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The use of a blockchain-based smart import declaration to reduce the need for manual cross-validation by customs authorities

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ABSTRACT

For determining the correctness of an import declaration lodged by a declarant within international shipping, customs authorities rely on manual cross-validation of the declaration with other trade documents. However, the sheer volume of import declarations lodged annually makes it impossible to manually cross-validate each declaration. Smart contracts have the potential to automatically aggregate relevant information from blockchain-based ledgers for lodging and cross-validation. In this paper we explore how such smart contract could be implemented. We demonstrate that a smart import declaration can be used to automatically aggregate information from different sources (e.g., pro forma invoice data elements stored on the blockchain ledger). However, technical and organizational considerations that are inherent to blockchain technology need to be addressed for the smart import declaration to be acceptable for both customs authorities and declarants. It is therefore suggested that future work focusses on data standards required to enable automatic aggregation of relevant trade information and the generation of the import declaration and governance of the smart import declaration by customs authorities to assure correctness.

CCS CONCEPTS

• Security and privacy~Hash functions and message authentication codes • Applied computing~Electronic data interchange • Applied computing~Transportation • Computer systems organization~Peer-to-peer architectures

KEYWORDS

Smart import declaration, blockchain technology, cross-validation, e-customs, international shipping, smart contract

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1 Introduction

In international shipping, for each importation of a shipment of goods into a customs territory a declarant has to lodge an import declaration with the respective customs authority [13]. Customs authorities use the import declaration for risk assessment and determination of customs duties. Therefore, the information on the import declaration should be sufficiently detailed and correct. However, the information provided on the import declaration is often vague or inaccurate [8, 25]. It contains aggregated information from other documents like the Bill of Lading which are not the original sources of information and thus do not provide sufficient details or ensure correctness [8]. For example, due to the complexity of international shipping, Freight Forwarders often take care of paper-work. As a result, the import declaration may specify the Freight Forwarder as consignor and

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consignee while the Freight Forwarder is not the actual consignor and consignee. This makes risk assessment more difficult. Due to vague or inaccurate information, cross-border tax and duty fraud via falsified documentation is a growing problem in international shipping [20]. Falsification is the manipulation of information in documents for financial gain [21]. Document fraud in international trade can cost nations billions annually. A common type of document fraud is the undervaluation of the transaction value of imported goods to reduce due custom duties [9].

To determine correctness of the information on the import declaration and fight document fraud, customs authorities use other trade documents to cross-validate information. For example, the invoice value specified on the import declaration is cross-validated with the value specified on the pro forma invoice provided by the consignor as it is the original document that specifies the invoice value. However, due to a lack of automatization, cross-validation is often performed manually even if documents are already exchanged electronically (e.g. as electronic invoices) and available to customs authorities via for example a data pipeline or single window [12, 22]. This results in time-consuming bureaucracy that can delay shipments as goods have to be cleared before they can enter a customs territory. The number of declarations illustrates this problem. Within the Netherlands alone, the customs authority processes around a 160 million declarations annually [3]. The Customs Administration of the Netherlands expects this number to increase to over 500 million in the next few years. Consequently, cross-validating each import declaration manually would simply be impossible. Therefore, customs authorities are in need of new ways to automatically cross-validate information provided on the import declaration [26]. Fast and efficient processing of import declarations reduces document fraud, shortens lead times of shipments and reduces cost [11].

In recent years, a new technology called 'blockchain technology' has emerged that can drive automation of processes that involve multiple parties, including customs-related processes within the domain of international shipping [2, 17, 24]. For example, van Engelenburg, Janssen and Klievink [23] propose a blockchain-based architecture to exchange information of shipment events between businesses and customs authorities that can be used for risk assessment. Blockchain technology, as introduced by Nakamoto [16] in 2008 makes it possible for parties that do not (fully) trust each other to exchange information without the need for a central ledger that keeps track of exchange transactions or is managed by a trusted intermediary to handle these transaction to avoid fraud such as double spending [15].

Currently, no research on the use of a blockchain-based smart contract to automate customs-related processes like lodging and cross-validation within international shipping exists. Therefore, in this paper we explore how a blockchain-based smart contract could contribute to automation of the process of lodging and cross-validation of the import declaration to render time-consuming and bureaucratic manual cross-validation by customs authorities obsolete.

The remainder of this paper is structured as follows. First, in section 2 we present the essential characteristics of blockchain technologies. Section 3 presents the research approach to explore the added value of blockchain based customs declarations. This is continued in section 4 in which we provide background information on the process of lodging an import declaration by a declarant and the manual cross-validation of the import declaration by customs authorities. Section 5 demonstrates how an import declaration can be represented by a smart contract to automate the process of lodging and manual cross-validation. In section 6, we evaluate the smart contract and identify technical and organizational considerations that are to be addressed. Section 7 derives conclusions and suggestions for future work.

2 Blockchain essentials

Blockchain technology is based on cryptography and a peer-to-peer (P2P) network of parties (or nodes) in which a blockchain ledger is distributed [4]. Instead of a central ledger managed by a trusted intermediary, each party in the network holds its own copy of the ledger. Within the ledger, timestamped and digitally signed transactions are stored in cryptographically linked blocks consisting of multiple ordered transactions in which each block contains the cryptographic hash of the previous block, hence the name blockchain ledger [4, 16]. The use of cryptography ensures that no party can singlehandedly alter or add new (fraudulent) transactions to the ledger as it would invalidate the ledger. This ensures that once stored, transactions are immutable and non-repudiation by parties involved in the transaction, identifiable by their respective digital signature, is ensured [24]. To add a new transaction to the ledger, parties rely on a consensus mechanism in which parties in the network reach agreement on the validity of transactions [16]. Only if a majority of the parties agree, a new block of transactions is appended to the blockchain ledger. Within the consensus mechanism, a consensus protocol is responsible for deciding on the order of transactions. Proof-of-Work is the most commonly known consensus protocol. It requires a party to put computational effort into solving a cryptographic puzzle before it can propose a new valid block of ordered transactions. The resulting delay makes it harder to double spend a transaction as it would require additional computational power [16]. All other parties in the network check validity of the block proposal before appending it to their own copy of the blockchain ledger [16]. In return, the party that proposed the block will receive a reward. This overcomes the double spending problem as it is more beneficial for a party to act honest than to act malicious [4]. Without consensus, the blockchain ledger cannot be altered, thus rendering transactions (and information included in these transactions) immutable. As a result, information, for example in the form of documents, can be exchanged while at the same time integrity of the exchanged information is guaranteed [4, 7]. Since the introduction of blockchain technology, the use of smart contracts has gained widespread attention. Smart contracts are agreements between parties that are stored as code on the blockchain ledger that can

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be used to digitize assets and automate execution of business processes without involvement of a trusted intermediary [7, 19]. Transactions contain operations that serve as input to the smart contract. The outcome is stored in the state of the smart contract [19]. Contract code is stored on the blockchain ledger via a transaction. As a result, the code becomes immutable and thus ensures proper execution of processes [1, 24]. Each time a party executes the contract using the same input, the same output will be generated. This enables new ways for parties that do not (fully) trust each other to collaborate [6, 14].

Customs authorities can potentially benefit from the use of blockchain-based smart contracts as it increases trust with declarants [17]. The current import declaration contains aggregated information from multiple trade documents such as the purchase order, pro forma invoice, packing list or Bill of Lading of a shipment. The declarant lodges an import declaration by using these sources of information. However, customs authorities are not ensured that the declarant uses the correct information specified on other documents as integrity cannot be proved. The declarant can commit fraud by for example specifying a lower invoice value on the import declaration than specified on the pro forma invoice to reduce the customs value and thus customs duties to be paid. The only option for customs authorities to prove integrity and thus ensure correctness of the import declaration is by manually cross-validating different sources of information. However, if information from trade documents would be stored immutably on the blockchain ledger, a single source of information that is trusted by both declarant and customs authorities exists. Because of the immutable character, customs authorities can easily check that a declarant has used the information stored on the blockchain ledger when lodging an import declaration by comparing information. The use of smart contracts can in potential even further automate the process. If the process of lodging an import declaration is represented by a smart contract stored immutably on the blockchain ledger, a declarant can automatically generate the import declaration by automatically aggregating information stored on the blockchain ledger, whilst customs authorities are ensured of correctness. This would completely remove the need for cross-validation as the import declaration can only contain aggregated information stored on the blockchain ledger, provided that there is agreement on the smart contract code. In the following sections we explore the feasibility and assess the practical implications of the introduction of a blockchain-based smart contract in e-customs.

3 Research approach

The research field of blockchain technology and specifically its application within international shipping is new and relatively unexplored. Therefore, this paper uses an exploratory case study to explore the use of a blockchain-based smart contract to automate the process of lodging and cross-validation of the import declaration. The use of an exploratory case study is suitable for this type of research as there is currently no theory on the use of a blockchain-based smart contract for customs-related processes. In addition, this type of research can be used to deal with 'how' questions [28]. To that extent, the case study first analyses the current process of lodging an import declaration for a shipment by a declarant and manual cross-validation of the import declaration by a customs authority. Next, it explores how a blockchain-based smart contract can be used to re-design the process to automate lodging and cross-validation of the import declaration.

4 Lodging and cross-validation of an import declaration

In this section, we describe the process of lodging an import declaration by a declarant and manual cross-validation of the import declaration by the customs authority as this is the unit of analysis of the case study. For each importation of a shipment, a declarant is responsible to lodge an import declaration with the respective customs authority [13]. To that extent, the declarant (e.g., Freight Forwarder that often acts as declarant) first retrieves all relevant trade documents required to create an import declaration as the declaration contains aggregated information from these documents. As mentioned in the introduction, this includes the purchase order, pro forma invoice, packing list and Bill of Lading. Next, the declarant creates the import declaration by specifying all required data elements. A typical declaration includes data elements like the consignor and consignee, date of issue, description of goods, country of origin, goods classification (Harmonized Systems Code), invoice value, duties and taxes, terms of delivery (Incoterm) and means of transport [5]. To determine the duty to be paid, the declarant first calculates the customs value of the shipment via the transaction value method [27]. Depending on the invoice value, transport cost after entry and Incoterm specified on the pro forma invoice, the customs value is calculated [10, 18]. For example, if a shipment is shipped under DDP Incoterm, the customs value is calculated as follows: customs value = invoice value – transport cost after entry. After creating the import declaration, the declaration is lodged with the customs authority. In most cases, the import declaration is lodged electronically.

For proper risk assessment and determination of customs duties customs authorities should know the exact details of the goods in a shipment [20]. In other words, the customs authority should be ensured of correctness of the import declaration. However, as already mentioned in the introduction information on the import declaration is often vague or inaccurate [8, 25]. Customs duties are determined based on the customs value calculated using the transaction value method and specified on the import declaration. Because it is difficult for customs authorities to determine correctness of the import declaration, undervaluation is a common type of fraud aimed at reducing due customs duties [9]. Customs duties are calculated ad valorem based on the custom value. By undervaluation of the invoice value on the import declaration the customs value is reduced which results in reduction of due duties. To avoid fraud, customs

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authorities have to check correctness of the import declaration. One approach to check correctness of the import declaration lodged by the declarant is by cross-validation of the import declaration with other trade documents like the purchase order, pro forma invoice, packing list or Bill of Lading that relate to the shipment. Figure 1 provides an BPMN of the current process of manual cross-validation of the import declaration by the customs authority using other trade documents such as the pro forma invoice. If a customs authority identifies irregularities in the lodged import declaration it can request other trade documents of which information is aggregated to create the import declaration. For example, the pro forma invoice is requested from the consignor. Figure 2 shows how a customs authority cross-validates the import declaration and pro forma invoice. Data elements specified on both documents are compared to determine if the elements match. If all elements match, the import declaration is based on other trade documents and therefore deemed correct. If there is a mismatch between data elements, for example the invoice value on the import declaration is lower than the pro forma invoice, this can be an indicator for undervaluation fraud.

The next section develops a blockchain-based smart contract that can contribute to automation of the process analyzed in this section.

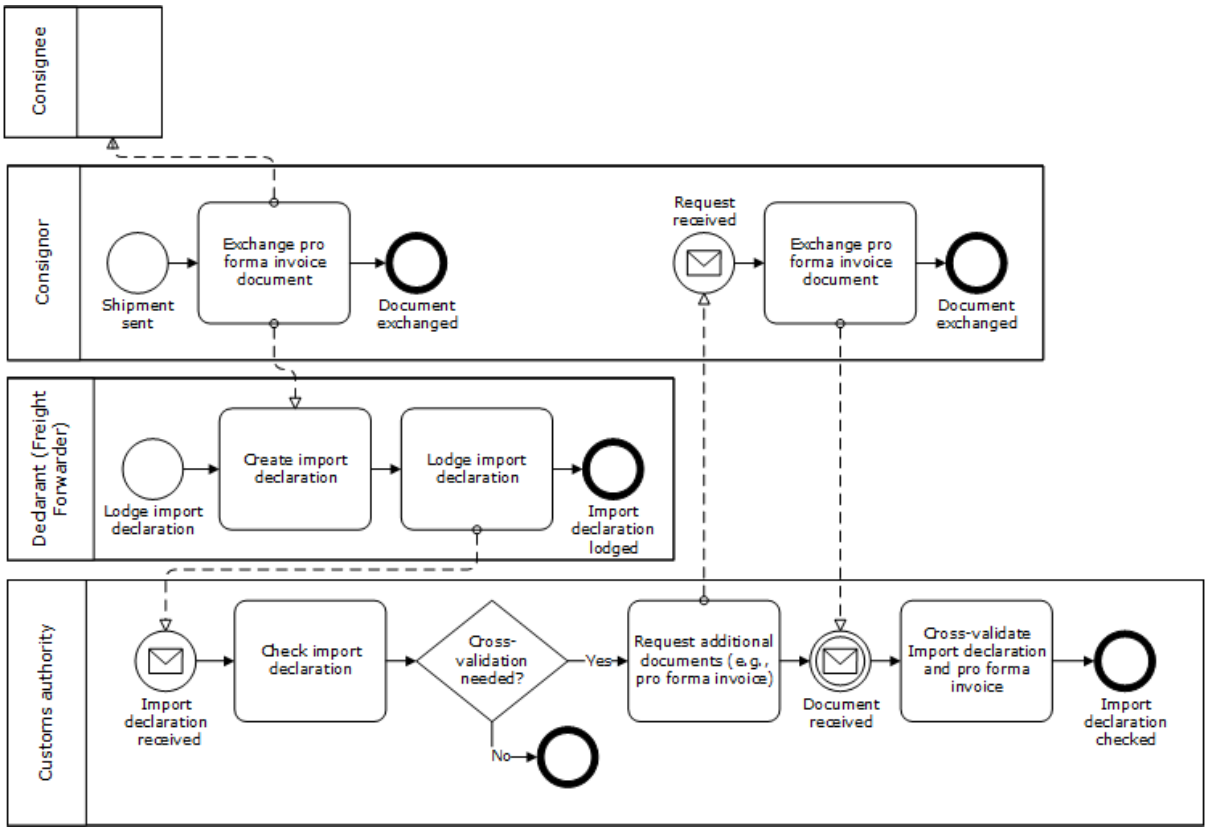

Figure 1: BPMN current process lodging and manual cross-validation import declaration.

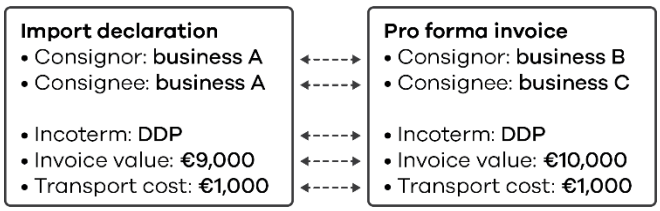

Figure 2: Cross-validation of information provided on import declaration and pro forma invoice with undervaluation.

5 Demonstration smart import declaration

In this section, we demonstrate what a blockchain-based smart contract that automates the process of lodging and cross-validation of the import declaration could look like. We refer to this smart contract as 'smart import declaration'. Figure 3 provides a BPMN that represents the automated process. Both declarant and customs authority are represented as node in the blockchain network. Each node has a copy of the blockchain ledger that contains all relevant data elements required to create an import declaration for a shipment. In this paper the focus is on consignor, consignee, invoice value, transport cost after entry and Incoterm data elements as specified on the pro forma invoice which is already exchanged by the consignor via a transaction.

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Data elements include a reference to a shipment via some form of ID to enable aggregation of data elements for generating the import declaration of a specific shipment. A smart import declaration developed by the declarant that implements all required business logic functionality to lodge an import declaration is stored on the blockchain ledger. Only smart import declarations authorized by the customs authority can be used to lodge an import declaration. The contract is deterministic so that only data already stored on the blockchain ledger can be used. We use a simplified example of a declarant lodging an import declaration to illustrate the functioning of the smart import declaration.

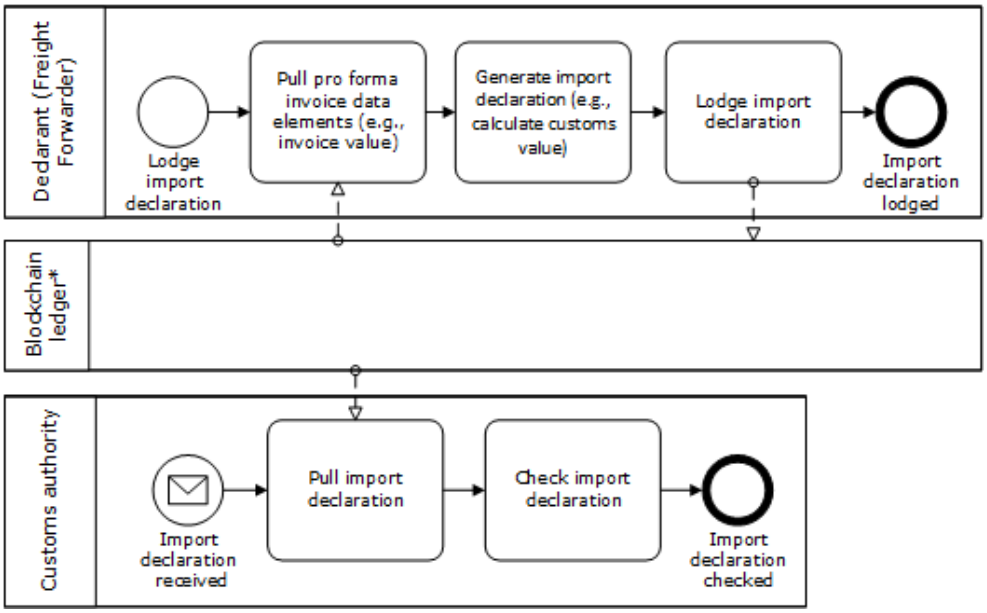

Figure 3: BPMN automated process lodging and cross-validation import declaration using blockchain-based smart contract. * Each party is represented by a node in the blockchain network and has its own copy of the blockchain ledger.

To lodge an import declaration, the declarant invokes the 'lodge import declaration' function of the smart import declaration via a transaction proposal that includes a shipment ID that is used as reference to the data elements stored on the blockchain ledger. Based on the ID, the smart import declaration queries the blockchain ledger to aggregate all relevant data elements of the pro forma invoice of the shipment that belongs to the ID. These data elements are used to generate the import declaration. To avoid redundancy, specifying only a reference to the data element is sufficient. The customs value data element of the smart import declaration is calculated automatically. To calculate the customs value, a set of calculation algorithms based on the transaction value method is implemented in the smart import declaration. Depending on the specified Incoterm data element, the applicable algorithm is selected. For example, if the Incoterm data element has value DDP, the smart import declaration selects the DDP algorithm in which the customs value is calculated as follows: customs value = invoice value – transport cost after entry.

The output of the smart import declaration is a transaction that includes at least a transaction ID, declarant ID, timestamp, calculated customs value, (at least a reference to) the consignor, consignee, invoice value, transport cost after entry and Incoterm. As part of lodging an import declaration the transaction is signed by the declarant as formality. This ensures non-repudiation by the declarant to enable the customs authority to pursue legal action in case of suspected fraud as the declarant is at any time responsible for correctness of the import declaration. However, if the transaction is only signed by the declarant, the customs authority is not ensured of correctness because the declarant could in theory create a fraudulent transaction without using the smart import declaration. This would require the customs authority to perform many audits that include cross-validation of the smart import declaration by re-invoking the contract. This would reduce the added value of using a blockchain-based smart contract to automate the process.

Therefore, each transaction also requires a signature from the customs authority. To that extent, the declarant sends the transaction to the customs authority to be confirmed. The customs authority re-invokes the 'lodge import declaration' function to determine correctness. If the output of the smart import declaration is equal to the output generated by the declarant, the import declaration is deemed correct and the customs authority signs the transaction as confirmation. Note that the signature of the customs authority only proves that the declarant has correctly used the smart import declaration to aggregate data elements stored on the blockchain ledger and calculated the customs value correctly. It ensures that no

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fraudulent transaction can be created by the declarant. It does however not shift liability towards the customs authority if the import declaration is incorrect due to fraudulent pro forma invoice data elements stored on the blockchain ledger. At all times, the declarant is responsible for ensuring correctness.

The final transaction thus includes a transaction ID, declarant ID, customs ID, timestamp, calculated customs value, (at least a reference to) the consignor, consignee, invoice value, transport cost after entry and Incoterm and is signed by both declarant and customs authority. Next, the transaction is sent to other nodes within the network that participate in the consensus mechanism protocol. The process of ordering transactions within the protocol left outside the scope. A block proposal containing multiple transactions, including the transaction to lodge the import declaration is sent to all nodes. All nodes check validity of the transaction by checking if the transaction was correctly signed by both the declarant and customs authority involved. If the transactions are valid, a node appends the block to its copy of the blockchain ledger. Once the block is appended to the blockchain ledger the transaction is immutable. As data in the transaction can only be based on pro forma invoice data elements immutably stored on the blockchain ledger there is no need for additional cross-validation. The customs authority is thus ensured of correctness of the import declaration. A customs authority can pull the import declaration from its own copy and check the document if needed for auditing purposes.

6 Evaluation

The previous section presented a demonstration of how a smart import declaration could be used to automate the lodging of an import declaration and overcome the need for manual cross-validation. In this section we evaluate if such smart import declaration can indeed contribute to automation of this process. We use two sample scenarios to show how the smart import declaration overcomes potential incorrectness of the import declaration that requires manual cross-validation. To that extent, we refer back to the problem of undervaluation of the invoice value. In the current situation, the declarant manually aggregates data elements from documents, including the invoice value from the pro forma invoice. However, the customs authority has no access to the invoice value. As a result, correctness of the import declaration is not ensured as there is no guarantee that the value used on the import declaration is correct and the declarant is committing fraud by undervaluation of the invoice value. Therefore, the customs authority has to manually cross-validate the import declaration with the pro forma invoice provided by the consignor to determine if the customs valuation is correct. In a second scenario, pro forma invoice data elements are stored on the blockchain ledger, but the declarant has to manually aggregate the data elements to create an import declaration. Correctness of the import declaration cannot be ensured because correct aggregation and generation of the import declaration is not ensured. A fraudulent declarant could still under valuate the invoice value. Therefore, the customs authority still has to cross-validate the import declaration with the data elements stored on the blockchain ledger. The smart import declaration overcomes the shortcomings of the previous two scenarios. The only option for a declarant to lodge an import declaration is to use a smart import declaration of which the code is immutably stored on the blockchain ledger. Because the contract is deterministic, only data elements immutably stored on the blockchain ledger can be aggregated. As a result, the blockchain ledger acts a single source of truth. A fraudulent declarant can no longer under valuate the invoice value because only the invoice value data element stored on the blockchain ledger can be used. In addition, the transaction to lodge an import declaration is signed by both declarant and customs authority. This ensures that the smart import declaration is correctly invoked. By storing the transaction on the blockchain ledger, the import declaration becomes immutable which ensures the generated import declaration cannot be tampered with. There is thus no need for cross-validation of the import declaration with for example pro forma invoice data elements because the import declaration can only include the data elements already stored on the blockchain ledger.

While a smart import declaration can ensure correctness of aggregating data elements and generation of the import declaration as data elements and contract code are stored immutably on the blockchain ledger, it cannot ensure that the values of the used data elements are reliable. In simple terms, if the data elements stored on the blockchain ledger are fraudulent (e.g., undervalued invoice value), customs authorities cannot rely on the outcome of the smart import declaration. This would make the smart import declaration unacceptable to customs authorities. However, some solutions to overcome this reliability problem exist. Customs authorities have already shifted their focus to systems-based control to ensure reliability of exchanged shipment-related data. This type of control relies on auditing of information systems used by businesses involved in shipments to ensure correctness [26]. Businesses that pass audits are certified as Authorized Economic Operator (AEO) and are allowed to use more efficient processes for the clearance of shipments. In addition, in context of a blockchain-based architecture to exchange shipment-related data, Van Engelenburg, Janssen en Klievink [23] propose transactions to be signed by at least two parties involved to ensure correctness of the data. In case of the exchange of pro forma invoice data elements, the consignor and consignee could both sign the transaction so that customs authorities can rely on correctness. For this case study we therefore assume that the pro forma invoice data elements that are aggregated are correct. The smart import declaration can thus be used to automate the process of lodging an import declaration by a declarant which overcomes the need for customs authorities to perform cross-validation. Cross-validation is an integral part of the automated process due to the immutable character of transactions stored on the blockchain ledger. However, some technical and organizational considerations need to be addressed in order to be acceptable to both customs authorities and declarants. The novelty of blockchain-based smart contracts, especially in context of

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customs-related processes poses a challenge in terms of standardization. There are yet no standards for the automatic aggregation of for example pro forma invoice data elements and generation of the import declaration using a blockchain-based smart contract. Without these standards, it is not possible to implement a smart import declaration. However, within the domain of international shipping standardization is widespread. Standards like UN/EDIFACT, the WCO Data Model, ISO and GS1 are the industry standard for the exchange of shipping-related data. For example, e-invoicing to exchange pro forma invoice data elements is widely adopted. It is therefore expected that implementation of a smart import declaration as demonstrated in this paper would be based upon these standards.

A second consideration relates to the governance of the smart import declaration. As the declarant is responsible for lodging the import declaration, it is expected that it develops the smart import declaration. Freight Forwarders that often act as declarant on behalf of the importing party have decades of experience of electronic exchange of shipment-related data and should have sufficient technological and financial capabilities to develop such smart contract. This could include the use of technology companies to support development. However, for the developed smart import declaration, the customs authority should have measures in place to ensure correctness of the contract code and thus be acceptable for lodging the import declaration. We base the governance of the smart import declaration on the systems-based control as discussed previously. Two governance measures can be distinguished in context of the smart import declaration: 1) provide standard specification for development and 2) perform audits on developed smart import declarations to ensure correctness and authorize contracts that have successfully been audited. To support development of the smart import declaration, the customs authority would have to provide standard specifications that if correctly implemented, ensure that the declarant can use the smart import contract to lodge the import declaration. The specification would predominantly be based on the WCO Data Model as it is used for customs-related processes. To ensure correctness, only smart import declarations that are authorized via audits by the customs authority can be used to lodge an import declaration. Authorization is realized by a customs authority signing the contract code as a stamp of approval after successful audit before a declarant can store it on the blockchain ledger. In addition, the transaction to store the contract code on the blockchain ledger can be signed by the customs authority. As previously mentioned, note that the signature does not shift liability towards the customs authority if the import declaration is incorrect. The declarant remains responsible for ensuring correctness. The signature only proves that the required standards are implemented correctly and the audit has been successful. Because all data elements and contract code are stored immutably on the blockchain ledger, it enables customs authority to perform additional audits at any moment in time to ensure correctness of the import declaration as the blockchain ledger provides an audit-trail of all activity (via transactions) or declarants. Taking these considerations into account enables the use of a blockchain-based smart contract that automates the lodging of an import declaration and overcomes the need for manual cross-validation. The next section concludes this paper and proposes future research.

7 Conclusion

In this paper, we used an exploratory case study to explore the use of a blockchain-based smart contract named smart import declaration to automate the lodging of an import declaration and overcome the need for manual cross-validation of the declaration by customs authorities. We find that a smart import declaration can be used to automatically aggregate relevant information stored on the blockchain ledger and generate an import declaration. In context of this case study, this includes retrieval of pro forma invoice data elements like consignor, consignee, invoice value, transport cost after entry and Incoterm. To generate the import declaration's customs value, a calculation algorithm implemented in the smart import declaration is used to calculate the customs value based on the Incoterm, invoice value and transport cost after entry. As data elements and smart contract code stored on the blockchain ledger are immutable, correct aggregation of data elements and generation of the import declaration, e.g. calculation of the customs value, is guaranteed provided that the smart import declaration complies with data standard specifications set out by the customs authority and is authorized via audits. As a result, there is no longer the need for customs authorities to manually cross-validate the import declaration with for example the pro forma invoice document because the lodged import declaration can only be generated by aggregating already exchanged pro forma invoice data elements. The customs authority is thus ensured of correctness of the import declaration. In context of the smart import declaration, two technical and organizational considerations need to be addressed for the smart import declaration to be acceptable to both customs authorities and declarants. Data standards are needed to enable automatic aggregation of trade information like pro forma invoice data elements stored on the blockchain ledger and generation of the import declaration. In addition, governance measures by customs authorities, e.g. in the form of audits, is needed to support development and ensure correctness of the smart import declaration. Future work should therefore focus on the development of data standards, actual development of a blockchain-based smart import declaration and governance by customs authorities.

This paper is limited to investigating the possibility to use blockchain and smart contract in the context of import declarations and concerning the interactions between supply chain parties and customs. However in the area of international trade there is a large potential for using blockchain and smart contracts that will cross-cut domains such as supply chains, banking and insurance. One example of that is the Bill-of-Lading which is a document that is used by banks, as proof that the

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seller shipped the goods, in their Letter of Credit for buyers of goods. The smart contract presented in this paper could also be used as smart contract letter of credit where the seller gets paid automatically when he presents the bill of lading to his bank. In future research we will further investigate the application of these customs blockchain solution to develop logistics and finance blockchain solutions.

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