchain technology with smart contracting can support overcoming this challenge. Governments will need to work internally to streamline the processes and procedures and develop enabling frameworks, supporting horizontal collaboration in a PI network.

4.7.5 Security and privacy

As new technologies rely on large amounts of data processing and collection, a robust system and a proper framework are essential for collecting and storing data. Governments need to establish necessary policies and regulations for collecting and sharing data. With appropriate regulations in place, the data management frameworks can be decentralised such that no single entity has all the data, encouraging collaboration among various entities. By embracing open data standards, governments can ensure that data is available for other actors, avoid duplication in data collection, and improve resource efficiency.

Governments can pave the way for data sharing and control how much data is collected through proper regulations and frameworks. For example, a centralised data-sharing platform for freight operators will encourage data sharing.

Through standards set by the governments, freight operators can be compelled to follow standards in terms of package sizes and loading requirements. Therefore, standardisation can be a crucial element in implementing Physical Internet. At the same time, data sharing can be a key to implementing IoT in the freight sector.

4.7.6 IDEA - a 4-step approach

To identify suitable policy measures, policymakers will need to have an iterative process. Identifying measures is not a one-time event, and it will need proper monitoring and evaluation in place. Such that future developments can incorporate the lessons learnt and improve future implementation.

The reiterative process is mentioned here in a 4 step approach, which in simple terms, is called IDEA. The elements of the approach, i.e., Identify, Define, Experiment and Assess, are described below:

Identify

In the first stage of the process, the policymaker needs to clearly understand the problem they wish to address in the freight sector. The problem identification stage usually involves several consultations and analysing available information on freight operations and management. Suppose no information is available on the freight sector. In that case, this becomes an issue and has to be added to the identified list. At the end of this problem-identification stage, a list of issues is identified, and these are discussed in a stakeholder group to prioritise the key issues.

One major challenge for policymakers in the freight sector is to identify the various stakeholders involved in the sector. In developed countries and cities, the nature of the freight sector is more organised compared to emerging economies. However, in developing cities and countries, the freight sector often has various operators, some very small with one vehicle to large multi-national companies operating freight.

#1 Identify

the problem, stakeholders, available and missing data

A cohesive policy needs to include the needs of all the operators in the sector. Hence the first stage is to identify the various operators. Once the operators are identified or mapped, their operating environment needs to be studied.

Knowledge of the operating conditions provides further information on the characteristics of freight. The kind of freight transported, its needs, the average distance, its storage, and the intermediary actors, who are often invisible at a macro level.

In addition to the operators, the other stakeholders are also identified and mapped in this stage. Stakeholders are not just members of communities or non-governmental organisations. These entities affect and/or could be affected by an organisation's activities, products or services and/or associated performance concerning the issues to be addressed by the engagement (AccountAbility, 2015). A non-exhaustive list of stakeholders is mentioned below:

Stakeholder Group	Actors
Governments / Regulatory bodies	National Government Local Governments and sub-national governments Regulatory bodies for freight and urban freight
Logistics Operators	Commercial operators (both small-scale and large-scale) Hazardous goods transporters Operators from various modes (road, rail, water-based) Informal operators Postal and courier services
Freight Associations	Freight associations (National, sub-national and local) Representatives from small and medium enterprises
Enforcement agencies	Police department Road Transport departments Border security and customs Parking inspectors (relevant esp. in an urban context)
Academia	Universities (local, regional and national) Research institutes Think Tanks
Civil Society Organisations	Residents' associations NGOs working towards environmental and social issues
Vehicle manufacturers	Electric Vehicle manufacturers Truck manufacturers Automotive industry representatives
Media and communication	Local news media Communications and outreach companies

The stakeholder identification is followed by assessing the value each stakeholder can bring to the decision-making process. This is done by mapping the stakeholders based on their levels of engagement, the amount of time they will be involved in the activity and the extent of their communication. Upon mapping the stakeholders, it is also beneficial to categorise them as primary, secondary and tertiary stakeholders, depending on their role in the project. Engaging with the stakeholders at regular intervals is essential regardless of their category.

In consultation with the stakeholders, it is essential to collate the available data on the freight sector. This will be a crucial step and will support the decision-makers in monitoring the measures that will be implemented in the future. In this stage, it is also prudent to identify the technological

Define

> **#2 Define**
>
> Vision for the freight sector, goals and targets, actions and stakeholder roles, and Key Performance Indicators (KPIs)

Upon identifying the stakeholders and the data gaps, policymakers will need to work with the stakeholders to define the targets at different levels in the freight sector. The targets that are defined need to be in line with the overall goals for the freight sector.

At a city level, if a vision for urban freight does not exist, then this is an opportunity for the local policymakers to define a vision in consultation with the stakeholders and consider the available data on urban freight.

Having a clear vision enables the development of realistic goals. The goal for the city may be broad as multiple actions will address the goals. While defining the goals, it is essential to consider the future and take stakeholder inputs to sufficiently include the environmental and technological benefits.

Innovative concepts such as blockchain, IoT and synchromodality must be considered to make the measures compatible with future developments.

Once the goals are identified through stakeholder participation, a matrix of actions needs to be developed. The matrix essentially displays the low-hanging fruits or easy-to-achieve actions, and policymakers will get expert input through stakeholder involvement in developing this matrix of actions.

Implementing the actions in short-term demonstration projects or pilot actions is suggested. This will enable the city to efficiently utilise the resources and adopt the lessons learnt in future project iterations.

Based on the data gaps identified and upon consultation with the stakeholders, key performance indicators (KPIs) need to be identified and developed. The KPIs are developed keeping in mind the goals and targets for urban freight. Certain stakeholders from the group are selected to monitor and track the KPIs during and after the project implementation. Before defining the KPIs, using the data that is identified, a base case or the business-as-usual scenario is developed.

From an organisational perspective, it is important to define a framework where stakeholders are properly represented and their respective roles are defined in implementing the actions. In some cases, there might be a need for formal approval by the elected body to bring the organisational framework to life.

A common result at this stage of the process will be the development of an action plan that details the vision, goals and targets that the group has agreed upon. The action plan will also detail the various actions identified to be implemented in the short, medium and long term.

Experiment and Enact

In this stage, the actions identified earlier are implemented, possibly as demonstration activities. While implementing the actions, it is important to clearly define the roles and responsibilities of the involved stakeholders. Some of the stakeholders may be involved in the implementation to measure the effect of the implementation. Again, a multi-stakeholder consultation is crucial. The public and private sectors need to work collaboratively. The agreements from the earlier stage need to be reminded and met.

#3 Experiment and Enact

Implement actions as demonstration projects or pilot projects to measure their potential impact

Before implementing the demonstration project, the government needs to ensure that the necessary funding is secured and the necessary personnel support is also ensured. Regarding raising funding, the governments can explore the allocation of resources from available budgets and implement demonstration actions in coordination with private entities.

At regular stages of implementation, it is essential to keep the stakeholder informed of the updates. In addition, the general public in the implementation area will also be curious to know about the project. They will require reminding of the benefits that the implementation will bring to their everyday activities.

This would mean there is a need to involve the necessary communication personnel and take advantage of the media outlets. Furthermore, involving the media in stakeholder consultations and providing exclusive interviews and insights on the actions and the expected benefits will spread positive news about the implementation.

This is also the stage where any legislation that needs to be enacted for a smooth project implementation needs to be in place. The implementation needs to be followed by an assessment stage where the KPIs defined

Assess

> **#4 Assess**
>
> Progress of implementation, the feasibility of a full project, and provide indications for future actions

The assessment of the implementation needs to follow a robust monitoring and evaluation framework. To measure the progress, a base situation needs to be established (as mentioned in the #Define stage).

Post-implementation and at various stages of implementation, the progress is measured against the KPIs identified in the second stage of the IDEA process. As the measurement of the KPIs is supported by verifiable evidence, measuring them is distributed among the stakeholders depending on their strengths and access to information.

The project assessment will allow the stakeholders to scale up the demonstration activities or transform the demonstration activities into full-fledged permanent projects.

The assessment of the KPI will also feed into the initial stage of the process, and thus the process becomes iterative.

When properly implemented, each iteration should reduce the issues identified in the previous iteration and provide new insights and ideas for future implementation.

Use the KPIs to assess the implementation and explore the areas and needs for improvement with the stakeholders.

5 Conclusions

This deliverable of the PLANET project provides knowledge tools for policymakers in emerging economies to conceptualise, plan and embed innovative logistics concepts into their local decision-making process. If politically supported, innovation and technology can accelerate the transformation in the freight sector, contribute to more sustainable urban mobility systems and reduce transport-related greenhouse gas emissions. We find that policymakers and local administrations in emerging economies need more insight into innovative technologies such as the Physical Internet, Blockchain, Synchromodality and the Internet of Things. In addition, there is a lot of potential for public and private sector collaboration, and this option is less explored in the emerging economy context. Through proper collaboration, synergies can be unlocked, benefitting the country's social, economic and environmental aspects.

Similarly, logistics providers are subjected to various government policies and regulations to conduct operations. These policies and regulations can allow logistics companies to embrace innovation, benefitting governments in achieving climate-related goals.

Promoting aspects such as synchromodality and hyperconnected logistics systems can enable emerging countries and cities to advance technologically towards multimodal freight transportation systems. As a result, multimodal freight systems can potentially reduce the CO_2 emissions from the sector and thus allow countries to meet their climate goals.

In many emerging economies, a structured approach to addressing the issues in the logistics sector is absent. This is primarily due to the number and diversity of stakeholders involved in the supply chain. To achieve tangible results, decision-makers need to (a.) follow a multi-stakeholder participatory approach, (b.) extend their arms to include non-government sectors, (c.) have access to the data that is being generated and shared in the supply chain, (d.) increase their technical awareness and capacity, and (e.) be open for innovative business models.

There is a lot of potential for public and private sector collaboration, and this option is less explored in the emerging economy context. Through proper collaboration, synergies can be unlocked, benefitting the country's social, economic and environmental aspects.

In conclusion, at a macro level, if policymakers aim to improve the logistics sector, three key aspects form the bedrock: stakeholder involvement, standardisation, and collaboration (both among actors and concerning data). If these aspects are implemented, innovation and technologies can thrive, unlocking economic, environmental and social benefits in emerging economies.

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