Digital Innovation in Maritime Supply Chains

Experiences from Northwestern Europe

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Abstract

This study examines 15 cases in Northwestern Europe where digital innovations have been developed to improve connectivity, visibility, and, therefore, performance in maritime supply chains. The solutions focus on smoothing cargo, document, or financial flow throughout supply chains. Given the importance of seaborne trade for countries in Latin America and the Caribbean, the efficient management of maritime supply chains becomes critical for such countries. To this purpose, this paper identifies best practices and lessons learned from analyzing the selected cases. We expect this paper to increase awareness of the relevance and need to strengthen the adoption of digital technologies for improved supply chain performance in the region's public and private sectors.

JEL Codes: G20, G21, G28, L25, L16
Keywords: connectivity, innovation, maritime transportation, supply chain, technology, visibility

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Contents

List of Figures

List of Tables

Glossary

APCS	Antwerp Port Community System
APICS	Antwerp Port Information and Control System: a set of port-related processes that enable the port to efficiently plan, direct, and monitor shipping traffic
API	Application programming interface
BTS	Barge Traffic System: a unique online slot request and monitoring system for container barges and terminal operators (www.portofantwerp.com/en/instream)
Cubix	An application that allows all involved parties to follow break bulk shipments by means of a unique reference throughout the supply chain
DC	Distribution center
EC	European Commission
eDesk	An easy and free web application allowing users to notify the terminal operator about upcoming cargo and to pass declaration details electronically (http://www.portofantwerp.com/apcs/en/e-desk)
EDI	Electronic data interchange
EU	European Union
EUWIN	European Workplace Innovation Network
ICT	Information and communication technology
IDB	Inter-American Development Bank
LAC	Latin America and the Caribbean
MarSCs	Maritime supply chains
OCR	Optical character recognition
SME	Small and medium-sized enterprises
TEUs	20-foot equivalent units

1. Introduction

In the context of the Fourth Industrial Revolution, digital technologies such as the Internet of Things, artificial intelligence, robotics, unmanned vehicles, and 3D printing are changing production and consumption as we know them today (Schwab, 2017). In the field of supply chain management, adopting digital technologies promises to bring new levels of connectivity and visibility to supply chain actors and processes, thus enabling better management of increasingly complex global supply chains (Wu et al., 2016; Haddud et al., 2017). Particularly relevant to this paper is that new technologies make the electronic linkage—or connectivity—among supply chain partners possible and that, with data on processes, parts, and final products readily available to supply chain partners, visibility can be significantly improved (Calatayud, 2017). Benefits of increased supply chain connectivity and visibility suggested in the literature include better inventory control, better demand forecasting, shorter order fulfilment lead times, and improved logistics flexibility and asset performance (Closs and Swink, 2005; Swafford, Ghosh, and Murthy, 2008; Coronado-Mondragon et al., 2009; Calatayud et al., 2016).

Around the world, there are different examples of digital technologies being developed and adopted to improve supply chain management. This paper focuses on 15 cases of innovation and technology adoption in maritime supply chains (MarSCs) in Northwestern Europe,[1] and the lessons countries in Latin America and the Caribbean (LAC) can learn from those experiences. MarSCs encompass the actors and activities that enable the movement of (containerized) cargo from its point of origin to its point of destination (Lam, 2011), including maritime transportation. Given that 73 percent of goods traded by LAC countries are seaborne (Calatayud, Mangan, and Palacin, 2017), efficiently managing MarSCs becomes critical. Northwestern Europe is relevant for LAC countries since it hosts two of the 15 most important ports in the world—Antwerp and Rotterdam—, with over 22 million 20-foot equivalent units (TEUs) handled in 2016 (Lloyd's List, 2016). Together with Zeebrugge, these ports serve as the gateway for 33 percent of European seaborne international trade (Lloyd's List, 2016). It is particularly important to note that, for the past five years, operators in the MarSCs in Northwestern Europe have been developing and adopting digital technologies to improve supply chain performance in an increasingly complex and competitive environment.

The research conducted in the framework of the BNP Paribas Fortis Chair (Sys, Vanelslander, and Carlan, 2015a) has shown that innovation is being used as a tool to strengthen the competitive advantage of port-related stakeholders, stimulate growth in the maritime sector, and manage the risks and challenges for MarSC operations. Since 2015, with the development of new digital technologies, partners in MarSCs have launched initiatives of collaborative innovation, or co.innovation. Beyond individual innovation, co.innovation refers to the intention to build new knowledge and insights together, to create content based on the

[1] For the purpose of this paper, Northwestern Europe encompasses Belgium and the Netherlands and, particularly, the ports of Antwerp and Rotterdam, where a number of significant initiatives for MarSCs digitization and co.innovation has emerged in the past two years.

behavior of port users, and to generate new opportunities for cooperation along supply chains (Sys, Vanelslander, and Carlan, 2015b). According to available literature, digital technologies will push MarSCs, including the port sector, toward co.innovation (Carlan, Sys, and Vanelslander, 2016). In turn, the digitally enabled tools developed from co.innovation will improve connectivity and visibility throughout MarSCs, enhancing supply chain performance.

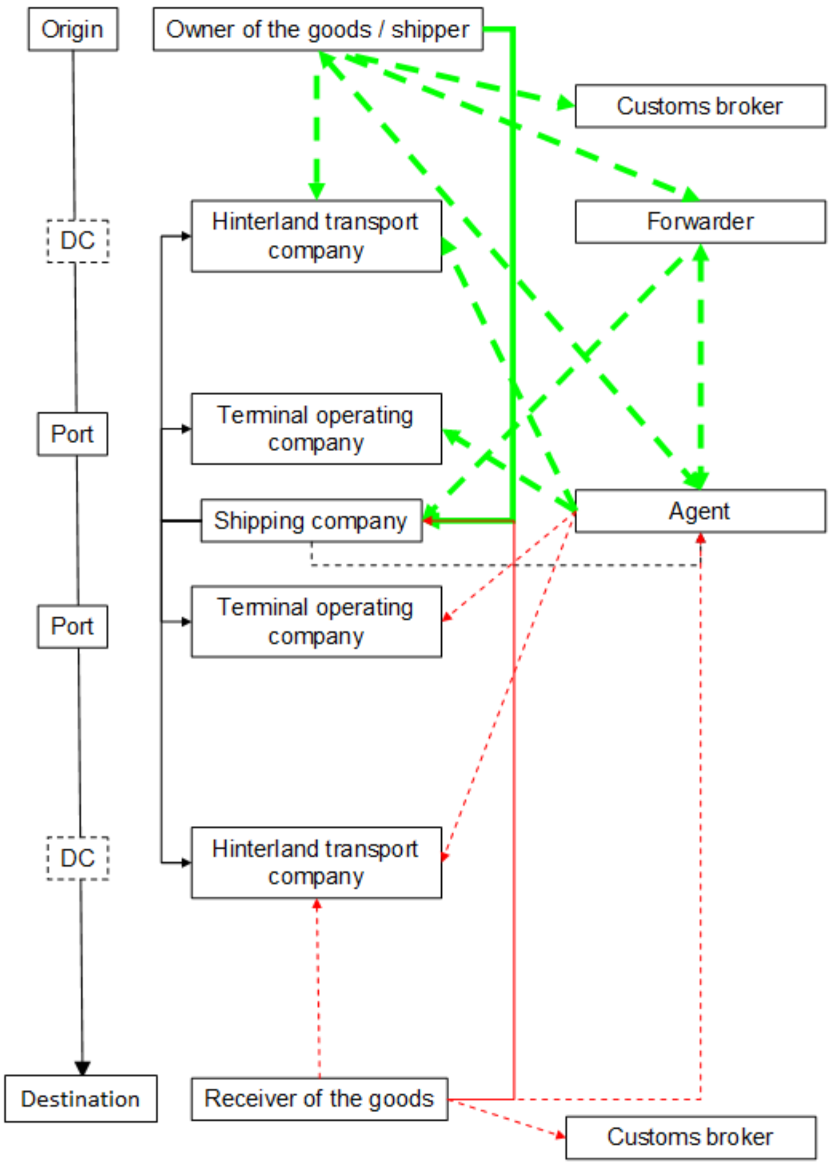
This paper contributes to the work of the Inter-American Development Bank (IDB) in supporting the transition of LAC countries toward the Fourth Industrial Revolution. Recent studies have evidenced a lack of awareness in both private and public sectors in LAC countries of: (i) the benefits of technology adoption for supply chain performance and the economy in general and (ii) the compelling need to catch up with the new digital wave that is transforming production and economies around the world (ECLAC, 2017; gA, 2017). To reverse this trend, the IDB is implementing projects in applied research, technical cooperation, and investment loans. In this context, this study gathered and analyzed experiences in MarSCs innovation in two leading countries: Belgium and the Netherlands. This paper discusses the information attained and the lessons that LAC supply chains can learn from it.

The paper is organized as follows: Section 2 introduces the concept of MarSCs and discusses the importance of improving performance through innovation and by adopting technology. Section 3 analyzes a selection of cases in Northwestern Europe where digital technology was implemented to improve the performance of MarSCs. Cases are grouped in three clusters according to whether the innovation supports the physical flow of cargo (Section 3.1), the flow of documentation (Section 3.2), or the flow of financial resources (Section 3.3) across the supply chain. Section 4 presents the policy framework in place to incentivize innovation in sectors and processes related to MarSCs. Section 5 discusses the lessons learned for LAC countries. Section 6 concludes.

2. Improving Performance in Maritime Supply Chains

With globalization and fragmentation of production, maritime transportation has emerged as the backbone of global supply chains. In this context, ports have turned into strategic supply chain nodes and a key part of global distribution channels (Panayides and Song, 2008; Calatayud et al., 2016). Moreover, port-related stakeholders such as shipping companies, terminal operators, and port agencies have become actors whose decisions can significantly impact supply chain performance. Because of this, there is increasing interest from supply chain practitioners, public agencies, and researchers about the relationship between maritime transportation and supply chain management. In this paper, the supply chains that include maritime transportation are referred to as MarSCs. These supply chains encompass the actors and activities that enable the movement of (containerized) cargo from its point of origin to its point of destination (Lam, 2011) using maritime transportation, in addition to other modes (e.g., road, rail, and inland navigation). Figure 1 illustrates the actors involved in MarSCs and the flow of materials and information among them (Meersman, Van De Voorde, and Vanelslander, 2010).

Figure 1. Illustration of the Maritime Supply Chain



Note: DC = distribution center.
Source: Meersman et al. (2010).

Often involving international trade flows, the green lines in the MarSC show export flows, while the red lines correspond to import flows. Solid lines represent the relationships between supply chain actors that take place in any case, while dashed lines are relationships that involve one or more intermediaries and thus may or may not occur. According to Incoterms 2010, the shipper of the goods, which can be the owner (bold lines) or the receiver (non-bold lines), selects a shipping company (a carrier) with or without mediation by a freight forwarder or a logistics services provider. Next, the carrier chooses a port of call and a terminal operator within the port. The first or last mile entails a choice of transport modes (road, rail, inland navigation, or a combination). To store the goods, a distribution center (DC) (dashed box) may be used. The shipper may rely on a customs broker if customs processes are involved (Meersman et al., 2010).

Given the relevance of port and maritime transportation in global supply chains and the number of processes and actors involved, available literature encourages increasing visibility with port-related stakeholders (Panayides and Song, 2008; Woo, Pettit, and Beresford, 2013). A key aspect of increasing visibility in MarSCs is connectivity or information sharing using electronic linkages among supply chain partners (Calatayud et al., 2016). Available literature shows that increased information sharing between the port and supply chain actors contributes to reduce order cycle times and inventories, and to increase the flexibility of the systems (Woo et al., 2013). In addition, evidence shows benefits for ports since increased connectivity and visibility can help them better accommodate the growing capacity of maritime transportation and other relevant trends in a highly fluctuating, competitive, low-margin industry (Panayides and Song, 2013; Woo et al., 2013). Therefore, the partnership between port-related actors and supply chains can be beneficial for all actors involved in MarSCs processes. This new vision of collaborative work between the port and the stakeholders in the supply chain will shape the future landscape in the port and shipping industries (Deloitte, 2015).

According to Song and Panayides (2008), there are three elements of effective information sharing between the port and supply chain actors: (i) using electronic data interchange (EDI) to communicate with port-related stakeholders, (ii) having integrated information technology platforms to share data with such stakeholders, and (iii) having computerized port service systems to coordinate operations with shipping lines and trucking companies. Central to this paper is the question of whether innovative information communication technology solutions or new digital technologies can contribute to better (and cheaper) integration of MarSCs. From the research done in the framework of the BNP Paribas Fortis Chair (Sys, Vanelslander, and Carlan, 2015a), it has become clear that stakeholders are interested in digital technology solutions to improve MarSCs performance, as well as their own competitive advantage (Carlan et al., 2017). For example, of the 75 cases of port innovation in Northwestern Europe analyzed between fall 2013 and spring 2015, around half were experiments in digital innovation (Sys, Vanelslander, and Carlan, 2015a; Carlan et al., 2017).

Innovation[2] can be defined as a technological or organizational change to the product (or service) or to the production process that either lowers the cost of the product (or service) or increases its quality (Arduino et al., 2013). In addition to reducing costs and improving quality, Roumboutsos, Sys, and Vanelslander (2016) suggest that a key role of innovation in the context of a MarSCs is to improve information flow. For port terminals, which operate in a highly complex and competitive environment, seamless information flow can contribute significantly to the overall efficiency (and therefore competitiveness) of their key operation: handling cargo (Roumboutsos et al., 2016). Beyond individual innovations, the experience of MarSCs in Northwestern Europe suggests the emergence of co.innovation.

Co.innovation is a new term that refers to the intention of actors taking part in MarSCs to build new knowledge and insights together, to create content based on the behavior of port users,

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[2] For a typology of innovation, see Vanelslander et al. (2013).

and to generate new opportunities for cooperation along supply chains (Sys, Vanelslander, and Carlan, 2015b). According to available literature, digital technologies will push MarSCs, including the port sector, toward co.innovation (Sys, Vanelslander, and Carlan, 2015b; Vanelslander, Sys, and Carlan, 2015; Carlan et al., 2017). In turn, the digitally enabled tools developed from co.innovation will improve connectivity, visibility, and integration among MarSCs. Hence, co.innovation is key to further growth in MarSCs.

With the aim of strengthening co.innovation in MarSCs, the BNP Paribas Fortis Chair brings key actors in Northwestern Europe together for co.innovation sessions.[3] The purpose of these sessions it to share information and look for solutions to tackle inefficiencies in the MarSCs that operate through the ports of Antwerp, Rotterdam, and Zeebrugge (Figure 2). For this paper, 15 cases using digital technologies to improve processes related to MarSCs were selected among the initiatives analyzed during the sessions. For each of these cases, six features were examined: (i) the implementation stage of the technology, (ii) the investment source, (iii) the type of data collected and integrated by the technology, (iv) the leading stakeholder or innovation champion, (v) the supply chain actors addressed, and (vi) the benefits provided to MarSCs. The success factors and the challenges are also indicated. The analysis of these 15 experiences served as a basis for identifying best practices for LAC countries to improve MarSC performance by adopting digital technologies.

Figure 2. Northwestern Europe

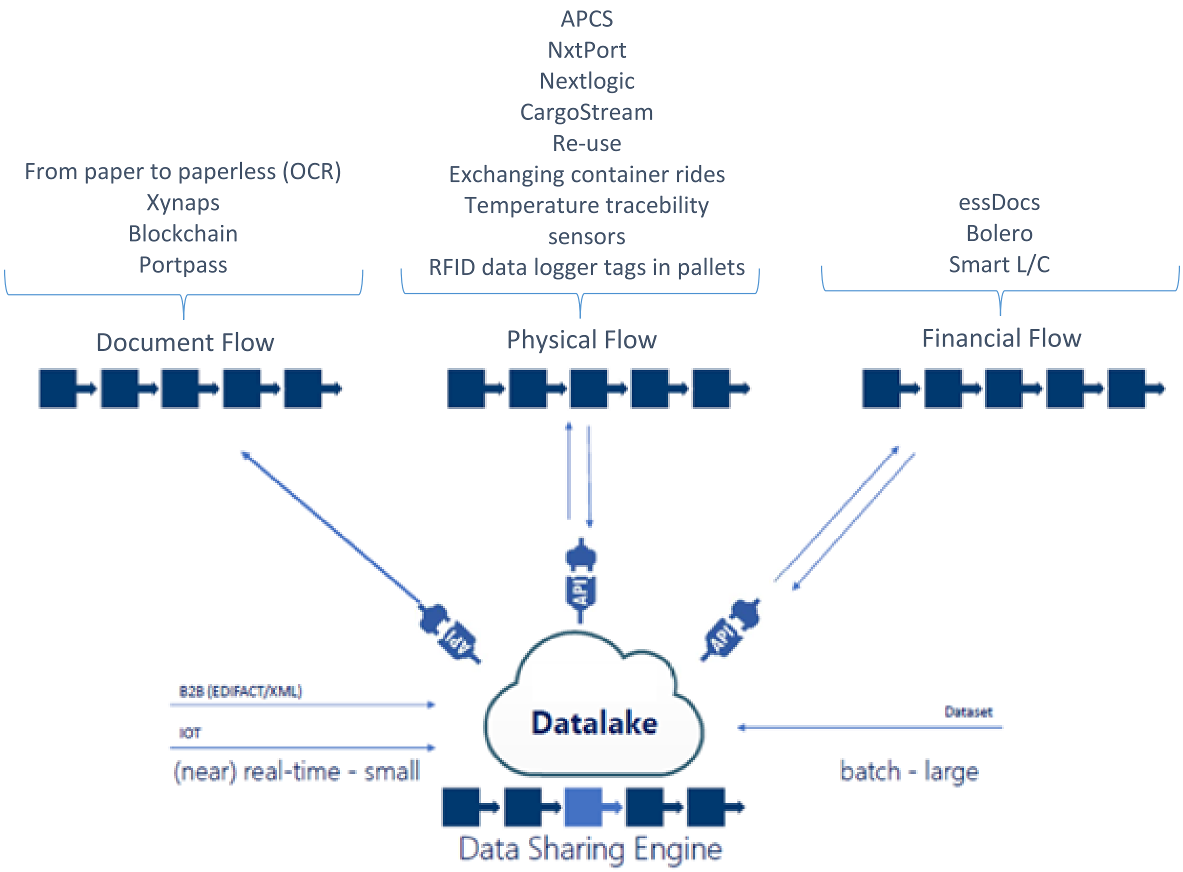
Source: worldatlas.com

[3] More information is available at https://www.uantwerpen.be/en/rg/transport-and-regional-economics/bnp-paribas-fortis-c/.

3. Experiences in Digital Innovation

For a seamless flow of goods, information, and financial resources, MarSCs often rely on information technologies. Therefore, the digital innovations analyzed in this paper can be classified in three clusters according to whether they support physical, documentation, or financial flow throughout Figure 3).

Figure 3. Overview of Digital Solutions and Clusters Included in the Study



Source: Authors based on NxtPort.

The first cluster concerns digital technologies supporting the physical flow, or the flow of cargo, in Northwestern Europe. We examined eight innovation cases that deploy two types of technologies: (i) technologies that set data hubs and (ii) technologies that enhance traceability along MarSCs. Data hub refers to platforms collecting data from multiple sources for increased information sharing among MarSCs actors. Traceability refers to the ability to track the origin and location of a component, product, or document, hence strengthening end-to-end supply chain visibility and control over cargo.

The second cluster focuses on the flow of documents throughout MarSCs. Indeed, MarSCs processes involve the exchange of a large number of physical documents. Delays in document transmission, errors in document compilation, and damage to or loss of physical documents can significantly affect the smooth operation of a supply chain. New digital solutions have been created to transition into a paperless supply chain and four such solutions available in Northwestern Europe are analyzed here.

Finally, the third cluster relates to the flow of financial resources. The goal of digital solutions in this area is to streamline financial operations while enhancing transparency and risk management. Three initiatives available in Northwestern Europe are examined.

Figure 3 summarizes the 15 digital solutions analyzed in this paper and the cluster they belong to. It also shows that, eventually, the three clusters could be connected via application programming interfaces (APIs) with a data lake, so that the data gathered by the different technologies could be stored in its original format in a single system or repository, avoiding the risks of data silos. The data-sharing engine could turn data into information and make it accessible in real time to MarSC actors.

In analyzing each digital solution, we provide a short description of the solution, followed by explanations of its applicability and characteristics according to the following features:

1. Implementation
2. Investment source
3. Type of data collected and integrated
4. Leading stakeholder or innovation champion
5. Supply chain actors
6. Expected benefits for MarSCs

Finally, the factors influencing the success or failure of each solution are listed. At the end of each cluster, we provide a comparative analysis of the cases examined.

3.1. Innovations Supporting Physical Flow

This section focuses on innovations supporting the flow of goods along the MarSCs that operate in Northwestern Europe. Given the predominance of containerized cargo in the region, many of the cases involved handling and transporting containers. Eight solutions were analyzed. Among them, six innovations were related to developing a data hub, while the other two solutions aimed to enhance end-to-end supply chain traceability. The ultimate goals of these innovation initiatives were to optimize the movement of goods along the entire MarSCs, or given segments of it, and to align performance with environmental policies.

3.1.1. Data Hub/Community Application

Data hub refers to platforms collecting data from multiple sources to increase information sharing among MarSCs actors. Effective exchange of information contributes to more efficient handling of cargo, improved inventory management, and reduced lead times. Six newly developed platforms were analyzed: Antwerp Port Community System (APCS), NxtPort, NextLogic, CargoStream, a technology to optimize the use of container equipment, and a technology to optimize trucking.

3.1.1.1. Antwerp Port Community System

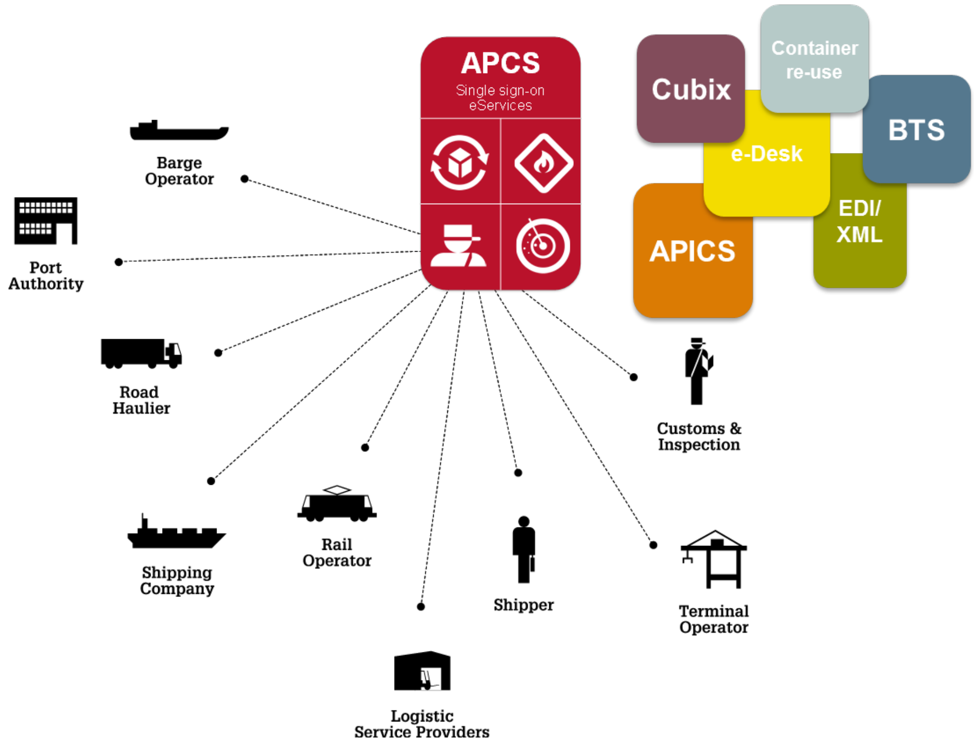
The APCS[4] is a multi-user platform that supports the cargo flow of MarSCs operating at the Port of Antwerp by enhancing the day-to-day administrative activities and logistics operations to and from the hinterland. APCS can be used for all types of goods and transport modes, and connects all stakeholders in the MarSCs operating at the port. The objectives of APCS are threefold. First, APCS centralizes the extensive offer of existing applications in the Port of Antwerp via a web portal. Second, this network of systems gives access to several applications by means of a single sign on (personal application dashboard with a single user ID and password). Third, it stimulates the use of standardized EDI, which increases the productivity and efficiency of service providers and thus the flow of goods.

Figure 4 shows the design of APCS. Based on standard exchangeable messages (EDIFACT and XML), data is exchanged related to cargo and logistics; customs procedures during import, export, and transit; the declaration of the transport of hazardous cargo; and nautical services. Moreover, user-friendly software applications like eDesk, APICS, Cubix, and BTS can be accessed via the platform. In 2013, APCS was expanded with three new modules for import services: container re-use by the carrier (see Section 3.1.1.5); e-transit for faster and error-free creation of T1s[5] by re-using data from the import customs manifest; and a container release module to electronically generate a secure PIN number for the commercial release of the container by the ship. Given increased focus on cyber as well as physical security, a pilot project based on blockchain technology is currently being implemented to generate a secure PIN number (see Section 3.2.3 for further details). Some of the software applications are developed in house by the Port Authority, while others are offered by external providers. The Port Authority opts for a pull strategy, meaning that new developments (e.g., book a lock) are market-driven. This is done in strong collaboration with both private companies and public agencies, becoming a good example of co.innovation.

[4] www.portofantwerp.com/apcs

[5] T1 is a transit document used to transport goods from the customs office at the place of departure to the customs office at the destination without paying customs duties and taxes within the territories of the countries included in the transit agreement.

Figure 4. Functional Design of APCS



Source: www.portofantwerp.com/apcs

Applicability

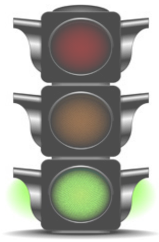
Cargo and Logistics	Customs	Hazardous Cargo	Nautical
Enables electronic communication to efficiently manage the entire logistics chain	Assists administrative operations in the process of customs declaration	Provides an efficient data flow channel for transport of hazardous cargo	Guarantees a 24/7 service to monitor and plan vessel traffic

Characteristics

Implementation stage	Implemented			
Investment source	Public–private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X	X	
Initiating stakeholder (Innovation champion)	Port Authority			
MarSCs actors addressed	All			
Expected benefit	Increase port community's competitiveness			

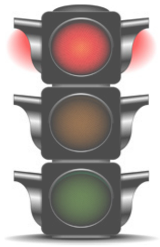
APCS has succeeded in integrating data and platforms related to the nautical and commercial aspects of the Port of Antwerp, securing data transmission, and introducing the highest cyber security standards. However, the overall success of this initiative will depend on its ability to attract major private port users and deal with the challenges of competing port platforms.

Success Factors



- Broad focus: from vessels traffic to customs and commercial purposes
- Integration of new technologies
- Legislative support
- Highest cyber security standards
- Secure data transmission

Challenges



- Integration of other systems used by port users
- Ability to attract major port users

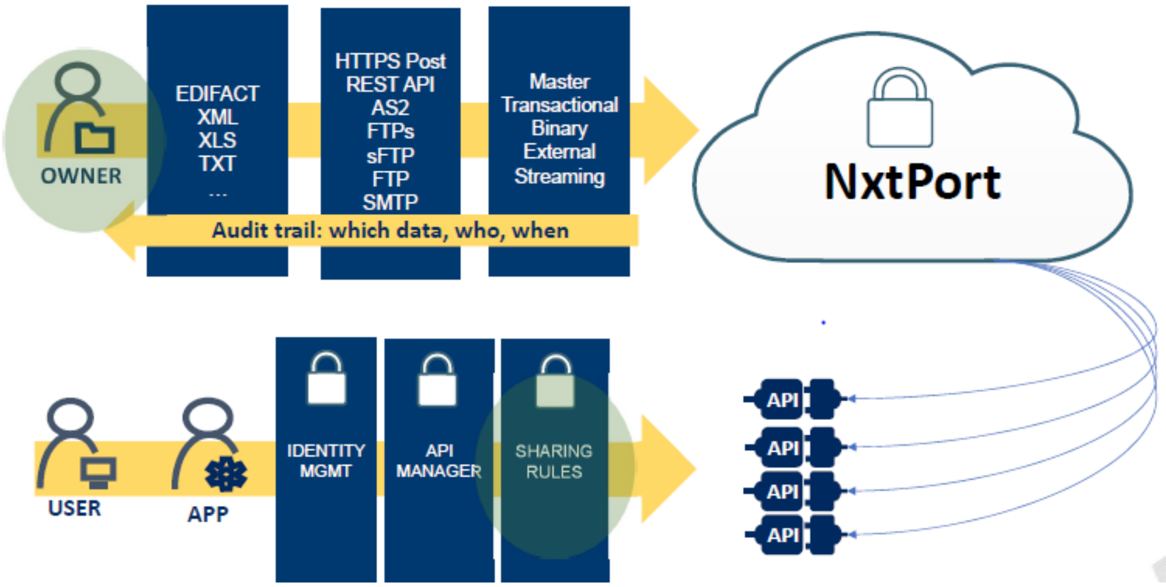
In 2016, a number of large maritime and logistics players in the Port of Antwerp, together with professional associations and the chamber of commerce, opted for a new platform called NxtPort to collect data from various stages of MarSCs. The initiators state that this platform will lead to more efficient and transparent data interchange, as well as easier interoperability between existing platforms. The link between APCS and NxtPort has not been defined. Here, two development tracks are possible: either APCS functionalities are completely integrated into NxtPort or NxtPort develops new services only by using public APCS API's (e.g., vessel stay API). Both scenarios are possible since Antwerp Port Authority and the Federal Participation & Investment Company jointly acquired a stake in NxtPort in November 2017.

3.1.1.2. NxtPort

The data utility platform NxtPort was created to facilitate data-sharing practices among the users of the Port of Antwerp. NxtPort addresses the specific type of data transfers that was not covered by other community systems. It was set up by a private company and it aims mainly, but is not limited, to integrating data from terminal operators. NxtPort is expected to increase the operational efficiency of port stakeholders by overlapping a new layer of data on existing information. Furthermore, the platform seeks to create added-value for data owners and users by allowing market applications to be built on existing data.

Figure 5 shows that data can be uploaded to NxtPort in different formats (e.g., EDIFACT or XML). During the audit trail, decisions are made regarding which data, who gets access to data (i.e., identity management and sharing rules), when, and via which API. Data owners and platform users can share information with supply chain partners but also build applications on top of NxtPort according to their information needs.

Figure 5. NxtPort Design



Source: www.nextport.eu

Applicability

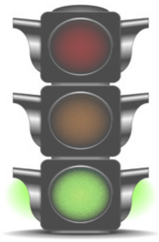
Data Storage	Data Share	Applications Uptake
Provides a safe data storage environment	Assists port users in sharing data and holding ownership rights	Stimulates the IT industry to make use of data and create new applications

Characteristics

Implementation stage	Initiating			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		X
Initiating stakeholder (Innovation champion)	Private IT developer			
MarSCs actors addressed	All			
Expected benefit	Offer added-value services to port users			

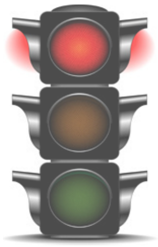
Factors that contribute to implementing this solution are the protection of ownership rights, the ability to integrate data in one platform, and the possibility of building APIs in order to gain value from the information already available. Challenges for the sustainability of this solution may be lack of trust between the stakeholders along the MarSCs, the delay in developing reliable business cases to evidence the advantages of NxtPort, and uncertainty regarding rules for monetizing data (e.g., data fee and transaction fee).

Success Factors



- Focus on the data of terminal operators
- Integrating existing data
- Protecting ownership rights
- Offering added-value data

Challenges



- Gaining trust among port users
- Developing reliable business studies
- Participation costs and data usage

The Port of Rotterdam introduced a parallel initiative—NextLogic (see below)—established for and by the market; however, its approach is different from NxtPort's. NxtPort is a data integration platform that, after integrating information from different sources, seeks further development opportunities. Instead, NextLogic has a bottom-up approach: from the very beginning, the platform was targeted to provide solutions to a number of optimization problems faced by logistics parties operating at the Port of Rotterdam.

3.1.1.3. NextLogic

NextLogic (www.nextlogic.nl) is a data integration platform that addresses the MarSCs parties involved in inland container shipping (e.g., barge operators, inland terminals, deep-sea terminals and depots, shipping companies, and, ultimately, also freight forwarders and shippers at the Port of Rotterdam). NextLogic focuses on more efficiently handling inland container shipping by providing a platform where the entire chain of container shipping by barge can work together. Benefits for supply chain stakeholders adhering to the NextLogic platform include more reliable planning and thus a predictable turnaround time; better use of the quays, cranes, and barges; and fewer calls at the seaport.

The platform is financed by the Port Authority and Rijkswaterstaat, the agency responsible for designing, building, managing, and maintaining the main infrastructure facilities in the Netherlands. Public sector goals include strengthening the competitiveness of the Port of Rotterdam and stimulating growth of inland container shipping. Private sector companies have signed agreements to use NextLogic and provided input to the platform design and operation.

Applicability

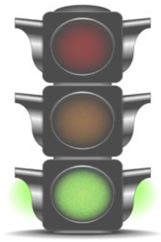
Integrated Planning	Information Exchange	Performance Dashboard	Information Platform
Offers integrated planning for containers and inland navigation vessels	Provides data communication channel between vessel operators and other logistics stakeholders	Provides a customizable performance dashboard to monitor operations	Uses API to share up-to-date information about schedules, calls, containers, and quay capacity

Characteristics

Implementation stage	Initiating			
Investment source	Public			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X	X	X
Initiating stakeholder (Innovation champion)	The Port of Rotterdam and Rijkswaterstaat			
MarSCs actors addressed	Inland vessel operators, inland terminals, shippers			
Expected benefit	Stimulate the growth of inland navigation transport			

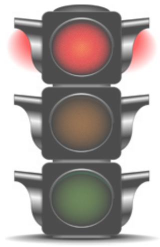
The port-wide approach, joint efforts of all parties involved in the MarSCs, and the integration of data from multiple sources are key factors that may contribute to the success of NextLogic. To ensure its sustainability, the platform will need to strengthen the trust of port stakeholders on the platform, as well as guarantee a cost-efficient level of participation from such stakeholders.

Success factors



- Port-wide approach
- Joint efforts of all parties involved in the logistics chain
- Integrate data from multiple sources

Challenges



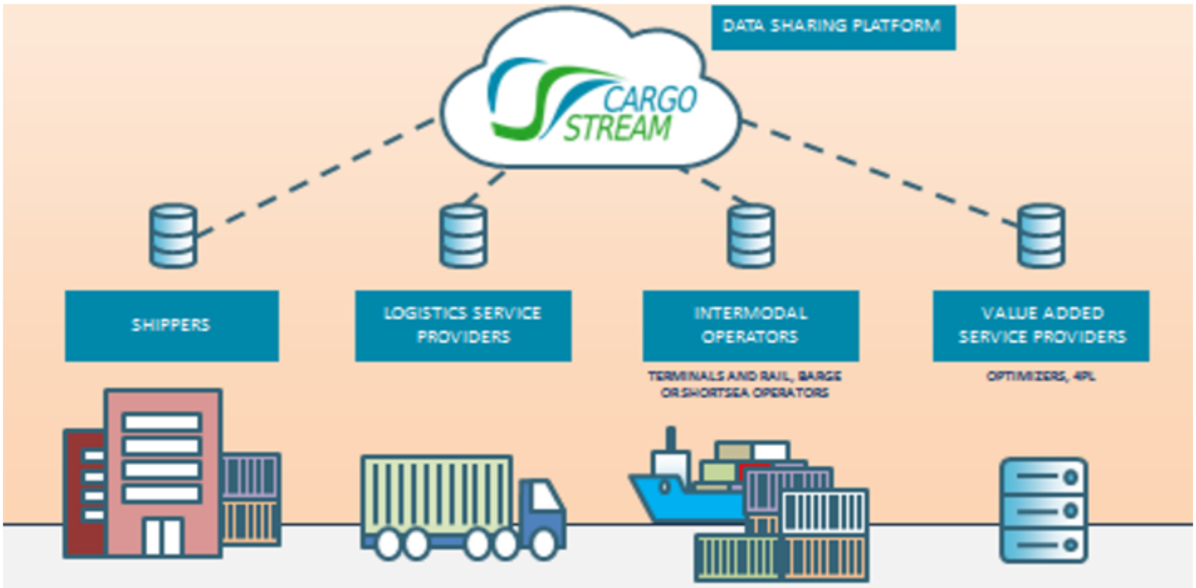
- Participation costs
- Gain trust among the port users

3.1.1.4. CargoStream

CargoStream (www.cargostream.net) is a data integration initiative that relies on the participation of all MarSCs stakeholders (e.g., shippers, intermodal terminals, rail and barge operators, and logistics service providers) (Figure 6). Such multi-actor supply chain collaboration is another good example of co.innovation. The platform was developed by Nallian, a five-year old company focused on improving supply chain collaboration (www.nallian.com). Being an open platform, CargoStream offers a plug & play architecture, allowing solution providers to offer their algorithms on the platform. In addition, participating shippers contribute to its development by providing input and sharing knowledge.

The purpose of this independent, neutral, open, and pan-European platform is to help participating shippers reduce their truck transportation kilometers by bundling their regular transportation needs with other shippers, so that vehicle fill rates can be improved, distribution routes can be optimized, and use of multimodal transportation can be improved. By doing so, CargoStream seeks to help tackle challenges such as truck driver shortage, pollution, and congestion. Shippers communicate their regular shipping needs to CargoStream and the platform anonymizes this information, aggregates needs over multiple shippers, and applies state-of-the-art optimization algorithms to provide shipping options for the specific cargo. In addition, being a neutral platform, data ownership by shippers is guaranteed as it remains at the source.

Figure 6. Set Up of CargoStream



Source: www.nallian.com

Applicability

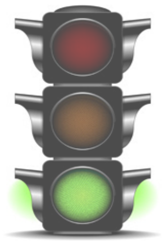
Data Sharing	**Cargo Bundling**	**Multimodal Transport**
Shippers are encouraged to share data about their shipments	Generates data on possible cargo bundling	Using algorithms, generates multimodal transport solutions to optimize available transportation capacity

Characteristics

Implementation stage	Initiating			
Investment source	Public–private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
	X	X		X
Initiating stakeholder (Innovation champion)	Technology developer in collaboration with a shipper			
MarSCs actors addressed	All logistics stakeholders			
Expected benefit	Optimize transportation and reduce pollution and congestion			

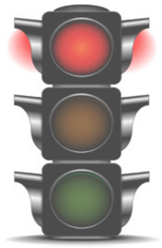
Factors leading to the success of CargoStream include achieving a critical mass of users, incorporating the transport conditions of each user, integrating information about transport capacity, shifting knowledge from the air sector to the logistics sector, and improving service, inventory, and cost levels. In order to achieve this success, trust must be gained and sufficient volume and scale must be reached.

Success Factors



- Achieving a critical mass of users
- Incorporating the transport conditions of each user
- Integrating information about transport capacity
- Shifting knowledge from the air sector to the logistics sector
- Improving service, inventory, and cost levels

Challenges

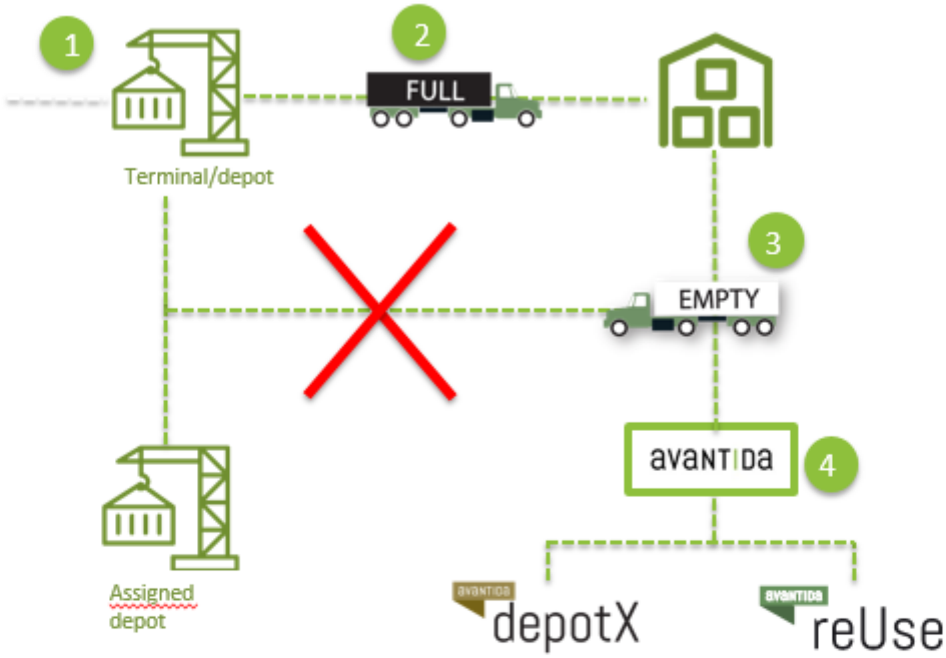


- Enough scale and volume
- Trust

3.1.1.5. Optimization of Container Equipment

Avantida (www.avantida.com), a software developer, initiated the innovative concept of re-use. The goal is to provide shipping companies and container owners with a way to use their equipment (containers) more efficiently. Through this platform, empty containers from import operations can be requested to be re-used for export operations (Figure 7), thus enabling the matching of full transport orders with planned empty trips of containers. In other words, this application allows maritime carriers (or container owners) to communicate with land operators and integrate their transport necessities with the unused land transport capacities. By using this platform, the unproductive transport of empty containers is being capitalized on, so that it brings benefits to all the involved parties. In addition, this innovative initiative results in decreasing transport costs and CO_2 emissions for the carriers and could contribute to a decline of port congestion.

Figure 7. Re-using Container Equipment



Source: www.avantida.com

The platform also allows transport companies to opt for an alternative container drop-off or pickup location, for instance at an inland terminal. Indeed, the DepotX platform is another innovation that emerged from the re-use concept. DepotX allows trucking companies to drop or collect empty containers in around 80 depots in the Benelux, Germany, and Switzerland. This innovative concept optimizes trucking operations, reduces congested areas around ports, decreases CO_2 emissions, and increases efficiency by avoiding waiting times at terminals.

User access is enabled through a pay-per-use fee. This way, the goals of the application administrator remain directly linked with the user's interests. Given that this application is operating in a multi-carrier environment, in 2015, Avantida connected with APCS (see Section 3.1.1.1). The company's technology applications attracted the attention of INTTRA, the industry leader in digitized container logistics, which bought Avantida in spring 2017. Furthermore, there is also a movement to work together with other start-ups. For example, Avantida is a partner in the technology developed by Hakka, which is discussed in 3.1.1.6.

Applicability

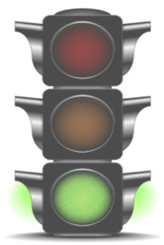
Empty Equipment Re-use
Transport operators or shipping companies change their logistics process in order to avoid unnecessary trips with empty containers.

Characteristics

Implementation stage	Implemented			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		
Initiating stakeholder (Innovation champion)	Initiated by IT developer with the support of the ocean carriers			
MarSCs actors addressed	Carriers, shipping companies, road transport operators			
Expected benefit	Optimize the use of empty equipment			

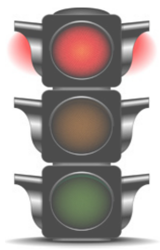
The following three elements contributed to the successful implementation of this technology: The involvement of the container owner, the pay-per-use fee, and the support from local administration. One challenge that remains for sustainability of this initiative is some resistance from the trucking industry.

Success Factors



- The involvement of container's owner
- Pay-per-use fee
- Support from the local administration

Challenges



- Resistance from the trucking industry's side

3.1.1.6. Optimizing Transport Schedules by Exchanging Container Rides

Another example of co.innovation in MarSCs is the matching engine developed by Hakka (www.hakka.eu), a spin-off of the technology company Inuits. This solution is based on an innovative concept introduced by a trucking company and called EuroTransCon, whereby container rides are exchanged in order to improve collaboration and communication in the trucking industry. This way, empty containers are not sent back to the inland port depots but are reloaded in the vicinity of where they were unloaded (Sys, Vanelslander, and Carlan, 2015a). Thus, Hakka brings together road transport operators in the port area with the goal to complete their transport tasks more effectively. In particular, Hakka provides transport operators with a virtual space where they can communicate and agree on consolidating their tasks.

While the EuroTransCon platform started as a tool that optimized transport operations of 10 trucking companies, it has expanded with the inclusion of other companies, now forming a trusted community. With the help of new open-source technologies, Hakka will rebuild the EuroTransCon platform and add new functionalities that can help 130 member carriers optimize their planning. The development path of this application has followed a bottom-up approach. After gaining success at the level of the developer company, it attracted the interest of several other trucking companies and access was then opened to third parties. Access to its services is based on a monthly subscription fee and leaves the users to pick and combine their own transport tasks.

Applicability

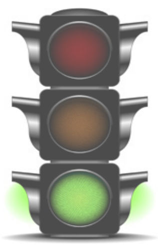
Marketplace	Matching	Announcement	Re-use
Creates a virtual place where trucking companies can exchange information about their transport operations	Integrates matching algorithms to avoid empty trips	Offers a single sign-in platform for truck appointments at empty depots and terminals	Offers re-use services to transport empty containers

Characteristics

Implementation stage	Initiating			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		X
Initiating stakeholder (Innovation champion)	IT developer together with a community of trucking companies			
MarSCs actors addressed	Trucking companies			
Expected benefit	Reduce costs for trucking operators, avoid empty runs, reduce traffic congestion and CO_2 emissions			

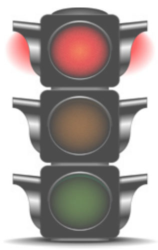
Two key factors are driving the success of this initiative. First, there is a community of trust already established. Second, that community can be leveraged by using the matching algorithm made available through the technology. The main challenge faced by this solution is competition from other initiatives.

Success Factors



- Exploring the benefits of an already established community of trust
- Integrating collaborative conditions within the matching algorithm

Challenges



- Facing competition from other similar developments

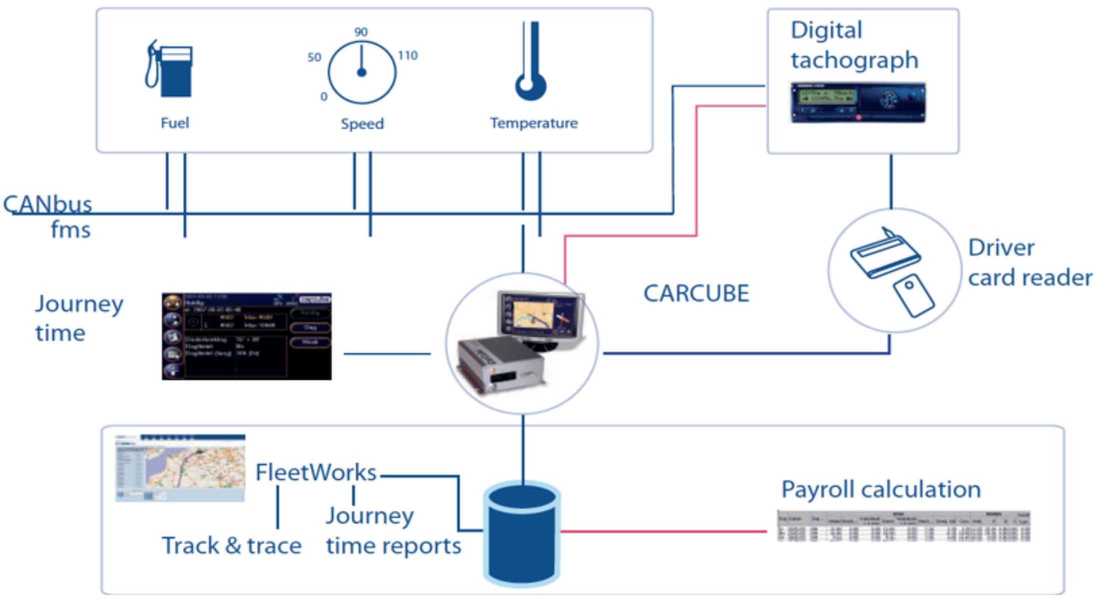
3.1.2. Traceability

In the context of increasingly complex and global supply chains, ensuring traceability has become a priority for supply chain operators. Traceability refers to the ability to track the origin and location of a component, product, or document, hence strengthening end-to-end supply chain visibility and control over cargo. While consumers' attention to product quality, safety, and sustainability is growing, shippers (for example in pharmaceutical and food industries) are investing in technologies that enhance product monitoring and ensure unbroken chains. In addition, better traceability along the supply chain improves inventory management, asset utilization, agility, and risk management, among other factors. Two of the digital solutions analyzed in this study focus specifically on traceability, namely: the use of sensors to monitor temperature in road transportation pharmaceuticals and medical devices, and the deployment of RFID technology in the kiwifruit supply chain. These cases are discussed below.

3.1.2.1. Temperature Tracking Sensors

A trucking company operating in the geographic area analyzed deployed dedicated sensors to monitor temperature inside trailers. These trailers are used for transporting pharmaceutical products and medical devices that require the product temperature to be maintained within certain ranges. In addition to sensors, trucks have on-board units that collect data on unit location, speed, fuel consumption, and other operational data. The information gathered through different technologies is combined to provide a complete status of the transported goods. The solution architecture is shown in Figure 8. Aside from enhancing traceability along the transport leg of the supply chain, these technologies provide the trucking company with useful information for vehicle routing, asset management, and payroll calculation.

Figure 8. Solution Architecture for Temperature Tracking Sensors



Source: www.ninatrans.eu

Applicability

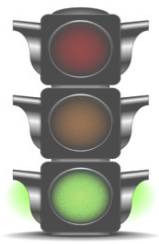
Product Traceability in Road Transportation
This solution integrates information captured by different technologies such as: digital tachographs, truck on-board-units, GPS, equipment management software, and dedicated sensors. The information generated adds value to trucking services since shippers can monitor product status during transport operations.

Characteristics

<table>
<tr><td>Implementation stage</td><td colspan="4">Initiating</td></tr>
<tr><td>Investment source</td><td colspan="4">Private</td></tr>
<tr><td rowspan="2">Type of data collected and integrated</td><td>Transport tariffs</td><td>Cargo/ container information</td><td>Nautical information</td><td>Truck/ transport data</td></tr>
<tr><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>Initiating stakeholder (Innovation champion)</td><td colspan="4">Trucking company</td></tr>
<tr><td>MarSCs actors addressed</td><td colspan="4">Trucking company, shippers</td></tr>
<tr><td>Expected benefit</td><td colspan="4">Value-added services</td></tr>
</table>

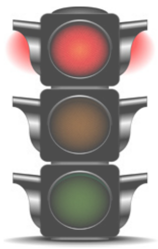
A key success factor of this solution is that it enables data integration from heterogeneous sources. The main challenges to be faced in near future are incentivizing customer’s willingness to pay for the data provided by this service—on top of transport services—and the use of the right methods to standardize and exploit the big data generated by the technologies deployed.

Success Factors



- Data integration from heterogeneous sources

Challenges



- Find the customer’s willingness to pay and develop a business model
- Methods of to standardize and use big data

3.1.2.2. RFID Tags on Pallets

Zespri, the world leader in kiwi trade, has deployed RFID tags on pallets to identify, monitor, and trace the products shipped by the company. This technology is aligned with the company’s goal to control product status and ensure product quality along its extended and complex supply chain. Indeed, Zespri sells kiwifruit to more than 50 countries, it supplies 137.7 million trays of kiwifruit annually, and it manages 30 percent of global kiwi volume.

Figure 9. Zespri Supply Chain

Source: www.zespri.com

Another innovative solution and example of co.innovation was developed by Zespri and the Dutch-headquartered shipping firm Seatrade. The solution relates to maritime transportation of pallets with kiwifruit from New Zealand to Northern Europe. Until recently, Zespri chartered reefer vessels with entire decks filled with pallets of kiwi. Last year, Zespri and Seatrade started using container-specialized reefer vessels. In this way, the fruit is transported in 40-foot individually cooled containers containing about 20 pallets of kiwis. In February 2017, the first 2,200 TEU specialized reefer container vessel arrived at Belgian New Fruit Warf, at Port of Zeebrugge, bringing 10,060 pallets of kiwifruit. For the port, this was a record load, as a traditional reefer ship could only transport 5,000 pallets.

Figure 10. Seatrade's New Colour Class Ship

Source: www.zespri-europe.com

Applicability

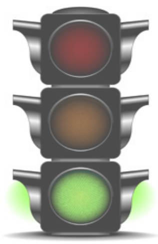
Traceability and Supply Chain Management
Zespri uses RFID tags on pallets to record the container temperature. Data is transmitted to a device in close proximity. Together with the use of barcodes at the product level, automated RFID data capture allows full traceability along Zespri's global supply chain, from a coolstore in New Zealand, to a container on a vessel, to a coolstore in Europe. Moreover, this data can be used to, for example, monitor supply chain processes, identify deviations from targets, reduce losses (due to, for example, order modifications, changes in vessel estimate time of arrival, or fruit deterioration), and comply with regulatory requirements regarding food characteristics and safety. It is important to note that, rather than replacing barcodes, the company uses RFID as a complementary technology, leveraging the data gathered through barcodes with new, additional information.

Characteristics

Implementation stage	Implemented			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		X
Initiating stakeholder (Innovation champion)	Shipper			
MarSCs actors addressed	Shippers, consignees			
Expected benefit	Product quality improvement			

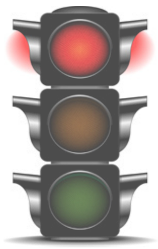
An important barrier for the deployment of RFID technology on a large scale is its (still) high cost. As the cost declines, the technology is expected to create significant advantages in terms of complying with regulatory requirements and standards, monitoring the supply chain, and avoiding costly product loss.

Success Factors



- Meets globally accepted standards
- Control of the supply chain backbone
- Avoids costly fruit loss

Challenges



- Technology cost

3.1.3. Summary of Cargo Flow Solutions

A comparative analysis of the eight digital solutions applied to cargo flow in MarSCs was conducted based on four criteria: (i) the source of the innovation investment, (ii) the initiating stakeholder (or innovation champion), (iii) the MarSC actors addressed by the solution, and (iv) the type of data collected. The criterion *type of data collected* encompasses transport tariffs, cargo and container information, nautical information, and truck and transport data. Table 1 presents the results of the comparative analysis.

Table 1. Comparison of Cases Supporting Cargo Flow

				Type of Data Collected and Integrated			
Case	**Investment Source**	**Developing Stakeholder**	**MarSCs Actors Addressed**	**Transport Tariffs**	**Cargo/ Container Information**	**Nautical Information**	**Truck/ Transport Data**
Data Hub/Community Application							
APCS	Public–private	Port Authority	All		X	X	
NxtPort	Private	IT developer	All		X		X
NextLogic	Public	Public authorities, deep-sea terminals, empty depots, and barge operators	Deep-sea terminals, empty depots, and barge operators		X	X	X
CargoStream	Public–private	IT developers and logistics stakeholders	All	X	X		X
Re-use	Private	IT developer	Carriers, shipping companies, road transport operators		X		
Exchanging container rides	Private	IT developer and road transport operator	Road transport operators		X		X
Traceability							
Temperature traceability sensors	Private	Road transport operator	Shippers, road transport operator		X		X
RFID data logger tags in pallets	Private	Shipper	Shippers, consignees		X	X	X

In the period 2012 through 2017, different digital solutions emerged in Northwestern Europe to tackle inefficiencies in cargo flows along MarSCs. The above comparison shows that these solutions were aimed at tackling three types of inefficiencies: low asset utilization (re-use and exchanging container rides), network congestion and CO_2 emissions (APCS, NxtPort, NextLogic, and CargoStream), and damage to product quality and waste (temperature traceability sensors and RFID tags). Regarding the investment source, the private sector took the leading financial role in most of the cases. In the cases of APCS and CargoStream, the investment source was a mix of public and private funds, while the innovative concept NextLogic was developed using public resources. When looking at the innovation champion, in most cases it was a supply chain actor who came up with an innovative idea to solve a problem. Close collaboration between this actor and an IT developer contributed to higher success in solution implementation, since it helped the move from an innovative concept to a mature solution. In very few cases, the initiator was a specialized software developer. Such were the cases of data integration platforms NxtPort and NextLogic.

In turn, there is high heterogeneity concerning the users targeted by the solutions analyzed. While some data hubs were developed with the intention that they would be used by all types of supply chain stakeholders (APCS and NxtPort), others had a more specific focus. In the latter case, the majority of the stakeholders addressed were those involved in optimizing hinterland connections (e.g., Hakka and Avantida for trucking companies, and CargoStream for shippers and freight forwarders). Finally, regarding the type of data collected and integrated by these digital solutions, the most common one was cargo or container information, while the second most common was truck and transport data. Interestingly, technology deployed to enhance traceability addressed the concerns of specific supply chains (high-value goods and a perishable), for which dedicated data collection, communication, and consolidation technologies were implemented. None of the general data hubs or community platforms collected data on traceability.

3.2. Innovations Supporting Document Flow

While the first cluster of digital solutions focused on smoothing cargo flow along MarSCs, the innovations in the second cluster aim to facilitate the compilation and exchange of documents related to MarSCs processes. Indeed, the efficiency of MarSCs can be significantly impacted by cumbersome and expensive procedures to fill in and submit paper documents. Paperless solutions have emerged to tackle this problem, making information and document exchange along MarSCs more efficient. Four cases from Northwestern Europe are analyzed here. The first case discusses the use of optical character recognition (OCR)—a technology to recognize text in documents—at an inland terminal. The second uses an electronic CMR, the consignment note that has a standard set of transport and liability conditions. The third explores the use of blockchain technology to securely release containers at port terminals. The last case is a platform to manage customs clearance for international trade flows.

3.2.1. Optical Character Recognition

To reduce the administrative cost of paper documents along the transport leg of MarSCs, an inland terminal replaced the pre-printed CMR with a digital form using OCR. Initially, this solution was designed for transport operations over a very short distance (a couple of hundred meters from the inland terminal to the consignee's warehouse on a public road), for which a hardcopy of the CMR had to accompany the transport operation. The next step in adopting the technology would have been deploying intelligent OCR (integrating machine learning algorithms) that recognizes the CMR model and automatically transfers the information into a terminal IT system. However, regulations adopted at the national level in Belgium required that an electronic CMR (Section 3.2.2) be adopted, therefore making the terminal replace the technology to adopt the electronic CMR recognized by the national authority.

Applicability

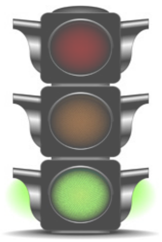
Paperless Transport	Digital Information
Represents early adoption of a digital solution to reduce costs related to transport operations	Uses new technology to reduce administration and paper documents

Characteristics

Implementation stage	Initiating			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		
Initiating stakeholder (Innovation champion)	Inland terminal			
MarSCs actors addressed	Inland terminal, consignee			
Expected benefit	Reduce administrative costs			

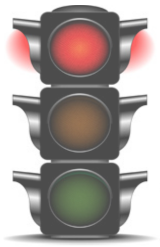
While the participation of transport partners and the consignee in the project, together with the benefits of rapidly transferring official documents, could have incentivized the adoption of OCR technology on a larger scale, delays in project implementation and changes in regulatory requirements made the project fail.

Success Factors



- Participation of road transport partners and the consignee
- Benefits for rapid transfer of official documents

Failure Factors



- Delay in project implementation and uncertainty with regard to regulations

3.2.2. Xynaps

Xynaps by Pionira is a cloud-based collaboration and data-sharing platform for transport and logistics. Organizations can create closed and secured collaboration groups to share information and give transparency to transport movements. Each connected stakeholder is notified in real time about changes in transport and freight documents. The platform originated from the application DigiCMR, implemented by Pionira. DigiCMR offers a government-accredited platform through which an e-CMR replaces the paper CMR to improve administrative processing and billing. From authoring the document and through its various stages in its lifecycle (e.g., digitally signing for pickup and delivery), each party is notified of any changes to the document. This guarantees that the document cannot be altered without notifying the parties involved. Furthermore, the complete digitally signed CMR implicitly guarantees non-repudiation of the contained and enriched data. The data gathered during the lifecycle of the CMR can be imputed into other connected systems. In addition, DigiCMR lowers administrative work by eliminating the need to decrypt and manually input handwritten data on the CMR. The reduction of manual inputs (up to 80 percent) is reflected in reduced administration costs, greater billing efficiency, and a substantial reduction in errors.

Table 2 compares the main functionalities of a paper CMR and DigiCMR. Through partnerships between Pionira and suppliers of transport management systems (TMS), warehouse management systems (WMS), enterprise resource planning systems (ERP), Telematics, and Internet of Things systems, users keep using their existing and known applications, eliminating the need to adopt an additional system and train on how to use it.

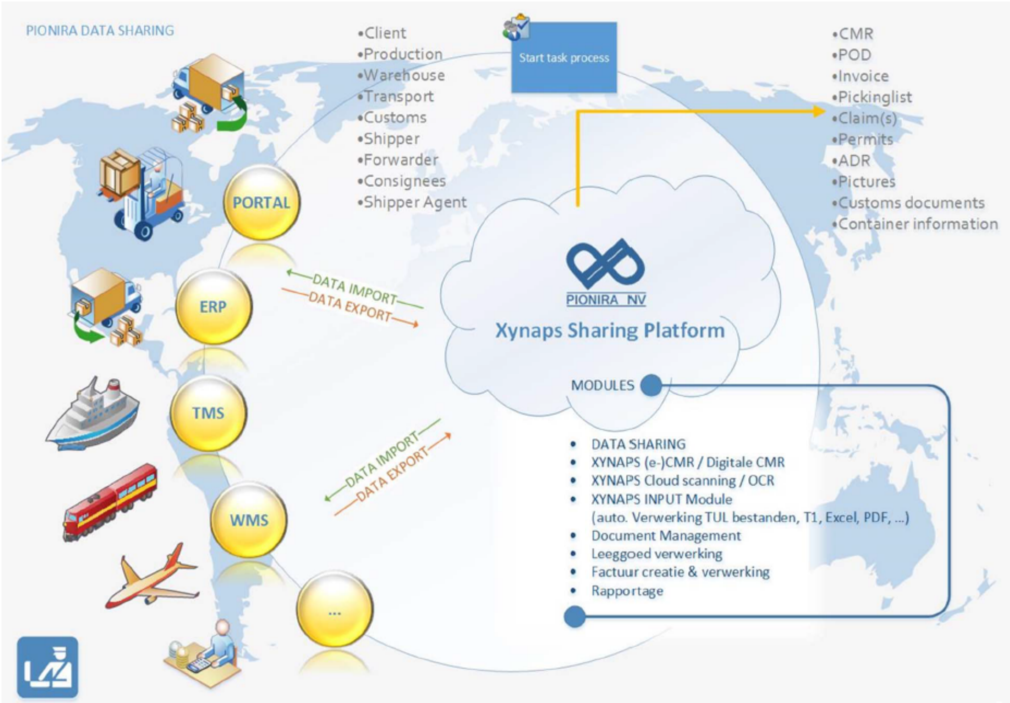
Table 2. Comparison between Paper CMR and DigiCMR

Functionality	Paper CMR	DigiCMR
Participative conditions	Unregulated	Only registered, checked, and contracted companies
Signing the CMR	Uncontrollable signature	Only by registered user of a registered company The user's name can be printed on the DigiCMR
Stamping the CMR	Uncontrollable stamp	With the uploaded stamp of a registered company
Driver's signature	Uncontrollable signature	By entering the name and driving license number of the driver, the drivers name is printed on the DigiCMR
Automatically pre-alert consignee	Not available	Pre-alert sent automatically by email with attached documents (e.g., delivery notes, invoices)
Track and trace	Not available	Possible to track the status of the shipment
Arrival and damage report	Not available	The system automatically sends the receiving report to the sender and the carrier. The confirmed DigiCMR document is attached in PDF format.
Queries and reports	Not available	Can query shipment by DigiCMR number, date, period, truck number plate etc. Excel export also available.
Archiving CMR documents	Printed version archived	The system archives all documents for 7 years.
Identifying sender and consignee	Not available	By the internet IP address of the sender and consignee.
Security and safety	Not available	Information about lost shipments. Immediately information about transport damage and responsibility.
Evaluating partners	Not available	Damages, delays per partner per period etc.
Digital signature and date stamp	Not available	Digitally signed by DigiCMR organization. Time stamp available.
GPS coordinates of consignee	Not available	Printed on the transport documents

Source: www.pionira.be

Originally, DigiCMR was specifically developed for carriers, but it raised interest from other supply chain stakeholders. Therefore, the company developed Xynaps as a cloud platform to facilitate the exchange of documents between supply chain stakeholders, regardless of the format in which data is stored (Word, Excel, txt, csv, pdf, xml, EDI, etc.). Once data is uploaded to the platform, Xynaps uses this data to feed other systems in the supply chain without having to re-input the data (Figure 11). Through specific apps like DigiCMR, data can be used to create the necessary transport documents.

Figure 11. Xynaps Sharing Platform



Source: www.pionira.be

Applicability

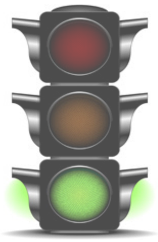
Data Storage and Sharing
Takes over creation, production, and management of document flows within organizations. Functionality ranges from producing a simple copy to managing entire document flows.

Characteristics

Implementation stage	Implemented			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		X
Initiating stakeholder (Innovation champion)	Software developer			
MarSCs actors addressed	Trucking companies, shippers, consignees, depots, agents			
Expected benefit	Reduce administrative costs			

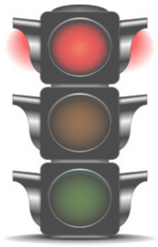
If a critical mass of users is achieved, this solution will succeed in integrating data from multiple sources, having at the same time the recognition of the Belgian Federal Public Service Mobility and Transport.

Success Factors



- Approved recognition by the Federal Public Service Mobility and Transport
- Integrates data from multiple sources

Challenges



- Achieving critical mass of users

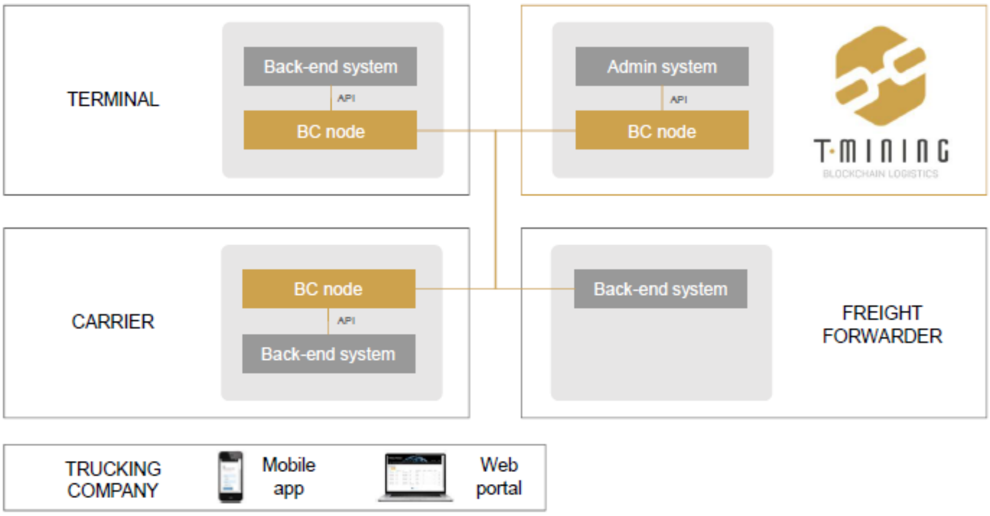
3.2.3. Blockchain ‘Made in Antwerp’

One of the cases analyzed tested blockchain technology to improve the security of container release at a port terminal. The start-up T-mining is currently piloting a digitized supply chain at the Port of Antwerp using distributed ledger technology. This proof of concept for container handling will set up a network among an ocean carrier (Mediterranean Shipping Company, or MSC), a terminal operator (PSA), a consignee, and transport companies.

The test aims to provide a solution for the administrative work related to the physical handover of containers at the port. Currently, the shipping agent uses an EDIFACT message to send information about the container and the PIN code to both the terminal and the consignee of the goods. The latter passes this information to the transport company, which often writes the PIN code manually on the CMR. When picking up the container, the driver types the code in the terminal operator’s system. However, this way of handling information not only increases the probability of errors (wrong PIN manually written on CMR, wrong PIN entered in the terminal system), but it also puts MarSCs at risk of security breaches, with PINs being copied or container information being manipulated for criminal purposes.

To overcome these challenges, blockchain technology is being tested so that the right truck driver picks up the right container at the port terminal, with no risk of a third party intercepting this information or counterfeiting PIN data. On arrival at the terminal, the driver receives a PIN via their smart phone. This PIN is generated and saved on a blockchain making it impossible to counterfeit. In the first phase of development, the driver still types this information at the terminal gate to gain access, but in the next phase, the mobile phone of the right driver at the right gate will be recognized automatically. Given that about 11 million containers are handled each year at the Port of Antwerp, this emerging technology is expected to help reduce operational and administration costs related to container release, enable more efficient information sharing, improve security in container release, and eliminate fraud (Figure 12).

Figure 12. Blockchain Community on Secure Container Release



Source: www.t-mining.be

Applicability

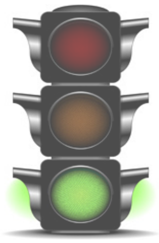
Secure Information Sharing Channel
The proof of concept of blockchain technology focused on secure container release at the Port of Antwerp. Beyond this, the technology promises to have a wide range of applications. In fact, T-mining is one of 20 technology providers setting up a cooperation agreement with the data platform NxtPort (see Section 3.1.1.2). In this context, the next step will be to roll out this technology with other trusted parties at the Port of Antwerp and look for other opportunities where blockchain technology could be applied, such as document sharing and secure financial transactions.

Characteristics

Implementation stage	Initiating			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		X
Initiating stakeholder (Innovation champion)	Software developer			
MarSCs actors addressed	Shipping companies, inland depots, road transport operators, inland vessel operators, customs, terminal operators (deep sea and inland)			
Expected benefit	Increase security and reliability of information transfer, reduce administration, increase operational efficiency			

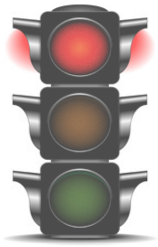
While there is growing attention to possibilities for different uses of blockchain technology, there is still limited testing and market penetration. However, such attention, together with close collaboration between MarSC actors and software companies, could lead to promising applications.

Success Factors



- Close collaboration between developing party and users

Challenge

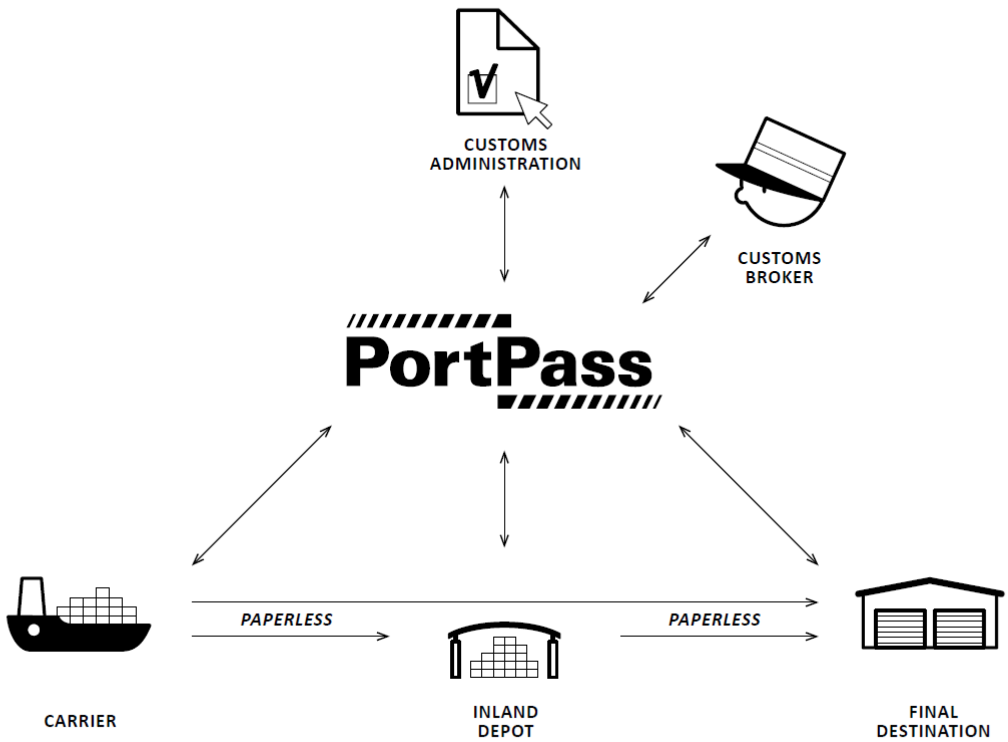


- Limited market penetration

3.2.4. PortPass

PortPass is a solution that enables paperless transit of cargo from the port of entry to the end-customer's warehouse. It is a cloud platform that stores and distributes information and documents required for international trade procedures among the parties involved (Figure 13). Using this platform, customs officers can benefit from transparent access to the cargo's documentation. In turn, customs brokers can monitor the clearance status of the cargo. The parties involved are released from handling paper documents and the related administrative and handling costs. This innovative concept could be compared to a fast lane ticket for containers that complies with the multiple formalities and customs requirements for international trade processes.[6]

Figure 13. PortPass Cloud Platform



Source: www.antenno.com

[6] http://www.antenno.antenno.com/wp-content/uploads/2017/03/Explainer-Video-PortPass.mp4?_=1

Applicability

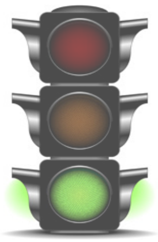
Administration	Logistics	Data Handling	Stakeholder Integration
Automates administrative and customs processes, reducing errors	Connects the entire supply chain by making information available to all logistics stakeholders	Offers complete data integrity and highly secure storage	Provides easy and integrative solution to administrative documents

Characteristics

Implementation stage	Initiating			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
		X		X
Initiating stakeholder (Innovation champion)	Shipping company			
MarSCs actors addressed	Shipping companies, inland depots, road transport operators, inland vessel operators, customs, agents			
Expected benefit	Reduce document administration costs, errors, and inland transit time, and improve security and data communication			

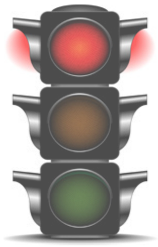
Success factors for PortPass are reduced transit time and human errors due to direct data exchange between electronic systems, and reliable overview of the customs clearance status. Challenges are gaining trust from targeted users, complying with the security requirements of customs administration, and interoperability with the platforms of logistics stakeholders.

Success Factors



- Reducing transit time and human errors due to direct data exchange between electronic systems
- Offering a reliable overview of the customs clearance status

Challenges



- Gaining trust and complying with security requirements of customs administration
- Interoperability with platforms of logistics stakeholders

3.2.5. Summary of Document Flow Solutions

Table 3 shows the results of the comparative analysis of the four cases discussed above. The comparison was performed according to the same four criteria used for cargo flow best practices (Section 3.1.3).

Table 3. Comparison of Cases Supporting Document Flow

				Type of Data Collected and Integrated			
Case	Investment Source	Developing Stakeholder	MarSC Actors Addressed	Transport Tariffs	Cargo/ Container Information	Nautical Information	Truck/ Transport Data
Optical character recognition	Private	Inland terminal	Inland terminal, consignee		X		
Xynaps	Private	Software developer	Road transport operators, shippers, consignees, depots, agents		X		X
Blockchain	Private	Software developer	Shipping company, inland depots, road transport operators, inland vessels operators, customs, agents		X		X
PortPass	Private	Shipping company	Shipping company, inland depots, road transport operators, inland vessels operators, customs, agents		X		X

In all the cases analyzed, innovation was driven by private parties. In two cases (Xynaps and blockchain) the initiating party was a software developer. The other two were initiated by MarSCs stakeholders, namely an inland terminal (OCR) and a shipping company (PortPass). Another characteristic of document flow solutions is that they address a wide range of users. Given that document exchange in MarSCs often involve many parties, the higher the number of supply chain actors that use the digital solution, the higher its likelihood of success. Currently, the type of information collected by these solutions concerns only cargo and container information and/or transport data. It is yet to be seen whether these or novel solutions will seek to include tariff information and nautical data as well.

3.3. Innovations Supporting Financial Flow

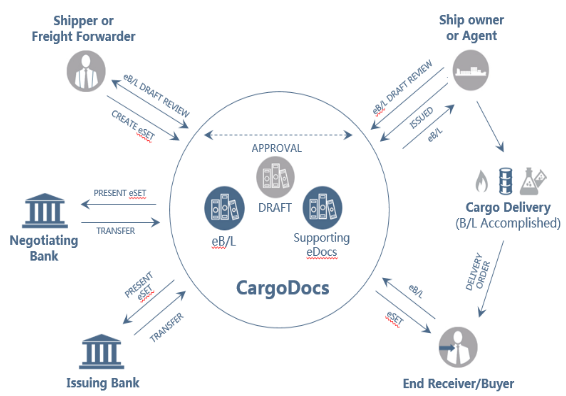
The digitization of documents related to MarSCs processes can be leveraged to improve the flow of financial resources. The digital solutions included in this third cluster—essDocs, Bolero, and a smart letter of credit—focus on increasing transparency in financial procedures; reducing costs and risks of credit, thus improving access to finance for MarSCs actors; and increasing the speed at which financial resources flow throughout MarSCs.

3.3.1. essDocs and Bolero

Strong demand for digital products in trade finance has given rise to different innovations that aim to foster the transition from paper documents to electronic solutions in commercial transactions. Digitization of trade finance and shipping documents is of increasing interest to shippers and receivers, carriers, and the banking sector. Combining digital trade finance instruments (eUCP, eDocumentary, and Bank Payment Obligation) with managing electronic bills of lading (eB/Ls) and other supporting electronic documents (e.g., electronic invoice, certificates of origin, inspection certificates, and insurance) can improve transparency, payment certainty, risk mitigation, and process streamlining (BNP Paribas Fortis, 2017).

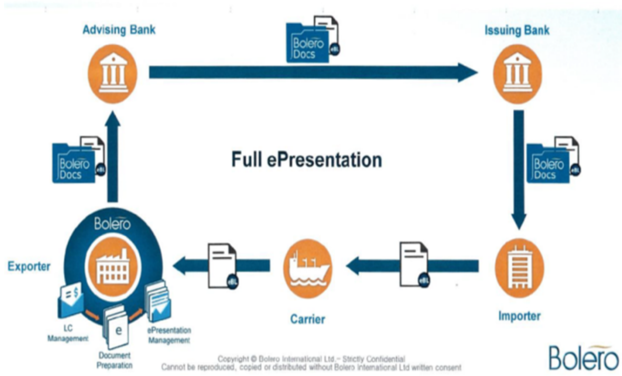
Two of the cases analyzed provide this type of solution to MarSCs in Northwestern Europe: essDocs and Bolero. Figures 14 and 15 describe the workflows for these platforms. In order to enable paperless trade, the platforms encourage the adoption of eB/L. From a financing perspective, eB/Ls make a significant difference when used on short routes (e.g., Port Hedland to Shanghai) since they significantly reduce document processing time. In the case of paper documents, the process from drafting, signing, and issuing the B/L to the buyer receiving the documents takes about 10 days. In the case of eB/L, the amount of document processing time can be reduced to 4 days (BNP Paribas Fortis, 2017).

Figure 14. Workflow essDOCS



Source: www.essdocs.com

Figure 15. Workflow Bolero



Source: www.bolero.net

Applicability

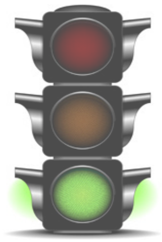
Working Capital	**Risk Reduction**	**Customer Offerings**	**Operational Efficiencies**
- Reduced time to cash - Reduced inventory - Optimized credit line usage	- Compliance - Auditability - Improved controls and traceability	- Reduced fees - Reduced financing costs - Reduced demurrage costs	- Standardized processes - Automation - Reduced manual processing - Reduced paper

Characteristics

Implementation stage	Implemented			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
	X	X		
Initiating stakeholder (Innovation champion)	Software developer			
MarSCs actors addressed	All			
Expected benefit	More time efficient and reliable financial operation			

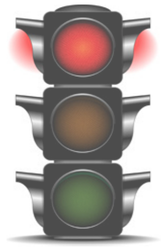
Factors that contribute to the success of these platforms are the ability to reduce processing time for financial transactions, as well as the immediate applicability on short shipping routes—compared with a seaway bill—where there is no time to sell the cargo during the journey. A key challenge is obtaining access to reliable information from different sources and actors.

Success Factors



- Reducing the financial transaction processing time
- Immediate applicability on short shipping routes

Challenge

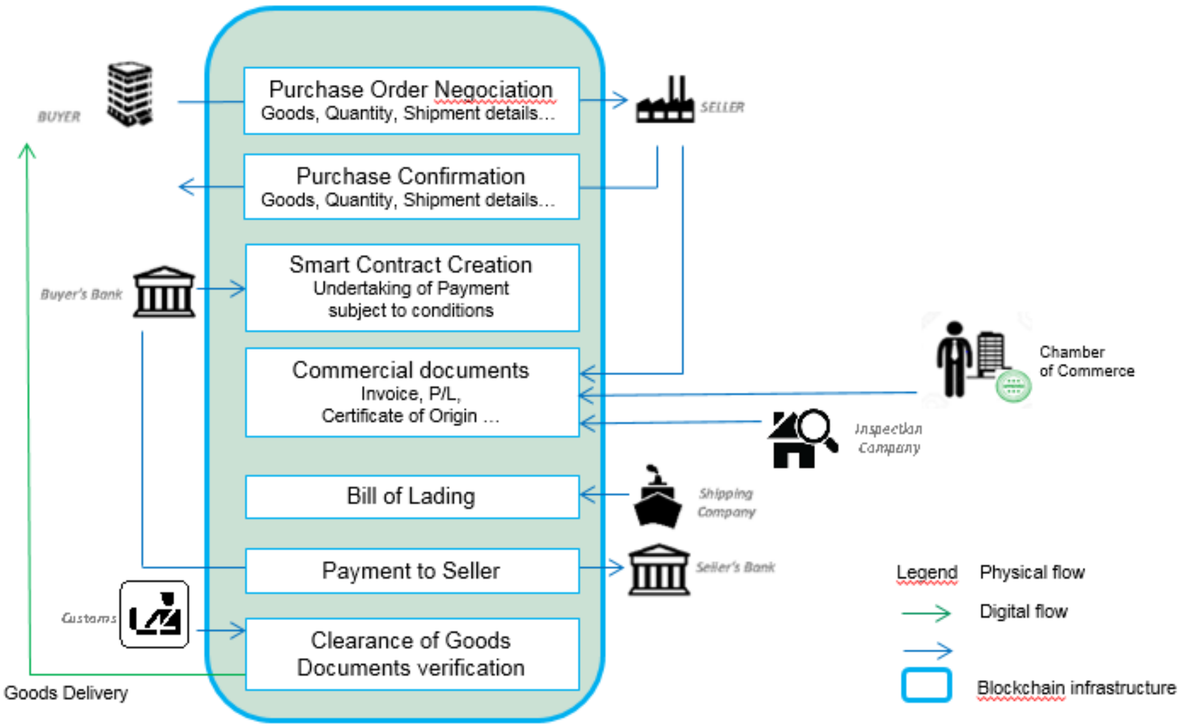


- Obtaining access to reliable information from different sources

3.3.2. Smart Letter of Credit

Another solution in this cluster used blockchain technology to create a smart Letter of Credit (L/C). The term "smart" refers to contracts written in computer code that can be completed automatically once certain conditions are satisfied. Figure 16 shows that, once the blockchain is in use, all stakeholders benefit from better visibility of financial transactions and the status (and the content) of official documents.

Figure 16. Smart L/C: Process Flow Involving a Blockchain



Source: BNP Paribas Fortis, 2017

Applicability

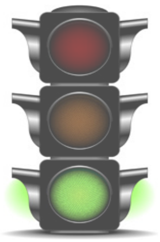
Working Capital	Risk Reduction
More predictable financial transactions	Improve security

Characteristics

Implementation stage	Initiating			
Investment source	Private			
Type of data collected and integrated	Transport tariffs	Cargo/ container information	Nautical information	Truck/ transport data
	X	X		
Initiating stakeholder (Innovation champion)	Banking			
MarSCs actors addressed	All			
Expected benefit	Streamlining manual processing of import/export documentation			

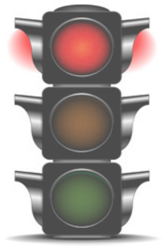
While there is still limited testing and market penetration of blockchain technology, streamlining financial and administrative procedures can bring significant benefits to MarSCs.

Success Factors



- Visualizing data in real time
- Streamlining financial and administrative processes

Challenge



- Limited testing and market penetration

3.3.3. Summary of Financial Flow Solutions

Table 4 shows the comparative analysis of the cases discussed above. The comparison was performed according to the same four criteria used in Sections 3.1.3 and 3.2.5.

Table 4. Comparison of Cases Supporting Financial Flow

				Type of Data Collected and Integrated			
Case	**Investment Source**	**Developing Stakeholder**	**MarSC Actors Addressed**	**Transport Tariffs**	**Cargo/ Container Information**	**Nautical Information**	**Truck/ Transport Data**
essDocs and Bolero	Private	Software developer	All	X	X		X
Smart L/C	Private	Consortium of banking institutions	All		X		X

All three cases were financed by the private sector; however, the innovation champions were different. While essDocs and Bolero were the initiative of software developers, the smart L/C was initiated by a consortium of banking institutions. In all three cases, targeted actors are stakeholders in MarSCs and the type of data collected involves cargo and transport information.

4. Policy Framework to Foster Innovation in MarSCs

This section summarizes the policy framework in Europe that incentivizes innovation in sectors and processes related to MarSCs. Indeed, due to market failures in innovation (e.g., externalities and public goods), public policy support is critical to create an enabling environment (e.g., human capital, regulation, and access to finance) and provide the financial support for innovation when it generates benefits for the economy and society. In Europe, the European Union (EU) has adopted an innovation strategy that encompasses two general tracks: policy and funding.

The policy component includes social, public sector, public procurement, and workplace innovation. With regard to social innovation, the EU facilitates the inducement, uptake, and scaling-up of social innovation solutions. The EU also encourages public sector innovation and seeks efficiency gains, better governance, faster delivery, and more citizen involvement in the public sector. Best practices are identified through market surveys and disseminated among the European countries. Furthermore, the EU supports public procurement innovation, so that the public sector can act as an early adopter of innovative solutions and use its purchasing power to stimulate innovation. A public procurement innovation platform has been set up for this purpose. Finally, the EU supports workplace innovation as a means to cope with changes in the work environment.

Several projects are contributing to create an innovation environment in Europe. Table 5 shows a sample of these projects.

Table 5. EU Innovation Policies and Related Projects

EU Goal	Approach	Related Projects
Social Innovation: New ideas that meet social needs, create social relationships, and form new collaboration initiatives		
- Facilitate inducing, taking up, and scaling-up social innovation solutions	- Facilitate networking - Organize competition - Ensure funding for programs (e.g., employment and social innovation programs, Horizon 2020, collective awareness platforms) - Create ecosystems for social innovation by attracting private investors - Disseminate evidence about the impact of social innovation - Support EU-wide incubators (e.g., Transition and Benisi) - Seek new ideas, applications, or fields for social innovation	- Social Innovation Community - European Social Innovation Competition
Public Sector Innovation: Innovation in European governments as regulators, service providers, and/or employers		

EU Goal	Approach	Related Projects
- Seek efficiency gains, better governance, faster delivery, and more citizen involvement in the public sector	- Launch the European Public Sector Innovation Scoreboard - Identify trends and challenges in public sector innovation in Europe by explaining the different understandings of public sector innovations in EU countries, identifying the main drivers and barriers to public sector innovation, and drawing lessons from specific cases. - The EU study collates data from interviews with public officials, national experts, and academics, as well as national statistics.	- The Red Tape Challenge in the UK - The Hungarian Economic Development Centre (MAG) - The Central Unit for Public Administration Reform in Romania (UCRAP) - The Energy-Efficiency Program in Stuttgart, Germany (SEE) - The Quality Labels of the Spanish National Agency for the Evaluation of Policies and Quality of Services (AEVAL) - The Irish Acute Medicine Program (AMP)
Public Procurement of Innovation: The public sector using its purchasing power to act as an early adopter of innovative solutions that are not yet available on a large-scale commercial basis		
- Improve public procurement practices, promote demand for innovative goods and services in Europe, and foster the uptake of innovation in the EU	- Public authorities act as first/launch customers and promote the use of innovation-friendly procurement practices - The EC supports the development of groups of procurers, provides guidance, and sets up a support platform to help contracting authorities implement innovation procurement - EU countries are encouraged to take measures to stimulate innovation through public procurement practices	- Public procurement of innovation platform
Workplace Innovation: Addresses changes in business structure, human resources management, relationships with clients and suppliers, and the work environment.		
- Improve motivation and working conditions for employees that lead to increased labor productivity, innovation capability, market resilience, and overall business competitiveness	- Prioritize workplace innovation (e.g., the reinforced 2012 EU Industrial Policy Communication) - Launch the European Workplace Innovation Network (EUWIN) in 2013 to support this priority	- The EUWIN is a Europe-wide learning network launched to sustainably improve the performance of organizations and the quality of jobs

Source: Authors based on EC (2017a, 2017b) and Digital Innovation in Europe (2017).

To support policy goals, the EU allocates funding to develop or implement innovative projects. Three funds are particularly relevant for this study since they make resources available to overcome challenges in logistics and private sector development. The first fund is Horizon 2020. For the period 2014–20, the goal of this fund is to support innovation from the development stage—“the lab”—to the market. The second fund is the European Structural and Investment Fund, which focuses on financing innovation for small and medium-sized enterprises (SMEs) for the period 2014–20. Finally, the European Strategic Investment Fund aims to overcome market failures and mobilize private investments for innovation. There has been €21 billion allocated to this fund, with a potential to mobilize up to €315 billion in private sector investment. Table 6 summarizes the main characteristics of these funds.

Table 6. EU Funding for Innovation

Types of EU Innovation Funding	Timeframe	Funding	Prioritized Activities (Applicability)
Horizon 2020 and SMEs: Financially supports innovation from the lab to the market and ensures that H2020 prioritized activities are implemented.			
	2014–20	€80 billion	Biennial project calls (2014–16; 2016–18; 2018–20) on the following investment sections: - Excellent science - Industrial Leadership - Societal challenges - Science with and for society - Cross-cutting activities - Fast track to innovation pilot
European Structural and Investment Funds: Finance innovation activities, information and communication technology (ICT), SME competitiveness, and the low-carbon economy.			
- European Regional Development Fund (ERDF) - European Social Fund (ESF) - Cohesion Fund (CF) - European Agricultural Fund for Rural Development (EAFRD) - European Maritime and Fisheries Fund (EMFF)	2014–20	€110 billion	Focuses on five areas: - research and innovation - digital technologies - supporting the low-carbon economy - sustainable management of natural resources - small businesses
European Fund for Strategic Investments: Aims to overcome current market failures by addressing market gaps and mobilizing private investment.			
	2015–20 (extended from 2018)	€21 billion (mobilize up to €315 billion in additional investment)	Finance strategic investments in key areas such as: - infrastructure - research and innovation - education - renewable energy and energy efficiency - risk financing for SMEs

Source: Authors based on EC (2016a).

Along with the innovation strategy, the EU is currently pursuing different initiatives to specifically facilitate digitization and the transition to the digital economy. To set up policies in this area, the EU consults with a broad range of stakeholders. Table 7 shows two public consultations held by the EU on topics related to digital innovation: one on ICT-driven public sector innovation and the other on a European single data market. These consultations have pointed to new strategies and policy development in line with market needs. Regarding the single data market, a strategy has been developed for EU countries to complement the free movement of people, services, and capital. Under a single data market, individuals and businesses can seamlessly access and exercise online activities under conditions of fair competition. Finally, another interesting initiative regards the creation of a digital innovation showcase in Europe, which is a network of digital players that gathers and shares best practices and lessons learned to support the data-driven economy in Europe.

Table 7. EU Support for Digital Innovation

Approach	Related Projects	Timeframe	Results
Public consultation on directions for ICT-driven public sector innovation: Provide input for research and innovation activities at EU level in the area of ICT-enabled public sector innovation			
- Held expert discussions and inputs made during and after a workshop - Carried out online public consultation with stakeholders (administrations, businesses, researchers, innovators, academia, and users)	N/A	- Expert meeting in Brussels: 31/01/2013 - Online survey: 08/03/2013–15/04/2013	- Orientation paper: research and innovation at EU level under - Horizon 2020 in support of ICT-driven public sector - Innovation - Draw a common vision on ICT-driven public sector innovation
Public consultation on building a European data economy: Foster the best possible use of digital data to benefit the economy and society			
- Online public survey with 332 responses covering public authorities, non-governmental organizations, researchers and research organizations, and consumers - Addresses barriers to developing a European single market with a free flow of data and legal issues surrounding access to and transfer of data, data portability, and liability of primarily non-personal, machine-generated digital data	N/A	Online survey 10/012017 – 26/04/2017	- Data localization restrictions should be removed and a legislative instrument providing data transparency would be a preferred alternative
Digital Single Market: Endorse open science and open access to scientific results to provide European science, industry, and public authorities with excellent digital infrastructure: supercomputing and data storage			
- Invests in world-class ICT research and innovation in order to boost growth and jobs - Encourages innovative public–private partnerships to boost innovation	e-Infrastructures (under FP7 'Capacities', H2020) address the needs of European researchers for digital services in terms of networking, computing, and data management	06/05/2015–31/01/2017	- Complements the free movement of persons, services and capital - By this initiative, individuals and businesses can seamlessly access and exercise online activities under conditions of fair competition, and a high level of consumer and personal data protection, irrespective of their nationality or place of residence
Digital Innovation Showcase Europe: A network of innovative European digital players that are driving the transition to the data-driven economy in Europe			
- Share best-case examples, highlighting new business models the internet is fostering and giving its European pioneers a voice in the policy debates	N/A	From 2014 on	- Manifesto release of "Ten Steps to Unlock Europe's Digital Potential"

Source: Authors based on EC (2016b).

Finally, the EU supports projects specifically related to improving processes in MarSCs. This takes place under the Horizon 2020 program, which funds projects in 11 categories: aviation, rail, blue growth, road, green vehicles, safety, infrastructure, urban mobility, intelligent transport systems, waterborne, and logistics. Table 8 gives an overview of the main projects financed under the H2020 fund that relate to improving MarSC performance by adopting digital technologies. For each project, its goals, period, and budget are indicated.

Table 8. H2020 Funded Logistics Projects

Projects/Goals	Period	Budget
AEOLIX: Establishes a cloud-based collaborative logistics ecosystem to manage information pipelines that support logistics decision-making		
- Create visibility across the supply chain, enabling more sustainable and efficient transport of goods across Europe - Enable low-complexity and low-cost connectivity of local ICT platforms and systems	01/09/2016 to 31/08/2019	€16.2 million
Clusters 2.0: Set the basis of European logistics clusters for an efficient and fully integrated transport system in Europe and demonstrate the scaling effects for the companies collaborating within logistics clusters		
- Implement the CargoStream portal (see Section 3.1.1.4) - Develop new modular loading units - Implement a first-of-a-kind prototype on a cluster community system	01/05/2017 to 30/04/2020	€6.3 million
LessThanWagonLoad: Develop a smart and specialized logistics cluster for the chemical industry in the Port of Antwerp to shift transport volumes from road to rail freight		
- Mitigate greenhouse gas emissions - Reduce costs of rail freight - Increase inter-modality and higher resilience of the transport system - Stimulate local economic growth and employment - Decrease congestion and traffic casualties	01/05/2017 to 30/04/2020	€3.9 million
NEXTRUST: Increase efficiency and sustainability in logistics by developing interconnected trusted collaborative networks along the entire supply chain		
- Build trusted collaborative networks (ideally bottom-up) - Develop cloud-based smart visibility software to support re-engineering of the networks - Improve real-time use of transport assets	01/05/2015 to 31/10/2018	€18.1 million
RCMS: Address the growth and capacity problems of sea terminals by improving automated container management systems		
- Develop a detailed simulation model for RCMS to be evaluated in the Gdansk and Koper terminals - Assess and compare RCMS performance with other state-of-the-art container handling technologies for the Gdansk and Koper terminals - Simulate a transport network in terms of efficiency, reliability, capacity, performance (e.g., travel times and average speed), and impacts (noise and air pollution) in the Port of La Spezia	01/05/2015 to 31/01/2017	€4.1 million
SELIS: Establish a network of logistic communities' specific shared intelligent information spaces termed SELIS Community Nodes (SCN)		
- Establish a consortium of logistics stakeholders and ICT providers that can leverage EU Information Protocol (IP) from over 40 projects to create proof of concept Common Communication and navigation platforms for pan-European logistics - Establish a research and innovation environment to provide data than can be used to discover new insights that will enable continuous value creation, supporting the large-scale adoption of SELIS	01/09/2016 to 31/08/2019	€17.7 million
SYNCHRO-NET: Establish a SYNCHRO-modal supply chain that can catalyze the uptake of the slow steaming concept and synchro-modality, guaranteeing cost-effective robust transport solutions that slow down and better organize the supply chain		
- Optimize real-time synchro-modal logistics (e-Freight-enabled) - Simulate slow steaming shipping and control systems - Statistically analyze synchro-modal risk/benefit - Assess dynamic stakeholder impact - Design synchro-operability communications and governance	01/05/2015 to 31/10/2018	€7.5 million

Source: Authors based on EC (2017c).

In sum, Northwestern Europe has a strong policy framework to foster innovation and the transition to a digital economy. Indeed, the EU has adopted a set of policies for this purpose and has allocated significant funds to technological development and to create an enabling environment for innovation. Under the Horizon 2020 program, part of these funds have specifically financed innovations in MarSC processes.

5. Lessons Learned for LAC Countries

This section discusses the lessons that countries in LAC can learn from the experiences in Northwestern Europe discussed above. The cases analyzed show that there are a number of initiatives concerning development and adoption of digital technologies that are intended to improve the connectivity, visibility, and, therefore, performance of MarSCs. It is important for LAC countries to improve the performance of their MarSCs because 73 percent of goods traded by LAC countries are seaborne (Calatayud et al., 2017). However, not only are companies in LAC countries not tapping the benefits of digital solutions, they are lagging in adopting such technologies. For example, the average percentage of enterprises that have their own webpage is about 60 percent, below the average of 71 percent of OECD countries (IDB, 2017). In addition, there is no homogeneity between LAC countries. While only 11 percent of firms in Suriname have their own webpage, the averages in Chile and Brazil are closer to international results (70 percent).

In this context of digital divide, public sectors are designing strategies to incentivize the transition of their economies to the emerging digital economy and the Fourth Industrial Revolution. In addition, business associations and individual companies are taking actions to enhance technology adoption in the different sectors and supply chains that operate in LAC. There is thus increasing awareness in the region of the need to start closing the digital divide and be up to date on the technologies used by supply chains. In this context, it is important to learn from international experiences. The paragraphs that follow present the lessons that can be learned from the cases from Northwestern Europe. Broadly speaking, these lessons can be grouped into four areas: (i) stakeholder collaboration, (ii) the scope of technology, (iii) stakeholder approach to change, and (iv) the role of the public sector.

One important area of lessons learned relates to the collaboration of supply chain stakeholders to develop, adopt, and scale a technology. Many of the cases analyzed required not only the participation of the technology company, but also active involvement from the private and public sectors for the technology to fulfill its goal(s). For example, APCS needed to integrate data from the port authority, customs, shipping lines, terminal operators, trucking companies, and shippers for the platform to serve as a one-stop-shop for MarSCs using the Port of Antwerp as its gateway. Similarly, to more efficiently handle inland container shipping, NextLogic needed different logistics stakeholders (e.g., barge operators, inland terminals, the Port of Rotterdam, and shipping companies) to be willing to share information about their processes and to use the platform to plan logistics operations.

Indeed, MarSCs involve a variety of actors that are interlinked through different supply chain processes; therefore, to efficiently deploy any technology at the supply chain level, stakeholders should be involved and willing to electronically share information. For this to happen, processes and data need to be digitized and information sources and technology have to be interoperable. In turn, some investment in terms of hardware, software, and staff training may be required. Consequently, it is not sufficient that a single actor develops or adopts a technology to improve the performance of a MarSCs process. Instead, other key supply chain stakeholders need to see the benefit of adopting the technology and be willing to invest their time and resources on it.

An important lesson for LAC countries in this regard relates to the need to increase collaboration between private and public sectors when technologies to improve supply chain processes need the participation of both sectors. In the case of MarSCs, it is particularly important to involve port authorities, customs, and other control agencies in the discussions about, for example, making ports a more efficient gateway for freight flow. The role of the public sector is further discussed below.

A second lesson learned is that, even though some of the cases analyzed integrated more than one functionality in the digital solution, the scope of the technology, the supply chain processes, and the actors targeted by the digital solution can vary. Cases like Avantida and Hakka show that technologies can be developed to solve a specific problem in MarSCs, which in the case of these solutions was to optimize the use of container equipment. In turn, specific solutions can evolve toward more integrated platforms to share different types of information, like APCS and NxtPort, where data on cargo, vessels, and customs processes in the case of APCS is exchanged by platform users.

The lesson learned for LAC countries is that there is no one-size-fits-all solution to improve information sharing along the supply chain. Instead, different solutions can emerge to solve specific or/and broader issues in the MarSCs. This implies that a different range of actors may be involved in the different solutions implemented. In any case, it is important for stakeholders to ensure that the digital technologies they use can be interoperable with other platforms, so that there will not be problems integrating data with current or future digital solutions. In addition, supply chain actors should be aware of not duplicating or increasing process complexity when adopting solutions that should help them simplify and improve supply chain management.

Another area of lessons learned relates to the approach stakeholders take to change. In the cases analyzed, while there were actors who took the role of champions or innovation promoters, others were followers, merely spectators, or even reluctant to change. Concerning innovation champions, they came from different sectors. In some cases, they were technology companies—usually start-ups—who teamed up with an important MarSCs player to implement the solution. Some of them were later acquired by companies in industries related to MarSCs. This was the case of Avantida, which was acquired in spring 2017 by INTTRA, the industry leader in digitized container logistics.

In other cases, it was the major company in the MarSCs that introduced a technology to be used along its supply chain. For example, Zespri introduced the use of RFID data logger tags in pallets transporting kiwis from New Zealand to Belgium to increase product traceability. This pushed other actors in the supply chain, particularly those involved in transportation, warehousing, and distribution of kiwis, to upscale the technology used in their processes and facilities so that product traceability would not be lost because of lack of RFID technology. Interestingly, there were cases where it was a transportation company that was the champion in increasing digitization and, therefore, information sharing along MarSCs.

In order to increase the value added of services provided in a competitive trucking market, and to improve operations performance, the trucking company introduced the use of sensors to monitor the temperature inside the trailers transporting cold chain products, GPS to monitor the location of trucks, and a digital system to communicate among the company's office, the truck driver, and the shipper. By implementing these technologies, the data gathered could be used to benefit not only the individual trucking company, but also the shippers and warehouse operators, improving overall quality control and turnaround time for pick-ups and deliveries.

Apart from champions and followers, any change creates pockets of resistance that can threaten to make technology adoption fail. Some of the cases analyzed in this paper experienced or are currently experiencing a certain degree of resistance. To overcome this challenge, a key lesson learned is the critical role that the champion, particularly when it is an important player in the MarSC or an alliance of champions that take part in the same supply chain, can play to boost technology development and its adoption by other partners.

For LAC countries, the globalization of MarSCs and rapid diffusion of technology imply that technologies being developed and adopted elsewhere (e.g., whether at the shipper or a third party logistics provider, or 3PL headquarters) can become mandatory for firms in the region when they are members of the same MarSCs and the technology adopter has enough market power to enforce it on its supply chain partners. In addition, for supply chain actors or technology companies in LAC interested in developing a digital solution, the lesson learned from Northwestern Europe is that adoption is more likely to succeed when the major players in the supply chain are involved.

Finally, there is a role for public policy in promoting digital technology development and adoption in MarSCs, like in other supply chains. On one side, the public sector can create an enabling environment to enhance private sector collaboration or leverage private sector investment in developing and adopting such technologies. Such an environment is the result of regulations that promote technology and, at the same time, mitigate risks for the economy and society. This is the case of, for example, regulations on data privacy, data ownership, and intellectual property. In addition, an enabling environment includes public policies and programs that financially incentivize research and development, as well as technology adoption by the private sector. The EU has regulations, policies, and funding in place to stimulate innovation in sectors related to MarSCs, which shows the significant contribution that the public sector can make. Particularly, the public sector can help tie innovation to other public goals, such as environmental protection. In the case of the EU, some of the programs and resources available provided funds to advance innovation in supply chain processes (e.g., logistics and transportation) seeking not only process optimization but also compliance with environmental standards, therefore aligning performance with environmental goals.

On the other side, public agencies are usually members of MarSCs and, in this role, they can directly incentivize technology development and adoption in the supply chain. The case of APCS is evidence of this. The participation in the platform by the Antwerp Port Authority and the Belgian customs authority stimulated platform use by shippers and carriers, not only to clear customs, but also, with the modules later developed, to improve container utilization and monitor vessel traffic.

Cases like this can be found in other geographic areas as well. For example, the Port of Hamburg is implementing a smartPORT initiative that includes modernizing its IT infrastructure to coordinate all aspects of port operations by installing sensors to coordinate ship–road traffic and monitor infrastructure performance (DHL, 2015). To realize the full potential benefits of this project, logistics operators are improving their information systems capabilities to receive and use the notifications sent by the port to truck drivers on available parking spaces and bridge closures. This allows drivers to optimize route planning and reduce travel time (Calatayud, 2017).

For LAC countries, this last lesson is very important. Despite the benefits of adopting digital technologies in terms of operational efficiency and risk management, the reality is that supply chains and firms, particularly those in developing countries and those of smaller size, are lagging behind vis à vis large firms that operate in more advanced economies. According to recent surveys (IDB, 2017; WEF, 2017), the main barriers for technology adoption in LAC countries are:

- cost of technology adoption;
- lack of access to finance;
- outdated or lack of information systems capabilities/resources;
- managers' short-term perspective;
- poor organizational structures;
- lack of labor skills;
- regulatory uncertainty;
- adverse business climate;
- privacy and security protection; and
- lack of trust, willingness to collaborate, or common goals.

While the solutions to some of these barriers belong in the private sector, the public sector can play a role in overcoming others. Like in the case of Northwestern Europe, the public sector in LAC countries can create an enabling regulatory and policy environment to enhance private sector collaboration or leverage private sector investments, increase access to finance for technology development and adoption, and be a champion and an early adopter of new technologies in those supply chain processes public agencies take part in, such as customs clearance.

6. Conclusion

This paper examined selected cases of digital innovation to improve information sharing (connectivity), visibility and, therefore, performance in MarSCs. The 15 cases analyzed were classified in three clusters according to whether the technologies supported the physical flow, document flow, or financial flow in MarSCs. The paper focused on experiences in Northwestern Europe, where two of the top 15 ports in the world are located: Antwerp and Rotterdam. Together with Zeebrugge, these ports serve as gateways for 33 percent of European seaborne international trade (Lloyd's List, 2016).

The solutions to improve cargo flow in MarSCs (first cluster) focused on creating data hubs or improving traceability along MarSCs. The data hub applications were mostly developed by software companies relying on the experience of logistics stakeholders, while traceability solutions were mostly developed by logistics stakeholders themselves, such as transport operators or shippers. Financial resources came from either private or public sectors, as well as a combination of both sectors. Most of these technologies collected and integrated data related to container or cargo characteristics, and beneficiaries of the technologies were many or all actors in MarSCs. In turn, the solutions that enhanced document flow in MarSCs (second cluster) were the result of private sector initiatives, with software developers being the main innovation champions. Again, most of these technologies collected and integrated data related to container or cargo characteristics, as well as transport data. Given that document exchange in MarSCs often involves many parties, the solutions in this cluster addressed many or all supply chain stakeholders. Finally, the solutions focusing on financial flow (third cluster) were funded by private sources, addressed the entire range of supply chain stakeholders, and bundled transport data with cargo/container and truck/transport information to increase access to financing and smooth financial flow in MarSCs operations.

Ultimately, an enabling environment is needed for innovation to emerge. In Europe, the EU has set a policy framework to incentivize innovation in sectors and processes related to MarSCs. Indeed, due to market failures in innovation (e.g., externalities and public goods), public policy support is critical to create an enabling environment (e.g., human capital, regulation, and access to finance) and provide financial support for innovation when it generates benefits for the economy and society. The EU framework encompasses an innovation strategy, initiatives to facilitate the transition to the digital economy, and specific funding for innovation in MarSC processes.

For countries in LAC, experiences in Northwestern Europe provide a series of lessons learned about innovation in MarSCs:

1. **Stakeholder collaboration:** Given the interdependency of actors and processes in MarSCs, it is not sufficient for a single actor to develop or adopt a technology to improve the performance of a MarSCs process. Instead, other key stakeholders need to see the benefit of adopting the technology and be willing to invest time and resources on it.

2. **Technology scope:** There is no one-size-fits-all solution to improve information sharing along the supply chain. Instead, different solutions can emerge to solve specific or/and broader issues in the MarSCs.

3. **Stakeholder approach to change:** A champion or an alliance of champions that take part in the same MarSC can play a key role in boosting technology development and adoption by other partners, particularly when there are pockets of resistance. Conversely, digital technologies that do not have the support of key supply chain players are less likely to succeed.

4. **Critical role of the public sector:** On one side, the public sector can create an enabling environment to enhance private sector collaboration or leverage private sector investment in developing and adopting such technologies. On the other side, public agencies are usually members of MarSCs and, in this role, can directly incentivize technology development and adoption in the supply chain.

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