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Public value creation through voluntary business to government information sharing enabled by digital infrastructure innovations: a framework for analysis

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ABSTRACT

Public value creation is traditionally considered as the citizens' collective expectations with respect to government and public services. Recent e-government literature indicates that what exactly constitutes public value in digital government is still debated. Whereas previous research acknowledges aspects such as co-production and the orchestration role of government in the context of public value creation, there is only a limited understanding of how public value is created by the interactions between government and business actors, and the role digital technologies play in that process. Furthermore, so far, research into public value creation processes is limited to specific services that aim to meet a specific goal; for a more complete view, an integrative perspective is required to address the multiplicity of goals. Societal challenges including climate change, sustainability, and the transition towards circularity will require governments to play a crucial role. Businesses are also transforming their vision by adding societal goals to their economic objectives and contributing to these societal challenges. This necessitates even more the need to explicitly consider the role of business in public value creation processes. In this paper we argue that there is a need to understand public value creation as an interactive process, involving both government and business actors. In this process, voluntary information sharing enabled by digital infrastructures has the potential to contribute to the value creation processes, but the increased complexity of digital technologies obscures the effects they can have on value creation. Therefore, we develop a framework that allows to reason about public value creation as an interactive process, involving government and businesses, facilitated by voluntary information sharing. The framework also allows to reason about how the technological design choices of the underlying digital infrastructure influence this value creation process. For the framework development, we use an in-depth case study from the domain of international trade. We analyze the interactions between customs authorities and supply chain actors for jointly creating public value related to revenue collection, as well as safety and security of goods entering the European Union, using business data made available via a global blockchain-enabled infrastructure. In future research, the framework that we developed can be used to analyze more complex cases with additional public value aspects, such as sustainability and circularity.

1. Introduction

Over several decades, research has focused on understanding public values and the role of digital technologies in the public value creation (e.g. Moore (1996), Bannister and Connolly (2014), Twizeyimana and Andersson (2019); Panagiotopoulos, Klievink, and Cordella (2019)).

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Nevertheless, despite the progress made, current literature still offers limited underrating with respect to a number of aspects.[1] (1) First of all, there is a limited understanding of the public value creation as an *interactive* process, where not only government, but also businesses play a role in the value creation process. (2) Second, there is still a limited understanding of the public value creation as an *integrative* process, taking multiple goals into account, rather than focusing on services aimed at a single specific goal. (3) Third, further attention is needed regarding the role that voluntary business-government information sharing plays with respect to public value creation. (4) The underlying technical design choices regarding the digital infrastructures supporting the voluntary information sharing and how they influence the public value creation processes is an area that is largely unexplored.

With the above in mind, the objective of this paper, is to develop a framework that allows to gain a better understanding of the public value creation processes, taking the aspects discussed into account. In the following sections, we provide further background information related to the topic of public value creation and digital government and we provide further elaboration of the aspects introduced above.

1.1. Public value and digital government

Moore (1996) defines public value as the citizens' collective expectations in respect to government and public services. In the era of digital government, attention turned to public value creation where governments make use of digital technologies to provide their services. For example, Bannister and Connolly (2014) propose a taxonomy of public sector values and relations to digital government initiatives. Recently, starting from Moore (1996) definition and conducting a thorough literature review, Twizeyimana and Andersson (2019) developed a descriptive and multidimensional framework for the public value of e-government from different viewpoints. Although the topic of public value has been a subject for research for decades, recent research indicates that what actually constitutes public value in digital government is still debated (Panagiotopoulos et al., 2019).

1.2. Public value creation as an interactive process and the need for an integrative perspective

Over the years research into public values moved towards a perspective to highlight the interactive perspective of governments and other actors. For example, Pang, Lee, and DeLone (2014) identify co-production as one of the capabilities when discussing public value creation. Stakeholder management capabilities are identified as important for public value creation by Cabral, Mahoney, McGahan, and Potoski (2019), and recent research (Cabral et al., 2019; Kattel & Mazzucato, 2018) supports the view of the public sector as orchestrator of collaboration in public value creation (Crosby, 't Hart, & Torfing, 2017).

Despite these earlier efforts, in view of the big challenges that our society is facing today (including public concerns related to safety and security, sustainability, circularity, and climate change), the interactive aspect where government creates public value jointly with businesses and other actors is largely unexplored and deserves further attention. For example, when it comes to safety and security, but recently even more when it comes to sustainability and circularity, not only government but also businesses and other actors feel responsible and take action to address these societal concerns. Therefore, it is worth to explore public value creation processes not only from the view of government and its responsibility to serve citizens and society but to also look at the opportunities for public value creation processes as a joint business-government responsibility, where both businesses and government together aim to address public concerns.

Furthermore, current digital government research insufficiently takes into account the need for an integrative perspective; as initiatives aim to fulfill specific policy goals they may be pursuing different goals and may lead to different outcomes, and the types of value that each digital initiative might yield can vary depending on expectations and/or outcomes (Panagiotopoulos et al., 2019). Therefore, the interactive value creation processes may look very different when it comes to revenue collection than when it comes to safety and security or sustainability concerns.

1.3. Public value creation and voluntary business-government information sharing

One area where business and government interactions have been examined in relation to public value creation is related to voluntary business-government information sharing. A decade ago Gil-Garcia (2012) advocated that there is a potential for government organizations to generate public value if they broaden the information sharing beyond the single level of government by also including information from businesses and not-for-profit organizations. Subsequent research has focused the attention on exploring the area of business-government information sharing to create public value. For example, research on data collaboratives focuses on data sharing among stakeholders from various sectors to create public value (Susha & Gil-Garcia, 2019; Susha, Janssen, & Verhulst, 2017; Verhulst & Sangokoya, 2015; Verhulst, Young, & Srinivasan, 2017). However, apart from the data that businesses are legally obliged to share with the government, it is very difficult for governmental organizations to use the wealth of business information that resides in business infrastructures unless this data is shared voluntarily. By using the term 'voluntary' we refer to data sharing arrangements where information is shared- on a voluntary basis - as opposed to when it is formally necessary (e.g., for legal reasons). Such voluntary sharing includes situations in which data is shared on a voluntary basis with government at an earlier point in time (e.g., when created), as opposed to when it is formally required by law. One area in which voluntary information sharing has received a lot of attention is the international trade domain for trade facilitation. For example trade facilitation can be that customs reduces the intensity of inspection for companies that provide more and better type of data about their goods when crossing borders. In this domain, many studies report on how interactions between businesses and government can be improved based on voluntary sharing of business data and enabled by digital trade infrastructure innovations, such as the *Data Pipeline* (Baida, Rukanova, Liu, & Tan, 2008; Heijmann, Tan, Rukanova, & Veenstra, 2020; Hesketh, 2010; Hulstijn, Hofman, Zomer, & Tan, 2016; Jensen, Vatrapu, & Bjørn-Andersen, 2017; Klievink et al., 2012; Rukanova, Henningsson, Henriksen, & Tan, 2018; Tan, Bjørn-Andersen, Klein, & Rukanova, 2011; Van Stijn et al., 2011). However, achieving voluntary information sharing arrangements is not obvious. Gascó-Hernandez, Feng, and Gil-Garcia (2018) argue that voluntary sharing arrangements critically depend on proper incentives for businesses to share their data. Susha and Gil-Garcia (2019) address the diverging interests and costs associated with voluntary sharing as well as different motivations for parties to enter voluntary sharing initiatives. Susha, Rukanova, Ramon Gil-Garcia, Tan, and Hernandez (2019) examine voluntary data sharing in cross-sector partnerships to create public value and distinguish motivations for parties to enter voluntary information sharing collaborations. In recent research, Rukanova et al. (2020) developed a framework for analyzing voluntary information sharing in the cross-border trade domain. This framework provides a rich conceptualization to understand the context of voluntary information sharing in terms of actors and information systems involved. It also includes the factors and governance processes that foster the creation of value in terms of benefits for business and government. This framework, however, treats the underlying technical infrastructure for data sharing largely as a black box.

[1] For the sake of clarity, we only list these aspects here. Extensive overview of the background literature and elaboration related to these four aspects is provided later in the Introduction section, in Sections 1.1-Section 1.4.

1.4. Digital infrastructures enabling the public value creation processes and introduction to blockchain infrastructures

The reality of today, is that the technological complexity of digital technologies has exponentially increased which requires policy makers and public managers to explore new approaches and roles for value creation opportunities (Janssen & Helbig, 2016; Panagiotopoulos et al., 2019). This is also the case in voluntary information sharing. Nevertheless, current research on voluntary information sharing to create public value offers limited insights into the technological complexities and how the technological design choices can affect the value creation process. Over the last years, blockchain technologies have captured the interest of government and business organizations and there is a search for both business and government actors on where blockchain technologies can bring benefits and create value and where the limitations lie. Blockchain was proposed (Nakamoto, 2008) to support the cryptocurrency Bitcoin. Blockchain has several properties, viz. high transparency, immutability, and robustness without requiring an intermediary in information sharing processes. These characteristics can support value creation in domains other than cryptocurrencies (Ølnes, Ubacht, & Janssen, 2017; Segers, Ubacht, Rukanova, & Tan, 2019; Tan, Rukanova, Van Engelenburg, Ubacht, & Janssen, 2019; Van Engelenburg et al., 2020). Accordingly, in the past years, blockchain has been applied to many other domains, among which e-government, supply chain management and business process management (Batubara, Ubacht, & Janssen, 2018; Korpela, Hallikas, & Dahlberg, 2017; López-Pintado, García-Bañuelos, Dumas, & Weber, 2017; Mendling et al., 2017; Ølnes et al., 2017; Saveen & Monfared, 2016; Schweizer, Schlatt, Urbach, & Fridgen, 2017; Tan et al., 2019; Tian, 2016; van der Aalst, De Masellis, Di Francescomarino, & Ghidini, 2017; Van Engelenburg, Janssen, & Klievink, 2017; Weber et al., 2016). Blockchain-based data-sharing infrastructures can be designed in many ways, which offers an interesting context to explore how technical design choices can contribute to voluntary data sharing to create public value. Many *different blockchain types* with *different design choices* (e.g., public vs. private blockchains) can be created to fit different application domains and functions. Although features of blockchain technologies, like immutability, are of interest to government organizations (e.g. to create an audit trail), the technical design choices behind the different blockchain solutions are not easy to comprehend for non-technical experts. To enable the reasoning about stakeholders' interest in data sharing and the underlying technical design choices of the blockchain technology, Van Engelenburg et al. (2020) proposed a *blockchain governance framework*. This framework allows stakeholders to reason about the benefits and trade-offs of using specific blockchain infrastructures and examine different options when issues such as data confidentiality are of great concern. Therefore, such a framework can allow to better understand the underlying technical complexity and choices related to the underlying blockchain-enabled infrastructure for supporting the voluntary business-government information sharing and to reason about the influence of these technical design choices on the public value creation processes.

1.5. Objectives and structure of the paper

Building on the above, the objective of this paper is to gain a better understanding of the interactive public value creation processes in the context of voluntary information sharing, enabled and constrained by digital infrastructures. In this paper, we develop a framework that allows to reason about public value creation as a joint responsibility and as emerging during a process of interactions between business and government actors (through voluntary information sharing), where the value creation processes are enabled and constrained by a blockchain-enabled infrastructure. For this research, we use a case study from the international trade domain in the context of importing tires from China to the Netherlands. The public value creation process takes place between the tire importer in the Netherlands and Dutch customs as focal actors. The public value creation is related to two societal concerns, namely (1) revenue collection- where the revenue is intended to be used by the Dutch government for services and activities to benefit the public, and (2) the safety and security concerns in international trade flows. In our case, these value creation processes are enabled by TradeLens,[2] a global blockchain-enabled infrastructure.

The remaining part of this paper is structured as follows. In Section 2, we present our conceptual framework. The background information about our empirical setting and the case study method are discussed in Section 3, followed by our case findings presented in Section 4. In Section 5 we discuss our findings from a broader perspective, and we end the paper with conclusions and recommendations. Additional details on the method and the case are added in the annexes.

2. Public value creation from voluntary business-government information sharing as an interactive process enabled and constrained by (blockchain) digital infrastructures

2.1. High-level conceptual framework

Fig. 1 captures our high-level conceptual framework, which we will further detail in this section.

In our high-level conceptual framework, we distinguish three layers, i.e., the public value layer, the actor layer including their own internal IT systems, and the layer of complex multi-actor infrastructures, in this paper a blockchain-enabled infrastructure.

We consider blockchain-enabled infrastructures as complex infrastructures in which multiple actors are involved, who have ownership of the infrastructure, who can make decisions about the technical design, and who are allowed to access and use the infrastructure. Therefore, we chose to treat these blockchain-enabled infrastructures in a separate layer, outside of the actors' own digital systems. This allows us to unravel the entailed complexities of these types of infrastructures.

The high-level framework allows to highlight the main layers and relationships, but it is too abstract to be used in practice. Therefore, in the next section we discuss the operationalization of the framework by filling in more details.

2.2. Detailed conceptual framework

As discussed in the introduction, we intend to examine public value creation (arrow C in Fig. 1) as a result of joint interactions between government and business (and other actors) and their related own IT systems (arrow A), and these interactions and the respective value creation processes can be enabled or constrained by complex multi-actor digital infrastructures that these actors utilize (arrow B). For the operationalization we build on the work of Twizeyimana and Andersson (2019), Rukanova et al. (2020) and Van Engelenburg et al. (2020) and developed a detailed framework (see Fig. 2) which we elaborate on below.

For operationalization of the value layer we utilize the categories from the framework presented by Twizeyimana and Andersson (2019). The framework identifies three main dimensions of public value of eGovernment, namely *improved public services*, *improved administration* (including administrative efficiency, open government, and ethical behavior and professionalism) and *improved social value* (which refers to improved social value and well-being, and improved trust and confidence in government). These dimensions serve as structure to the public value layer of our framework and are added to the value layer in our detailed framework.

For operationalizing the interaction between business and government actors and the link to public value we build upon the framework

[2] https://www.tradelens.com/

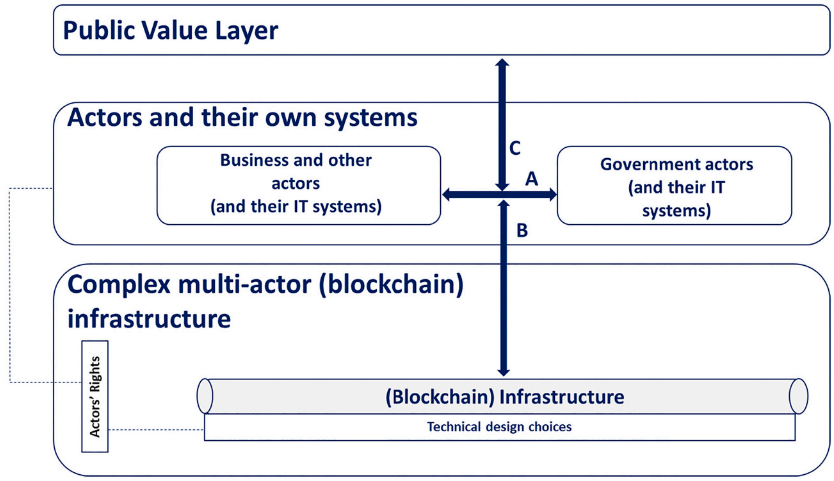

Fig. 1. Initial conceptual framework.

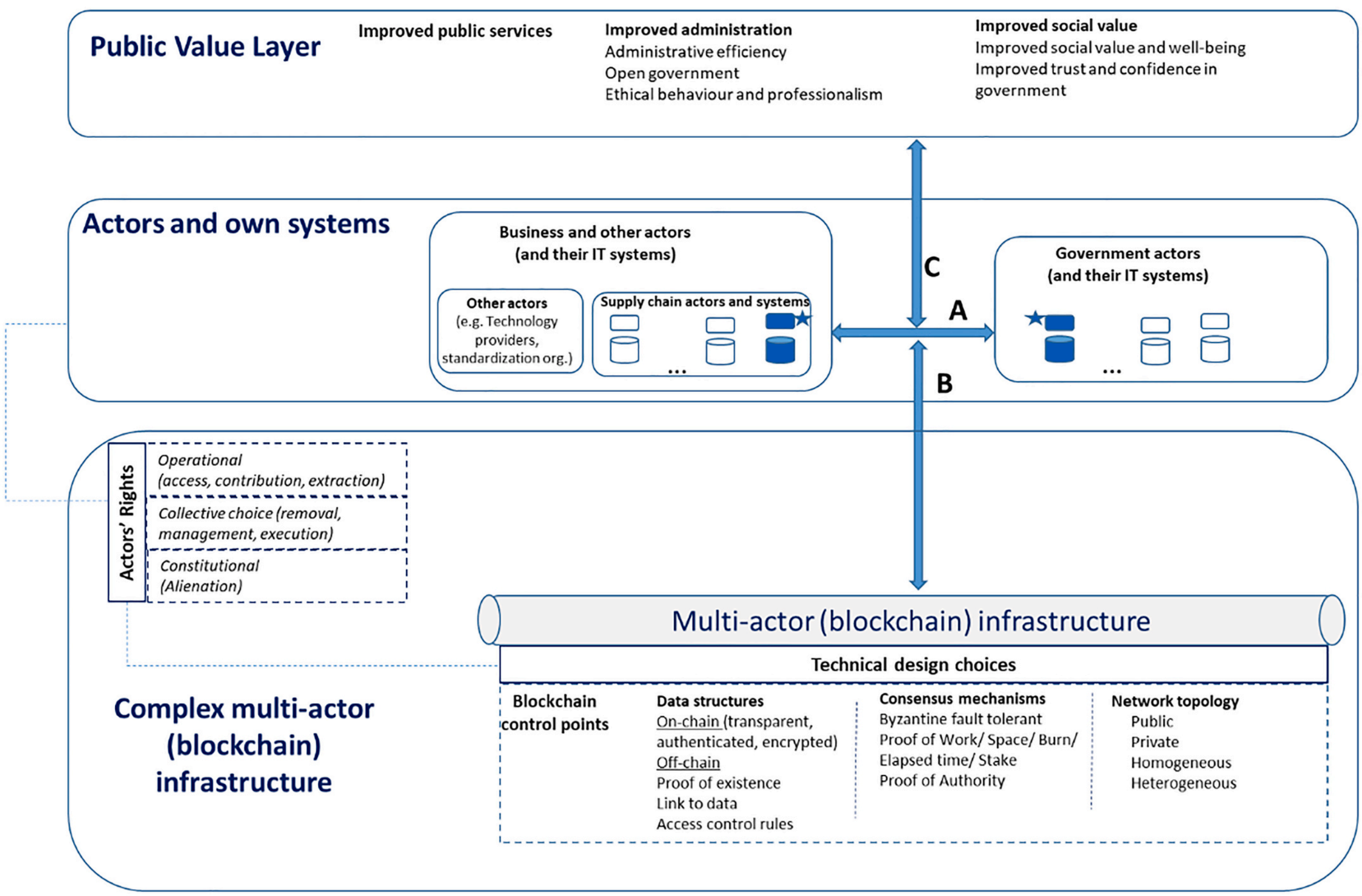

Fig. 2. Detailed conceptual framework.

for voluntary business-government information sharing by Rukanova et al. (2020). This framework makes the link between the voluntary information sharing context in terms of business and government actors and their IT systems and benefits that such data sharing can create. Here the understanding of the business actor layer is seen through the perspective of the actors' supply chain. We distinguish between focal actors and their own IT systems (which are shaded in Fig. 2) to indicate that these are the focal actors that initiate the interaction for voluntary information sharing to create public value. Whereas the framework of Rukanova et al. (2020) acknowledges the role of the underlying data sharing infrastructure it treats it as a black box and does not examine blockchain technologies in particular.

To open the black box of the underlying technical infrastructure, we use the blockchain governance framework of Van Engelenburg et al. (2020). This framework is a useful addition to reason about the technical complexity because it links actors through their rights to the technical design choices of the data sharing infrastructure. The framework also shows the actors that have rights related to the data sharing infrastructure (e.g., technology providers and standardization organizations). These actors do not form part of the standard business operations but are important to understand the broader actor context and rights related to the technical infrastructure, therefore such actors are also added to the actor layer of our framework. The framework of Van Engelenburg et al. (2020) is instrumental in a number of ways. First, it contains concepts to understand the technical design choices behind a blockchain-enabled infrastructure. This is done through what they call the blockchain control points to identify the technical design choices for designing a blockchain-enabled infrastructure. Key design choices include:

a) The *data structure* of the blockchain (i.e., the content of the blocks and how they are connected). Relevant design choices are *on-chain storage* where the shared data is stored on the blockchain, either fully transparent, authenticated or encrypted, and *off-chain storage*, where only a proof of existence of data, or a link to data or access control rules for data are stored on the blockchain. Understanding where data is stored is very important. In ideal situations, the data can be stored on the blockchain and then every actor that is part of the blockchain network will have the exact same copy of the information. But for scalability and access control purposes, such a solution may not be feasible (Tan et al., 2019; Van Engelenburg, Janssen, & Klievink, 2018) and the alternative is to store the data off- the-chain;
b) The *consensus mechanism* (i.e., how consensus is achieved on what data is incorporated in the blockchain). A variety of consensus mechanisms can be chosen (e.g., proof-of-work, proof-of-authority), each with their own benefits and disadvantages and each with their own effect on the distribution of control over the data stored in the blockchain;
c) The *network topology* (i.e., who can be nodes in the network and how are they linked). Here a distinction is made between a *public network,* a network that can be open to everyone and a *private network*, a network in which only specific parties can be a node. Furthermore, a distinction is made between homogeneous networks in which all nodes store the same data and have the same links with each other, and heterogeneous networks in which nodes store different data and/or link in various ways to others.

Furthermore, Van Engelenburg et al. (2020) use the concept of rights to link actor's requirements to the underlying technical design choices of the blockchain data sharing infrastructure. Building on Constantinides (2012) and Ostrom (2003), three types of rights are discussed by Van Engelenburg et al. (2020):

a) *Constitutional rights*: these include *alienation rights* or the rights to determine who has which collective rights.
b) *Collective choice rights*: these include removal, management and exclusion and refer to rights to remove parts of the blockchain-enabled system, the right to determine how, when, and where parts of the blockchain-enabled system can be used and choices on control points may be changed, and the right to determine who has which operational and removal rights and how these can be transferred respectively.
c) *Operational rights*: these include access, contribution, and extraction. Access refers to the right to access parts of the blockchain-enabled system (i.e., nodes, external databases, or key management system). Contribution relates to the right to store, revise, or delete data shared on the blockchain. Extraction relates to the right to obtain access to data shared using blockchain.

The power dynamics at the actor layer can change rights that parties have, which also influences the technical design choices. In our conceptual framework we use the rights as a link between the actors and the blockchain data sharing infrastructure. Thus, in our detailed framework (Fig. 2) the rights act as a linking pin between the actors and their rights and the underlying technical design choices of the infrastructure.

3. Methodological approach

3.1. Interpretative case methodology

In this study, we apply an interpretative case methodology (Klein & Myers, 1999; Orlikowski & Baroudi, 1991; Walsham, 1993). Interpretive studies are "aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context" (Walsham, 1993, p. 4–5). The context of our study is voluntary business-government information sharing enabled by blockchain to create public value. We are particularly interested in understanding how the underlying technical design choices of the blockchain infrastructures used in the voluntary business-government information sharing is linked to the value of the information that is shared. In terms of theory type (Gregor, 2006), the combined framework that we develop can be seen as a theory for (1) analysis; and (2) explanation. For the data collection and data analysis we applied an iterative process, as an iterative approach allows for the development of theories that are deeply informed by the empirical context (Eisenhardt and Graebner (2007). Further details on our interpretative iterative approach are provided in Section 3.3. where we present the different phases of our data collection and analysis.

3.2. Empirical context: The PROFILE project and the Dutch living lab

This study was conducted in the context of the PROFILE research project funded by the European Commission's Horizon 2020 Research program. The Project brings together different EU customs administrations, technology providers, universities, and a research association for the development of data analytics solutions for customs risk management and for exploring the potential value of external data sources for customs.

The work in the PROFILE project is organized around Living Labs, which serve as an innovation environment to collaboratively develop and test innovative solutions in a real-life setting (Higgins & Klein, 2011). The research related to data sharing in the context of the import of goods formed part of the Dutch Living Lab, coordinated by Dutch customs and relates to the broader international trade research into the use of external data from digital trade infrastructures and big data analytics for customs risk management (e.g. Hesketh (2010); Klievink et al. (2012); Rukanova et al. (2021; 2020; 2019, 2018, 2017); Tan et al., 2011; Zhou, Tan, and Rukanova (2021), Heijmann, Peters, & Veenstra (2022)).

Our in-depth case study takes the import of tires from China to the Netherlands as a starting point. The key company involved was a tire importer, an SME company based in the Netherlands. This importer buys tires from a seller in the United States of America (US), which in their turn orders the production of tires in China. Subsequently the tires are imported from China to the Netherlands.

In this case study, the value of sharing business data with customs on a voluntary basis and early in advance of formal requirements for information provision to the Dutch customs, was explored in relation to two business documents. These documents are the *commercial invoice* issued by the seller to the byer (in this case the Tire Importer), and the *Bill-of-Lading*, issued by the carrier.

Data elements within the invoice and Bill-of-Lading match data required for customs procedures and this principle is supported by different international developments and standardization initiatives such as the EU Customs Data Model. Table 1 provides an example of the data elements in these documents.

Both documents can be made available via the TradeLens blockchain infrastructure. The value of sharing such documents with customs was examined in relation to two customs procedures, namely: (1) the safety and security procedure and related risk assessments (based on the so-

Table 1
Example of data elements that can be found in commercial documents.

Commercial invoice	Bill-of lading
• Seller (US)	• Bill of Lading number
• Buyer (NL)	• Booking number
• Purchase Order No	• Export references
• Invoice No	• Shipper
• Carrier	• Consignee
• Quantity	• Notify party
• Item code	• Vessel
• Price (unit)	• Port of loading
• Amount	• Port of discharge
• Ship (date)	• Goods description, said to contain by the shipper (Purchase Order number, goods, brand and types, pieces), weight, measures
• Bank info and account No Seller	• Freight charges invoiced to the Tire Importer– ocean freight, document fee, terminal handling at destination
• Payment terms: cash against documents	• Export fee, document service and terminal handling service at origin
• Country of origin of goods (China)	

called ENS declaration, and subsequently the so-called ATO declaration based on the ENS when the goods arrive in the Netherlands), and (2) the risk assessment of the import declaration related to collecting the right import duties. Both procedures can influence the container flow and can lead to delays in the transport of the tires to the Netherlands. Hence, to better manage the processes with the customs clearance, the Tire Importer was interested in the possibilities for streamlining these customs processes by voluntarily sharing business data with customs.

In recent years, the Dutch Importer became a client of TradeLens, a global blockchain-enabled data sharing infrastructure for international shipping and managed to realize business benefits (see Annex 3, Section A3.6). In 2021 the TradeLens team developed special interface software for the Tire Importer, where business data available via TradeLens (i.e., the Bill-of-Lading and data from commercial invoices of the Tire Importer) can be used to automatically generate an import declaration by the Customs declaration system of the Importer (Softpack) and submitted to the Customs declaration system of Dutch customs (AGS). This functionality was developed as a value-added service (enabled by TradeLens) to automatically generate customs import declaration from invoices that are available in TradeLens and is a significant improvement for the Tire Importer. The functionality replaces the previous process in which import declarations were prepared by manually processing information from commercial documents. This manual process is error-prone and can cause inaccuracies in the customs declarations.

In addition to the efficiency improvement for the Tire Importer, the other goal in the PROFILE project, was to explore whether voluntary sharing of business data early in advance with customs could bring additional benefits for both customs and for the Dutch Tire Importer for (1) the safety and security risk assessment, and/or for the (2) risk assessment of the import declaration related to collect the right import duties.

3.3. Iterative approach for data collection and data analysis

For the case study, as part of the Dutch Living Lab of the PROFILE project, an expert team was formed consisting of domain experts from Dutch customs, the Dutch Tire Importer and TradeLens (see Annex 2). In addition, a university partner acted as a research partner. This team worked closely together through the 3 phases of the research project (see Fig. 3). Phase 1 was focused on qualitative data collection and analysis; in Phase 2 data sets from the Tire Importer were analyzed and compared to customs data to analyze the value creation for customs risk management and in Phase 3 we focused on refinement based on the insights gained. These activities took place in the period of the Summer of 2020 till December 2021.

The process of data collection and analysis was done iteratively

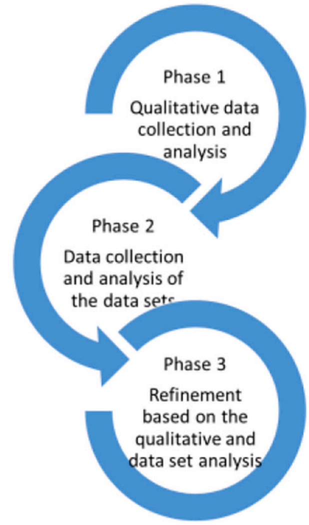

Fig. 3. Phases for the data collection and analysis.

where data collection was followed by interpretation of findings, identification of differences and further iteration to reconcile differences and interpret the findings. This iterative interpretive process was on-going through the collective meetings, workshops, and follow-up communications, and gradually advanced and sharpened our understanding of where the value creation lies, especially after Phase 2, and helped to clarify aspects on the underlying blockchain technology. An overview of the data collection and data analysis activities is presented in Annex 1.

In *Phase 1*, a qualitative analysis was conducted to better understand the supply chain processes and the contractual relationships, the data exchanges, and the data elements, as well as the interactions with the government and related systems. Furthermore, we analyzed the TradeLens infrastructure and its technical architecture. In addition, various workshops with Dutch customs and the Tire Importer were organized to elicit the potential value in terms of benefits from voluntary data sharing. This value articulation evolved over time based on the additional data that became available, and discussions took place to clarify aspects that were still unclear and to reconcile differences. Beyond what is presented in this paper, additional results from this process can be found in Annex 3, where we provide a detailed description of the context including processes, contractual relationships, data elements and potential value creation.

In *Phase 2*, the goal was to collect business data of shipments of the Tire Importer for the period of 6 months and to share these with Dutch customs. Subsequently customs could compare the data with data in their own systems with the goal to study the potential benefits from voluntary sharing of such business data with customs and to compare these to the benefits identified qualitatively in Phase 1. Dutch customs received data from the Tire Importer regarding tire shipments (events) that took place in the period October 2020 –April 2021. This data was available via TradeLens and subsequently a data set was retrieved and shared with customs for further analysis. It concerns a dataset with business documents that are used for deriving the necessary information for filing the import declaration. The data concerned two types of documents: (1) the *commercial invoice* issued by the seller to the buyer (the Tire Importer), (2) the *Bill-of-Lading* issued by the carrier. A data scientist at Dutch customs worked on the following assignment for the document analysis:

- Link the data to the *safety and security* (ENS) declarations that were submitted to customs to analyze whether the additional business data can help customs to improve their safety and security risk assessment of goods in containers arriving in the port of Rotterdam;

- Link the business data to the *import* declarations data of the Tire Importer that were submitted to Dutch customs to analyze whether the data corresponds. As customs declarations are now generated via TradeLens data automatically to the customs declaration system of the Tire Importer (SoftPack), which then submits the declarations to the customs declaration system of Dutch customs (AGS), the expectation was that this data should match one on one. In the study, this had to be confirmed based on the document analysis;
- Analyze the time frame when the business data is submitted to customs and whether this could lead to an 'avant -la-lettre'[3] declaration on import.

For each of these questions it was required to link the information received from Tradelens about the Tire Import to the two types of declarations for the same consignment in the two declaration systems of Dutch customs, namely (1) the DMF system of Dutch customs for the Entry Summary (ENS) Declaration related to safety and security procedures, and (2) the AGS system of Dutch customs for import declarations related to fiscal matters such as import duties.

Further details on the data analysis of the data sets can be found in Annex 4. The data analysis from Phase 2 aimed to confirm some of the observations about potential benefits from using the Bill-of-Lading and Invoice information earlier in advance, as articulated during the Phase 1 qualitative analysis. As some differences were identified, in Phase 3 of this study, additional iterations among the stakeholders were needed to interpret the findings and clarify inconsistencies. In the next section we present the summary of our case findings which are the result of this iterative research process.

4. Case analysis

4.1. Summary of the case findings using the conceptual framework

For the case analysis, we analyzed the public value creation processes from the voluntary business-government information sharing of the Dutch Tire Importer with Dutch customs, enabled by TradeLens, using the detailed conceptual framework presented in Fig. 2. A summary of the results from applying the framework to the case are visualized in Figs. 4 and 5, where Fig. 4 focusses on the import declaration and public value related to revenue collection and Fig. 5 to public value related to safety and security. Explanation of Figs. 4 and 5 and the related analyses is provided in the subsequent Section 4.2 – Section 4.4. In the discussion section we revisit the application of the framework to include an outlook on taking an integrated view at both public values of revenue collection and safety and security and we discuss the possibility of adding other public values (e.g., sustainability) to take a more integrated view on public value creation as a joint business-government responsibility.

4.2. Voluntary business-government information sharing: The actor (and their own IT systems) layer

We first analyze the actor layer for understanding the key actors and their related IT systems (see Fig. 2). With respect to the actors, we start with the supply chain actors and the government. In our case, the key business actors that play a role in voluntary information sharing are the seller, the carrier, and the Dutch Tire Importer, where the Dutch Tire Importer acts as the focal actor that enters collaboration with the government (Dutch customs) to explore the possibilities of value creation via voluntary data sharing.

When the study was conducted in 2021, one carrier was responsible for the full route: for the original vessel picking up the container from China to the trans-shipment port in Malaysia, and for the second part of the journey where the container is loaded onto another vessel in Malaysia for the journey towards Europe.[4]

Fig. 6 zooms in on the logistics flows and the responsibilities of parties for sending declarations to Dutch customs.

The Dutch Tire Importer orders tires from a seller based in the US. The US seller then orders the tires from a factory in China and subsequently the tires are transported by a sea carrier to the Netherlands. For bringing the tires to the EU and importing them to the Netherlands, Dutch customs needs to perform two risk assessment procedures to allow these goods to enter the EU and be imported for so-called free circulation to the EU market. The first customs procedure is the safety and security risk assessment by a customs administration. This procedure relates to the role of government to provide public value by ensuring safety and security of its citizens. The safety and security risk assessment procedure is based on a declaration submitted by the carrier to Dutch customs (the so-called Entry Summary declaration, ENS), which is submitted to the DMF system of Dutch customs (see Fig. 5). For making the ENS declaration the carrier uses information available in commercial documents such as the Bill-of-Lading which is issued by the sea carrier when the goods are loaded on the vessel. Dutch customs performs a risk assessment process on the ENS 24 h before the goods are loaded on the vessel that will bring the tires to the Netherlands. Subsequently, when the ship arrives in the Dutch Harbor of Rotterdam, the ENS data is also used as a basis for the so-called ATO risk assessment: the goods are risk-assessed based on national risk indicators when the ship arrives at the quay and the goods are reported in the Netherlands by an active arrival report.[5]

A second customs risk assessment procedure is related to fiscal matters, e.g., whether the right import and the Value-Added Tax (VAT) duties are declared. This procedure relates to the public value that customs delivers to society with respect to revenue collection. Failure to perform this task well would result in loss of revenues for the EU Member States, which will in turn limit the resources government has for meeting public needs and providing public services. This risk analysis is based on the import declaration, which is submitted by the importer to the customs import declaration system (AGS system, see Fig. 6). The import declaration is based on data available in commercial documents such as Bill-of-Lading, issued by the carrier, or the commercial invoice issued by the seller. Customs then also performs risk analysis on the import declaration and if everything is correct, the importer is invited to pay the import duties, after which customs will release the goods, and the tire importer can pick-up the container with the tires.

At the supranational level, the EU issues the customs laws and regulations for international trade and logistics via the Union Customs Code

[3] This is customs import declaration that can be lodged in advance.

[4] For the description here we explain the situation with trans-shipments to clarify the complexity. However, a direct shipment can also be one of the scenarios.

[5] The ENS must be submitted for all goods on board the ship that are brought into the EU. It therefore, does not matter whether the goods are unloaded, or in which port the goods will be unloaded. Customs know what is on board of a ship. The ENS check uses Safety & Security (S&S) risk indicators: EU-imposed risk indicators (risk rules). The results of the S&S risk analysis are passed on to all planned successive ports in the EU that are listed in the entry summary declaration. A summary declaration of goods to be unloaded (ATO-– Aangifte voor tijdelijke opslag in Dutch or Declaration for temporary storage in English) must be made for all goods that are unloaded in a Dutch port. This must also be done for goods that are unloaded in the port but are then reloaded into another ship to be taken outside the EU again. All goods listed in an ATO are also included in the ENS. The ATO will be checked with national risk indicators. These are about Safety, Health, Economy and Environment aspects but no fiscal or financial aspects. These will be checked with the import declaration. The moment when an ENS declaration becomes ATO is when the ship arrives at the quay and the goods are reported by an active arrival report.

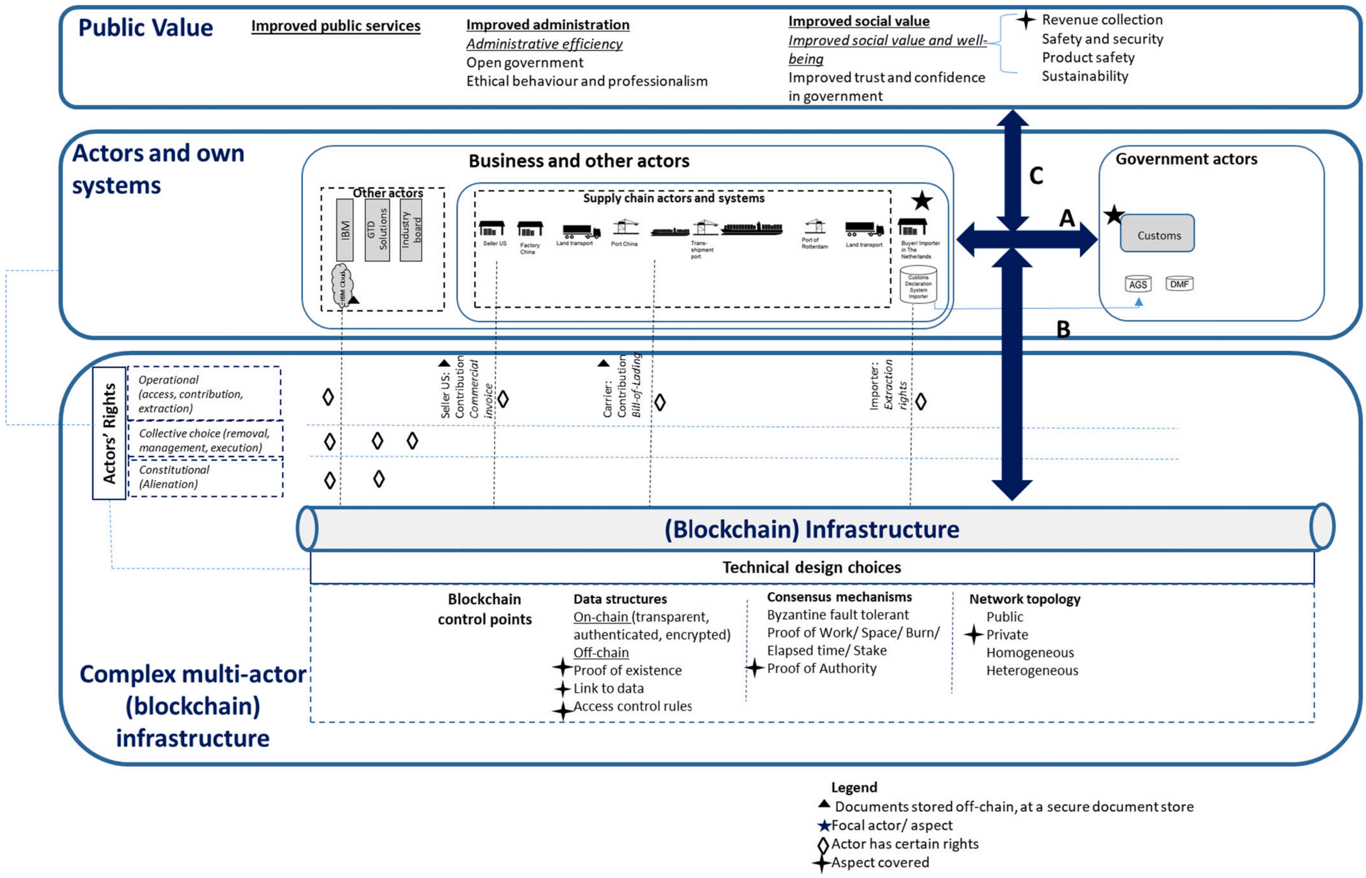

Fig. 4. Demonstration of the framework applied to the case on voluntary information sharing with focus on public value related to revenue collection.

(UCC).[6] Of particular interest is the clause in the Customs Code that allows for companies to submit their import declaration earlier in advance and to make use of the so-called *avant la lettre* declaration that can be used for earlier risk analysis.

On the IT infrastructure side, the TradeLens blockchain-enabled infrastructure is provided by IBM and GTD Solution,[7] where IBM is responsible for the technical development and the additional cloud services for the document storage. In Fig. 6, we show that the seller issues the commercial invoice, and the carrier issues the Bill-of-Lading, which are both made available via TradeLens. More specifically, these documents are stored on the secure document store of the IBM cloud, and only hash pointers to these documents are stored on the Tradelens infrastructure. These hash-pointers enable to establish an audit trail, as well as provide a link via TradeLens to the secure document storage location where the documents are stored.

In Fig. 6 we explicitly marked the ENS, ATO and the import declaration data that are required by law (marker with '*') to show that this is mandatory data. We marked the invoice and the Bill-of-Lading data as business data that is not required to be shared by law in advance (marked with '**'). In our case this business data forms part of the voluntary data sharing arrangement.

Whereas the Tire Importer already used TradeLens for its business efficiency, in the PROFILE project they explored the possibilities for further improving the interaction processes with the Dutch customs. The Tire Importer takes its responsibility and has an interest to have it supply chain and information under control, as it wants to be compliant and to fulfill its import duty obligations which relate to the public value related to revenue collection. It is also in its own interest that there are no safety and security issues related to its supply chain, as any breaches will affect its image and operations. The Tire Importer wants to show transparency and that it is in control of its supply chain operation both with respect to fiscal, as well as safety and security matters and collaborates with Dutch customs by voluntary sharing information. In this case the collaboration is to allow both parties to work together to better address these public values by means of voluntary information exchange facilitated by TradeLens.

To enable the automatic generation of an import declaration (see Fig. 4) based on available business documents in advance (such as the commercial invoice and Bill-of-Lading), IBM developed software that allows for automatic retrieval of relevant data fields from the commercial invoice and the Bill-of-Lading. These data fields are made available to TradeLens and mapped to the correct fields in the customs declaration software of the Tire Importer (Softpak). In this respect, IBM can be seen as an application provider developing value-added services for the tire importer based on data from TradeLens. Subsequently, this declaration is submitted via Softpak (the customs declaration software used by the tire importer) to the customs declaration system (AGS) of Dutch customs. As the software interface was only recently implemented, even though the declarations are generated automatically, the tire importer performs a final manual check before submitting the declarations to customs. In the future, when the process shows to be stable over time with little need for manual interventions, it can be fully automated.

Note that the customs declaration is automatically generated based on data available from TradeLens and via the Softpak system submitted directly to the customs declaration system (AGS) of Dutch customs. Thus, as far as the import declaration is concerned, no additional IT development is required on the customs' side, as they receive the

[6] For UCC, see https://ec.europa.eu/taxation_customs/customs-4/union-customs-code_nl

[7] GTD Solution is a subsidiary company of MAERSK

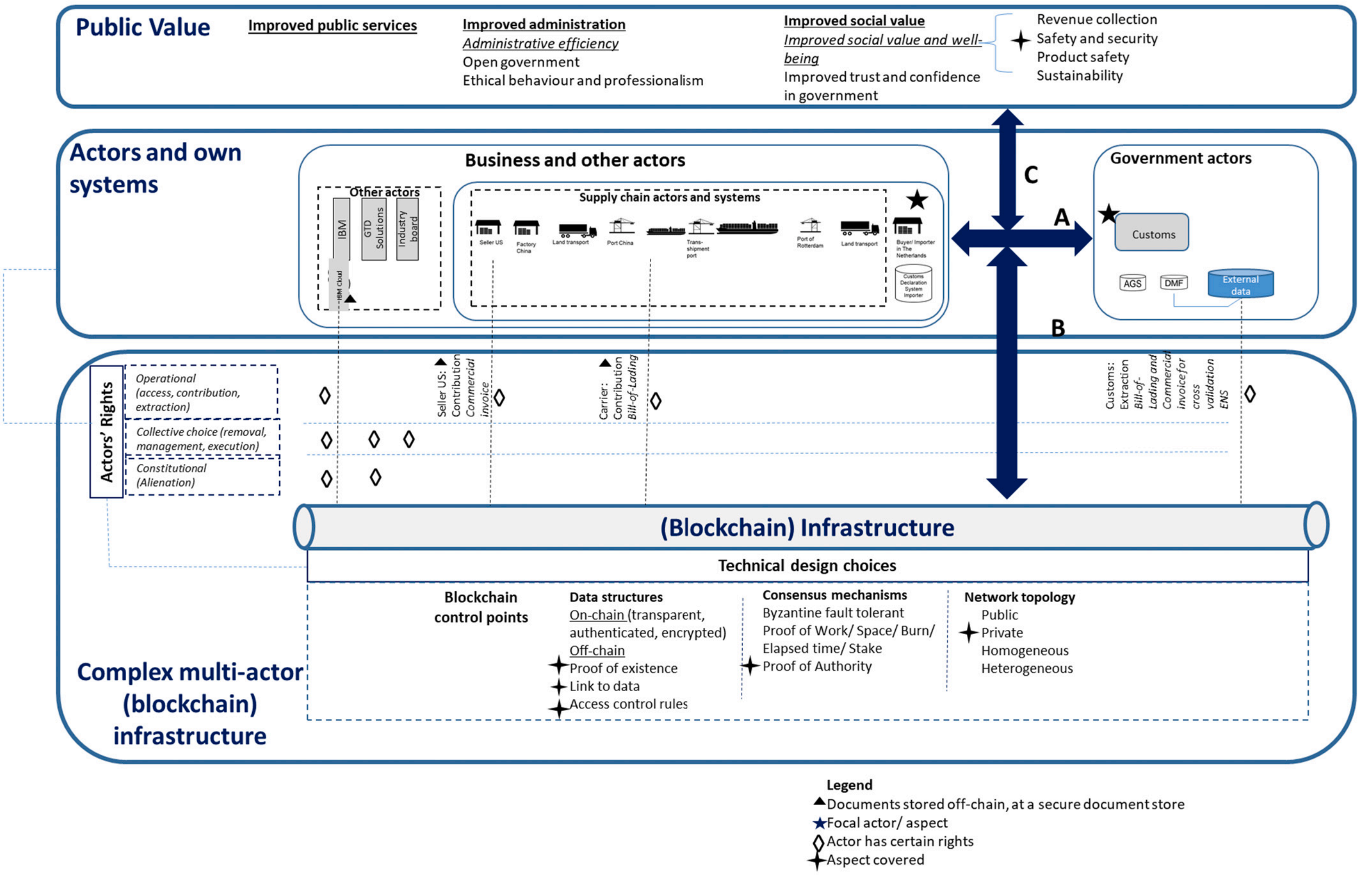

Fig. 5. Demonstration of the framework applied to the case on voluntary information sharing related to the public value safety and security.

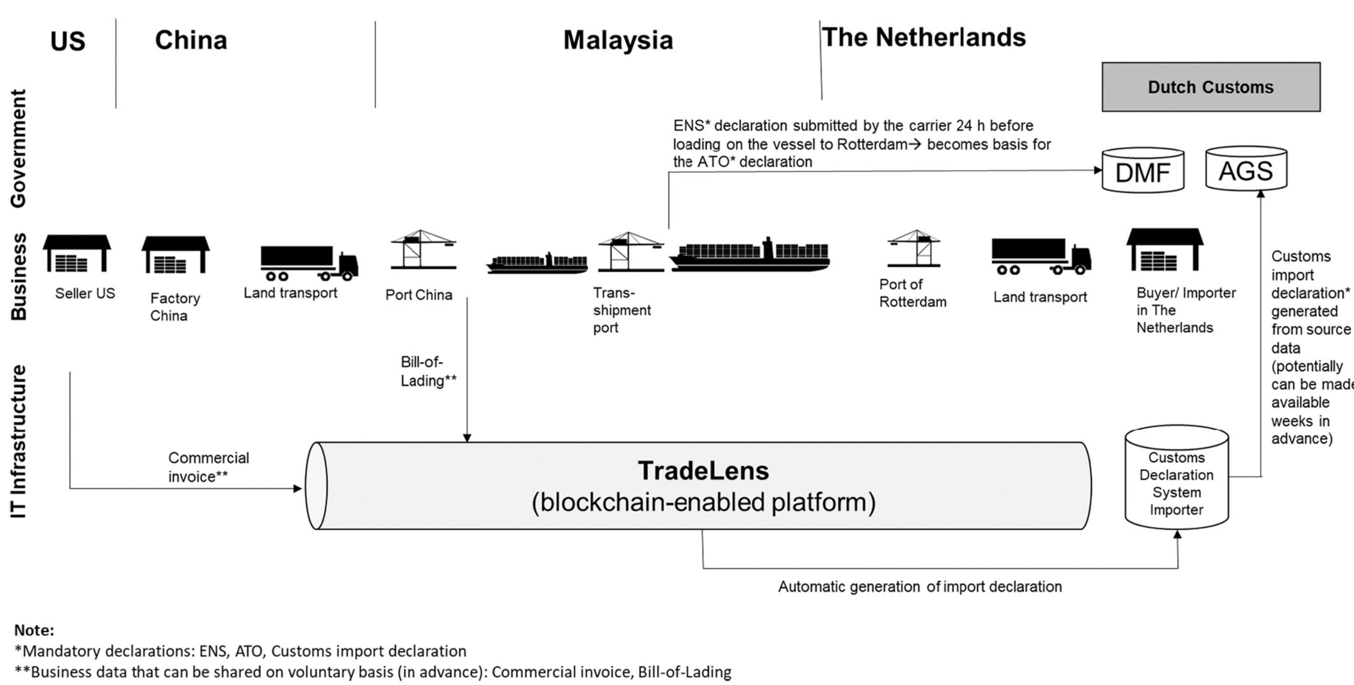

Fig. 6. Automatic generation of import declaration using data available via TradeLens.

declaration via their traditional channels. Also currently, the Dutch Tire Importer does not lodge this declaration long in advance but follows the current procedures to submit the declaration a few days before arrival of the vessel in Rotterdam, even though the data for the import declarations is available weeks before the ship arrives. However, with the automatically generated import declaration, the Tire Importer has the option to make the import declaration available to customs weeks in advance, and customs can do the risk analysis on this declaration earlier. One of the questions investigated in the project was whether such earlier declaration is stable and reliable (i.e., that it is not adjusted over time while the ship sails) to be used in the customs risk assessment process.

For advanced declaration data to be of value for the Dutch customs to perform earlier risk assessment and for granting trade simplification benefits associated with concepts such as trusted traders and trusted trade lanes enabled by data pipeline innovations (Heijmann et al., 2020), Dutch customs needs to:

(1) have good visibility into the TradeLens system to gain assurances that the data on which the declaration is based can be trusted and has not been tampered with, and.
(2) be able to audit how this TradeLens data is used to compile the import declaration in Softpak.

Therefore, whereas for the import declaration part Dutch customs does not need to invest in traditional IT development of interfaces, Dutch customs would need to invest in auditing the Softpak system and the interface with TradeLens to ensure that data in the declaration is indeed originating from the commercial invoice of the seller. An example of a potential fraud is that the data of the commercial invoice is manipulated by the Softpak software in such a way that specific goods codes (Harmonized systems (HS) codes and related more detailed codes) for determining the import duties in the invoice[8] are replaced by more favorable HS codes. Hence, for upscaling to the operational environment it is crucial for customs to understand the technical details of the underlying technology and how the audit trail is ensured.

Looking for a wider applicability for cross-validation of customs declarations, Bill-of-Lading data can be used for cross-validation of the safety and security (ENS) declaration and the import declarations. Commercial invoice data can be used to cross-validate the customs declaration data that is available at AGS. It is important to distinguish the case of the automated generation of the import declaration from the cases of cross-validation, as they will differ in terms of technical infrastructure and capabilities that customs would need to have for upscaling. In case of the import declaration, as discussed, there will be no need for further development of the IT infrastructure on the customs side, as data will flow via the traditional channels, but efforts and skills need to be deployed in auditing the software of how the automated declarations are created. In case of accessing business data in advance for cross-validation purposes, customs needs to invest in IT infrastructure to enable customs to access data form external business infrastructures. In the following section we address the needed trust in the data itself.

4.3. Understanding the underlying technical design choices

An important condition for data that is voluntarily shared with customs for cross-validation and risk assessment purposes is the concept of trust in the data and the quality of the data. For auditability and reliability, governmental organizations need to be sure that the data has not been tampered with.

We use the bottom part of our conceptual framework to see how these assurances on the reliability and auditability of the data are visible in the technical design choices embedded in the Tradelens infrastructure used by the tire importer. We can start by examining the rights, which provide visibility into how the blockchain infrastructure is governed in terms of constitutional, collective choice and operational rights (see Fig. 3).

4.3.1. Governance requirements and rights in the tire import case

The governance requirements in the conceptual framework address three types of rights, namely the constitutional, collective choice and operational rights (see Section 2.2 for the general explanation of these rights).

The *operational rights* are those rights that are specific for the relevant supply chains. As a user of TradeLens, the Tire Importer mainly has operational rights. These encompass the rights to access and extract the relevant information provided by other actors such as the invoice data provided by the seller in the US and the Bill-of-Lading data provided by the carrier. Other parties with operational rights are the seller in the US that sells tires to the Tire Importer, as well as the sea carrier. These parties have contribution rights as they are allowed to provide data to TradeLens. By joining Tradelens, businesses voluntarily agree that relevant authorities related to their trade lanes (in our case Dutch customs) can have access to relevant business information (in this case business information related to the tire import) available via TradeLens (such as Bill-of-Lading and commercial invoices). Thus, Dutch customs has extraction rights to this data. IBM is providing secure document storage but is not allowed to view the content of the data unless agreed otherwise (e.g., for specific support issues or for specific value-added services). To this end, IBM has contribution rights to their document storage, but does not have extraction rights. The operational rights are reserved for the supply chain partners of the tire supply chain or the relevant government authorities.

For the *constitutional rights*, which define who may or may not participate in making collective choices, we see a shift from the supply chain actors towards ownership and decision making behind TradeLens. TradeLens is owned by IBM and GTD Solution. IBM also offers cloud-based secure data storage for companies using TradeLens, but formally this is not TradeLens. It is an additional commercial service, and all users are free to use their own secured databases for storing their trade documents.

Finally, for understanding how the rights are distributed in case of TradeLens, we also address the *collective choice rights*: the rights concerning users and components within the information system. Per design, although TradeLens is formally owned by IBM and GTD solutions and they hold the constitutional rights, TradeLens set-up a neutral platform regarding the collective choice rights. This entails that other carriers can join and participate in collective choices made related to TradeLens (e.g., choice of standards or other technical design choices). The TradeLens Industry Board plays a key role in making these collective choices. Other major carriers like MSC have joined the TradeLens Industry Board, paving the way towards a more neutral platform, where other carriers have the option to participate in the collective choices via the Industry Board. How the collective choice rights will be shaped and developed in the future is subject to further research. To summarize: beyond the layer of operational rights, where the Tire Importer and its supply chain partners, as well as the authorities play a role, there is also a formal ownership layer, as well as a decision-making layer where collective choices are defined.

Next to the rights which yield a better understanding of the decision-making structures, the blockchain control view provides additional insights into the underlying technical design choices. These are needed to understand aspects such as how immutability of data and how an audit trail can be secured.

Regarding the technical design choices on *data structure*, as indicated in Figures Figs. 4 and 5, TradeLens opted for an off-the-chain solution: the documents of the Tire Importer are stored in a secure cloud document storage of IBM, rather than on the blockchain itself. Only the hash pointer to the documents is stored on the blockchain, containing a hash of the document and a link to the location where the document is stored in the secure document storage. Storing only hash-pointers was a design choice of TradeLens and allows TradeLens to offer a scalable solution on a global level (Tan et al., 2019). Because of this choice, parties participating in TradeLens can decide which exclusion rights (one of the collective choice rights) are chosen for their data. For example, if they keep the data in their own ERP system, they retain their exclusion rights, but

[8] In our case, the HS codes were included in the invoices.

they can also decide that they trust a secure document storage provider to control, access, and store their data. This illustrates the different design options for storing the data. Especially in the case where customs wants to access additional business data for cross-validation purposes these different technical design choices reveal trade-offs and considerations about efforts, IT investments and required adjustments that need to be made on the customs side to access such information. These adjustments depend on whether the data is stored on the IBM cloud or in the company's own secure storage, or in case of other blockchain solutions if the data is stored on chain. These may seem very technical considerations, but customs can only realize value from business data if it is technically feasible to receive access to such data. Therefore, these technical considerations play an important role when reasoning about the value of voluntary business data for customs.

TradeLens is based on Hyperledger. As indicated in Figs. 4 and 5, the blockchain network of TradeLens is a *permissioned network* and the *consensus* mechanism for adding new blocks on the chain is based on *proof-of-authority*. This entails that only authorized parties can add new blocks to the chain: the parties that have contribution rights. In terms of *network topology*, TradeLens is a *private network* that is owned by IBM and GTD Solution and in correspondence with that, they have constitutional rights. TradeLens consists of limited number of nodes and makes use of channels to ensure that different carriers cannot see each other's data.

A full view on the different rights and blockchain design choices allows customs to gain more visibility into the mechanisms used for ensuring immutability of the data. Namely, customs can use the hash-pointer to identify the location where the document is stored and given the proper access rights, they can retrieve the document, calculate its hash, and compare it to the hash that is stored on the blockchain to see whether they match[9]. Customs can also evaluate how the audit trail is ensured. In practice, additional discussions can take place with the Tire Importer, TradeLens and customs on the duration for which the audit trail needs to be assured and how this functionality can be added. Decisions about the costs and benefits of such functionality needs to be part of the decision-making process for the tire importer and customs. The level of the investment costs will influence the value and the perceived benefits of the voluntary business-government information sharing. Yet, they need to be weighed against the benefits of potential future piggybacking on this investment to engage with other supply chains. In addition, the possibilities to consider other public value categories than can be served by these data sharing solutions (such as sustainability), may provide a new view on the cumulative effect on the attainment of public value creation. In the next section we turn to the value articulation and how this was applied in our case.

4.4. Value articulation

For the public value articulation layer in our conceptual framework (Fig. 2) we take a detailed look into the potential benefits of voluntary sharing of business data with customs. First, a qualitative assessment is presented (Phase 1 of the project, see Fig. 3), which is supplemented with the quantitative assessment of the data sets that was conducted in Phase 2 of the project.

4.4.1. Potential benefits: Qualitative approach

Based on the data analysis introduced in Section 3.3, several in-depth insights were gained on how two business documents, namely the *commercial invoice* and the *Bill-of-Lading* can create public value in the two public value creation processes we examined (revenue collection and safety & security checks). In the following paragraphs we present the main findings.

On a high level three issues and related benefits from voluntary data sharing were identified:

(1) *Time of the receipt of the customs declaration:* At the moment customs import declarations are received quite late in the process. Pre-lodged declarations earlier in advance allows for more efficient risk analysis;
(2) *Data quality of declarations*: At the moment customs experiences issues with data quality of both the safety and security (ENS declarations), as well as import declarations. Obtaining additional business documents in advance for cross-validation of declarations can save time for both businesses and customs;
(3) *Pre-lodged import declaration:* Pre-lodged import declaration is only of value for customs for their risk analysis if it contains very reliable data that will not be updated during the transport of the goods. Assurances of high reliability of pre-lodged declarations are of value to customs.

From the point of view of the value dimensions in our framework, these benefits are mainly linked to the public value dimension related to administrative efficiency (more efficient public administration). These improvements will, in its turn, allow customs to provide better public services (in this case to companies that take their public responsibility and are willing to be transparent by sharing data on a voluntary basis). From the point of view of societal benefit this improvement concerns revenue collection and safety and security.

While the issues and potential benefits were articulated based on qualitative interviews with experts, we also used a sample data set of business documents of the tire importer to assess the value creation. This quantitative data analysis is presented in the next section.

4.4.2. Potential benefits: Quantitative approach based on sample data sets

Based on the analysis of the data sets, several observations can be made (a more detailed overview of the data set is presented in Annex 4). First, for direct shipments (in our case around 40% of the shipments), where the container is loaded on a ship that sails directly to Rotterdam, the Bill-of-Lading data becomes available more or less at the same time as the ENS data. The data in this Bill-of-Lading will not be of value for the ENS risk assessment process that takes place before loading. But such information will be available for the risk assessment that takes place when the ship arrives, therefore it can be useful for cross-validation of the legally required ATO declaration. Our data analysis shows that in 99% of the cases that were investigated, the Bill-of-Lading data was available in TradeLens before the ATO, so availability of Bill-of-Lading data can be useful for this second safety and security risk analysis based on ATO.

In case of trans-shipments (in our case 60% of the cases), the Bill-of-Lading data is not only useful for the ATO, but also for the ENS risk assessment, as in these cases the Bill-of-Lading data is available in TradeLens before the ENS is lodged to the customs declaration systems. The reason why this Bill-of-Lading data is useful for both ENS and ATO risk assessment is because of the trans-shipment. Taking our example, the Bill-of-Lading will be issued before the container leaves China on a vessel. But the ENS will be issued only when the container is transferred from one vessel to another vessel in the port of trans-shipment, where the container is loaded on the vessel that will bring the goods to Rotterdam. In this case the ENS is submitted 24 h before loading on the second vessel, but the Bill-of-Lading information is already available before leaving China, therefore it can be used for cross-validation for both the ENS and ATO risk assessment processes.

4.4.3. Reflection on public value

The quantitative analysis was to a large extent aligned with the

[9] It is important to note that blockchain depends on the quality of the data that is put on the blockchain. For customs commercial invoices are considered as an interesting source of data, as they come from the source (compared to customs declarations that are based on data derived from other documents). Also the commercial documents are used for business perposes such as initiation of payment.

qualitative expectations, still there were some important new insights that were gained when going through the detailed exercise with the data sets. It allowed to further fine-tune in which cases the information in advance is providing more benefits. Therefore, while the value categories covered (see Figs. 4 and 5) do not shift much when moving from the qualitative to the quantitative analysis, the quantitative analysis shows more specific situations as to which procedures and how many procedures would benefit from this earlier information. This enables a more detailed investigation of the benefits and trade-offs and where exactly external data adds value in which pubic value process.

5. Discussion

In our introduction we addressed the issue that current academic research into public values has paid limited attention to the public value creation processes that occur based on the interactions between businesses and government. Furthermore, earlier research has argued that digital technologies are becoming increasingly complex, which makes it difficult for government to understand their impact on the public value creation processes. In this paper we developed a conceptual framework to gain better understanding of the public value creation processes that involve business and government actors and which are enabled and constrained by digital infrastructures. In our research we focused on business-government interactions with respect to voluntary business-government information sharing that lead to public value creation. We specifically focused on understanding the technical design choices of blockchain-enabled infrastructures that can enable or constrain the public value creation.

As a basis for our framework, we built on earlier frameworks research related to public value, voluntary information sharing and blockchain design options. We demonstrated the use of the framework with a case in the domain of international trade in which the blockchain-enabled infrastructure TradeLens was used. This case offers an in-depth understanding of the public value creation processes by looking at the context of the voluntary data sharing (including actors and their own systems), it highlights the detailed exploration processes of how this data can be of value, and shows for which government procedures and under which conditions public value is created. It also supports a detailed analysis of the technical design choices for the data sharing infrastructure, where the actors' rights provide the links between actors, their data requirements, and the technical design choices.

Looking at the Tire Import case, the availability of the data in advance is a benefit for customs but it is only of value if there are assurances that the data that is shared or is used for the pre-lodge declaration is based on information that is reliable so that customs can base their risk assessment on it. This reliability includes assurances that the data comes from the source (e.g., the commercial invoices from the seller), that it has not been tampered with, and that there is a clear view on how this information is used in the Softpak system of the Tire Importer to derive the declaration. By applying the framework, it is possible to reason about the blockchain features of TradeLens and how they enable the establishment of an audit trail which is a key technical feature to provide assurances on the immutability of the data. By looking at the technical design choices, it is possible to reason about how this is done in TradeLens. This is ensured by *off-the-chain storage* of documents and *on-the chain* storage of *proof of existence* links to the documents via hash-pointers, and access control rules. The consensus mechanism is based on *proof-of-authority* and the data is shared via a *private permissioned blockchain network*. Also, as the data comes from the source, immutability is ensured via the audit trail on the blockchain.

We used our conceptual framework to analyze Trade Lens, but it can also be applied to other blockchain solutions that e.g., may store the documents on the blockchain itself, or in cases in which the Ethereum platform or other public blockchains are used. The framework can be used to reason about their underlying design choices. To illustrate, in other cases data might be shared via a *public permissionless blockchain* which allows anyone to access the data. Such a blockchain can provide an even higher level of immutability (also depending on other design choices) as many more nodes will store the data and participate in the consensus mechanism process. This can be valuable in case organizations require a very high level of immutability while not being able to select a few parties that they trust with the authority to govern the blockchain. However, it would be more challenging to protect the confidentiality of the data stored in such a blockchain (Van Engelenburg et al., 2018). On the other hand, the very high level of transparency that such a blockchain offers could in itself create value in some cases. In our case we looked at different scenarios. The first is the scenario of an import declaration: as the import declaration is based on the source document there will be no need for customs to require additional trade documents for cross-validating the data on the customs declaration. The declaration already contains high-quality data from the source documents (assuming that the proper IT audits have taken place to ensure that the way the declaration is generated from the source via TradeLens to SoftPack is reliable).

In the case of safety and security declarations, information available in TradeLens can be useful for cross-validation purposes. Remaining issues to be solved include how to make the IT infrastructure on the customs side fit to access such external business data and to make use of it during the risk analysis processes. As discussed earlier, our framework can be useful here as well to make distinctions and identify trade-offs of what adjustments to the customs IT infrastructure would be needed to support data access if the data is (a) in the company's own system, or (b) in the secure document storage, or (c) on-chain, in case that other blockchain solutions are used. Notably, TradeLens was originally designed with the possibility for sharing data with relevant government authorities, which makes data access for the relevant authorities easier. This may not necessarily be the case in other blockchain-enabled infrastructures, where the governance requirements and rights related to the authorities are set-up differently. This elicits trade-offs and considerations related to how government access rights are arranged in different blockchain solutions, which in its turn has an influence on the public value creation of the voluntary data sharing arrangement.

A fundamental feature of blockchain-enabled solutions that is often addressed in the literature is the added value of removing a trusted intermediary in the information exchange chain. This decentralized aspect is often discussed without questioning whether there is a good reason to eliminate the trusted third party. In the international trade domain this may be less of an issue, and it may be sufficient to have a limited number of nodes for the blockchain solution to add value. As we see in the tire case, the added value is attained by creating an audit trail, which is very important for government for auditability and reliance on the immutability of documents for risk assessment purposes.

The case that we used represents a simple setting of one standard product (car tires), a relatively simple shipment (a full container with the same product and one carrier for the entire journey), which is sent to the same importer (an SME company). At the same time, this case also opens new challenges as it shows that even in a seemingly simple case, a great deal of complexity to develop the value creation processes arises. For example, in our case we focused on public value creation processes related to revenue collection and safety and security checks on imported goods. We examined how our framework can be applied to each of these procedures individually and we gained insights into the public value creation processes for the individual values. But this could be used as a basis to move towards a more integrative view and to reason about trade-offs and opportunities when more than one public value is pursued. And even more so, our framework allows to add new public values in the future. For example, if customs needs to address additional public concerns related to sustainability and circularity of imported goods, it will need relevant information related to the production process, such as material composition, and it may require item or batch level tracking instead of at the container level. Our integrated view accommodates the anticipation of such potential future responsibilities for customs, as illustrated in Fig. 7.

Another important aspect to consider is the underlying technical infrastructure that is used to enable the voluntary information sharing to create public value. The technical complexity is high as multiple actors with different rights are involved and different design choices can be made. But while these underlying technical infrastructures are complex and require time and investment of government to understand and engage with them, the benefit is that these infrastructures are not created for only one specific supply chain, but they can serve multiple supply chains and business communities. These network effects may benefit the government if they consider the required investments for obtaining data via such infrastructures. Equally, these infrastructures raise issues of data ownership, data confidentiality and security. Therefore, gaining insights not only into the operational rights about who can access which data but also about constitutional and collective choice rights which relate to who owns the infrastructure and who makes the decision is very important.

Whereas in this paper we went a level deeper in understanding the technical complexity and linking it to the value creation processes, we see this only as a first step. We looked only at one infrastructure (TradeLens) but in the future, when it comes to public values that link to e.g., circular economy monitoring, it is likely that data that is of value (e.g., data about origin of materials) will reside in different infrastructures (Kofos et al., 2022). This will add complexity on how to gain access to data across these infrastructures and raises issues about interoperability. The view on the technical complexity, especially when more blockchain-enabled infrastructures are involved in the process of voluntary data sharing, leads to governance questions on how governments can connect to these multiple blockchain-enabled infrastructures and how do these infrastructures connect to initiatives and innovations driven by government like Single Window[10] and Once Only.[11] Would government opt for directly connecting to a multiplicity of blockchain-enabled infrastructures developed by businesses with all the inherited complexity to be able to understand how these underlying solutions are designed? Or would it require that businesses that are willing to share data with government, need to connect via a government blockchain-enabled infrastructures such as the European Blockchain Services Infrastructure (EBSI)[12] currently developed in the EU? Other solutions are explored by organizations such as the International Data Space Association (IDSA),[13] the GAIA-X[14] development for cloud interoperability, and the semantic model of the FEDeRATED[15] project. These developments will gain momentum in the coming years and open opportunities for further research into voluntary business-government information sharing to create public value enabled by blockchain-based infrastructures and other data sharing architectures and solutions.

Looking specifically at the international trade domain there are other solutions such as Single Window, Port Community systems, and data pipelines (Rukanova et al., 2018). Single Windows and Port Community Systems have a more local function and play the role of a national hub. When it comes to receiving data from the source and sharing it for government control purposes concepts such as data pipelines are more applicable (Hesketh, 2010). TradeLens in that respect can be seen as a blockchain-enabled implementation of the data pipeline concept. Non-blockchain enabled implementations of the data pipeline concept are also possible but then other technical design choices related to the data sharing infrastructure and trust procedures need to be put in place to meet the requirements for immutability and audit trail. Further research can focus on a comparative study to establish how such requirements can be achieved in an alternative way and what adjustments this would bring to the framework to reason about these differences. Such comparisson will allow to better reason about is the blockchain really needed and what may be alternative approaches to technical solutions that would still enable the value creation process.

Reflecting on policy developments, business actors will step more and more forward and ensure that they take their responsibility seriously to create public value by tightening their control on their supply chain, by sustainable sourcing and green production. Government organizations will also gain more responsibility for monitoring advances in the circular and sustainable transition. Instead of focusing only on their own efforts on how they can create public value, they can benefit by more proactively interacting with businesses. They can consider the public value creation process as a joint responsibility which they can pursue with business actors that are willing to do so.

To this end, public administrations will need to develop competencies to be able to engage with businesses willing to contribute to the public value creation through data sharing on a voluntary basis. Next to traditional knowledge on supply chains and their own role in monitoring the import of goods, they also need to have knowledge and skills to understand the technical complexities of (multiple) blockchain data sharing infrastructures that enable and constrain these public value creation process. Especially in the context of circular economy, this will allow to further explore roles of government such as *organization* and *nodality*, which are currently less explored, compared to other roles that governments now take when it comes to circularity such as the *treasure* role for providing subsidies or the *authority* role for issuing and enforcing legislation (Medaglia, Rukanova, & Tan, 2022).

6. Conclusions

In this paper we focused on public value creation through voluntary business-government information sharing as an interactive process enabled and constrained by blockchain. We developed a conceptual framework that links the public value creation processes to the underlying technical design choices, where actor rights act as a linking pin between the layers. We demonstrated the applicability of the framework in a case from the international trade domain. The framework allowed us to reason about public value creation as an interactive process and to unravel the technical design choices that enable and constrain the public value creation process.

The framework that we developed is limited in several respects, which opens possibilities for further research. First, as we aimed for simplicity, we used high-level dimensions to operationalize the value level. This level can be further detailed and operationalized. Second, for the actor dimension, we took the supply chain perspective and interaction of government with supply chains as a starting point. These are specific types of relationships; further research can focus on other types of interactions. Third, we focused on blockchain-enabled infrastructures and for operationalization of the technical design choices we included aspects that are relevant for the blockchain context. In cases of other underlying infrastructures which are not blockchain-based, the concepts that allow to reason about the technical design choices need to be revisited.

We focused on one blockchain-enabled infrastructure. In case more (blockchain) infrastructures are needed to enable the public value creation process, the framework needs to be extended to allow to reason about the inter-relationship and interoperability among these infrastructures. In addition to that, in the current framework the concepts to reason about the blockchain design choices are limited and can be further extended. For example, energy efficiency of the blockchain solution is currently not part of the framework. As sustainability is high on the political agendas of governments, energy efficiency of the technical

[10] https://tfig.unece.org/contents/single-window-for-trade.htm
[11] https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/Once+Only+Principle
[12] https://digital-strategy.ec.europa.eu/en/policies/european-blockchain-services-infrastructure
[13] https://internationaldataspaces.org/
[14] https://www.gaia-x.eu/
[15] http://www.federatedplatforms.eu/

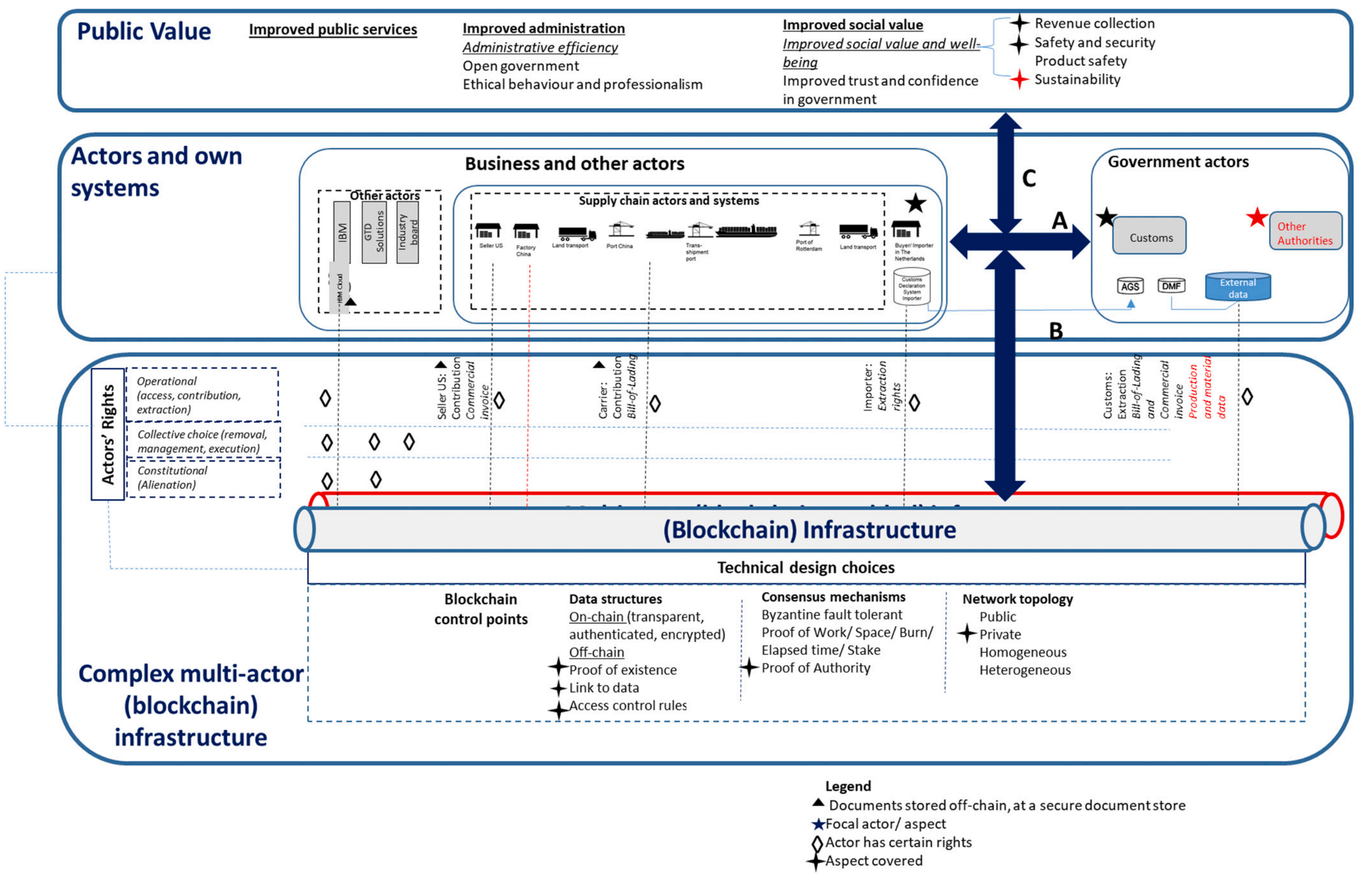

Fig. 7. Integrated view on public value creation looking at safety and security, revenue collection and potential future values such sustainability and circularity.

data sharing infrastructure can become an important factor for governments when deciding on the value of the data that is voluntary shared with them. Therefore, further research can identify other relevant concepts that allow for a richer conceptualization of the blockchain design choices. In the framework development the interactions that we examined are focused on voluntary data sharing. Further research can examine the applicability of the framework in contexts beyond the voluntary data sharing for creating public value and examine also other concepts such as open data. The framework that we propose has been demonstrated by using a case in the international trade domain. Further research can focus on other cases, from other domains and other types of data sharing solutions. This research avenue can contribute to continued development of the framework and to show its applicability and relevance in a wider context.

CRediT authorship contribution statement

Boriana Rukanova: Conceptualization, Methodology, Investigation, Writing – original draft. **Sélinde van Engelenburg:** Conceptualization, Writing – review & editing. **Jolien Ubacht:** Conceptualization, Writing – review & editing. **Yao-Hua Tan:** Conceptualization, Investigation, Funding acquisition, Writing – review & editing. **Marco Geurts:** Writing – review & editing. **Maarten Sies:** Writing – review & editing. **Marcel Molenhuis:** Writing – review & editing. **Micha Slegt:** Writing – review & editing. **Dennis van Dijk:** Investigation, Methodology, Writing – review & editing.

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Annex 1. Data collection and data analysis

Table A1
Overview of the data collection and analysis in each project phase.

Phases	Phase 1. Summer 2020-October 2020 Initial qualitative data collection and analysis	Phase 2. October 2020–April 2021 (collection of the data sets via TradeLens) April 2021- Sept-2021 (analysis of the data sets)	Phase 3. Sept- December 2021 Data collection to clarify issues based on the analysis

(*continued on next page*)

Table A1 (*continued*)

Phases	Phase 1. Summer 2020-October 2020 Initial qualitative data collection and analysis	Phase 2. October 2020–April 2021 (collection of the data sets via TradeLens) April 2021- Sept-2021 (analysis of the data sets) Data collection and analysis of the data sets with business documents	Phase 3. Sept- December 2021 Data collection to clarify issues based on the analysis in Phases 1 and 2 and further insights on upscaling to the operational environment
		Data collection and analysis of the data sets with business documents	in Phases 1 and 2 and further insights on upscaling to the operational environment
Data collection and data sources	• Interviews and workshops with experts from the Tire importer, Dutch Customs and Tradelens; e-mail communication for additional information; further information and discussions on issues related to the tire case in the bi-weekly calls of the Dutch Living Lab • Analysis of documents of the Tire Importer (business documents such as Invoices, Bills-of-Lading, Packing Lists, etc.), company website, presentations	• Commercial documents (Bills-of-Lading, Invoices) of the Tire Importer shipments for the period October 2020 –April 2021 available via TradeLens. A data data set of 1106 Bills-of-Lading was provided to Dutch Customs for further analysis • For the Bill-of-Lading data set of the Tire Importer matching customs declarations found in the customs declarations systems for safety and security declarations and import declarations. From the 1106 Bills-of-Lading of the Tire Importer, 926 security declarations (ENS) and 946 import declarations were found in the customs systems and were further analyzed. • From the invoices provided bythe Tire Importer, for a data set of 20 shipments, equal to 62 containers matching customs import declarations were found and analyzed.	• eMail communication and individual conference calls; a workshop with Dutch Customs, TradeLens and the Tire Importer for collecting additional data and for clarification of interpretations.
Analysis	• Rich description of the processes and the supply chain activities to understand the context of the tire case • *E*-mail iterations with experts from Customs, the Tire Importer and Tradelens to verify the descriptions and to identify and resolve inaccuracies	• Analysis of the matching cases Bill-of-Lading and customs declarations • Analysis of the time Bill-of-Lading data available in TradeLens compared to in the customs systems • Analysis of data available in the Bill-of-Lading compared to customs declarations taking specific risk indicators into account (weight, amount of coli) • Comparison of price of goods in Invoices and import declarations	• Analysis focused on clarifying open issues that were identified in Phase 2 or when comparing the expected benefits in Phase 1 with the results in Phase 2, and issues related to IT aspects of further upscaling the solution.

Annex 2. Key experts involved in the tire case study

Table A2 provides an overview of the key experts and their roles from Dutch Customs, the Tire Importer, and TradeLens who participated in the case study.

Table A2
Key experts and their roles from Dutch Customs, the Tire Importer, and TradeLens.

No	Expert	Role
1	Dutch Customs Expert	Secretary of the Innovation Coordination Group and Senior advisor Data & Analytics Project leader of the Dutch Living Lab
2	Dutch Customs Expert	Senior scientific staff member, Dutch Customs Laboratory
3	Dutch Customs Expert	Data scientist
4	Dutch Customs Expert	Head of Trade Relations
5	Tire Importer	Customs and Compliance Manager
6	TradeLens	Data analytics expert

Annex 3. Case background and insights from the qualitative analysis of phase 1

A3.1. About the tire importer

The Tire Importer is an international tire distributor with local warehouses and offices in different parts of Europe. The head office is in the Netherlands. The company exists for more than 50 years. It has annual sales of around 8 million tires. It has more than 300 employees and has developed a highly professional logistics network in Europe. The Tire Importer has a state-of-the art logistics tire centre in the Netherlands with an extremely advanced Warehouse Management System. The total premise is 90,000 m^2, including a 20,000 m^2 container terminal with a total stock capacity of 1,7 million tires. The Tire Importer offers same day delivery for customers in the Netherlands, 24–48-h delivery for customers in Central Europe, and 48–72-h delivery for customers in Northern and Southern Europe.

From the 8 million tires that the Tire Importer sells, significant volumes are purchased from an US company, here referred to as the *Seller*. The Seller in its turn purchases the tires from 2 to 3 Chinese suppliers, here referred to also as the *Factories*. As the Seller buys large volumes from the Chinese suppliers it can negotiate better prices than the Tire Importer. Therefore, the Tire Importer buys the tires from the Seller rather than directly from the Chinese suppliers. The Tire Importer also buys tires from other suppliers all over the world and directly purchases from tire suppliers as well.

When tires are imported to the European market, government agencies (in this case customs), play a direct role in the import processes, having responsibilities for collecting duties and taxes and performing other controls related to e.g., safety and security.

For tires that are produced in China the customs import tariff in Europe is 4,5% (2021 data). Tires produced in other countries of origin have different tariffs. For example, tires produced in Turkey and Vietnam have a preferential origin, and the import tariff for these tires is 0% (2021 data). Apart from import duties, VAT is due on the imported tires. However, if the tires are imported in the Netherlands, and then sold somewhere else in Europe, the VAT payment is deferred, and is due in the country of the final customer. In this case no VAT is paid by the Tire Importer in the Netherlands.

In terms of organizational structure, The Tire Importer Group Holding B.V. consists of:

(1) International Wholesaler and Distribution centre (operating from the Netherlands);
(2) Foreign Companies that are Wholesaler and Distribution centres;
(3) Other activities, including transport and trucking services.

The Tire Importer offers a complete assortment, directly available from stock. The offerings include premium, quality, economy and budget brands and there are more than 30 different brands available. These include summer, winter and all-season tires.

When declaring goods to customs in the import declaration, the so-called Harmonized System (HS) codes are used. Based on these HS codes customs can decide what duties must be paid. Depending on the complexity of the business, companies trading with many different types of products will need to use multiple different HS codes when declaring the goods. The Tire Importer faces a limited complexity in that respect, as the goods it trades fall into three HS codes. For customs purposes the products offered from the Tire Importer fall into the following three HS codes (see below). It is important to mention that the HS codes are different than goods codes that are used by businesses on commercial documents such as invoices.

The number listed below with bold are the HS codes used. We give a description of the products that fall under each of the HS codes. We also provide examples how the goods codes used by the supply chain partners contain pointers that can help to identify to which HS code they relate.

- **4011.1000.00** = Passenger car tires
- **4011.2010.00** = Small van/bus tires (e.g., 215/60R16C, in the goods code in the invoice items ending with “C” indicate this HS category)
- **4011.2090.00** = Truck Tires (315/80R22.5, in the goods code in the invoice items ending with “22.5” indicate this HS category)

So, the HS codes can be inferred from the item goods descriptions in the invoice that the US Seller sends to the Tire Importer. If there is no code ‘C’ or ‘22.5′ in a line item in an invoice, then by default this item is a passenger car tire and the HS code 4011.1000.00 should be applied. This discussion becomes especially important, as customs receives limited information about the goods in the customs declaration. For customs for cross validating the accuracy of the customs declaration, additional data is needed and this additional data is available in business documents such as invoices and purchase orders. It is useful for customs to have a way to link the information that is available in such commercial documents to information on HS codes that is relevant for customs.

A3.2. Contractual relationships

While the Tire Importer may have different Incoterm arrangements with different sellers, for the case that we analyzed the FOB Incoterms are applicable. FOB stands for Free-on-Board.[16] Under FOB, the seller is responsible for the freight costs, risk and insurance until the goods are on board of the ship. The seller is also responsible to arrange the export formalities, including the lodging of the export declaration to the customs administration in the country of origin. After the loading the cargo on the ship, the freight costs, risks and insurance have to be covered by the buyer. The buyer is also responsible to arrange the import formalities with customs, which include lodging an import declaration for the import of tires to Dutch customs. Understanding the Incoterms, as well as the buyer-seller contractual relationships and related documents provides further insights into who has responsibilities when it comes to reporting to customs, as well as the contractual relationships and who holds what data. This is important since customs is interested in having access to additional business data and it will be important to understand where this data is produced and who holds it.

To understand the Tire Importer case, it is important to clarify the contractual relationships. Even though the goods are imported from China, the main contractual relationship is between the Tire Importer and the Seller in the US. The Seller, in its turn, is responsible for arranging the activities in China: it has a contract with suppliers in China for purchasing tires.

The tires are shipped from the factory in containers that are fully filled with tires for the Tire Importer (Full Container Load, FCL). (This in contrast to more complex cases in which a container can be filled with goods from different companies. In these cases, each of these companies has to arrange lodging customs declarations for their cargo). The US Seller also has a contract with a Chinese freight forwarding company for arranging transport of the containers from the factory up till the loading of the container on the vessel in the port of Qingdao. The freight forwarder arranges the Bill-of-Lading and Shipping Instructions of the container in China. The Bill-of-Lading is an important commercial document and contains valuable information that is used for filing the customs declarations, therefore it is a business document of interest to customs.

Periodically, the Tire Importer negotiates long term freight costs contracts with ocean carriers. Subsequently the Tire Importer instructs the suppliers to arrange booking with the carrier assigned by the Tire Importer. Lodging the customs export declaration to China customs are fulfilled by the Chinese freight forwarding company. This company pays the carrier for the export fee, document service and terminal handling service in China (port of Qingdao). The fees related to ocean freight, the document fee and the terminal handling in the Netherlands (Port of Rotterdam) are handled by the Tire Importer directly. The transport from the factory to the port in China is performed with trucks of the Chinese factory itself.

The Tire Importer does its own logistics on the Dutch side. It has their own trucks that can pick up the containers from the terminal at the Port of Rotterdam, and it arranges all the import formalities for the customs and terminal release. The Tire Importer also lodges its own import declarations to the import declaration system of Dutch customs (called AGS). It has an Authorized Economic Operator license, a special license that allows for some simplifications when it comes to customs procedures.

Although the Seller appears as a reference on customs documents, the Seller does not have any obligations towards the Dutch customs authorities, due to the choice of FOB incoterm. This is all handled by the Tire Importer.

[16] For further explanation of Incoterms and FOB, see https://en.wikipedia.org/wiki/Incoterms

It is important to note that as a trader, the Tire Importer does not have any responsibilities related to the lodging of the Entry Summary declaration (ENS). The safety and security procedure performed by customs is separate procedure, next to the import procedure related to fiscal matters such as collection of import duties. For the safety and security procedures, it is the responsibility of the sea carrier to lodge the ENS prior to loading the container on their vessel. The sea carrier is the party that transports the container over sea from the port of loading in Qingdao to the final port of unloading in Rotterdam. The first port of entry in the EU is Rotterdam, and hence the safety and security risk assessment of the ENS is done by Dutch customs. The sea carrier typically trans-ships containers from Qingdao in the port of Tanjung Pelepas in Malaysia from one vessel to another vessel when transported from China to the Netherlands, however other trans-shipment ports are also possible depending on the sea route.

Typically, the ENS is then prepared in Tanjung Pelepas and lodged to Dutch customs, because Rotterdam is the first port of call into the EU for these vessels. The carrier has the details on this trans-shipment and from which vessel to which vessel the container is moved. In the past the Tire Importer received only the name of the first vessel on which the goods are loaded in China, but not the second vessel on which the containers will arrive in Rotterdam. Once the containers were at sea, the Tire Importer had to periodically check the website of the carrier to obtain information about the ship on which the containers were subsequently loaded at the trans-shipment port and the estimated time of arrival in Rotterdam. Now this information and all related updates are received by the Tire Importer via TradeLens.

A3.3. Key business documents and data

Typically, three business documents are used for deriving the necessary information for filing the import declaration, namely: (1) the *Commercial Invoice* issued by the Seller to the Buyer (the Tire Importer), (2) the *Bill-of-Lading* issued by the carrier, and (3) the *Packing List* issued by freight forwarder and made available to the Seller. Next to that, there are two important documents that the Tire Importer receives from Dutch customs, namely (1) *Permission for Discharge* ("Toesteming tot Wegvoering-TTW") with which customs allows the Tire Importer to pick up the container from the terminal in Rotterdam,[17] and (2) *Invitation to Pay* ("Uitnodiging tot Betaling"), which is a document stating which duties and taxes the Tire Importer needs to pay for the import of this shipment, where a shipment can be one to a few dozens of containers.

We zoom-in on the available data in the commercial documents, as shown in Table A3.

Table A3
Examples of data field in the commercial invoice, packing list and Bill-of-Lading of the Tire Importer.

Commercial invoice	Packing list	Bill-of lading
• Seller (US) • Buyer (NL) • Purchase Order No • Invoice No • Carrier • Quantity • Item code • Price (unit) • Amount • Ship (date) • Bank info and account No Seller • Payment terms: cash against documents • Country of origin of goods (China)	• Seller (US) • Purchase Order No • Invoice No • Carrier • Ship to (Rotterdam) • Quantity • Item code • Weight • Ship (date) • Bank info and account No Seller • Payment terms: cash against documents • Country of origin of goods (China) • Carrier • Seal number • Driver signature	• Bill of Lading number • Booking number • Export references • Shipper • Consignee • Notify party • Vessel • Port of loading • Port of discharge • Goods description, said to contain by the shipper (Purchase Order number, goods, brand and types, pieces), weight, measures • Freight charges invoiced to the Tire Importer– ocean freight, document fee, terminal handling at destination • Export fee, document service and terminal handling service at origin

The *invoice* and the *packing* lists as used by the Tire Importer till 10-9-2020 contained very similar information on the seller, carrier, quantity, detailed information on item codes and descriptions. These are codes that are used by the seller to indicate the type of tires, which brand they are and other product specifics. The invoice contained price (unit) and amount, which was not in the packing list. The packing list contained information on weights, which was not part of the invoice. Next to that the packing list also contained information about seal number and signature of the driver.

The item codes were initially not linked to the HS codes of the goods. As of 10-9-2020 the Seller adjusted the format of the invoice and the packing list. Now the invoice contains additional information on the HS codes, number of tires per HS code (pieces), weight of tires per HS code, and the total amount in dollars per HS code. This is a new practice introduced by the business partners that allows to systematically link codes used in the invoice to HS codes, hence the two streams of information can be aligned.

In line with the examples discussed in Section A3.1. of this Annex, small van/bus tires (e.g., 195/75R16**C,** where in the goods code in the invoice items ends with "C") indicates HS code category **4011.2010.00.**).

This new way of compiling the commercial invoice is very interesting. First, the invoice directly provides information on the goods that are in the container per HS code, including the *weights*, *amount,* and *dollar amounts*. This makes the use of the packing list as a necessary document for generating the import declaration obsolete as the information related to goods, weights and amounts that is usually part of the packing list is now included in the invoice as well.

The third important business document is the Bill-of-Lading document is issued by the sea carrier. The Bill-of-Lading contains information regarding the port of unloading, the vessel, as well as information about the shipper, the consignee and the notify party (see Table A3). It also contains the goods description (said to contain) that was received by the shipper and information about the parties responsible to pay the freight and service charges at the ports of origin and destination.

Based on this new invoice format, the Tire Importer can use data from the *commercial invoice*, and the Bill-of-Lading for generating an import

[17] This is a paperless operation as the TTW is uploaded in Portbase, the Port Community System of the Port of Rotterdam.

declarations. The packing list is no longer needed for this purpose. The way in which this new invoice format is generated is specific for the Seller in the US. Other sellers do not have this enriched invoice format yet, therefore for other sellers the packing list information may still be needed.

We need to point out that this new invoice format is *not* a *pro-forma invoice* that is often sent and where the actual invoice is sent only later. In the Tire Importer's case, the commercial invoice that is sent from the Seller to the Tire Importer is available early in advance. Therefore, this information is the final information that is used for the payment. The difference between a pro-forma invoice and a commercial invoice is relevant for other types of goods, which are re-sold during transport. Typical examples of such type of cargo are electronics or oil, which are typically re-sold many times during transport, and in that case the initial pro-forma invoice prepared in the port of loading can be quite different from the commercial invoice at the moment of unloading the cargo in the port of destination.

The Tire Importer usually receives the commercial invoice two days after the ship sails from Qingdao. Based on this invoice, the Tire Importer pays the Seller, so that the Seller can pay the suppliers in China. This entails that both the *Bill-of-Lading* and the *commercial invoice* that are needed for generating the import declaration are available two days after the ship departs from China. Therefore, theoretically, the import declaration can be lodged to Dutch customs by the Tire Importer two days after the ship sails, as all relevant information is available early in the process. In practice, such an import declaration is lodged much later due to current procedures followed by Dutch customs but that also leaves limited time for customs to do risk analysis on the customs declarations. This put strains on the limited customs resources for performing the risk analysis, and if needed to plan and execute physical inspections on the cargo after they have been unloaded in the port of Rotterdam.

As it normally takes around 5–6 weeks for the ship to arrive to in Rotterdam (due to trans-shipment in Malaysia), if the Tire Importer pre-lodges a customs declaration as soon as it has the data available, this gives several weeks flexibility for Dutch customs to perform the risk analysis based on the pre-lodged import declaration. This allows customs for better planning and improves the use of their limited resources.

A3.4. High-level overview of the logistics flows from China to the Netherlands and related customs procedures

Fig. A1 provides a high-level overview of the flow of the tires from the factory in China to the warehouse of the Tire Importer in the Netherlands. On the business side the tires are produced in a factory in China. Subsequently they are transported by truck to the port of Qingdao in China. The government authority on the Chinese side is China customs, which processes the export declaration. After all the formalities for export are arranged, the container with tires is loaded on a vessel. There are different scenarios possible but usually the vessels sail to a trans-shipment port. One such transhipment port is the port of Tanjung Pelepas in Malysia, but other trans-shipment locations are possible. In the trans-shipment port, the container is trans-shipped to a larger vessel which brings the tires to the Port of Rotterdam in the Netherlands. In some cases, the vessel may travel directly from Qingdao to the port of Rotterdam. For entering the EU and importing the tires to the EU (in this case both procedures take place via the Netherlands and the port of Rotterdam), two customs procedures need to be performed. The first one is the safety and security procedure. For this procedure the sea carrier sends a special safety and security declaration to customs (called Entry Summary Declaration, ENS) before the goods are loaded on the vessel that will arrive at the port of Rotterdam. Dutch customs uses this declaration for performing safety and security risk analysis before the goods are loaded on the vessel. In case a threat is detected by Dutch customs, they can send a do-not-load message to the carrier and China customs, which will then assure that the container is not loaded on the vessel. The data from the ENS also forms the basis for the subsequent risk assessment for safety and security when the ship arrives in the Netherlands before the goods are unloaded. Next to the safety and security risk assessment, Dutch customs performs an assessment related to fiscal matters, i.e., related to the payment of import duties when goods are imported to the EU. For this second procedure, Dutch customs receives an import declaration from the importer (in this case the Tire Importer). This customs import declaration is the main document for customs to perform the risk analysis related to the import procedure for fiscal matters.

After the goods are risk assessed for customs for both the safety and security, as well as the import procedure, and cleared for pick-up, and if the importer has paid the necessary commercial fees and presented the necessary commercial documents, the importer can collect the goods from the terminal and transport them by truck to the warehouse of the importer.

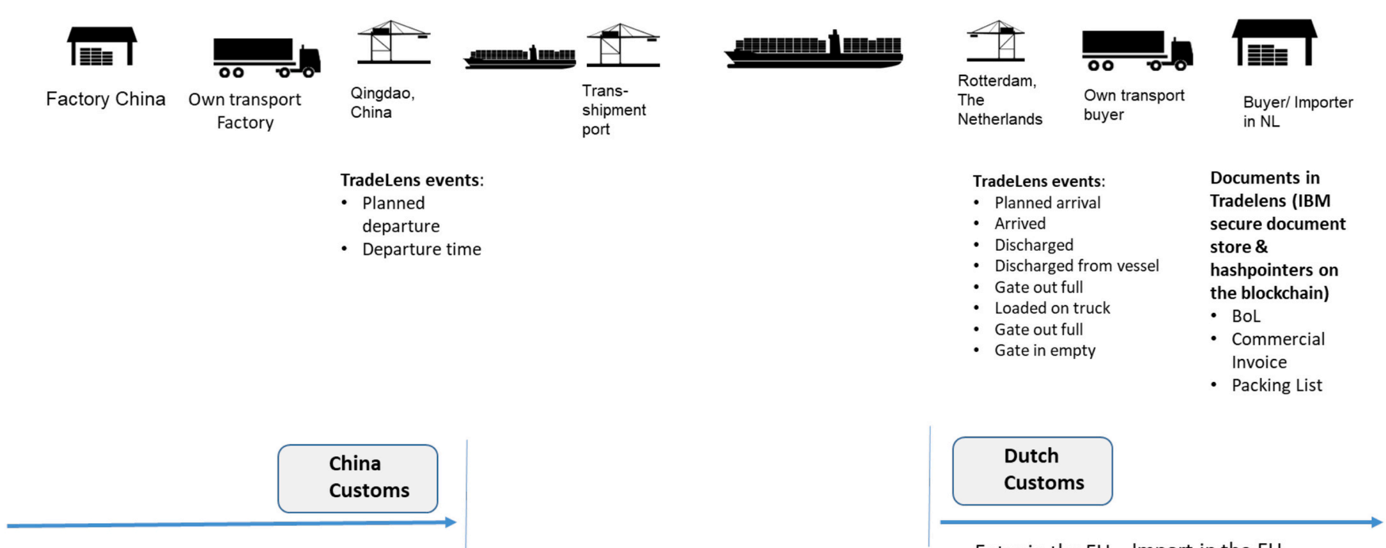

Fig. A1. Overview of the route of the container, related authorities, and examples of documents and events in TradeLens.

This high-level description of the process allows for a quick understanding of the key business and customs processes. From this high-level description, however it is difficult to see the detailed process steps and how they relate to the key documents. For that, a more detail overview of the processes and documents is needed (see Fig. A2). The Seller in the US receives a Purchase Order (PO) from the Tire Importer. Upon receipt of the Purchase Order the Seller submits the order to the factory in China. The tire factory will arrange the production and sends the Seller a production plan. The Seller will estimate the time when tires are ready to load. At the same time the Seller will arrange with the Freight forwarder to make a container booking with the Carrier to ship the tires to the Buyer.

After the Carrier has confirmed this booking to the Freight Forwarder, the Freight Forwarder (of the Seller) will forward the booking confirmation to the factory. The factory will arrange to pick up empty containers from the Depot according to the time of Container Yard (CY) cut off and the Shipping Instruction (SI) cut off within the free time of using containers (10 days). After the Factory has stuffed the tires into the containers, it will transport the containers to the port terminal. The tire Factory has its own truck team. They are responsible to pick up the empty container and send the containers to the terminal.

Subsequently, the Freight Forwarder and the Seller will get the loading details of these containers. The Freight Forwarder will provide the Seller with draft Bill-of-Lading to confirm and Freight Forwarder will also declare to customs. The Seller will arrange all paperwork (invoice, packing list) for the buyer according to these finished/loaded orders.

Approximately two days after the ship sails, the Buyer (the Tire Importer) receives the commercial invoice, packing list and copy of the Bill-of-Lading from the Seller.

The carrier is responsible to submit the ENS declaration to the customs at first port of Entry in the EU, which is in this case the Dutch customs. The ENS is submitted 24 h before loading in Malaysia on the ship that will arrive to the EU. When the ship arrives in the port of Rotterdam, a declaration for the goods to be unloaded needs to be submitted (called ATO declaration “Aangifte voor Tijdelijke Opslag” in Dutch or Declaration for Temporary Storage in English).The relationship between the ENS and the ATO is as follows. The ENS must be submitted for all goods on board the ship that are brought into the EU. It therefore does not matter whether the goods are unloaded, or in which port the goods will be unloaded. Customs know what is on board a ship. The ENS check uses Safety & Security (S&S) risk indicators: EU-imposed risk indicators (risk rules). The results of the S&S risk analysis are passed on to all planned successive ports in the EU that are listed in the entry summary declaration. A summary declaration of goods to be unloaded (the ATO) must be made for all goods that are unloaded in a Dutch port. This must also be done for goods that are unloaded in the port but are then reloaded into another ship to be taken outside the EU again. All goods listed in an ATO are also included in the ENS. The ATO will be checked with national risk indicators. These are about Safety, Health, Economy and Environment aspects but no fiscal or financial aspects (these will be checked with the import declaration). The moment when an ENS declaration becomes ATO, is when the ship arrives at the quay and the goods are reported by an active arrival report. If risks are identified, goods can be subject to inspection by Dutch customs after unloading.

Once the ship arrives at the port of Rotterdam, the Buyer is also notified. The Buyer submits the import declaration to Dutch Customs. Dutch Customs performs risk analysis also for the import procedure, where the focus is on taxation and import duties. If all is approved it sends an Invitation to Pay the necessary duties and a permission to pick-up the container from the container terminal to the Tire Importer. Once the permission has been received, collection can be arranged by the Tire Importer of the container from the container terminal.

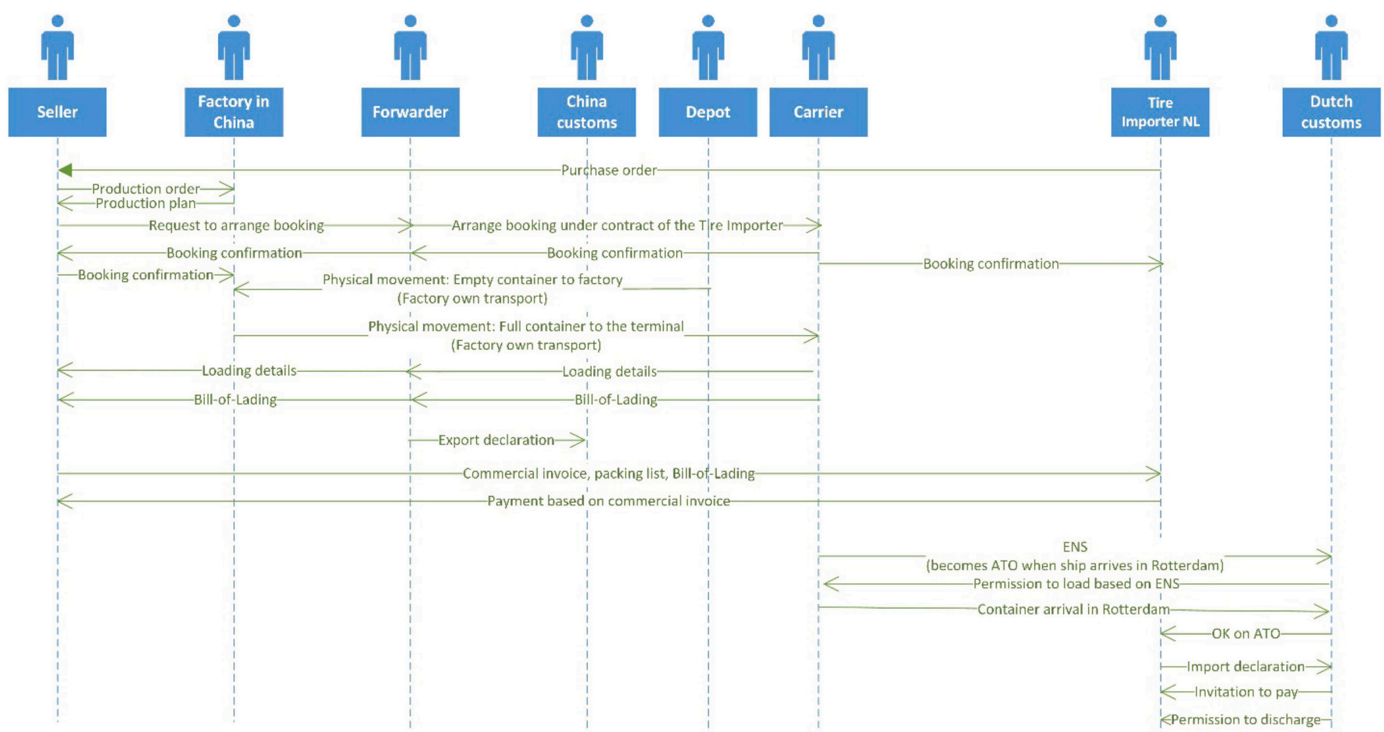

Fig. A2. Overview of key activities.

A3.5. TradeLens as a global blockchain-enabled infrastructure for international shipping

A few years ago, the Tire Importer decided to use the TradeLens global blockchain-enabled infrastructure, developed by IBM and MAERSK, to optimize its business operations. TradeLens is one of the first blockchain-enabled global infrastructure for international shipping. It is set-up as a neutral platform and aims to attract other carriers to join. Various carriers joined TradeLens, including some of the largest carriers such as MAERSK, CMA/CGM, MSC covering close to 60% of the containerized trade.

TradeLens aims to capture shipping milestones and shipment data that span across various supply chain partners that play a role in the processes, either on the exporting, or the importing side. These include the shippers (also called Beneficial Cargo Owners, BCO), freight forwarders (FF), inland transport, ports, and terminals, as well as the ocean carriers. In addition to the business parties, government authorities such as customs, as well other government authorities, are also part of this process. The TradeLens infrastructure enables to capture and share data among the ecosystem partners that are authorized to get access to the data.

The TradeLens infrastructure enables capturing and sharing all relevant logistics events on Shipping Milestones and Shipment Data such as: container closed and sealed, container ready to load, estimated time of arrival at a port (ETA) and Actual Times of Arrival (ATA) and many other.[18] These events provide full visibility about the journey of a container.

Next to the event data, the TradeLens infrastructure captures structured and unstructured Documents such as packing list, Bill-of-Lading, and the commercial invoice.

The TradeLens infrastructure is blockchain-enabled through the TradeLens Blockchain Business Network, which is based on open source Hyperledger Fabric.

On the Tradelens Blockchain Business Network, only hash-pointers of the documents are stored. This design choice to only store hash-pointers has two advantages. The first advantage is about scalability of the blockchain network so that it can process millions of documents (Tan et al., 2019). The second advantage is that it solves potentially serious privacy issues, because if documents contain privacy sensitive data, these are not stored on the TradeLens infrastructure. Hence Tradelens is compliant with GDPR regulation. The storage of the documents themselves is not done on the TradeLens blockchain but on a separate secure document store (either the separate secure document store) or an external secure document store, typically the ERP system of an actor.

When new versions of the documents are generated, a new hash-pointer is generated and is stored on the blockchain. For authorized parties to get access to a document they can make use of a hash-pointer, containing the hash of the document, as well as the URI link to where the document is stored on the secure document storage. An authorized party can access the secure document store. It can then calculate the hash of the document and compare it with the hash on the hash pointer, related to this document. If the hashes are the same, it is proven that the document has not been changed/tampered with. In such a way, it is possible to establish immutability and to create an audit trail of the documents. These features are very interesting for government authorities such as customs.

In the design phase of TradeLens the data sharing aspect with respect to government agencies such as customs was already taken into account. When businesses agree to join TradeLens they agree to allow relevant government authorities to have access to their data (e.g., customs authorities involved in a specific trade lane). This is quite different from other blockchain-enabled infrastructures that are developed for business purposes and do not consider sharing information with government as part of the original design. Invoice, packing list, Bill-of-Lading information is business information that can be accessed via TradeLens. Customs can request such information from businesses on a need-to-know basis if it needs to cross-validate customs declarations in the risk assessment process. Businesses are not legally required to share such documents in advance with customs; but they are free to share such early information on a voluntary basis. When joining TradeLens businesses voluntarily agree to allow relevant authorities to have access to their data. Some incentives for businesses to agree to such voluntary sharing are trade facilitation and faster clearance by customs administrations due to the higher level of transparency that these companies provide to customs to enhance the customs risk analysis.

A3.6. Logistic benefits for the tire importer using TradeLens

The motivation for the Tire Importer to join TradeLens was first and foremost to obtain business benefits and to streamline its business operations. One of the key improvements was the automation of a lot of manual work that was done in excel files. In addition, the Tire Importer was able to improve the visibility on the supply chain operations. Before joining Tradelens, the Tire Importer received visibility on their shipments only a few days before the vessel arrived in the Port of Rotterdam. Now with the notification already when the container is booked, the Tire Importer receives notifications 7 weeks in advance which gives them a forecast up to +3 months as bookings with the sea carrier can be made 5–6 weeks in advance of sailing date (Estimated Time of Sailing (ETS)). The visibility also applies to the warehouses outside the Netherlands (e.g., in Sweden and Spain), which are also connected through TradeLens. This provides greater visibility across warehouse locations. As shipments are visible way upfront, payment can be arranged a lot sooner (from the moment of the Estimated Time for Sailing), instead of 1–2 weeks before the Estimated Time of Arrival of the ship in Rotterdam. This gives the Tire Importer the advantage to receive the delivery order (released by the sea carrier) almost 2–3 weeks before the Estimated Time of Arrival in the Port of Rotterdam. Hence, the container is released for pick-up by the terminal immediately after unloading in Rotterdam. Another benefit is that the Tire Importer currently receives information about changes related to the Estimated Time of Arrival, changes of vessels and changes related to the terminal where the vessel will arrive. Such information was very difficult to obtain before the use of TradeLens.

A3.7. Qualitative analysis of benefits

In Table A4 we provide a summary of the issues and potential benefits of the data sharing arrangement via Tradelens. These are based on the qualitative analysis that we conducted in phase 1 of the project (see Annex 1).

Table A4
Summary of issues and potential benefits based on the qualitative analysis of benefits as performed in Phase 1 of the study.

Issues	Issue description	Potential benefits
Time of receipt of customs declaration	Normally customs receive the import declaration when the ship arrives at the national port (in our case in The Netherlands), which leaves a small-time window for Dutch Customs to perform their risk analysis, to allocate means of inspection, and to avoid delays in goods delivery. This links to the dual role of customs	Import declaration available to customs several weeks before the ship arrives; allows for early risk analysis and more efficient planning and use of customs resources.

(*continued on next page*)

[18] The full list of all logistic events captured in Tradelens can be found on https://docs.tradelens.com/learn/platform_event_model/

Table A4 (*continued*)

Issues	Issue description	Potential benefits
	where they have to control the trade flows but at the same time ensure trade facilitation and economic competitiveness.	
Data quality of customs declarations	Declarations submitted to customs (ENS declarations for safety and security, as well as import declarations for fiscal matters) often contain incomplete information. In such cases customs will request the business parties to provide additional business data so that customs can cross-validate the customs declaration against business documents such as the commercial invoice, Bill-of-Lading, and the packing list.	Reliable data from the source (including an audit trail enabled by blockchain), leading to high quality data for cross-validation purposes. More efficient risk assessment processes and less delays due to request of additional business documents for cross-validation of declarations.
Enhanced reliability and early lodging of the customs declaration for more efficient use of customs resources to avoid peaks	The Union Customs Code (UCC) allows to lodge import declarations in advance (this can be up to 30 days before the goods are discharged). In practice, however, these pre-lodged declarations are often subject to change. Every time an adjustment is made, the declaration needs to be risk assessed via the customs risk assessment software, putting additional burden on the IT systems. Due to the changes, Dutch Customs is reluctant to consider these pre-lodged declarations as final declarations and reluctant to base their risk analysis on them.	High degree of reliability of pre-lodged declaration (i.e., declarations are not changed any more after they have been lodged). As the declaration that is generated based on TradeLens data is based on the commercial invoice that is not further updated, this allows for a high level of reliability of the pre-lodged declaration. And allows for more efficient use of customs resources and avoiding peaks.

Annex 4. Quantitative data analysis of phase 2

In this annex we go into more detail on the quantitative analysis that was conducted in phase 2 of the project (see Annex 1). The TradeLens dataset contains 1106 unique shipments with Rotterdam as Port of Discharge. Each of these consignments has a unique Bill-of-Lading number containing at least one container. To retrieve the historical ENS declarations from the systems of Dutch Customs, the unique combination of the Bill-of Lading number with each of the containers in the shipment was used. This retrieved a declaration for each individual container, which is used in the analysis. To acquire the corresponding import declaration only the Bill-of Lading number is used to retrieve all the information of a shipment from the systems of Dutch Customs. Most of the times, if a shipment consists of multiple containers, each of these container numbers are given in only one of the different declarations available in the customs system. Therefore, by using the same unique combinations as for the ENS declarations the same declaration will be returned multiple times.

The Bills-of-Lading data set was provided to customs in a machine-readable format which enabled the matching with customs data. Table A5 provides an overview of the cases for which it was possible to match the Bill-of-Lading data from TradeLens (TL) to a ENS safety and security declaration, as well as to an import declaration (the so-called SAD declaration). As the table illustrates, from the 1106 Bills-of-Lading provided from TradeLens, for 926 of those matching ENS declarations were found. And in 946 cases the matching import declaration was found.[19]

Table A5
Matching Bill-of-Lading (BoL) data with ENS and SAD customs declaration data.

Commercial documents	TL and customs data sets	% overlap in data	Comment
Bill-of-Lading	TL(*BoL*)-ENS	84%	926 (1106–180) (~84% of BoL returned ENS; in some cases, 1 BoL links to more than 1 container/ ENS declaration)
	TL(*BoL*)- SAD	~86%	946 (1106–160)

Regarding the invoices, they were provided in a pdf format to Dutch Customs. The TradeLens team developed a software tool to convert the pdf invoices provided by the Seller in US, to a machine-readable data set that is interfaced to Softpak, such that it can generate the import declaration automatically. For Dutch Customs, however, it was difficult to get access and acquire the necessary permissions to use the pdf conversion software within the limited timespan in which this study had to be conducted. Therefore, the invoices were not converted for Dutch Customs to a machine-readable format that would allow for automatic comparison. A work-around was used by Dutch Customs, where for the invoices, they followed a manual approach. For 20 shipments (corresponding to 62 containers, see Table A6, invoices from the TradeLens data set with data from the Tire Importer were manually processed by Dutch Customs to identify the corresponding import declarations. Subsequently a manual analysis was done by Dutch Customs on the accuracy of the stated value of the goods.

Table A6
Data set analyzed based on invoices.

Commercial documents	TL and customs data sets	Data set analyzed
Invoices	TL (Invoices)- SAD	20 shipments, 62 containers, manually processed

[19] In the study we also made an initial investigation regarding the cases which did not match. There can be valid explanations for these mismatches, but these cases require further investigation and this is out of the scope of the current study.

A4.1. Bill-of-lading data

The Bill-of-Lading data was available in a machine-readable form from TradeLens, so it was easy for customs to do an automated comparison with their customs data. The Bill-of-Lading data was matched against customs declaration data used for:

(a) Safety and security (ENS declarations and ATO declarations). The ENS declarations are submitted 24 h before the container is loaded in the ship that arrives at the port of Rotterdam and ENS risk assessment is performed. Before the ship is unloaded at the Port of Rotterdam, most of the data from the ENS declaration is used as a basis for the so called ATO declaration for temporary storage, and a second risk assessment is performed before the goods are allowed to enter the Netherlands. The potential of the Bill-of-Lading data to be used for cross-validation of the safety and security declarations was explored.
(b) Import declarations. To this end import declaration data from the customs systems was extracted from the Dutch customs import declaration system (SAD). It was investigated whether the Bill-of-Lading data available via TradeLens would be of value for cross-validation of the import declarations.

A4.2. Invoice data

The data set that was provided to Dutch Customs also contained the invoices of the Tire Importer, made available by the US seller via TradeLens in a pdf format. There is an adaptor that can extract the information from the pdf documents in a machine-readable form to generate the import declarations. However, the data analytics team at Dutch Customs that was involved in the project did not have access to such adaptor tools and due to time constraints and internal procedures it was difficult to obtain the converted pdf files in a machine-readable format and to perform an automatic check within the timespan that was allocated for this task. Therefore, to analyze the value of the data in the invoices, a manual check of invoices for 20 shipments, corresponding to 62 containers was performed. This invoice data was compared to the import declaration data from the SAD customs systems with focus on the invoiced amount to see whether the amounts match. This check was to gain further confidence in the data in the declarations that are automatically generated via TradeLens data and which in the future can be also pre-lodged much earlier in advance.

For the Bill-of-Lading data for which machine processing was possible, the table below provides an overview of the overlaps between: 1) the Bill-of-Lading data available via TradeLens and ENS declarations available in the Dutch Customs systems, and 2) the Bill-of-Lading data available via TradeLens and the import declarations data found in the SAD system of Dutch Customs. As can be seen, for ~84%[20] of the Bills-of-Lading that were available in the data set of the Tire Importer, it was possible to identify the corresponding ENS and for ~86% it was possible to identify the import declarations in the Dutch customs systems to perform comparisons. That allowed customs to perform analysis of Bill-of-Lading information of 926 for the safety and security procedure and 946 Bills-of-Ladings for the import procedures.

For these Bills-of-Lading for which customs declarations were identified, Dutch customs analyzed the percentage of the declarations for which the data is available earlier in TradeLens. The results of that analysis are also presented in Table A7: for 60% of the ENS declarations, Bill-of-Lading data was available earlier in TradeLens. In addition, in 99% of the ATO and import declarations, the Bill-of-Lading data is available earlier in TradeLens, so it is available in advance and can be used for cross-validation purposes.

Table A7
Data set comparison between Bill-of-Lading, invoices and ENS declarations.

	TradeLens and customs data sets	% overlap in data	Comment
BoL	TL(*BoL*)-ENS	*84%*	*926 (1106–180) (~84% of BoL returned ENS; in some cases, 1 BoL links to more than 1 container/ ENS declaration*)
	TL(*BoL*)- SAD	*~86%*	946 (1106–160)
Invoice	TL (Inv)- ENS	–	*Not automatically analyzed*
	TL (Inv)- SAD	–	*Not automatically analyzed*
	Information earlier in TradeLens	**% of declarations for which data are available *earlier* in TradeLens**	
BoL	TL(*BoL*)-ENS	60%	For 60% of the ENS declarations, BoL information earlier in TradeLens
	TL(BoL)-ATO	99%	99% of the cases *information earlier in Tradelens*
	TL(*BoL*)- SAD	99%	For 99% of the import declarations BoL information earlier in TradeLens
Invoice	TL(*Inv*)-ENS	–	*Not automatically analyzed*
	TL(*Inv*)- SAD	–	*Not automatically analyzed*

When looking at the time of availability results, we wanted to know why only in 60% of the ENS cases the Bill-of-Lading data was available earlier in TradeLens. In a workshop with representatives from TradeLens, Dutch customs and the Tire Importer to discuss the results of the analysis, it became clear that the data set that was provided to customs contained both cases of direct shipment and trans-shipment. In case the containers are not trans-shipped, the ENS and the Bill-of-Lading are both issued in China before the container is loaded on a direct vessel to Rotterdam. In this case the Bill-of-Lading data cannot be used to cross-validate the ENS as the data is not available earlier in time, but can still be used for cross-validating the ATO and the import SAD declarations. In trans-shipment cases, the Bill-of-Lading is available in advance when the ship leaves China, while the ENS is available only before loading on the second vessel in for example Malaysia. Therefore in 60% of the cases (cases where there is trans-shipment), the Bill-of-Lading data can also be useful for cross-validating the ENS during the ENS risk assessment. This analysis shows that by looking into sample data sets it is possible to gain a finer level of understanding of the different sub-scenarios. With such a finer level it is possible to define for which scenarios specific business data can bring value.

A next step in the analysis was to get an indication about which data from the commercial documents was of value for the cross validation of the customs declaration to support the customs risk analysis. The value of the Bill-of-Lading data for cross-validating of the customs declarations was

[20] Several reasons were identified why the corresponding customs declarations were not immediately found.

considered using two risk indicators that are of interest to customs for their risk analysis, namely: (a) gross weight, and (b) the amount of coli. A mismatch would signal discrepancies and may require further investigation (see Table 8).

Regarding the analysis related to the risk indicator gross weight, in 96% (890 cases) of the cases there was a match between the gross-rate on the Bill-of-Lading and the ENS declaration. When comparing the Bill-of-Lading information with the import declaration data on gross-weight the match was even higher (i.e. 97%). Similar figures were found when comparing the Bill-of-Lading and the ENS and SAD data when looking at the second risk indicator, i.e., the amount of coli. Regarding the analysis of the invoice data related to the risk indicator 'price of goods', for the sample set of 20 shipments corresponding to 62 containers, there was, (as expected) a 100% match of the price of goods as found on the invoice and the amount that was declared on the import declarations.

Table A8
Analysis for risk indicators 'gross weight' and 'amount of coli'.

TradeLens (TL) data source	Risk Indicator	Cross-validation based on TL data	Marching	Different	Data set information used in the analysis		
Bill-of-Lading					Available[a]	Missing[b]	Total
	Gross weight[c]	TL(*BoL*)-ENS%[d]	890	36	926	180	1106
			96%	4%			
		TL(*BoL*)-SAD	918	28	946	160	1106
			97%	3%			
	Amount of coli	TL(*BoL*)-ENS	890	36	926	180	1106
			96%	4%			
		TL(*BoL*)-SAD	918	28	946	160	1106
			97%	3%			
Invoices					**Data used in the analysis**		
	Price of the goods	TL (Invoice)- SAD	100% match of invoiced amount	0	20 shipments, 62 containers, manually processed		

[a] BoL with matching customs declaration.
[b] BoL for with no matching customs declaration.
[c] Combined weight and total amount of coli of each BoL (also for the ENS).
[d] Of the available.

A4.3. Summary of quantitative data analysis

Based on the quantitative analysis, several in-depth insights were gained on how two business documents, namely the commercial invoice and the Bill-of-Lading can be of benefit for customs regarding two of their procedures, namely the safety and security procedure and risk assessment, and the import procedure and related risk assessment. We discuss the results per procedure. Only by zooming into the data sets it was possible to further fine-tune and identify in more specific terms where the value of specific data lies for customs.

Import declaration

The data analysis related to the import declaration was to check two aspects:

a) Whether data available in TradeLens can be used to cross-validate the import declarations. This is related to the traditional scenario where customs ask additional data for cross-validation. In this case getting data in advance would mean efficiency gains and more effective use of customs resources, as data will be available before the risk assessment process, rather than being requested during the process and leading to inefficiencies and delays. For businesses this can also leads to efficiency gains and trade facilitation;
b) To check whether the declaration generated in an automated way via TradeLens data is a reliable declaration that can be lodged earlier in advance as avant-la-lettre declaration, and which can be used for early risk analysis.

With respect to the import declaration, our findings show that in 99% of the cases the information on Bill-of-Lading is available before the import declaration. Therefore, Bills-of-Lading data can potentially be used as a source for cross-validating the import declarations.

Such figures were not available for the invoices due to not having the invoices in a machine-readable form. Future research can focus on confirming the percentage of invoice availability in advance, but our expectation based on the qualitative interviews is that such early availability of invoices will be confirmed.

For the 20 shipments/ 60 containers for which the commercial invoices were manually checked against the respective import declarations, focusing on the risk indicator 'price of the goods', our expectations were confirmed based on the document analysis: the invoiced amount on the invoice matched 100% with the amount declared on the import declaration. This result was expected, as the automatic software uses the commercial invoices as a source document for lodging the import declarations and the commercial invoice is the invoice that is also used for payment to the seller and contains highly reliable price information. The confirmation provides initial confidence that the way in which the import declarations are generated automatically based on source data available via TradeLens is correct.

For the lodging of the import declaration, the Bill-of-Lading is used. To ensure that the pre-lodged import declaration does not change over time, it is important to ensure that, next to the commercial invoice data, data from Bills-of-Lading also remain stable over time. In discussing results of the document analysis with the Tire Importer, we obtained further insights that can allow to further fine-tune the requirements for avant-la-lettre declarations.

As part of the iteration of the findings in Phase 3 of this study, we found out that, depending on the procedures used, some suppliers follow procedures such that once the Bill-of-Lading is generated it does not change over time. For such suppliers with stable processes, changes in the Bill-of-Lading will not be expected and for these cases the avant-la-lettre procedure can be suitable. The Tire Importer also works with suppliers that follow more flexible procedures related to the Bill-of-Lading, and in such cases adjustments and changes of the Bills-of-Lading can be expected. This can also result in adjustments of the pre-lodged declarations. This knowledge is very valuable, as it can allow Dutch customs to work with the Tire Importer to identify the sub-set of suppliers which follow stable processes, and for this sub-set of suppliers/ streams of goods to pursue avant-la-lettre declarations.

All these insights can serve as a basis for customs to conduct further data analytics on larger data sets to replicate the results and gain additional assurances and to differentiate scenarios where avant-la-lettre declarations can be stable over time. This can provide a basis for future piloting and upscaling to the operational environment the avant-la-lettre procedure with the Tire Importer. In addition, the approach can be expanded to other companies as well.

Safety and security declarations and the related risk analysis (ENS and ATO)

Regarding the safety and security procedure, customs faces issues with the quality of the ENS data. The risk analysis related to safety and security needs to be done very early in advance, while the container is overseas. Subsequently this data serves as a basis for the ATO declaration that is used for safety and security risk analysis when the container arrives at the Port of Rotterdam to ensure that an additional check is done before the container is allowed to enter the European Union. The main data for the safety and security risk analysis is the data from the ENS declarations that is risk-assessed before the container is loaded on the ship that will bring the container to the Netherlands. Subsequently, when the ship approaches Europe, the ENS data serves as a basis for the so-called ATO declaration, which is then used for the second risk assessment to decide whether to allow the container to enter the EU from the safety and security perspective. Ways to cross-validate the data in the ENS and to obtain additional information to allow for such cross-validation can be useful for the risk analysis and as such is potentially very valuable for customs.

Annex 5. Key documents in international trade and the role of tradelens

In this Annex we provide a brief introduction to the key documents in international trade and the role of TradeLens. The Buy-Ship-Pay reference mode[21]l of the UN/ CEFACT describes the main processes and parties in international supply chains. Here we provide only a brief introduction in a simplified form to some of these processes and to the role of TradeLens as a background information for understanding the case we present in this article.

In simple terms,[22] while there are many parties involved in international trade transactions, at the heart is that there is a buyer that wants to buy goods and a seller that sells these goods. Two documents that are key for this transaction are the Purchase order where the buyer expresses an interest to buy the goods. The seller sends an invoice to request the payment of the goods. As the buyer and the seller in international trade transactions are usually located in different countries, they make use of carriers for the transport of the goods. In container transport, the carrier issues a document called Bill-of-Lading. The Bill-of-Lading is issued by the carrier when they receive the goods. The Bill-of-Lading is also a key document to ensure that the goods are handed over by the carrier to the right party at the receiving end. In an international trade transaction, there may be many other parties involved including freight forwards and customs brokers. Information and documents pass many hands and that can lead to mistakes and errors. When leaving the country of export and entering the country (region) of import there are government procedures involved which include customs and other authorities. Supply chain partners are obliged by law to provide specific data in the form of declarations (e.g., the Safety and Security declaration (ENS) submitted by the carrier or import declaration submitted by the importer) to the customs at entry or import of goods to the European Union. Customs uses these declarations for the customs risk assessment to decide whether to select the goods for inspection or not. These customs declarations often contain inaccuracies or insufficient information. In case of doubt customs can ask the supply chain parties to provide additional business source documents (such as invoices, Bills-of-Lading) to cross-validate the data on the import declarations, as these business documents contain more accurate information from the source where the data was created. Customs requesting and waiting for such additional business documents for cross-validation purposes is a time-consuming process, and provides additional delay on both the side of businesses and of customs. It can also delay the clearance of the goods and have negative effects on the supply chain operations. Customs are, therefore, interested to have access to the business documents in advance, but they cannot formally ask for that. While businesses are normally reluctant to share information beyond what is required by law, prospects for trade facilitation and faster clearance can provide the right incentives for businesses to share information on voluntary basis.

TradeLens[23] is a blockchain-enabled infrastructure that was developed for overcoming information fragmentation in international supply chains, where documents change hands multiple times during the transaction. TradeLens aimed, first and foremost, at streamlining the data sharing among the business parties involved in the supply chain to allow for paperless and smoother processes with less errors. TradeLens also offered opportunities for supply chain partners to share, on voluntary basis, source business data with government authorities. What made TradeLens interesting is also that it wasan operational blockchain-enabled infrastructure with global coverage. It is important to point out that TradeLens is a digital infrastructure developed and used by the businesses. It is not a mandatory system and systems developed by government such as the customs declaration systems and Single Window solutions.

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[22] There is a specific terminology which specifically describes the different roles in international trade. For the purpose of this introduction we provide a simplified explanation. For the full details please refer to the description provided at the UNECE website.

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