An Institutional Blockchain as a Tool to Control the Export of Dual-Use and Military Goods

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Abstract

International security requires accurate export control of dual-use and military items. Ideally, all goods moving across borders would be checked. However, this is currently unaffordable, since it would imply excessively slowing down customs clearance operations and, consequently, trade itself. To achieve this goal, the authors propose a system of institutional blockchains and smart contracts for those parties involved in cross-border trade. Blockchain could be further improved with artificial intelligence and machine learning algorithms to autonomously determine whether or not a good in transit is dual-use or military. This would lead to increased accuracy in identifying goods being transited cross-border and decrease time spent waiting for customs' inspections and authorizations.

Keywords

Blockchain, smart contract, artificial intelligence, export control customs, dual-use and military goods

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Introduction

Monitoring companies' distribution chain is difficult, expensive and – because inspections and audits tend to be random – not particularly comprehensive. End-users have their own difficulties: they may be aware of an item's place of origin, but they do not know details about the existing network behind that item, the producers, distributors, transporters, or any of the warehouses or storage areas through whose hands or doors the item may have passed. Supply chains, in general, remain relatively obscure. Therefore, some of the problems concerning the export of dual-use technology are related to fragmentation in the logistics process, differences in the implementation of international agreements, and large volumes of trade and commerce that have all contributed to the creation and exploitation of illegal supply networks.in dual-use goods and technologies.

According to numerous authoritative sources, as well as reporting from the United Nations and the United States, North Korea and Iran have been able to remain relatively well-connected to the global trade system – while avoiding financial sanctions – thanks to networks of shell companies that obscure the source of payments. In addition, these states have built partnerships with foreign financial institutions, exploited jurisdictions with poor export control measures, and falsified import and export documents for the transit of controlled items for nuclear applications.[1,2,3,4,5] On its webpage dedicated to the control of dual-use items, the Italian Ministry of Economic Development states that:

> *"An effective system of export control of dual-use items is necessary to ensure compliance with the international commitments and responsibilities assumed by the States that have adhered to the export control regimes, in particular with regard to nonproliferation. The existence of a common system of harmonised rules and policies on export controls in all EU Member States is a prerequisite for the free movement of dual-use items within the European Union. The export of dual-use goods and technologies is governed by a variety of regulations, criteria, and procedures which respond to national and international security requirements. Council Regulation (EC) No 428/2009, and subsequently amended, establishes a Community regime for the control of exports of dual-use items and technology*

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1 Borzou Daragahi, "How Iran Can Evade Sanctions This Time," *The Atlantic*, May 22, 2018, <https://www.theatlantic.com/international/archive/2018/05/iran-sanctions-trump-nuclear-turkey/560819/>.

2 Claudia Rosett, "Our Nagging North Korea Problem," *The Journal of International Security Affairs*, No. 27 (Fall/Winter 2014), <http://www.securityaffairs.org/sites/default/files/issues/fall_winter2014.pdf>.

3 Kambiz Foroohar, "To Avoid Sanctions, North Korean Ships Often Switch Names," *The Sydney Morning Herald*, March 1, 2018, <https://www.smh.com.au/world/asia/in-avoiding-sanctions-north-korean-ships-often-switch-names-20180301-p4z27q.html>.

4 Liu Zhen, "How North Korea Evades UN sanctions," *South China Morning Post*, October 12, 2017, <https://www.scmp.com/news/china/diplomacy-defence/article/2111440/how-north-korea-evades-un-sanctions>.

5 Rishi Iyengar, "Report: 49 Countries have been Busting Sanctions on North Korea," *CNN Money*, December 6, 2017, <https://money.cnn.com/2017/12/06/news/north-korea-sanctions-countries-violation/index.html>.

listed in Annex I."[6,7]

This article will highlight the role that blockchain technology can assume in combating illicit transfers in the international market.

The United States' Congressional Research Service (CRS) has published numerous white papers on the topic of blockchain. Notable among these is "Blockchain and International Trade."[8] The paper explores the potential for blockchain in "increasing the efficiency and security of customs and border control, food and product safety supply chain traceability, or other applications."

In addition, the World Trade Organization (WTO) has dedicated several papers to emerging technologies in international trade. A WTO report on the future of world trade points out the huge impact that the Internet of Things, artificial intelligence, blockchain, and 3D printing can have on "the way we trade, who trades, and what is traded."[9]

In "Can Blockchain Revolutionize International Trade?" the WTO again deals with this issue, highlighting how the disruptive characteristics of blockchain, when paired with smart contracts, "could help administer border procedures and national single windows [...] in a more efficient, transparent and secure manner, and improve the accuracy of trade data."[10]

In light of the above, the writers propose to set up a blockchain shared by the main parties to trading operations, in order to improve accuracy in the export control of dual-use and military items, resulting in the enhancement of both international security and commercial competitiveness.

The article is organized as follows: section one describes blockchain technology and the benefits of adopting it; section two highlights the importance of digital identities; section three underlines the key role of smart contracts; section four investigates potential contributions of the Internet of Things; section five examines the idea of using blockchain as an export control tool; and Section six proposes an integration of blockchains with artificial intelligence.

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6 "Dual-Use: Prodotti e Tecnologie a Duplice Uso," Ministry of Economic Development, Italy, <http://www.mise.gov.it/index.php/it/commercio-internazionale/import-export/dual-use>.

7 "Council Regulation (EC) No 428/2009 of 5 May 2009 Setting up a Community Regime for the Control of Exports, Transfer, Brokering and Transit of Dual-Use Items," EUR-Lex, <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32009R0428>.

8 "Blockchain and International Trade," Congressional Research Service (CRS), June 25, 2019, <https://fas.org/sgp/crs/row/IF10810.pdf>.

9 "The Future of World Trade: How Digital Technologies are Transforming Global Commerce," World Trade Organization, 2018, <https://www.wto.org/english/res_e/publications_e/world_trade_report18_e.pdf>.

10 Emmanuelle Ganne, "Can Blockchain Revolutionize International Trade?," World Trade Organization, 2018, <https://www.wto.org/english/res_e/booksp_e/blockchainrev18_e.pdf>.

1. Blockchain Technology as an Export Control Tool

Blockchain is a new technological paradigm based on Distributed Ledger Technologies (DLTs).[11] This technology uses cryptography and a distributed ledger between two parties in order to perform different types of operations, ranging from simple value transfer operations to complex operations that involve the execution of a real digital contract called a "smart contract."[12] This ledger and the transactions recorded in it are persistent, immutable, and practically incorruptible. The blockchain concept excludes the need for a third party or intermediary between the parties involved in the transaction, since a consensus algorithm is clearly defined within the network.

Blockchain technology potentially represents the most disruptive means of controlling the "life" of a good or item, including during export. Customs procedures are now not only a question of being able to check the geographical route from the point of origin to the point of destination, but also a check on all intermediate points on the route in terms of both space and time. In other words, it monitors all points on the supply chain.

In addition to providing traceability in the export of goods and technologies, blockchain also allows end-users to verify the authenticity of the item, to understand if a given good is really what is expected, and to identify its current location at a specific point on the globe. In this way, it can assist corporations in adhering to and benefiting from international regulations and policies regarding import and export. Several multinational companies (notably De Beers, Walmart, and Maersk) have already been experimenting with the idea of adopting blockchain to monitor the implementation of European Union trade standards and policies.[13,14,15]

The solution proposed in this paper achieves important and substantial benefits. It would:

(1) Increase transparency in all stages of the export process;

(2) Increase visibility in the export process;

(3) Increase trust among stakeholders;

(4) Reduce fraud;

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11 "How Could New Technology Transform Financial Markets?," European Central Bank, April 19, 2017, <https://www.ecb.europa.eu/explainers/tell-me-more/html/distributed_ledger_technology.en.html>.

12 "What is Blockchain Technology? A Step-by-Step Guide For Beginners," Blockgeeks, <https://blockgeeks.com/guides/what-is-blockchain-technology/>.

13 "De Beers Group Progresses Development of First Clockchain Initiative to Span the Diamond Value Chain," De Beers Group, January 16, 2018, <https://www.debeersgroup.com/en/news/company-news/company-news/de-beers-group-progresses-development-of-first-blockchain-initia.html>.

14 Helen Partz, "Walmart To Implement Blockchain-Based Delivery System," *Cointelegraph*, March 2, 2018, <https://cointelegraph.com/news/walmart-to-implement-blockchain-based-delivery-system>.

15 Kyunghee Park, "Blockchain Is About to Revolutionize the Shipping Industry," *Bloomberg*, April 18, 2018, <https://www.bloomberg.com/news/articles/2018-04-18/drowning-in-a-sea-of-paper-world-s-biggest-ships-seek-a-way-out>.

(5) Reduce risk;

(6) Reduce costs;

(7) Decrease counterfeiting;

(8) Decrease delays in transmitting document;

(9) Reduce human error.

The use of blockchain will achieve these benefits by decentralizing data and removing centralized archives and systems that could represent the so-called Single Point of Failure (SPOF).[16] Moreover, blockchain lends itself well to use in situations requiring consensus or agreement among parties that do not necessarily trust one another. All users linked to the blockchain have the ability to verify the status of a transaction at any time and at any point of the export, without ambiguity or points of disruption.

Blockchain can also eliminate the need for "manual" human input. There are many documents and certificates that need to be managed in international trade, which are often subject to tampering – such as counterfeiting due to corruption or sinister efforts at social engineering – while en route to their destination.

Blockchain allows for the representation of a physical good as a virtual good so that:

∑ The physical good is tracked along its the geographical path and follows the expected normative steps of export;

∑ The virtual good is simultaneously "transcribed" on the blockchain to ensure that everyone agrees with the transfer, thereby avoiding disputes in terms of legitimacy.

This "transcription" contains a series of attributes required for control, such as a unique identification mark, the quantities involved, GPS-derived position, etc. The information inputted into the blockchain by specific users is authentic because the digital identity of the user is authentic. This authenticity is guaranteed by the encrypted digital signature.

The level of transparency offered by blockchain also means that any "interaction" carried out within the system is traced, documented, and made available to anyone who wants to reconstruct particular inputs, adjustments, or inspections.[17]

2. The Relevance of Digital Identities

The blockchain, therefore, can be a valuable tool for controlling the export process. In order to

16 "Single Point of Failure," Blockgeeks Thesaurus, <https://blockgeeks.com/thesaurus/single-point-of-failure/>.

17 "Interaction" refers to any reading or writing of data that may occur at any point along the supply chain.

support this claim, it is necessary to analyze the current process in place.

In order to use blockchain as a control tool, stakeholders must be "translated" into digital identities. Each of them can have a different degree of interaction with the blockchain, such as varying levels of data visibility (partial or total), or in terms of access to information within the blockchain. The creation of digital identities is a fundamental step in establishing the basis of a trusted network of users. Responsibility for creating these identities could be assigned to an agency or agencies of the European Union, in order to ensure that a user's real identity matches their digital identity. At the company level, such identity verification could be carried out at the moment that the digital identity is created to better monitor any illegal activities and therefore further increase oversight, control, and security.

The identity component of blockchain technology is achieved through the use of cryptographic keys. The combination of a public key and a private key creates a strong digital identity reference based on ownership. On the one hand, it is possible to "sign" digital information using one's own private key; on the other hand, it is possible for anyone to verify the signature's authenticity using the signer's public key. Each stakeholder, therefore, is provided with a digital identity with which they can interact with the entire system.

3. The Key Role of Smart Contracts

A smart contract is a key component of using blockchain as an export control tool.[18] These contracts can be used to exchange money, property, and anything of value in a completely transparent and conflict-free manner without the involvement of intermediaries.

A smart contract can be "built" on the blockchain, meaning that:

- The logic and reasoning to be applied to the contract is established as programming code;
- Each smart contract is stored and replicated on the blockchain;
- The contract is executed by the network that maintains the blockchain;
- The distributed ledger is updated as appropriate.

In general, a smart contract can:

- Carry out computations;
- Keep information;

18 A digital contract is "smart" because it "self-executes" itself through the "if-this-then-that" paradigm and performs specific actions only after one or more required conditions have occurred. Smart contracts are therefore autonomous and do not require the involvement of third parties.

- Start a specific action;
- Securely send transactions to other accounts.

Benefits of the smart contract include:

- Autonomy – it is not necessary to rely on the potentially risky involvement of third parties;
- Trust – all documents are encrypted on the distributed ledger, which all involved parties can access;
- Redundancy – documents are duplicated and maintained on the blockchain, avoiding the risk of loss;
- Security – with encryption, smart contracts can be made inaccessible to any malicious parties;
- Speed – smart contracts are self-executing and do not require manual action;
- Savings – the costly involvement of third parties is unnecessary;
- Accuracy – an automated system reduces the potential for error;
- Transparency – since there is always a DLT paradigm at the blockchain's core.

Blockchains and smart contracts can be a valuable tool as well as an innovative technological solution for management and assist in the control of dual-use goods and technologies. Below (Figure 1) is an indication of how this could work.

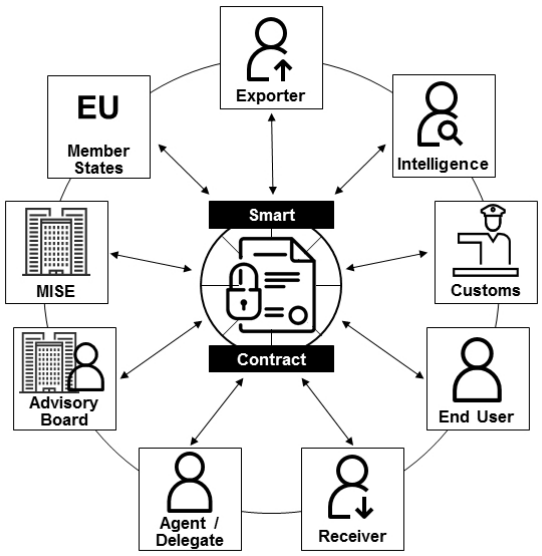

Figure 1. Logical scheme of the solution

The blockchain solution described in this section is derived from European Union application for the export of dual-use goods with data drawn from EU Member States and their customs agents, in order to increase the transparency level and to facilitate information exchanges at border points.[19] It is clear, however, that the proposed solution can also to be applied to different actors beyond the EU. It should also be noted that the blockchain suitable for controlling the export process of dual-use goods is a permissioned blockchain that reflects the principles of "community." In the future it could move towards a public blockchain to respond more clearly to the principles of transparency and participation that underlie the blockchain paradigm.

Thanks to this model, it is easy to understand that all the processes and information exchanges that take place between stakeholders can be replaced by a decentralized and autonomous mechanism requiring a close relationship between smart contracts and blockchain. It clearly defines the relationships between all the parties involved and adds a fundamental aspect: trust.

In addition to all necessary information and data, the smart contract code is able to incorporate the agreed conditions, and to automatically carry out the subsequent requirements. These conditions and actions are specified in the blockchain and are therefore transparent, reliable, and safe, since they are distributed among all stakeholders, with communication maintained secure conduits allowing for the discussion of private or particularly sensitive issues. Ultimately, smart contracts represent the digitization of an extremely complex process, and have the potential to make control of dual-use goods and technologies more effective.

The process of incorporating blockchain and smart contract is outlined below (technologies flexibility adopted makes it possible to manage all types of authorizations). It should be noted that each step requires robust communication among the stakeholders.

(1) The exporter requests authorization for export via a "Smart Contact Platform" through the Italian Ministry of Economic Development (MISE);

(2) The platform "converts" the exporter's request into a smart contract containing all the rules and regulations with which the exporter must comply;

(3) The smart contract is placed in a "pending" status;

(4) The MISE Advisory Board provides positive feedback on the proposal (if the feedback is negative, the exporter should be informed accordingly, noting any specific actions required to amend the request);

(5) MISE implements the smart contract that becomes transparent and immutable through the sharing process on the blockchain;

(6) All stakeholders are informed of the contract terms and of the contract's launch. From this point on, every step of the smart contract will incorporate specific detailed information into the blockchain, allowing for the transparent, immutable, and shared dissemination of information;

19 These forms are made available on the website of the Italian Ministry of Economic Development.

(7) The export process is initiated;

(8) As necessary, the smart contract's conditions – exact, accurate, and known to all – enable it to verify the legitimacy of the export, promptly inform stakeholders of changes and progress, and updating data on the blockchain, as necessary;

(9) The previous step continues until confirmed delivery, and the export process is complete.

4. The Contribution of the Internet of Things

A technological paradigm that could support the process described above is the Internet of Things (IoT).[20]

This consideration is important because the main challenge in realizing an approach incorporating blockchain, such as the one proposed above, is to understand how to correlate a physical good to the corresponding digital good. The solution may be rather straightforward, such as applying information labels to goods in a manner similar to that used with food products at a grocery store, but incorporating special types that enable more data and information to be processed. These modified barcodes would require particularly sturdy physical labels to protect both from accidental damage or counterfeiting attempts during the export process.

Currently, there are some valid ways to guarantee the physical security of a good, and it is important to underline that the association between a physical and a digital good must be unambiguous. Among these, it is worth mentioning Quick Response (QR) codes, Near-Field Communication (NFC), and Radio Frequency Identification (RFID).[21,22,23]

A QR code is a two-dimensional barcode consisting of black modules arranged within a white square pattern. It generally stores information in order to be read by a smartphone or a tablet. These codes can contain web addresses, texts, SMS, phone numbers, e-mails, etc. and can be read by a particular app (a so-called "QR readers.")

NFC technology (jointly developed by Philips, LG, Sony, Samsung, and Nokia), provides short-range bidirectional wireless connectivity, up to 10 cm. Communication is two-way and takes place by creating a peer-to-peer network between NFC nodes that come into contact as they approach each other. The operating frequency is 13.56 MHz and the communication can reach a maximum transmission speed of 424 kbit/s.

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20 The "Internet of Things" indicates a whole set of devices, sensors, and devices connected to the Internet and able to exchange data.

21 "What is a QR Code?," <https://www.whatisaqrcode.co.uk/>.

22 "NFC Technology," Unitag, <https://www.unitag.io/nfc/what-is-nfc>.

23 "Glossary of RFID Terms," *RFID Journal*, <https://www.rfidjournal.com/site/glossary-of-terms#Anchor-50274>.

RFID technology uses the radio frequencies and data storage capacity of specific electronic tags to identify and/or automatically store information about objects, people, animals, etc., even at a significant distance. These tags react to specific queries made by special readers who, even if acting mainly as readers, can also perform writing operations. RFID technology can be divided into two families: passive and active RFID. In the first case, the reading systems provide the tags with the energy required to enter into operation and, depending on the operating frequency (from low to very high), react at different distances. In the second case, the tags have their own power supply thanks to a long battery life. In this case, distances are longer, up to 100-500 meters.

Of these three, RFID is the most suitable option for use with the export control blockchain since it has the advantage of long-range utility, can be encrypted to prevent cloning or counterfeiting, and incorporates both Physical Unclonable Function (PUF) and GPS technology (as hybrid RFID tags have been introduced that work with GPS transceivers).[24,25,26]

Each RFID chip is uniquely identified and shared on the blockchain in terms of both its ID and the data it provides. This means that the smart contract can be programmed to alert all stakeholders, for example, in the following cases:

- The RFID chip does not report any data, alerting the stakeholders that the asset could be compromised;
- The RFID chip communicates with a different ID, indicating that the chip may have been counterfeited;
- The chip communicates information other than what is expected, in another sign that the shipment may have been compromised.

5. Tailoring the Blockchain Approach to Control the Export of Dual-Use and Military Goods

For the sake of clarity, the export process has been divided into specific steps below, accompanied by explanatory figures to better highlight the key role of the blockchain and smart contract, as well as the fundamental contribution of the IoT.

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24 Claire Swedberg, "PUF Technology Catches Clones," *RFID Journal*, September 4, 2008, <http://www.rfidjournal.com/articles/view?4304>.

25 Srinivas Devadas, Edward Suh, S. Paral, Ross T. Sowell, T. Ziola, Vinod Khandelwal, "Design and Implementation of PUF-Based "Unclonable" RFID ICs for Anti-Counterfeiting and Security Applications," Semantic Scholar, 2008, <https://www.semanticscholar.org/paper/Design-and-Implementation-of-PUF-Based-%22Unclonable%22-Devadas-Suh/16067e259fb094ab2087b81e4ef672ec2c4c3a18>.

26 "Has RFID Been Integrated With GPS?," *RFID Journal,* September 17, 2013, <http://www.rfidjournal.com/blogs/experts/entry?10729>.

5.1 Step 0

In compliance with Article 10 of Italian Legislative Decree 221/2017, the application for export of dual-use and military items must be accompanied by specific documentation.[27] The exporter, therefore, submits the authorization request using the MISE "Smart Contract Platform" in order to digitally provide the information. The platform then prepares the smart contract, pending the opinion of the MISE Advisory Board. If the result is positive, the export process begins, with the smart contract used as business logic for subsequent checks. In case of a negative outcome, or in case the exporter decides to start the export of a good without requesting authorization, there would be no corresponding digital good on the blockchain, enabling the customs agents to react immediately. The process described is shown in Figure 2.

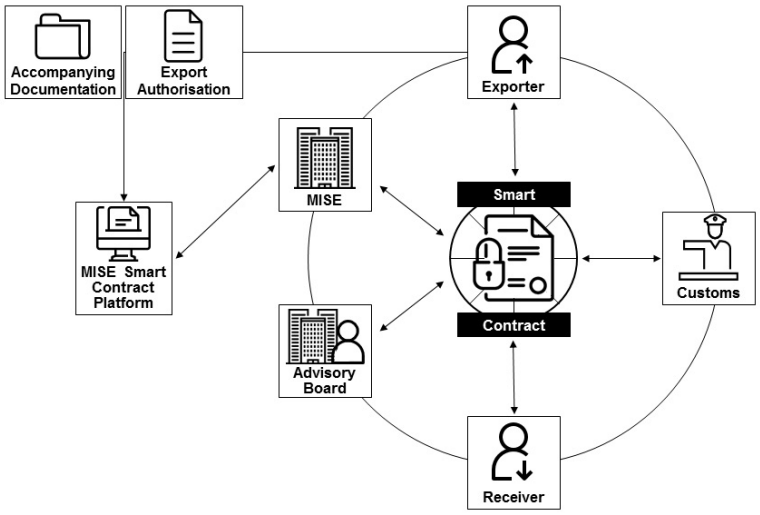

Figure 2. Interaction example between the dual-use good and institutional blockchain - step 0

5.2 Step 1

The export process begins with the dual-use good (Figure 3).

27 Italian Legislative Decree 221/2017, <http://www.gazzettaufficiale.it/eli/id/2018/1/17/18G00007/sg>.

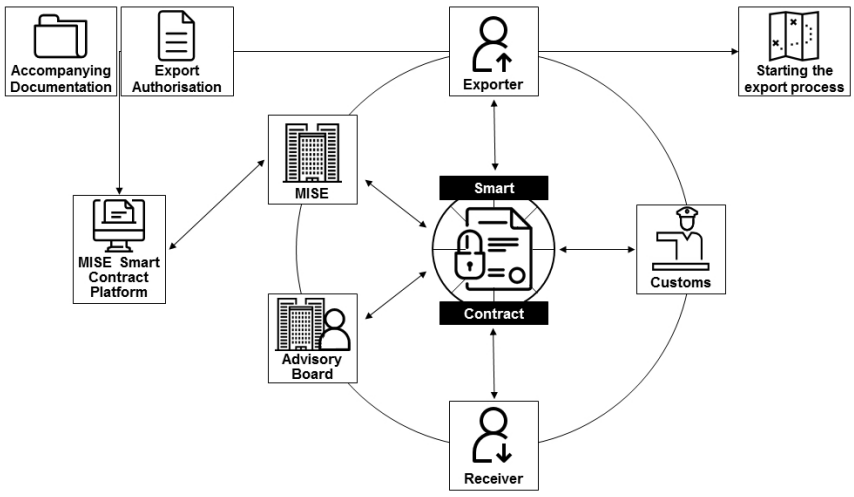

Figure 3. Interaction example between the dual-use good and institutional blockchain - step 1

5.3 Step 2

The geographical path the good will take, as well as all of the good's identifying and related data recorded on the blockchain (including Step 0 data). The dual-use good, while in transit, meets all of its anticipated checkpoints (Figure 4).

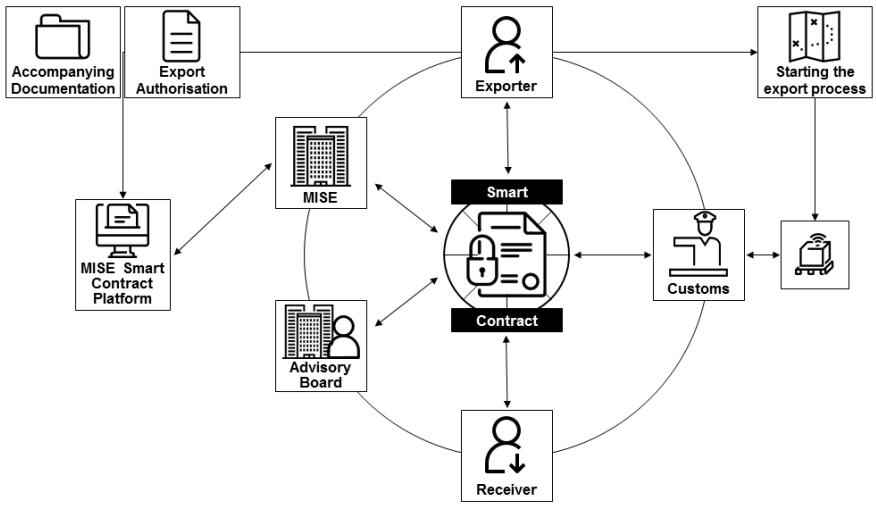

Figure 4. Interaction example between the dual-use good and institutional blockchain - step 2

5.4 Step 3

At customs checkpoints, the RFID tag transmits the collected data to the smart contract, which verifies its correctness on the basis of what is established *a priori*, recorded on the blockchain, shared by all stakeholders, and (Figure 5).

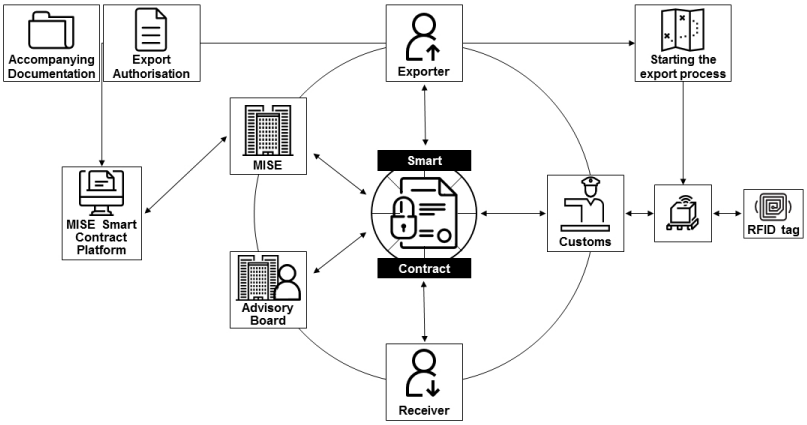

Figure 5. Interaction example between the dual-use good and institutional blockchain - step 3

5.5 Step 4

The export process continues until the dual-use good reaches its final destination. Also, in this case, the communication process involves all stakeholders (Figure 6).

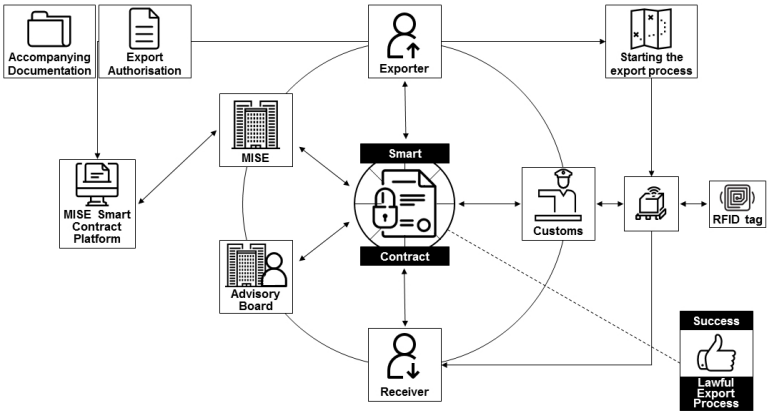

Figure 6. Interaction example between the dual-use good and institutional blockchain - step 4

Now suppose that, during the process, the good is compromised before it reaches a customs

checkpoint (Figure 7).

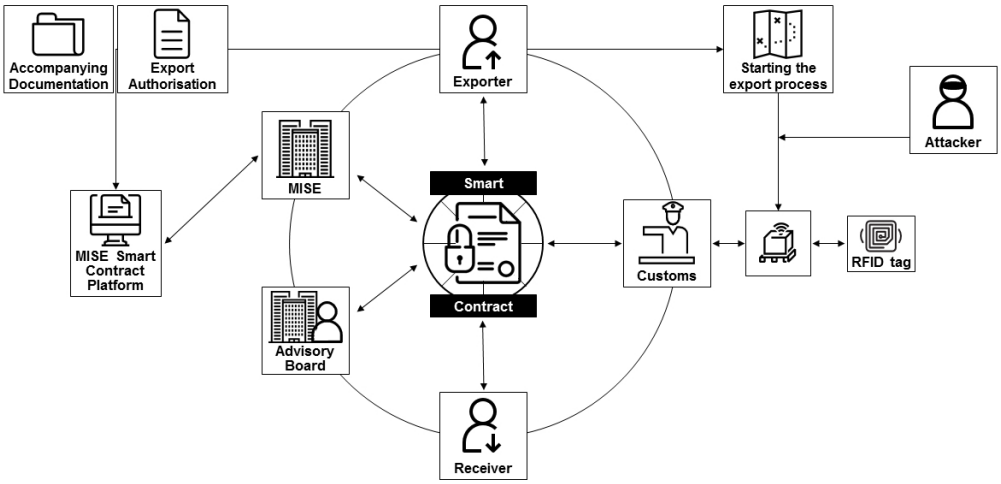

Figure 7. Interaction example between the dual-use good and institutional blockchain – compromised good

5.6 Step 1

As before, the RFID tag transmits the collected data to the smart contract in order to verify its correctness, as recorded on the blockchain and shared by all stakeholders.

5.7 Step 2

The data are not valid, the export process is stopped (Figure 8).

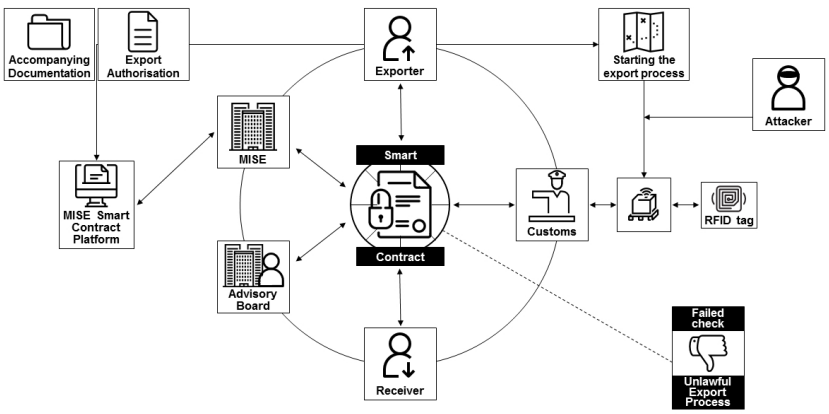

Figure 8. Interaction example between the dual-use good and institutional blockchain – compromised good – steps 1, 2

5.8 Step 3

All stakeholders are informed of the good's compromise.

5.9 Step 4

The RFID tag communicates the recorded data to the blockchain and the smart contract verifies that the process is not legitimate due to (for example):

- Unexpected GPS positions of the asset;
- Incorrect RFID tag identification data;
- Unfulfilled terms and conditions of its contract;
- Irregular documentation.

Compromise of the good in transit could take place both physically and through cyber-related means. To prevent this, the Physical Unclonable Function (PUF) can be used, which makes the cloning of RFID chips impossible, ensures the unambiguous function and production of the chips, and provides security protocols to ensure the authenticity of a good (the physical characteristics of silicon and the variations in the manufacturing process of integrated circuits are exploited), even when a network connection is unavailable.[28] Additionally, GPS technologies contribute to making the process less vulnerable to attackers.[29]

Customs offices around the world need to make themselves ready for blockchain and smart contract-enabled goods and update to digital processes rather than relying on paper-based ones. These offices will need to equip themselves with RFID readers suitable for handling a large flow of goods.

In addition, the data stored and shared between blockchain stakeholders will allow continuous verification of the RFID chip's data integrity, which is, *de facto*, the digital version of the physical good. The lawful digital version of the good has already been approved and validated by the network nodes, so a good customs inspection must reflect this digital passage, otherwise it is an indication that fraud has occurred.

Transparency, immutability, decentralization, and validation of data typical of the blockchain paradigm that will help prevent attackers from modifying the data held at network nodes (an attacker would have to attain very high computational power, as well as be able to compromise the several copies of the distributed ledgers).

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28 Pim Tuyls, Lejla Batina, "RFID-Tags for Anti-Counterfeiting," in Pointcheval D. (ed.), *Topics in Cryptology, – CT-RSA 2006. CT-RSA 2006. Lecture Notes in Computer Science*, Vol. 3860 (Berlin: Springer, 2006), <https://link.springer.com/chapter/10.1007/11605805_8>.

29 Ruijian Zhang, "A Transportation Security System Applying RFID and GPS," *Journal of Industrial Engineering and Management*, Vol. 6, No. 1 (2013).

6. Integration with Artificial Intelligence

As previously mentioned, the smart contract is capable of autonomously verifying the occurrence of certain established conditions and automatically carrying out established requirements. Integrating blockchain with a smart contract, therefore, creates an entire system that makes a decisive leap forward in terms of reliability, transparency, and security. At the same time, the smart contract prevents subjective interpretations of the export agreement or eliminates the ability of the various stakeholders to make independent and conflicting decisions on how the contract is implemented.

This valuable integration can be further refined and evolved through the contribution of Artificial Intelligence (AI).[30] In this way, the process of exporting a dual-use item can be both automated and continuously improved thanks to AI's ability to continuously process massive amounts of data. In 2019, the Italian Ministry of Economic Development published "Proposals for an Italian strategy for artificial intelligence," in which it highlighted:

> *"With the spread of distributed ledger technologies (of which the blockchain is a specific case) and in particular of smart contracts, the role of artificial intelligence could become even more relevant according to some experts, especially if some problems related to computational cost and scalability of DLT solutions will be overcome in the coming years. The decentralized nature of these technologies and the possibility to validate the data collected from them will thus allow a greater accuracy of AI systems, as well as to distribute the computational power over several nodes, potentially reducing costs and therefore the accessibility of the technology."*[31]

AI and Machine Learning (ML) are often, incorrectly, used as interchangeable expressions.[32] AI represents a wider concept of machines capable of performing tasks in a way that can be considered "intelligent," while the ML is an AI application based on the idea of providing machines the access to data in order to enable them to learn autonomously.

With the passing of time, the term "AI" has evolved from simply referring to computers carrying out more and more complex calculations to its current usage, signifying imitation of the "human" decisional processes and on the execution of "human" tasks. A key factor that has contributed to "teaching" machines to think and understand in a human way mirrors the way that human neural networks classify information. In AI, this "feedback loop" allows the machine to understand whether its decisions are right or wrong, thus changing future behavior. Similarly, the AI algorithm undergoes a "training" phase through which it can learn and improve itself.

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30 "Artificial Intelligence," Encyclopædia Britannica, August 17, 2018, <https://www.britannica.com/technology/artificial-intelligence>.

31 "Proposte per una Strategia Italiana per l'Intelligenza Artificiale," Ministry of Economic Development, July, 2019, <https://www.mise.gov.it/images/stories/documenti/Proposte-per-una-strategia-italiana-2019.pdf>.

32 "Machine Learning," Encyclopædia Britannica, <https://www.britannica.com/technology/machine-learning>.

This process is continuous and dynamic, allowing the system to increase its "experience" just as if it were a human.

Basically, machine learning can be seen as a way to achieve artificial intelligence.[33] There are several types of machine learning, including:

- Supervised learning, involving the provision of specified inputs and desired outputs with the aim of enabling the machine to define a general rule that associates the input with the correct output;
- Unsupervised learning, which does not involve any predetermined inputs as in supervised learning, but allows the machine identify structures on its own;
- Reinforcing learning, where a machine interprets its actions and involvement with its environment in order to achieve some optimal outcome;
- Semi-supervised learning, that consists of providing the machine with an incomplete dataset for training, without defining a desired output.[34,35]

There is also a strong relationship between AI and IoT, which can be viewed similarly to the relationship between the brain and the human body. As the body picks up sensory inputs (sight, touch, hearing), the brain analyzes the data and determines what to do next. The IoT (the "body") allows for the acquisition of an enormous amount of data, which in turn vastly improves the level of Artificial Intelligence accuracy. AI (the "brain") then optimizes the adoption and collection of data from the IoT environment, establishing a positive loop.

In the world of dual-use technology, the use of blockchain and smart contracts will undoubtedly increase the reliability and transparency of an entire system, allowing that system to achieve the desired outcomes in line with related laws and regulations. A smart contract "executes what it has been programmed for" in full compliance with what has been established in advance by the parties. Therefore, smart contracts should be equipped with AI, thereby strengthening and increasing the smart contract's decision-making capabilities, as well as managing and filtering all of the data that the sensors placed on dual-use goods transmit to a specific IoT platform. The benefits are many and varied, including:

- Reduction of informational noise;
- Reduction of false negatives;

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33 Calum McClelland, "The Difference Between Artificial Intelligence, Machine Learning, and Deep Learning," December 4, 2017, Medium, <https://medium.com/iotforall/the-difference-between-artificial-intelligence-machine-learning-and-deep-learning-3aa67bff5991>.

34 Ronald van Loon, "Machine Learning Explained: Understanding Supervised, Unsupervised, and Reinforcement Learning," February 5, 2018, Big Data Made Simple, <http://bigdata-madesimple.com/machine-learning-explained-understanding-supervised-unsupervised-and-reinforcement-learning/>.

35 Pierre Lison, "An Introduction to Machine Learning," University of Oslo, October 3, 2012, <http://folk.uio.no/plison/pdfs/talks/machinelearning.pdf>.

- ∑ Correlation of data received from different sources;
- ∑ Improvement in the accuracy of AI;
- ∑ Evolution of the smart contract.

Some potential benefits enabling smart contracts with AI are:

(1) An improved ability to manage export applications submitted to MISE. This could be done by enabling real-time verification of the application's adherence to procedural constraints and requirements, and avoiding the need for future revisions of the application;

(2) An interpretation of Council Regulation (EC) No. 428/2009 that sets up a regime for controlling dual-use exports;

(3) Better management of exceptional cases and/or the occasional "black swan."[36]

In the first case, AI could manage export applications by coding "grey areas" not managed by a smart contract. This would result in shorter processing times and quicker and more consistent export approval or rejection decisions.

The second case is undoubtedly interesting, but at the same time crucial: evaluating whether a good can be considered dual-use or not, without requiring a human decision. A smart contract equipped with AI could not only recognizes the nature of a good (dual-use or not), but also associate it autonomously to the correct category of Council Regulation Annex I. This would also result in continuous learning and higher analytical accuracy.

The third case is particularly challenging: making the smart contract so "smart" that it can manage any doubts, disputes, imprecisely codified rules or instructions, or even manage so-called "black swans."[37,38]

AI, therefore, would be placed at the center of the entire blockchain system and would not only intelligently automate the process of exporting dual-use goods, but would also allow, through ML, the system to refine and improve its own activity in a continuous and dynamic way. Figure 9 represents the central role in the blockchain system that AI could acquire.

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36 Nassim Nicholas Taleb, "The Black Swan: The Impact of the Highly Improbable," *The New York Times*, April 22, 2007, <https://www.nytimes.com/2007/04/22/books/chapters/0422-1st-tale.html>.

37 "An event or occurrence that deviates beyond what is normally expected of a situation and that would be extremely difficult to predict."

38 "Definition of Black Swan," *Financial Times Lexicon*, <http://lexicon.ft.com/Term?term=black-swan>.

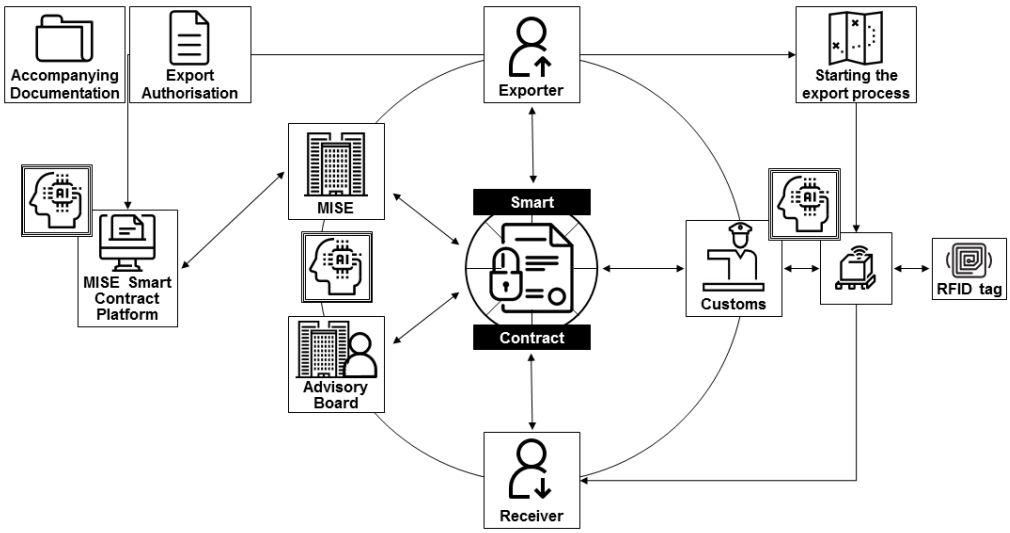

Figure 9. The AI central role

In light of the above, the relationship between blockchain, smart contracts, and AI is so powerful that the concept of Blockchain Intelligence can now be introduced.[39] Blockchain Intelligence will ensure the correct and efficient execution of autonomous operations. It will encompass areas like smart contract quality assurance, checking for vulnerabilities within the smart contract code, as well as blockchain performance control and automatic detection of malicious behaviour. To use an expression common in technological innovation communites, combining blockchain and AI makes smart contracts smarter.[40]

Combining these two approaches outlines that *AI could not be used without the assurance of the safety and reliability of the data provided by blockchain and vice versa the value of many blockchain applications will be limited without AI*. In conclusion, complementary data development and sharing between AI and blockchain maximizes the efficiency and effectiveness of a export system, particularly in the case of dual-use goods and technologies.

7. Conclusions

At the end of 2015, the Italian National Cybersecurity Laboratory drafted "The Future of

39 Zibin Zheng, "Blockchain Intelligence: When Blockchain Meets Artificial Intelligence," arXiv.org, December 11, 2019, <https://arxiv.org/pdf/1912.06485.pdf>.

40 "Combining Blockchain and AI to Make Smart Contracts Smarter," Global Legal Blockchain Consortium, November 27, 2017, <https://legalconsortium.org/uncategorized/combining-blockchain-and-ai-to-make-smart-contracts-smarter/>.

Cybersecurity in Italy: Strategic Project Areas" white paper to describe the main cybersecurity challenges facing Italy in the next five years.[41] Among the "Enabling Technologies" described in Chapter four, blockchain and distributed ledger technologies were highlighted. From that, the following should be mentioned among the objectives related to the development of Distributed Ledger technology:

> *"The supply chain is the basis of today's production and distribution processes on a global scale and comprise various activities, including: contract management, payments and invoice issuance, labelling and packaging, logistics and transport. In this regard, solutions must be developed that allow for the use of DLTs for efficient, reliable and transparent tracking of interactions taking place in a supply chain, with the aim of significantly reducing costs due to poor performance and errors of current management processes, often partially entrusted to human operators. The proposed solutions will also represent an important deterrent for illegal activities, as the transactions reported in the ledger will be relatively easy to use for anti-fraud and anti-counterfeiting checks.*
>
> *As a result, the entire supply chain will become more efficient and safer, with important impacts on management costs, authentication guarantees of end products, and the possibility to reliably reconstruct the entire history of any product, from its origin to its retail distribution".*

This article attempts to address some of the challenges presented in the white paper. Using blockchain as a tool to support the control of exports of dual-use goods and technologies allows for numerous benefits, such as streamlining authorization procedures, so that the Italian market can better compete on the international market. Additionally, it would improve national and international security, both in terms of physical and infrastructural security, as well as in terms of the information present in export application data.

Incorporating AI into blockchain is a significant step forward in effectively managing the export control of dual-use goods and technologies. AI will allow Customs officials to maximize the benefits of machine learning in their devices and sensors in order to determine whether a good in transit is dual-use or not. Finally, this incorporation would increase capacity for conducting inspections, while improving the accuracy and reliability of export controls over time.

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41 Italian National Cybersecurity Laboratory of Consorzio Interuniversitario Nazionale per l'Informatica and Laboratorio Nazionale di Cybersecurity, "The Future of Cybersecurity in Italy: Strategic Project Areas," January 2018, <https://www.consorzio-cini.it/images/Libro-Bianco-2018-en.pdf>.