Enhancing Visibility in International Supply Chains:
The Data Pipeline Concept

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ABSTRACT

With increasing global trade and growing emphasis on security, enhanced information sharing between actors in global supply chains is required. Currently, the data about cargo available in the supply chain does not provide a timely and accurate description of the goods. To solve this data quality issue, data should be captured upstream at the point where goods are packed for transport to the buyer. Without ICT, it was not possible to get timely access to the original trade data. The data pipeline concept is an IT innovation to enable capturing data at the source. The data pipeline accesses existing information systems used by the parties in international supply chains. This paper explores the data pipeline concept and the benefits that businesses and governments could obtain from such an innovation. This study also identifies the need for a public-private governance model that has to accompany the technical innovation.

Keywords: *Business-Government Interoperability, Data Pipeline, Data Sharing, E-Government Infrastructure, Supply Chains, System Based Approach*

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INTRODUCTION

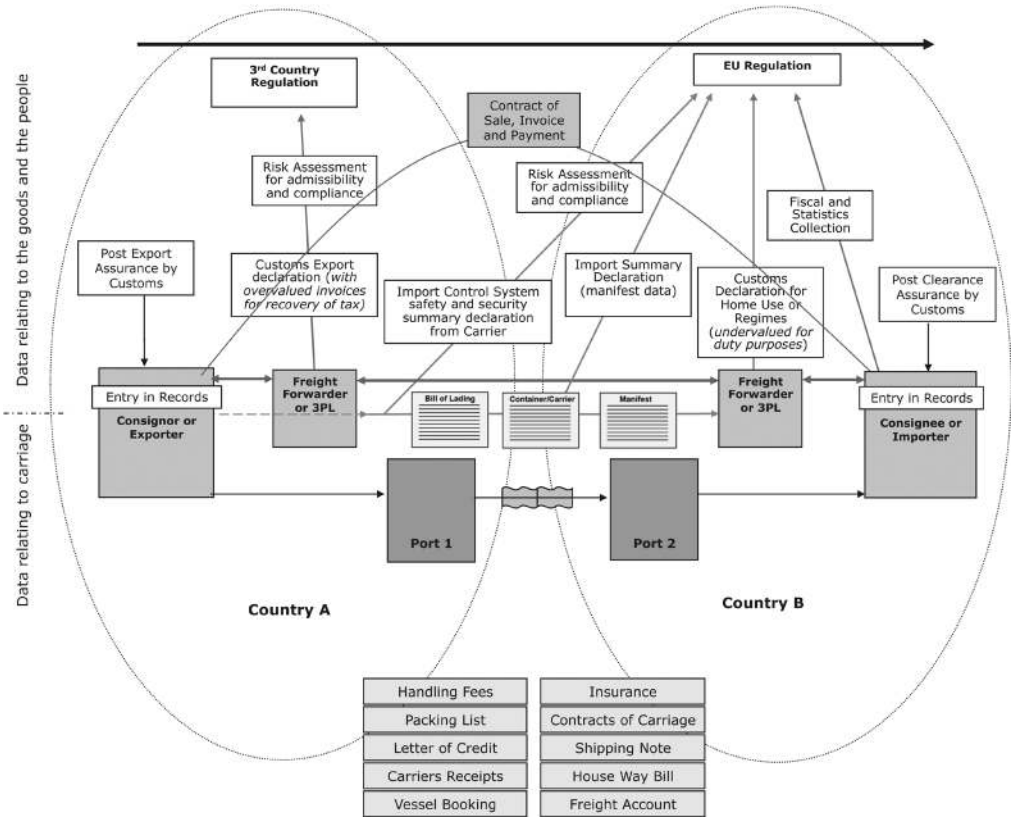
The systems used in international trade have developed since the eighteenth century to cater for general cargo and paper-based transactions (Van Stijn et al., 2011). Since the advent of the sea container in the twentieth century, the carrier has entered into a so-called contract of carriage with the shipper concerning the transport of goods in a container, due to which the actual goods are hidden from view. Outsourcing, consolidating cargo and multi-modal transport chains have allowed the identity of the true seller or sender to be clouded and contractual terms to be complicated. Currently, carriers and importers are being asked to make legal declarations about goods they have never seen and the documents containing crucial information can lag three days behind the goods. Due to the complexity, the buyer and seller engage with a range of logistics and other service providers to handle the processes on their behalf resulting in a lack of visibility of events, costs and assurances. Given the increase in international trade, and the substantive risks involved, border management has also increased in complexity, and can cause time delays, cost increases, as well as reductions in the competitiveness of supply chains (Holloway, 2010). For border agencies such as customs to perform their functions they need accurate supply chain information to assess risks and to make intelligent decisions. For these reasons, supply chain visibility is consistently ranked as a top priority for internationally operating businesses and for governments that have to supervise goods flowing across borders (Aberdeen Group, 2006).

To minimize safety, security, legal compliance and commercial risks and to improve the effectiveness and efficiency of both business and government operations, it is important to have a genuine and complete packing list of the goods that are packed in a container, preferably matched with the underlying commercial transaction (i.e., a purchase order). This data has to come from the source. To ensure that the documents contain reliable data on the consignment, the first point where such data can be made available in a digital format could be at the point where a consignment is completed (Hesketh, 2010). The consignor needs to ensure that the order of the buyer matches the packing list, which in turn matches the invoice (i.e., the logistics information needs to match the commercial information). The packing list should match the shipping note that matches the contract of carriage that matches the waybill that feeds the manifest. If the packing list is wrong, then they are all wrong, which may harm the interests of all the parties involved (Hesketh, 2010).

The best party to provide quality information about the goods being transported is the original seller or another actor that 'packed the box.' However, for commercial reasons, parties often do not want to let the next party in the chain know where the goods came from originally, i.e., who the producer is, in order to prevent that they are bypassed by another party who seeks contact with their partners directly. Therefore, the information that finds its way into the transport documents – and from there into the customs declarations – is often not from the originator; not from the actor that actually knows which specific goods are being shipped. As a consequence, buyers, sellers, customs and other parties in the supply chain have to manage the supply chain with second-hand information that is filtered, altered and likely to be inaccurate (Hesketh, 2010). This current situation is visualized in Figure 1.

In paper-based procedures, on average 40 documents are required to import or export one single container, which causes significant delays and extra administrative costs for businesses. Information elements upstream in the supply chain (e.g., the purchase order, an accurate description of the actual consignment, and transport terms (i.e., Incoterms) need to come together and be verified between buyer and seller (Hesketh, 2009). At that point everything relevant to the consignment entering the international trade supply chain for export, transport and import should be made available to the appropriate actors. If the full amount of data related to the goods and relevant parties that

Figure 1. Current international trade system and customs (© 2010, Hesketh and Heijmann)

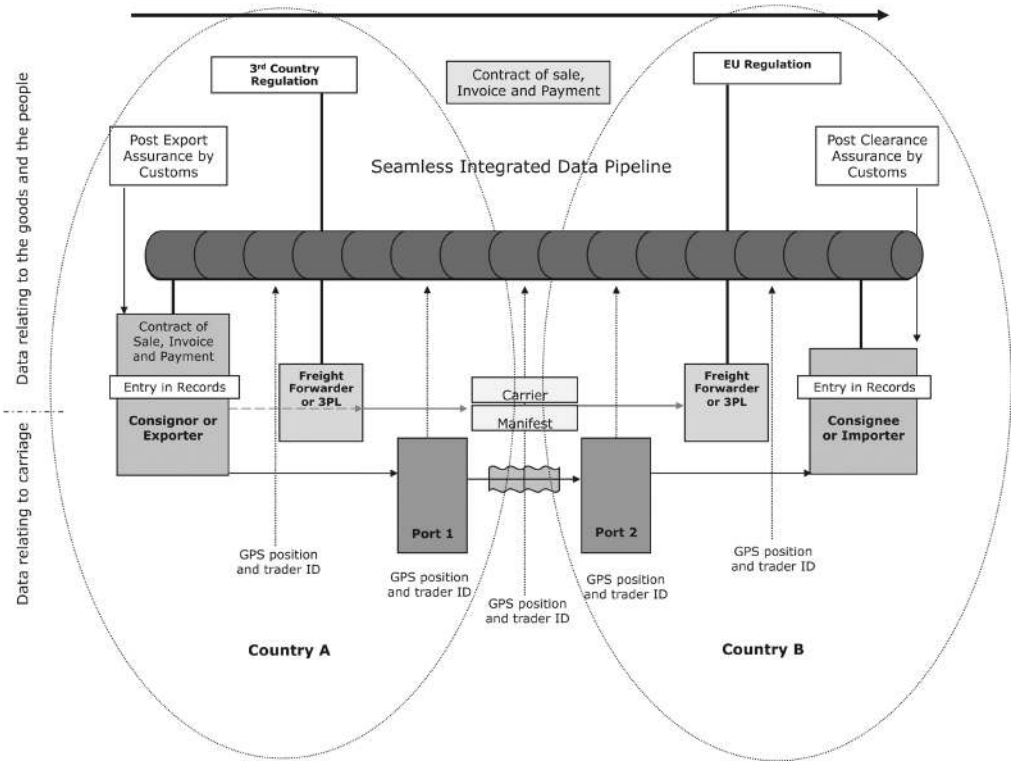


are required by customs and other regulatory agencies for an export declaration is provided electronically, this complete and accurate data can be used for more efficient risk assessment. Furthermore, based on this information, the business actors in global trade have a better visibility of their supply chains. The timely provision of data captured at the source from different sources in the supply chain can be realized by means of a *data pipeline*, consisting of the various data sources and information systems available in the supply chain.

The role of the pipeline vis-à-vis the situation presented in Figure 1 is shown in Figure 2. It shows how each subsequent party in the chain makes data accessible via the pipeline (the bus), resulting in the availability of source data at the moment it is available to the providing party. The access to this data is controlled in the data pipeline by security technology in such a way that only actors, authorized by the owner of the data, can have access to this data. Typically, customs is such an authorized party. This means that at the importer side, the first information about goods movement can be available at the moment the box is packed at the point of departure. In every step, the data is further enriched with other relevant information.

This paper analyses how a data pipeline as a data-sharing infrastructure leads to the availability of better data quality in the supply chain, which is beneficial for commercial parties as well as government (inspection) agencies. It is beneficial for businesses, because better data may provide supply chain optimization. We illustrate this with an example on synchromodality, in which better data visibility can even have a positive effect on fostering more

Figure 2. International trade system and customs in pipeline situation (© 2011, Hesketh and Heijmann)



sustainable supply chains. The availability of better data in the supply chain is beneficial for government inspection agencies, because it enables them to do a better risk analysis of the goods. In many cases, it also means that they know in advance which trade lanes are low-risk and which flows of goods have a higher risk potential. Overall, this may have the effect that customs can reduce its inspections on trustworthy supply chains, which is also another benefit for the commercial parties because the transport of their goods is no longer delayed at the border due to these border inspections. A finding from our analysis of these benefits is that a public-private governance model is required to realize the concept of a data pipeline, and thus its benefits.

The paper is structured as follows. First, we detail the research approach. Then we discuss the background and concept of a data pipeline in further detail. In our research, we explored how the data pipeline benefits both government and businesses. These benefits are discussed in afterwards. To realize these benefits, we found the need for a public-private governance model, which is described in the following section. Finally, conclusions are presented in the last section.

RESEARCH APPROACH

Our study takes place in the context of two research projects. These two projects share a focus on the development of the data pipeline for information sharing in international supply chains. The background of the two research projects consists of two parts: (1) the data issue in global supply chains, as discussed in the previous sections a data pipeline solution for this as provided in the upcoming sections.

This paper presents an exploratory study, which is suitable in our context as the data pipeline is at this point in time in conceptual stage and is currently being set-up for piloting. The study explores the benefits foreseen when such a pipeline is developed in practice. This explorative research is based on a series of interviews and primary and observational data from workshops and expert meetings. In our interviews and meetings, and our analysis thereof, we analyzed how a data pipeline is expected to affect the current ways of working of the various stakeholders involved. In total there were five structured interviews with logistic parties, four semi-structured interviews with customs authorities from two countries, and two workshops with both businesses and government. We supplemented these data with a review of practitioners' secondary sources. Given the sensitivity of the topic, we have anonymized the actor names and country of study.

Given the exploratory nature of our study, generalization has not been aimed for at this stage. Though presenting a single case may be seen as a limitation of our research, the parties involved are considered to be leading organizations in the innovation towards a data pipeline, hence our analysis can also serve as the basis for further research to generalize our findings, which is needed for both the public-private governance model and benefits of a data pipeline.

BACKGROUND: CONCEPTUALIZATION OF A DATA PIPELINE

A data pipeline requires an ICT infrastructure for information sharing. In this section we discuss relevant background of inter-organizational information sharing and the role of digital government infrastructure, and based on that provide the details of the pipeline and the role of standards.

Inter-Organizational Information Sharing

To enable the wide variety of actors in the supply chain to share data within the business community and between the business community and government agencies, ICT infrastructural facilities need to be developed. On the one hand, businesses have a number of systems in place that contain the data needed. In order to exchange this source data with government organizations, business information systems and business community systems need to interoperate with a variety of e-government systems and infrastructures. Digital government infrastructures support many users and are the shared responsibility of several organizational entities (Janssen, Chun, & Gil-Garcia, 2009). The challenges with infrastructures is that they have no central authority, are governed by public-private networks and contain both emerging and purposefully designed parts (Janssen et al., 2009). Hanseth et al. (1996) depict these infrastructures as information infrastructures to emphasize a more holistic, socio-technical and evolutionary perspective to place the growth in the combined social and technical complexity at the center of an empirical scrutiny (cf. Henningson & Henriksen, 2011). The realization of these infrastructure requires transformations, meaning radical changes in core processes

across organizational boundaries (Kim, Pan, & Pan, 2007; Murphy, 2005; Weerakkody & Dhillon, 2008; Weerakkody, Janssen, & Dwivedi, 2011). Organizations that have implemented information integration solutions have reported significant benefits that support the evolution process (Irani & Love, 2002). Themistocleous and Irani (2002) analyzed and explained the benefits that derive from the use of information sharing and integration technologies and classified them into five categories, namely organizational, managerial, strategic, technical, and operational. Transformation towards information sharing encounters significant barriers in technical, organizational, political, and legal categories (Gil-Garcia, Chengalur-Smith, & Duchessi, 2007).

The information sharing issues are not unique for the domain of international trade itself. Pertinent information sharing across various government agencies as well as non-governmental and private organizations is an essential part of, for example, effective emergency management and response (Shafiq, Vaidya, Atluri, & Chun, 2010). Interoperability is a key requirement for information sharing from disparate systems and organizations. Literature indicates that it is important to discern three levels of information sharing in a supply chain (Cho & Lee, 2011), of which the pipe line is related to the third level. At that level, the supplier and the logistics providers share real-time demand information by using information technologies. As a result, the supplier and logistics providers can achieve optimal performance to minimize the total inventory cost in the supply chain. Sharing information has enabled some organizations to reduce their cycle times, fulfill orders more quickly, reduce excess inventory, and improve customer service (Stein & Sweat, 1998).

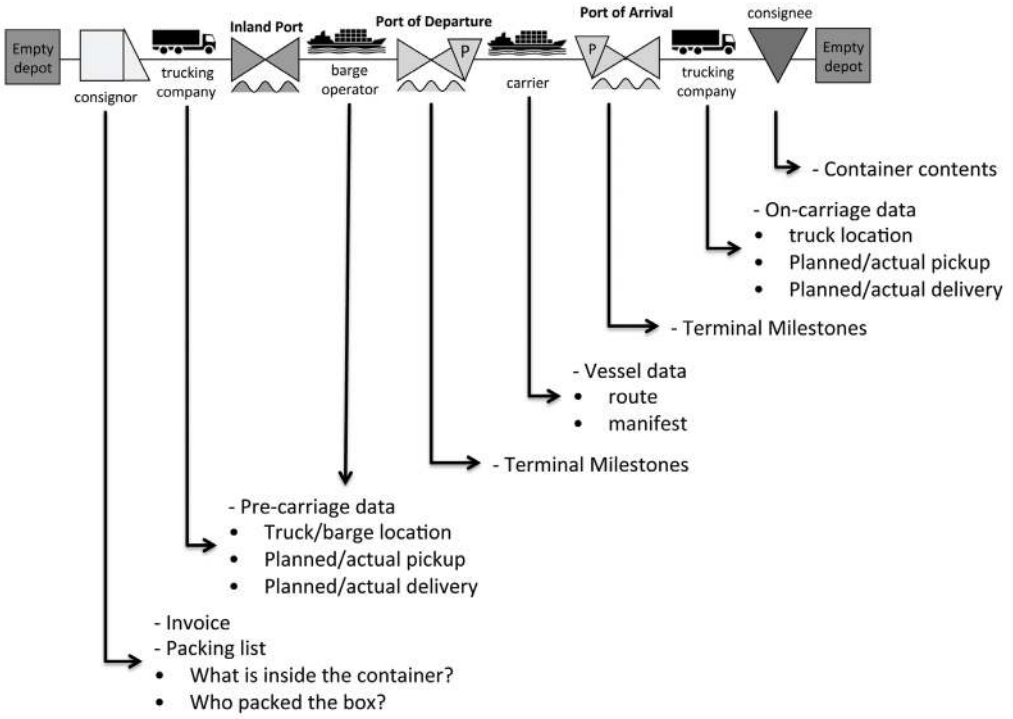
Five core IT enablers of information sharing in supply chains have been identified in the literature (Li & Lin, 2006): (1) Electronic Data Interchange (EDI); (2) Electronic Fund Transfer (EFT); (3) The Internet; (4) Intranet (internal information sharing in an organization); and (5) Extranet, which is a collaborated network that uses Internet technology to link businesses with their supply chain and provides a degree of security and privacy from competitors. Electronic data interchange (EDI), Internet, and extranets have helped many organizations achieve operational excellence and competitive advantage (Jones, 1998). As the data pipeline is foreseen to be a federated solution for information sharing, these IT enablers serve as the foundations for a more advanced way of information sharing.

The Data Pipeline Innovation

The data pipeline is a concept based on the use of Service-Oriented Architectures (SOA) to enable access to the existing information systems that are used and operated by the various parties in global supply chains (Overbeek, Klievink, Hesketh, Heijmann, & Tan, 2011; Van Stijn et al., 2011). The data pipeline is a virtual bus, created by linking the companies enterprise systems (where e.g., data on purchase orders, invoices, and packing lists originate from), inter-organizational systems connecting parties such as freight forwarders and shipping lines, and systems for tracking, tracing and monitoring the goods (Overbeek et al., 2011). The data pipeline provides one integrated access point to the different sets of information that already exists fragmented throughout the supply chain and is held in the different types of documents. An example of the variety of sources of data in global supply chains is presented in Figure 3. All of these data sources provide information that has to be fed to the data pipeline in order to create supply chain visibility for the organizations involved. By capturing this data, and by matching and updating data along the way, accurate data are available to authorized parties at the time they come in existence, instead of only much later in aggregated and abstract manner through – for example – a bill of lading.

The data pipeline is intended as a federated IT solution; the data remains with the individual companies that are responsible for it. Clever linking of data through data references creates an integrated data view. For example,

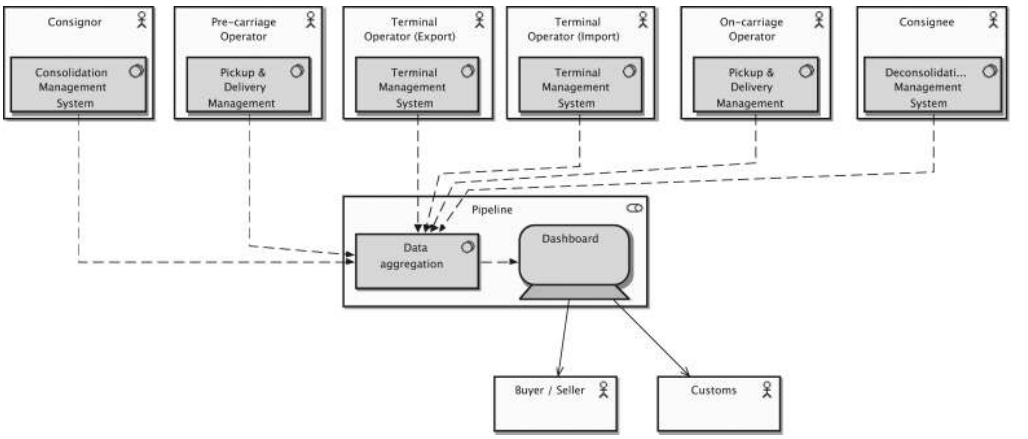
Figure 3. Various data sources in a trade lane



manifest data is made available by shipping companies (as they still store it), but through a data reference (e.g., the container number) authorized viewers can collect information about the container's contents from the consignor (who owns the consolidation data, e.g., packing lists). Via data references on the packing list (such as order numbers and customer references), data can be obtained about the seller, buyer, value of the goods in the container, etc. Each of the companies involved have their own information systems, with different (internal) data models, IT architectures, etc. These have to be linked in order to get a full picture of the trade lane. Figure 4 illustrates how the data pipeline is fed by multiple data sources and presents a view on these data through (for example) a dashboard.

The data that has to be available in the pipeline is the original data that the businesses have on the shipment in their own (operational) systems, such as the description of the goods, their value and price, number of items, weight, Incoterms, buyer and seller, planned movement of the goods, corresponding with data from the invoice, purchase order, International Contract of Sales, packing list, and contract of carriage (Hesketh, 2010). The container can then be moved and loaded onto the ship and further data are added, such as the location of the container on the ship and the actual movement of the goods throughout the journey, notifications of carriers and terminal operators, or tracking and tracing data. Monitoring data, for example in the case of perishable food products, where *smart* seals are placed on containers, can also be added (Van Stijn et al., 2011). These original data are shared real-time with the relevant business and governmental actors. If there have been no alerts or suspect changes en route, upon arrival in the port of arrival, the goods could in principle receive a

Figure 4. Example of joining-up information systems to provide visibility to businesses and customs



green lane treatment. If there is an additional need for inspection, but the goods do not pose a direct security threat, the goods may also be inspected at e.g., the premises of the importer, rather than at the Port. Furthermore, post-clearance audits (particularly fiscal) can take place after import (even much later). Thus, the data pipeline facilitates a decoupling of border management activities from the actual moment of border crossing.

The ability to pull data from several data sources is not intended for all partners in the supply chain. Only some specific partners, most notably the buyer, seller, and government authorities, will be granted access to all the information (note that the full data access profiles design of the pipeline is outside the scope of this paper). The extended visibility provided by the data pipeline can help businesses to optimize their supply chains, and provides government authorities with the required increase in data accuracy and quality to do their security and risk assessments. With whom exactly the data may be exchanged from a legal perspective depends on the countries in which the goods move, and is thus determined by national, EU, as well as federal legislations (Overbeek et al., 2011).

The Role of Standards

Key for realizing this innovation is a standardized, uniform means to describe, offer and discover data that are used for interaction (Baida, Koldijk, Tan, & Higgins, 2011). This means that data sharing standards are a prerequisite and that organizations providing open standards are also important stakeholders in this context. They include, for example, the United Nations (in particular UN/CEFACT), the World Customs Organization (WCO), and organizations like GS1 and Descartes. Interviewees agree that a major adoption factor for the data pipeline will be whether it can leverage on global standards developments. We discussed the available standards with the interviewees and incorporated the outcomes in the pipeline model. This includes message standards by the WCO and business community standards like those by GS1. Both are detailed in the following:

The WCO has adopted the view of UN/CEFACT and stresses the importance of a standard data set that will meet governments' requirements for standardized message exchange in international trade. In this respect, WCO has developed the WCO Cross-Border Data Model

Version 3. The special feature of version 3 is that it incorporates all the trade data message standards from the Core Component Library (CCL) that has been developed by the UN/CEFACT group. CCL is an extended version of what is known as EDI message standards. Based on this data model, EDI messages and XML Schemas have been defined, both for communication between cross-border regulatory agencies and for declaration of all types of cargo movements, including incoming, outgoing, import, export, and bonded warehouse type of movements.

The standardization approach as applied by GS1 concerns the provisioning of standards of which the intention is that everyone involved uses these standards globally (e.g., the barcode). One of the most widely used set of standards that is tailored for data sharing in international supply chains is offered by GS1 and is called EPC Global. The definition of EPC Global standards is still an on-going process. The EPC Global standards are open, vendor-neutral, standards ensuring that the SOA based on EPC Global standards will work anywhere in the world on heterogeneous hardware and software platforms.

The way that standardization efforts are approached is also an important matter in the context of the data pipeline as this will have consequences for how stakeholders communicate with each other by means of the pipeline. Based on the approach as applied by GS1, every stakeholder will then have to adopt one set of uniform international standards, while an alternative approach could be that the data pipeline offers translation modules between messages that are based on different standards.

ANALYSIS: BENEFITS OF A DATA PIPELINE

The implementation of a data pipeline is a complicated endeavor, both from a technical point of view and from many other perspectives, including strategic, organizational, and political. Moreover, a large number of stakeholders from different organizations are involved in interfacing existing systems and using the data pipeline. Given the global scale of a data pipeline, it ultimately needs to be driven by business, as governments cannot, because they have neither the funds, the IT expertise, nor the international jurisdiction to act outside their own country. Therefore, the business benefits should be clear to the participating companies for a successful development and adoption of the data pipeline. In other words, a market-driven approach is needed (cf. Beverland, Ewing, & Jekanyika Matanda, 2006).

The market-driven stakeholder approach concerns the stakeholders that benefit from a data pipeline in international trade, which is aimed at minimizing administrative burden in trade and logically linking the parties involved. Stakeholders that can be identified from a market-driven approach range from the seller to the buyer and include the economic operators in-between, such as inland carriers, freight forwarders (which usually take the responsibility for planning, arranging, and optimizing shipments; Chow, Choy, & Lee, 2007), shipping agents, sea terminal operators, Port Community Systems (which enables all the links within a logistics chain of a seaport or airport to efficiently exchange information with one another; Toh, Nagel, & Oakden, 2009), customs, inspection authorities and port authorities. These actors play a role in both the exporting country and the importing country. Between the countries (at sea) the shipping line is an important actor (Baalen, Zuidwijk, & Nunen, 2008).

The main benefit of the pipeline is increased visibility. This visibility enables businesses to better organize the global flow of goods. Especially the parties with an interest in the goods themselves (e.g., the buyer and the seller) can use this visibility to monitor their goods and to make better business decisions and planning. One example of how increased visibility can improve planning and operations of businesses is that the pipeline can facilitate synchro-modality, which we discuss in this section.

In addition to business-to-business information sharing, global supply chains are highly regulated and for purposes of compliance (e.g., to duties and security regulation), companies are required to report a variety of information to various government organizations (Rukanova, Van Stijn, Henriksen, Baida, & Tan, 2009; Tan, Bjørn-Andersen, Klein, & Rukanova, 2011; Winne, Janssen, Bharosa, Wijk, & Hulstijn, 2011). This requires intensive information exchange in which a company typically interacts with, among others, customs, tax, police, and food safety inspection agencies. IT-enabled inter-organizational information sharing technology plays a key role in the simplification and harmonization of cross-border control procedures.

As part of an information and systems based control approach, governments can piggyback on the business data (Tan et al., 2011). The strength of piggybacking can be even enhanced if government agencies can verify how businesses themselves ensure data quality in their own systems. Assessing the way that the business systems operate and process data on the good flows, instead of assessing the data of individual transactions, is called a System-Based Approach (SBA). This system-based approach can be combined with a certification of business actors, resulting in known traders and more trust in data sources. For governments, the main benefit is that the data pipeline enables piggybacking, which (especially when combined with a system-based approach) can greatly enhance the government's ability to gather information on global flows of goods and to assess all kinds of risks on these goods flows. For businesses, piggybacking can reduce the administrative burden. Furthermore, as they open up information systems for authorities, benefits may also include trade facilitation and coordinated border management. We explain these key benefits of the data pipeline in this section.

The Data Pipeline: Enhancing Supply Chain Visibility

Supply chain visibility is required from both a government perspective and from a commercial perspective of the businesses that drive the supply chain (e.g., buyers and sellers). The data pipeline can be seen as a catalyst towards such visibility. Supply chain visibility relates to accessing the transaction data that are necessary for a private-sector operator or government agency to assess what is actually happening in the supply chain (Van Stijn et al., 2011). Without accurate and timely data about the goods, the people involved, the payments and the integrity of the logistics, the risk of something going wrong increases, effective planning is inhibited and confidence decreases (Christopher & Lee, 2004). Visibility can be considered a precondition for the parties to understand the actual state of the goods in a supply chain and to make informed decisions.

In today's global trade, many supply chains have grown in complexity to a point where clear visibility is masked from those who need to know what is going on. This is particularly so in the case of "less than container load" (LCL) shipments where a consolidator packs consignments from several shippers into one container, and often provides only summary data of the contents to the shipper. Data deficiencies and gaps, together with an outdated paper trail—as updates and changes may not clearly be reflected in them—are creating financial, safety and planning risks. However, some organizations may also see visibility and transparency as a threat to their business operations, or they may even benefit from the fact that it is complex and obscure at the moment. For example, interviewees indicated that some carriers are concerned that more visibility in the supply chain might lead to more liability of damage or loss of the cargo while being transported by them. Currently, if the carrier does not have detailed information

about the type of cargo that is in the container this liability is limited per container according to the Hague-Visby and Rotterdam Rules. However, when it can be proven that the carrier knows that a container contains, e.g., valuable goods, the liability in case of loss of the container can increase by a thousand times. One of the non-technical challenges is to identify such conflicting commercial (and public) interests of different stakeholders, and to find revenue sharing or equity exchange models to better align these interests.

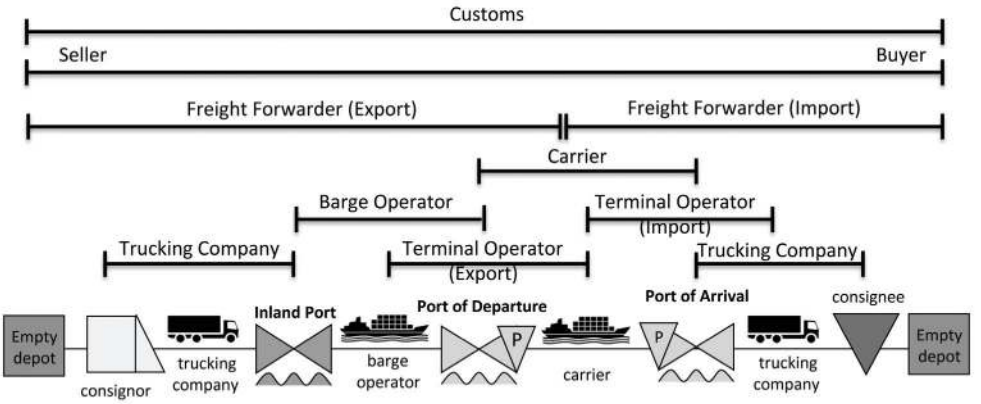
As mentioned in the previous section, current access control has to be respected, as not every party needs to see everything. Only customs and the buyer or seller (depending on the INCO terms) can see all data. All other partners share their information with only a few other partners and have access to the information that they require for performing their logistic service (based on 'need-to-know,' e.g., only operational data). The data visibility for a variety of parties in the global supply chain is visualized in Figure 5.

The Piggybacking Principle and System-Based Approach

The data pipeline enables the principles of piggybacking and increased data pull. Explored in the ITAIDE project, piggybacking means that data are re-used for other purposes than they were originally intended for (Tan et al., 2011). In this case, original commercial data from businesses are re-used by governmental actors for government control purposes like risk assessment, customs clearance, and coordination of inspections. This means a transformation away from the use of document-based controls, in which businesses provide data on specific transactions in a specific predefined format towards government organizations. The transformation is towards sharing original trade data (which businesses use for their own operational processes) with government inspection agencies. As these data are vital to the operations of businesses themselves, they are of better quality than data that is filed in specific formats (which often differ for the various actors that require data from the supply chain). Governments can piggyback on that original business data and use that as the source for government control purposes.

In addition to such piggybacking, the data pipeline can enable a shift from a situation where businesses are pushing the declarations and other official documents to multiple governmental agencies, the so-called *data push* approach, towards an increased *data pull* approach, where the governmental agencies can "pull" data out of the systems that feed the data pipeline, when

Figure 5. Data visibility for each of the trade lane partners



needed. To assess whether government can rely on the data it pulls from business systems and their internal procedures, governments can focus on assessing the systems and operations of a company, instead of assessing individual transactions. This is called a *System-Based Control* approach. To further assert the reliability of this concept, organizations can get a certification if certain system-based approach requirements are met. In the context of international trade, several of such certifications exist, including the Authorized Economic Operator (AEO) certification as defined by the European Commission, and the US C-TPAT certificate (which focuses more on security). An operator with AEO security and safety certification implies that it is compliant to security and safety standards and could therefore be considered as a 'secure' trader and thus a "reliable trading partner" (Tweddle, 2008, p. 103). As the trusted trader status refers to demonstrating to be in-control, visibility is an important aspect. In an extended form, the piggybacking principle can also include the re-use of internal control data and mechanisms (e.g., from quality controls or risk assessments) and even further rely on the internal controls of an organization. We discuss the underlying concept of a systems-based approach in more detail.

System-Based Control and Risk Management

Customs and other government agencies assess the flow of goods by targeted physical inspections and by analyzing the information that businesses are required to submit. This requires accurate and timely data about the goods, about the parties buying, selling and moving the goods and about the location and security of the consignment. Much of that data resides in the systems of commercial parties and is used every day to order and buy goods, ship them from seller to buyer and pay for them. System-based control entails that rather than inspecting goods, the information systems of businesses are audited, i.e., by EDP auditors, in order for companies to demonstrate that they are in-control of the data capturing, data security, and so forth (Tan et al., 2011). This could be organized as part of a certification (like AEO), and would add to the trust that customs and other government agencies will have in a business. This will determine the extent to which trade and transport facilitation can be offered. For example, if a company that produces beverages can show to the government how they – for themselves – make sure that when their system reports that a container is stuffed with a specific type of beverage in a specific quantity, it in fact is so, then the government can pull that data from the company system and be sure that the data is correct, because it is in the company's commercial own interest to register the right information, or in the interest of another party, e.g., the retailer purchasing the beverages. In return, government organizations can reduce physical inspections, and hence reduce waiting times and administrative burden for that AEO-certified company. A certification of such a company is typically not limited to the systems only, but also includes e.g., an assessment of how a company makes sure only certified people have physical access to the goods.

Business Benefits of the Pipeline: The Synchro-Modality Example

Apart from the benefits of enhanced supply chain visibility, a potential reduction of the administrative burden and the potential for trade facilitation, the data pipeline offers other direct benefits as well. One of such benefits can be found in synchro-modal logistics.

Synchro-modality concerns the switching of transport modes (e.g., rail, road, or barge) between transportation hubs. A key factor of synchro-modality is that the choice of transport modality requires predictability, which requires accurate trade data. The choice of modality is typically based on a set of optimization criteria such as timeliness, cost, or CO_2 emission. Currently, the logistics of the separate modalities are not properly coordinated, as timely and accurate information for the planning is often not available in the port of arrival. With ICT in-

novations like a data pipeline to track individual products, supply chain actors try to develop more synchro-modal capabilities, which can lead to considerable reductions in traffic jams and CO_2 emission. This fits in the long-term EU strategy as described in the Roadmap to a Single European Transport Area.

An example presented to us in the interviews is an importer of fruits who ordered bananas from a certified grower in South America. They have negotiated the terms of the order, agreeing on the amount and price, the delivery details, and so forth. When the bananas are ready for shipment, the grower verifies the relevant data in its own system, and then makes it available to the data pipeline. Relevant government agencies in the country of import can now decide whether there would be need for an inspection of the goods when they arrive. Ideally, they could also provide pre-clearance, under certain conditions, e.g., that the container is sealed. Moreover, they could ask their counterpart agency in the country of export to conduct extra inspections on the cargo.

At present, when the containers with bananas arrive in the port, most of them are shipped (by a freight forwarder) to the hinterland by road transport. This is done because fruit is a perishable good that has to be shipped as quickly as possible. However, some fruit types like bananas do not need fast shipment, since they are picked unripe and ripen during transport. Unless the freight forwarder knows precisely when a specific container containing a specific type of fruit is offloaded, it is near impossible to make the necessary arrangements for barge transport, resulting in that the goods are transported by truck. While barge transportation is much cheaper and has lower CO_2 emission than road transport, it is also slower and more difficult to plan. It is relatively easy to plan road transport (one container per truck); it takes much longer to fill a complete barge. In order to switch from road to barge transportation more accurate information about the logistic details is required (not only container contents, but also more accurate data about arrival times, expected flow quantities, etc.).

Traditional data - based on bills of lading and manifests - are too inaccurate for this. The data pipeline provides precisely the type of real-time accurate data that is required for this. Potentially, with the data pipeline, each of the following stakeholders could have access to the data that is required to contribute to synchro-modality services: container terminals, port community systems, and freight forwarders. In general, the availability of timely and accurate data enables actors to use that data for purposes beyond the primary process and the administrative procedures, but also to optimize for (public) values such as CO_2 reductions or fair trade.

The decisive factor for the successful development and adoption of the data pipeline is the current data share that each of these parties has in the port environment. This may impact their willingness to contribute to the development of a data pipeline. If the port community system has most of data, then they are best positioned to provide synchro-modality. If the container terminal has most of the data, then they can do it. In all cases, the party that currently has most of the data, may also be most reluctant to share this data with the other supply chain actors, and hence reluctant to contribute to the development the data pipeline. However, if synchro-modality could generate so much benefits for the data pipeline community as a whole that even the most dominant partner would generate additional revenue from it, this could be the proper incentive to get a buy-in from all stakeholders in the data pipeline. More research is needed to identify this tipping point. Hence, overall the challenge is to find revenue sharing or equity exchange models to better align these conflicting interests in such a way that all stakeholders have an incentive to contribute to the development of a data pipeline.

THE NEED FOR PUBLIC-PRIVATE GOVERNANCE RESEARCH

One of the main characteristics of the data pipeline is that it has to be a business-driven innovation. Businesses have to build the majority of the data pipeline; it is their data and in their commercial interest. In the business-government interaction, the data pipeline is a digital infrastructure that has to be connected to digital government infrastructures in order to enable governments to access the business data and to enable businesses to submit information to governments through the data pipeline. Transformation towards information sharing between business information systems, community systems and e-government systems and infrastructures encounters various barriers, including both technical and organizational (Gil-Garcia et al., 2007). In interviews and meetings, we found the importance of the interplay between interdependence at the level of data and information systems, and the socio-organizational level (cf. Klievink, 2011). The stakeholders come from both the public and the private sector and have to collaborate to realize the pipeline. Consequently, the development of a pipeline has major implications for the organizations involved, also where the public and the private sector meet. The boundary between the sectors shifts as the current division of public and private functions and roles blur. In this research, we found that this governance issue needs to be addressed alongside the further exploration and development of a data pipeline.

Although the pipeline has to be a private sector driven development, currently the business community is too fragmented and has too many and too diverse interests to realize a data pipeline infrastructure. Therefore, government organizations have to create some of the conditions to facilitate the innovation in order to enable realizing the benefits for the entire community. Such conditions could include: (1) developing regulation or providing subsidies which provide sufficient room for businesses to make a fair revenue on their investments in the data pipeline; (2) developing and operating those parts of the data pipeline that are essential for its functioning, but that do not have a viable business model; and (3) lead in developing and adopting (open) standards via standardization bodies (e.g., WCO, UN/CEFACT, ISO, GS1) to ensure interoperability of company information systems and the data pipeline.

Giving this strong organizational and governance component, we find that research and development of a data pipeline in global supply chains should be accompanied by research or design of a *Public-Private Governance Model* (PPGM) to deal with these public-private boundary challenges. As this is a key theme in our ongoing research, in this paper the description of such a model is necessarily limited to its outlines.

Public-Private Governance Model

The data pipeline is typically developed and operated by the private sector, for example by the IT departments of supply chain parties like carriers, logistic service providers, port community systems etc. However, to enable all proposed benefits, this private sector digital infrastructure has to be connected to digital government infrastructures to exchange data with the border inspection agencies. Furthermore, data and message standards need to be developed (on an international scale). Also, governments are expected to regulate the room for private development of the data pipeline in their jurisdiction such that it becomes a level playing field. Such a level playing field is needed because in logistics there are numerous stakeholders with opposing interests, especially in the international supply chain. On the one hand information is a key commercial asset (e.g., no trader wants to reveal the prices paid for goods) hence actors are reluctant to share information. On the other hand, sharing of this data among all the parties in the supply chain is key for making the supply chain as a whole more efficient (Lee, Padmanabhan, & Whang, 1997).

A national single window can facilitate message exchange between businesses and government. Intelligent functionality of such a single window can interpret the data from the B2G message interactions and determines which data is relevant for which government organization (e.g., customs, food inspection agencies). This also includes additional status information on containers. For example, for a specific way bill additional insight might be provided for all public authorities involved, such as insights in which public agencies have acquired data related to that way bill and if there are public authorities that have already accepted or rejected received messages that are based on data related to a specific way bill. Some of the parties that can play a vital role in connecting these digital government infrastructures with the business community are port community system (PCS) providers. These PCS providers or other intermediaries are a custodian (but not the owner) of the data of business actors and play a key role on the private side for the data provisioning from the business community towards authorities. As they are currently already in a position to offer much of the data needed, they may also play a key role in the data pipeline. Because development of the data pipeline is supposed to be business driven, the challenge is to identify the economic drivers for the business. Opportunities that we see are the development of intelligent business functionality to process supply chain data (i.e., 'apps'), for example to improve route planning, reduce waiting cues of trucks to deliver or pick-up containers from the container terminals in the port, to reduce traffic congestion in port regions, to enable synchro-modality etc.

This creates major governance challenges, for example on which functionality is inadmissible (e.g., apps to counteract risk targeting systems of the customs) and on rules for these apps to access data. The latter is important as apps can offer more functionality when they can combine data from various actors in the supply chain. The question however is what the reward or revenue structure will be for the actors that have to make their data available for the app functionality. This requires revenue-sharing models, as the data is often (partially) available in the data hubs in the data pipeline, which are also part of the critical IT infrastructure for government and businesses.

In our first explorations of the governance of the vital parts of the data pipeline infrastructure, we find that there are a number of possible governance instruments that can be utilized in the model. First, the vital infrastructure connecting the actors in the private sector to each other and to governments can be operated and maintained by either a private party, a government organization, or as a neutral infrastructure. In case of it being a neutral infrastructure, the PPGM would require the enactment of a governance body, which could consist of all or a selection of stakeholders in a specific setting. This governance body typically has to decide what kind of functionality may be based on the data in the infrastructure (e.g., to avoid that one or a few parties can gain an unfair competitive advantage from their access to community data). Furthermore, as not all organizations have implemented the same set of standards, the selection and setting of standards is another important task of it. Finally, determining the costs of the use of the facilities and functionalities that are inside such a neutral infrastructure is also among the governance instruments. In case a government or a private party would operate the infrastructure, the PPGM has to be a framework that creates on the one hand a level playing field, and on the other hand offers enough economic incentives for business to make their contributions to the data pipeline commercially viable. The objective of this PPGM is to provide a means to analyze, explain and design the governance of the data pipeline. In this context, it is critical to obtain a thorough understanding of the different stakeholders involved, their interests, and how to mitigate between these stakeholders to ultimately come to implementation and adoption of the data pipeline vision.

CONCLUSION

In this research we have explored benefits and concepts accompanying the concept of developing a data pipeline aimed at advanced data sharing among and between business actors and government agencies. A pressing issue for both government and business actors in global trade is that, currently, the data available does not fit their supply chain visibility needs. Improving the timeliness and accuracy of data can only be realized by cooperation between businesses and government and by making investments that pay off for businesses as well as government organizations involved in international trade. The data pipeline offers a number of advantages for businesses by enhancing the visibility of goods in global supply chains. For example, an enhanced data position can be used to optimize logistics and terminal operations by means of synchro-modality. Furthermore, if businesses allow governments to piggyback on the business (to business) data, they can benefit (for example) from a lower administrative burden because government agencies can pull data from the systems, instead of that businesses have to provide the same information in a variety of ways to multiple government organizations. If businesses invest in their internal operations and are audited at a systems level, government is better able to assess the validity of the information pulled from business systems. This enables governments to target their physical inspections better, which may lead to reduced waiting times or other green lane treatment benefits for businesses that demonstrate compliance at a systems level. In other words: if governments can pull data from information systems and can assess how these systems handle all business transactions, there is less need to have businesses demonstrate compliance for individual transactions.

Realizing these benefits by using a data pipeline that consists of interconnected business information systems also presents a shift in the data and organizational positions of public and private actors. Most of a data pipeline needs to be developed and driven by businesses; it is their data and needs to address their commercial interests. However, to enable the business community to realize this innovation, some facilitation of key components without a viable business model is needed and potential commercial tensions with existing actors need to be mitigated. Another issue is whether governments are willing to secure the funding of national data exchange infrastructure components, or whether they require them to become financially self-supporting with new business services. These issues stress the need for a public-private governance model to accompany a data pipeline that enables data visibility to all involved parties and for achieving reliable and secure international trade supply chains.

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